

# **Annotated Bibliography: Fisheries Species and Oil/Gas Platforms Offshore California**

**MBC Applied Environmental Sciences**

**Costa Mesa, California : MBC Applied Environmental Sciences, February 1987.**

**OCS study MMS 86-0092.**

Funded by the Pacific Outer Continental Shelf Region of the Minerals Management Service, US Department of the Interior.

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The Annotated Bibliography: Fisheries Species and Oil/Gas Platforms Offshore California presents 879 references on important fisheries species offshore California and on the ecology of fish and invertebrates which associate with oil and gas platforms offshore California.

This Bibliography was published in:

Annotated bibliography: fisheries species and oil/gas platforms offshore California. Costa Mesa, CA: MBC Applied Environmental Sciences, 1987. OCS study MMS 86-0092. Funded by the Pacific Outer Continental Shelf Region of the Minerals Management Service, US Department of the Interior. [Preface of printed version says there are more than 950 citations but the Sci-Mate database obtained by SIO Library had 879 citations.]

This Bibliography comprises almost all the references cited in these two printed reports:

1: Ecology of important fisheries species offshore California. MBC Applied Environmental Sciences. MBC Applied Environmental Sciences. Costa Mesa, CA: MBC Applied Environmental Sciences, 1987. OCS study MMS 86-0093. Funded by the Pacific Outer Continental Shelf Region of the Minerals Management Service, US Department of the Interior.

2: Ecology of oil/gas platforms offshore California. MBC Applied Environmental Sciences. MBC Applied Environmental Sciences. Costa Mesa, CA : MBC Applied Environmental Sciences, 1987. OCS study MMS 86-0094. Funded by the Pacific Outer Continental Shelf Region of the Minerals Management Service, US Department of the Interior.

Prosobranchia: Marine snails.

AUTHOR(S): Abbott, D. P., and E. C. Haderlie.

YEAR: 1980.

SOURCE: Pages 230-307 in R. H. Morris, D. P. Abbott, and E. C. Haderlie (eds.), Intertidal invertebrates of California, Stanford Univ. Press, Stanford, CA.

KEYWORDS: Red abalone, *Haliotis rufescens*, fishery, economics, distribution, reproduction, life history, physiology, reproduction, growth, feeding, mortality, habitat.

ABSTRACT: This section of Intertidal Invertebrates of California addresses the

subfamily Prosobranchia, the largest of the three main divisions of the class Gastropoda, which includes the red abalone, *Haliotis rufescens*. The biology of the animal is discussed as well as its distinctive characteristics, range, habitat, interactions with other species, economic importance, and current research.

A probability sea survey plan for estimating relative abundance of ocean shrimp.

AUTHOR(S): Abramson, N. J.

YEAR: 1968.

SOURCE: Calif. Fish Game 54(4):257-269.

KEYWORDS: *Pandalus jordani*, ocean shrimp.

ABSTRACT: A method was designed to estimate relative abundance of the ocean shrimp, *Pandalus jordani*, using a stratified two-stage research vessel survey. First and second stage units were random otter trawl hauls and a random subsample of the catch, respectively. Relative abundance and variance formulas are given. The most feasible design was proportional allocation at the first stage and a constant sample size at the second.

Distribution and abundance of sardine and anchovy larvae in the California current region off California and Baja California, 1951-64: A summary.

AUTHOR(S): Ahlstrom, E. H.

YEAR: 1966.

SOURCE: U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 534:71 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, distribution.

ABSTRACT: Larval distribution and abundance of the northern anchovy, *Engraulis mordax*, in 1951-1964 from waters off California and Baja California are reported. Similar information on the Pacific sardine, *Sardinops caeruleus*, is given. Numerous tables are given summarizing the occurrence and abundance of larvae by cruise and area, and the size composition by cruise. Most anchovy larvae were distributed between Point Conception, California, and Point San Juanico, Baja California. The southern and offshore extent of anchovy spawning has been adequately circumscribed, while the northern extent has not been well delineated. The major portion of anchovy larvae were taken off Baja California, except in 1957, 1959, and 1964. Few anchovies were taken off northern California where less than 5% of hauls contained larvae. As a whole, central California was more important for eggs and larvae with the area between Point Sur and Point San Luis the most significant. Anchovy populations increased markedly since 1951, rapidly until 1954, reaching a plateau through 1957, and again increasing rapidly until 1962. Approximately nine times as many larvae were

taken per year during the recent period as during the early 1950s. Numbers of larvae decreased markedly with increase in size.

Sardine eggs and larvae and other fish larvae, Pacific Coast, 1957.

AUTHOR(S): Ahlstrom, E. H.

YEAR: 1959.

SOURCE: U.S. Fish Wild. Serv. Spec. Sci. Rep. Fish. 328:99 pp.

KEYWORDS: Eggs, larvae, distribution, abundance, northern anchovy, *Engraulis mordax*, *Scomber japonicus*, chub mackerel, jack mackerel, *Trachurus symmetricus*.

ABSTRACT: The size, distribution and abundance of Pacific sardine, *Sardinops caerulea*, eggs and larvae were reported. In addition, the larvae of northern anchovy, jack mackerel, Pacific mackerel, Pacific hake, and rockfish were also considered. Samples were collected, with plankton nets, from San Francisco to Cabo San Lucas at depths of 140 m to the surface. Anchovy larvae was the most abundant species in the survey area, followed, in decreasing importance, by hake, rockfish, jack mackerel, sardine, and Pacific mackerel. Sardine larvae were found further south than eggs due to the southward transport. Larger larvae were found only in the southern part of the distribution. Eggs were obtained in the northern part of the range during June, and in the southern part of the range from March to July and October.

Co-occurrences of sardine and anchovy larvae in the California current region off California and Baja California.

AUTHOR(S): Ahlstrom, E. H.

YEAR: 1966.

SOURCE: CalCOFI Rep. 11:117-135.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, spawning.

ABSTRACT: The co-occurrences of the Pacific sardine, *Sardinops caeruleus*, and northern anchovy, *Engraulis mordax*, are reported along with their interactions off California and Baja California during 1951-1960. In recent years the Pacific sardine and northern anchovy have experienced reduced spawning off central California. Anchovy egg and larval distribution changed less than that of sardines, with a spread northward in 1958 and 1959. Sardine larvae were more abundant in 1954 but in 1962 anchovy larvae outnumbered sardine larvae by more than 90 to 1. High and low abundance estimates for sardine and anchovy larvae were 7.3 to 1.2 and 55 to 15.1 trillion, respectively. An increase in co-occurrences of anchovy larvae in collections with sardine larvae from 62% (1954) to 87% (1960) was observed. For the decade as a whole, anchovy larvae co-occurred with sardine and sardine larvae co-occurred with anchovy in 69.8% and 22.0% of hauls, respectively. The co-occurrence of eggs is less than that for larvae. More larvae per sample were obtained in hauls with both species than when that species occurred alone. Newly hatched larvae co-occurred less than older larvae. Anchovy abundance quadrupled during the 1950s, while after 1954 sardine abundance progressively decreased. Anchovies should have had an advantage over sardines if interspecies competition was a factor in larval survival and co-occurrence was a measure of competition. Even though numbers of larvae per tow were larger in hauls which contained both species, there was no indication of better survival.

Report of neuston (surface) collections made on an extended CalCOFI cruise during May 1972.

AUTHOR(S): Ahlstrom, E. H., and E. Stevens.

YEAR: 1976.

SOURCE: CalCOFI Rep. 18:167-180.

KEYWORDS: *Engraulis mordax*, northern anchovy, larvae, *Anoplopoma fimbria*, sablefish, *Sebastes* sp., *Trachurus symmetricus*, jack mackerel.

ABSTRACT: This paper reports on neuston net hauls made simultaneously with oblique plankton tows by the California Cooperative Oceanic Fisheries Investigations. In neuston tows, the number of fish larvae collected ranged from zero to 1,039 with 50% having zero to 10. Oblique hauls with zero to 10 larvae were found 13% of the time. Overall, the average catch in neuston samples was about one-third that taken in oblique tows. In neuston hauls, six species and four genera accounted for 91.4% of the total taken: *Engraulis mordax* (43.3%), *Cololabis saira* (15.6%), *Oxyporhampus micropterus* (11.2%), *Anoplopoma fimbria* (6.7%), *Tarletonbeania crenularis* (4.2%), *Oligoplites* sp. (3.6%), *Opisthonema* sp. (2.1%), *Sebastes* sp. (1.9%), *Vinciguerria lucetia* (1.9%), and *Auxis* sp. (0.9%). Taken exclusively in neuston samples were larvae-juveniles of *A. fimbria*, *Macrorhamphosus gracilis*, and *Opisthonema* sp. Almost 2.5 times as many species were taken in the oblique hauls, with eight species and two genera contributing 87.1%. Offshore and inshore species composition comparison are made. Northern anchovy, Pacific caury, jack mackerel, sablefish, rockfish, slender snipefish, and myctophid lanternfishes are all discussed in detail in relation to catches from surface neuston nets.

Neuston samples are beneficial in evaluating species which have stages from egg to juvenile which congregate near the surface. Some species are sampled more abundantly in neuston gear and some are not. It should not be regarded as a primary tool, but a supplementary one with potential.

Distributional atlas of fish larvae in the California current region: flatfishes, 1955 through 1960.

AUTHOR(S): Ahlstrom, E. H., and H. G. Moser.

YEAR: 1975.

SOURCE: CalCOFI Atlas 23:207 pp.

KEYWORDS: Groundfish, larvae, distribution, California halibut, *Paralichthys californicus*, English sole, *Parophrys vetulus*, Dover sole, *Microstomus pacificus*.

ABSTRACT: Eight species of larval flatfish were sampled in the California current off California and Baja from 1955 to 1960. The species and total abundance were speckled sanddabs, *Cithericthys stigmaeus*, 8040; sanddabs, *Cithericthys* spp., 66,657; slender sole, *Cyopsetta exilis*, 3074; halibut, *Paralichthys californicus*, 1662; English sole, *Parophrys vetulus*, 1770; turbot, *Plerromichthys* spp., 3161; vex sole, *Glyptocephalus zachirus*, 303; and Dover sole, *Microstomus pacificus*, 798. Abundances were summarized according to stations and years. A species description, the most common distribution and peaks in occurrence, were presented for each species.

B. Y. Sumida.

Pleuronectiformes: Development.

AUTHOR(S): Ahlstrom, E. H., K. Amaoka, D. A. Hensley, H. G. Moser, and  
YEAR: 1984.

SOURCE: Spec. Publ. No. 1, Amer. Soc. Ichthyo. Herp.: Ontogeny and  
Systematics of Fishes 640-670 pp.

KEYWORDS: Early life history, growth, petrale sole, *Eopsetta jordani*,  
English sole, *Parophrys vetulus*, California halibut,  
*Paralichthys californicus*, Dover sole, *Microstomus pacificus*,  
growth, larvae.

ABSTRACT: A summary of information known about the development of the  
eggs and larvae of Pleuronectiformes species. Development of the  
egg stage is described in general for the different species. Eggs  
are also described for the species which lack oil globules,  
species with a single oil globule, and those with multiple oil  
globules. Larval development is described at the family level.  
Corresponding drawings of larvae with lengths are presented along  
with the descriptions.

Population fluctuations of California seal lions and the  
Pacific whiting fishery off central California.

AUTHOR(S): Ainley, D. G., H. R. Huber, and K. M. Bailey.  
YEAR: 1982.

SOURCE: Fish. Bull. 80(2):253-258.

KEYWORDS: Pacific hake, *Merluccius productus*, population trends,  
fishery.

ABSTRACT: This study presents data that points to a direct correlation  
between population trends (fluctuations) of California sea lions  
(*Zalophus californianus*) and Pacific whiting (*Merluccius  
productus*) from 1971 to 1980, in the Farallon Islands, central  
California. The assumption is that regulations restricting the  
hake fishery off central California in 1976 has led to the  
observed increase in the population levels of California sea  
lions and possibly other marine mammals. Scatological evidence  
reveals that Pacific whiting is significant in the feeding habits  
of the California sea lion. The sea lions were most abundant at  
the sites when whiting predominated the diet. A direct  
correlation existed between the human fishing effort and the  
prevalence of whiting in the diet of sea lions from 1974-1976.  
Starting sometime between 1963 and 1967, and lasting until 1975,  
a decline in sea lion population existed at Ano Nuevo Island and  
the Farallons. Since then numbers have been increasing. A similar  
argument is also proposed for the changes in occurrence of the  
northern fur seal (*Callorhinus ursinus*) at the Farallons. The  
general feeding behavior and biology of the Pacific hake  
(*Merluccius productus*) was studied. 552 stomachs of Pacific hake  
were examined. The major food items in the stomach were, in  
decreasing importance, euphausiid shrimps (*Thysanoessa spinifera*  
and *Euphausia pacifica*), fish (*Thaleichthys pacificus*), pandalid  
shrimp (*Pandalus jordani*), penaeid shrimp (*Sergestes similis*),  
crab larvae, cragonid shrimp, and squid. Very little variation could  
be discerned in the seasonality of the food preferences. The data  
tends to indicate a more concerted feeding effort by the hake during  
the hours of twilight and darkness. It was also suggested that the  
diel vertical migration of hake was in response to the diel vertical  
migration of their main prey items.

S. H. Morrell.

Study of marine mammals at the Farallon Islands, California,  
1975-76.

AUTHOR(S): Ainley, D. G., H. R. Huber, R. P. Henderson, T. J. Lewis, and  
YEAR: 1977.

SOURCE: Mar. Mam. Comm., Washington, D. C. Rep. MMC 75/02, 32 pp.

KEYWORDS: Pacific hake, *Trachurus symmetricus*, mortality.

ABSTRACT: Five species each of pinnipeds and cetaceans were observed on or near the South Farallon Islands from September to August. Gray whales were observed daily from December to July. Humpback whales were observed almost daily from September to November, and several days in August. Killer and minke whales were observed twice, while Dalls porpoise was observed once. Observations of the pinniped species (Steller's sea lions, California sea lions, northern fur seal, harbor seal, and elephant seals) included information on censuses, pregnancy rates, pup mortality rates, feeding habits, and movements. The presence of large numbers of California sea lions is thought to be caused by the availability and preference for Pacific hake.

Spatial overlap and competition in congeneric surfperches  
(Embiotocidae) off Santa Barbara, California.

AUTHOR(S): Alevizon, W. S.

YEAR: 1975.

SOURCE: Copeia 1975(2):352-356.

KEYWORDS: Habitat, feeding, community, behavior.

ABSTRACT: This paper presents the results of a study of two pairs of congeneric embiotocid fishes which live in and about great kelp beds off Santa Barbara, CA. Data generated by the study suggests that species may segregate themselves to some degree through a behavioral mechanism, each associating with different structural features of the habitat which might enable the congeners to coexist while exploiting the same food resources. Data for this study were compiled from 128 two-and-one-half minute underwater movie strips taken by SCUBA divers swimming in and about kelp beds off Santa Barbara and Santa Cruz Island. Tables are used to report the data and subsequent analyses.

Notes on the spiny lobster (*Panulirus interruptus*) off the  
California coast.

AUTHOR(S): Allen, B. M.

YEAR: 1916.

SOURCE: Univ. California Publ. Zool. 16(12):139-152.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, feeding, distribution, seasonality, life history.

ABSTRACT: A brief overview of spiny lobster, *Panulirus interruptus*, biology is presented. Most lobsters are less than 6 pounds and any over 10 are very uncommon; the larger ones are usually males. They are found in rocky areas that can range from shallow tide pools to depths of 18 fathoms. The nocturnal lobster eats a variety of foods and is, at times, cannibalistic. Chief enemies include the sheephead, conger-eel, jew-fish, and devil-fish. Lobster movements documented through tagging studies revealed a maximum distance traveled of 9.6 miles in 28 days, and a maximum rate of travel of 0.43 miles per day. The average distance and time traveled was 1.4 miles and 22 days, respectively. Their

movements were apparently haphazard in direction, with size and sex having no bearing on direction or extent. A seasonal offshore migration was also noted. An estimated 16% of the total number of spiny lobsters is caught per year. Spawning is as early as March 1 with a maximum spawn around the end of June. Eggs hatch in 9 to 10 weeks, well on into August. Females spawn each year in areas that are sheltered and close to shore. Sex ratios vary greatly with time and place.

A habitat analysis of the nearshore marine fishes from southern California.

AUTHOR(S): Allen, L. G.

YEAR: 1985.

SOURCE: Bull. So. Calif. Acad. Sci., 84(3):133-155.

KEYWORDS: Habitat, *Sebastes* spp., rockfish, *Paralabrax clathratus*, kelp bass,

*Prachurus symmetricus*, jack mackerel, *Sarda chiliensis*, Pacific bonito, *Engraulis mordax*, northern anchovy, *Scomber japonicus*, chub mackerel, *Paralichthys californicus*, California halibut.

ABSTRACT: Data from 38 ichthyofaunal studies of habitats within the California

Bight were synthesized to determine fish species and the habitats in which they occur. Nine distinct habitats were identified using quantitative clustering of the 105 species reported in the studies. This paper presents a quantitative classification of nearshore marine habitats and fish species according to habitat affinity. General patterns of diversity within habitat types are described, accompanied by explanations for this diversity. Schematics of the nine habitats illustrating the species found in that location are also provided.

Temporal and spatial patterns of nearshore distribution and abundance of pelagic fishes off San Onofre, Oceanside, California.

AUTHOR(S): Allen, L. G., and E. DeMartini.

YEAR: 1983.

SOURCE: Fish. Bull. 81(3):569-586.

KEYWORDS: *Engraulis mordax*, northern anchovy, distribution.

ABSTRACT: Pelagic fish groups were sampled from various depth strata in the

nearshore waters approximately 0.5 to 3.0 km off San Onofre, southern California over a 2-year period. Six hundred and forty-three net hauls were made at 5-11 m, 12-16 m and 18-27 m during the day and night. Sixty-two species were collected (thirty-three families). The catch was dominated by five species, making up 98% of the individuals. These included *Engraulis mordax* (81%) *Seriphus politus*, *Genyonemus lineatus*, *Peprilus simillimus* and *Atherinops* spp. The catch per unit effort was highest during the summer due to increases in the anchovy population, and fluctuated little throughout the rest of the year. The five most common species exhibited depth shifts over a diel period. Gut content analyses suggested the species dispersal pattern offshore at night was related to nocturnal feeding. These patterns were partly related to differences in water clarity and to day/night differences in catch efficiency.

Structure and seasonal dynamics of the fish assemblage in the Cabrillo Beach area of Los Angeles Harbor, California.

AUTHOR(S): Allen, L. G., M. H. Horn, F. A. Edmonds II, and C. A. Usui.  
YEAR: 1983.

SOURCE: Bull. So. Calif. Acad. Sci. 82(2):47-70.

KEYWORDS: Distribution, Pacific bonito, *Sarda chiliensis*.

ABSTRACT: This paper reports the results of a sampling study conducted from

February 1979 to January 1980 in the Cabrillo Beach area of Los Angeles Harbor to study the structure and seasonal dynamics of fish assemblages. Quantitative clustering of juvenile-adult species in each sample produced five distinct groups of resident and periodic species. Sampling methods used and the results obtained are discussed in detail. Illustrations of the fish assemblages at the various depths are provided for easy reference.

Functional structure of softbottom fish communities of the Southern California Shelf.

AUTHOR(S): Allen, M. J.

YEAR: 1982.

SOURCE: Ph.D. dissertation, Univ. Calif., San Diego, CA. 577 p.

KEYWORDS: Distribution, feeding, behavior, mortality, community, northern anchovy, Pacific hake, bocaccio, vermilion rockfish, sablefish, Dover sole, English sole, California halibut.

ABSTRACT: This study describes the organization of the softbottom fish communities of the southern California mainland shelf from 10 to 200 m depth in terms of the resource partitioning relationships of the fishes. Size and distributional data on the fishes were collected from 342 otter trawl samples taken from 99 stations during 1972 to 1973. Catches were dominated by pleuronectiform and scorpaeniform fishes and included 126 species from 43 families. To determine the feeding habits of the fishes, 1,013 stomachs were examined; these contained 461 prey species from 218 families and 31 classes. From this information, species were classified into 15 major foraging guilds. A set of the depth displacement graphs for each guild was arranged to describe the functional structure and species composition of the communities. Community structure is described in terms of the number and type of feeding guilds that are found at a given depth and the species composition in terms of which species of each guild dominates at that depth. This description of the communities provides a framework around which further studies can be directed to determine what natural or man-related factors contribute to or alter community organization.

Life history of the Dover sole.

AUTHOR(S): Allen, M. J., and A. J. Mearns.

YEAR: 1976.

SOURCE: Pages 223-228 in Coastal water research project annual report, 1976. Southern California Coastal Water Research Project, El Segundo, CA.

KEYWORDS: Dover sole, *Microstomus pacificus*, life history, spawning, migration, contaminant susceptibility.

ABSTRACT: This paper summarizes life history information of the Dover sole, *Microstomus pacificus*, as pertinent to the southern California population. Although Dover sole are distributed from the Bering Sea to Baja California, the only commercially important stocks occur from British Columbia to Santa Barbara, California. Adult Dover sole are migratory in that they move into deeper water (up to 1,189 m) to spawn in the fall and winter.



Movements along the coast are believed to be limited in general. South of Santa Barbara, Dover sole are generally most abundant near deepwater municipal wastewater outfalls where infaunal food organisms are abundant. Adult and juvenile Dover sole are important members of deep mud-bottom communities in southern California. Refer to article for a discussion of species associated with Dover sole, primary prey items, competitors and predators. Fecundity is generally correlated with size, with smaller individuals of about 40 cm producing 40,000 to 50,000 eggs and larger individuals of 50 to 60 cm producing about 250,000 eggs. The southern California population of Dover sole appears to be mainly supported by larval recruitment north of Point Conception. The growth rate of *M. pacificus* is lower in southern California populations than in northern California and specimens caught in southern California are generally less than 8 years old. Optimal conditions for growth are apparently not available at the southern end of its distribution. Growth rates are generally higher than island populations. The Dover sole is particularly susceptible to contaminant levels found near wastewater outfalls and exhibits a number of afflictions. Refer to article for a discussion of the various types of afflictions associated with populations located near wastewater outfalls.

Marine organisms around outfall pipes in Santa Monica Bay.

AUTHOR(S): Allen, M. J., H. Pecorelli, and J. Word.

YEAR: 1976.

SOURCE: Jour. Water Poll. Contr. Fed. 48(8):1881-1893.

KEYWORDS: *Sebastes goodei*, chilipepper rockfish, *Sebastes miniatus*, vermillion rockfish, *Sebastes paucispinis*, bocaccio, habitat, distribution, artificial reef, behavior.

ABSTRACT: Color photographs were taken at various locations along the submerged wastewater discharge pipes of the Hyperion Wastewater Treatment Plan (Los Angeles City Sanitation District) in order to describe the floral and faunal assemblages associated with those pipes. Estimates of abundance of each species were not made. *S. paucispinis* was observed to form dense aggregations in the water column. *S. miniatus* was observed to aggregate with the lower portions of the *S. paucispinis* aggregations or associate closer to (but not on) the bottom. These two species were particularly abundant at the deep terminal discharge points of the pipes. The pipe structure apparently attracts the water column aggregating fishes.

Hook and line survey of demersal fishes in Santa Monica Bay.

AUTHOR(S): Allen, M. J., J. B. Isaacs, and R. M. Voglin.

YEAR: 1975.

SOURCE: Southern California Coastal Water Research Project, 23 pp.

KEYWORDS: Fishing gear, *Sebastes* spp., Dover sole, *Microstomus pacificus*, English sole, *Parophrys vetulus*, groundfish.

ABSTRACT: The objective of this study was to compare the catch yield of otter trawl sampling with hook and line (rod/reel and setlines) sampling for species composition, abundance, size and disease frequency of demersal fish. This project was conducted at various sites within Santa Monica Bay, southern California. The hook and line fishing gear method provided fewer species per station than did the otter trawls. Rod and reel sampling was much more effective at sampling high-in-the-water-column species than the

setline or otter trawl methods. Hook and line also caught generally larger fish than did otter trawls. Setlines were more effective in shallow water than were hook and line methods. The greatest fish numbers for any method were caught near the Hyperion sludge outfall.

A biochemical-genetic population structure study of the market squid, *Loligo opalescens*, along the California coast.  
AUTHOR(S): Ally, J. R. R., and S. A. Keck.  
YEAR: 1978.  
SOURCE: Calif. Dep. Fish Game, Fish Bull. 169:113-122.  
KEYWORDS: Market squid, *Loligo opalescens*, distribution.  
ABSTRACT: Market squid, *Loligo opalescens*, were collected from several locations along the coast of California and the offshore islands. Electrophoretic and histochemical analyses were utilized to determine the genetic variation of the population. Most samples consisted of spawning individuals and in all but one case, males outnumbered females by 1.1:1 to 49:1 dominance. The results suggested some geographic and temporal discrimination in the squid population. However, without more data the study was inconclusive.

A population study of squid, *Loligo opalescens* Berry.  
AUTHOR(S): Ally, J. R. R., J. P. Christofferson, and J. Kashiwada.  
YEAR: 1978.  
SOURCE: Amer. Zool. 18(3):663.  
KEYWORDS: Market squid, *Loligo opalescens*, distribution, population trends.  
ABSTRACT: Squid, *Loligo opalescens*, populations at several sites in California as well as Baja California and Puget Sound, Washington were analyzed. The mantle muscle enzymes were extracted and found to be polymorphic. Morphological characteristics were also examined. The results, although inconclusive, suggest geographically and temporally structured populations of squid.

Food of Pacific hake, *Merluccius productus*, in Washington and northern Oregon coastal waters.  
AUTHOR(S): Alton, M. S., and M. O. Nelson.  
YEAR: 1970.  
SOURCE: U. S. Fish Wild. Serv. Circ. 332:35-42.  
KEYWORDS: Pacific hake, *Merluccius productus*, feeding, migration.  
ABSTRACT: Pacific hake were collected off the coasts of Washington and northern Oregon. Stomach contents were identified and the frequency of occurrence and weight determined for each prey species. In terms of frequency of occurrence euphausiids (90%), fish (25%), then pandalid shrimp (8.6%) were the most important prey species. Importance based on weight followed the same order as frequency of occurrence, but the percentages varied because of the small size of euphausiids relative to the size of fish and pandalid shrimp. Hake appear to feed between sunset and the following morning as evidenced by the greater number of empty stomachs late in the day. This observation corresponds with the fact that several of the hake's prey species make daily vertical migrations (e.g. some euphausiid and pandalid shrimp species), but this may be a correlative versus cause-and-effect relationship.

Sablefish (family Anoplopomatidae).

AUTHOR(S): Alton, M. S., and R. A. Webber.

YEAR: 1976.

SOURCE: Pages 425-438 in W. T. Pereyra, J. E. Reeves, and R. G. Bakkala.

Demersal fish and shellfish resources of the eastern Bering sea in the baseline year 1975. Processed Rep., Northw. Alaska Fish. Ctr., Natl. Mar. Fish. Serv., NOAA, Seattle, WA.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, physiology, distribution, migration,

life history, early life history, spawning, growth, age, length, mortality, feeding, fishery.

ABSTRACT: This paper discusses the distribution and abundance of the sablefish

occurring off North America from Mexico to the Gulf of Alaska and Bering Sea. Migration patterns, based on tagging studies conducted by Japan, the U. S. and the Republic of Korea are illustrated on maps. A detailed discussion of the sablefish life history, including but not limited to spawning, growth, age, feeding and mortality, is followed by a report on the fishery which outlines catch statistics, the condition of the resources and its protection and management.

A study of demersal fishes and fisheries of the northeastern Pacific Ocean.

AUTHOR(S): Alverson, D. L., A. T. Pruter, and L. L. Ronholt.

YEAR: 1964.

SOURCE: H. R. MacMillan Lectures in Fisheries, Univ. British Columbia, Vancouver, B. C. 190 pp.

KEYWORDS: *Sebastes entomelas*, widow rockfish, *S. goodei*, chilipepper rockfish, *S. miniatus*, vermillion rockfish, *S. paucispinis*, bocaccio, distribution, groundfishes, fishery, fishing gear, regulations.

ABSTRACT: History of the north Pacific coast groundfisheries including the fishing gear, regulations, research conducted (areas surveyed and methods of analyses) and commercial catch was summarized. Geographic ranges of commercially caught rockfishes from Oregon north to the Alaska Peninsula and depth distribution of commercially caught rockfishes was tabulated. *Sebastes entomelas*, *S. goodei*, *S. miniatus* and *S. paucispinis* ranged in depth from 50-199, 100-149, 100-149 and 50-199 fathoms, respectively. Abundance (weight) of each species collected by depth was tabulated for *S. entomelas*, *S. goodei*, *S. miniatus*, and *S. paucispinis*. The percent (by weight) of the total rockfish catch (and total fish catch) by depth intervals accounted for by each species was tabulated for *S. entomelas*, *S. goodei*, *S. miniatus* and *S. paucispinis*. The percent size composition of *S. entomelas* (male and female separately) was illustrated.

Status of knowledge of the Pacific hake resource.

AUTHOR(S): Alverson, D. L., and H. A. Larkins.

YEAR: 1969.

SOURCE: CalCOFI Rep. 13:24-31.

KEYWORDS: Hake, *Merluccius productus*, age, distribution, migration, length/weight, fishery, spawning, behavior.

ABSTRACT: A summary of the current knowledge of Pacific hake. The overview covers information on the general biology, distribution, abundance, migration patterns, size of the mature stock, stock components, school behavior, and design of a fishing rationale, Pacific hake range from the Gulf of Alaska to the Gulf of

California, although most of the species occurs between central Vancouver Island and Baja California. Except for local, resident stocks, in Puget Sound and perhaps other inshore areas, the entire coastal hake population apparently spawns off southern California and Baja California. Exploratory fishing surveys have suggested that during the summer the average length of hake decreases from north to south. The hake resources off California, estimated to be in the order of 3.6 million tons, is reported to be second in size only to the northern anchovy in the California current system. Available data are insufficient to indicate whether or not segments of the coastal hake population are isolated genetically.

Brown pelicans as anchovy stock indicators and their relationships to commercial fishing.

AUTHOR(S): Anderson, D. W., F. Gress, K. F. Mais, and P. R. Kelly.

YEAR: 1980.

SOURCE: CalCOFI 21:54-61.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, regulations.

ABSTRACT: One local population of brown pelicans (*Pelecanus occidentalis californicus*) is used to show the potential for interdisciplinary and interagency collaboration in a complicated management situation, dealing with this protected species and a commercially utilized wetfish, the northern anchovy (*Engraulis mordax*). Pelican breeding effort and reproductive rate are dependent largely on levels of anchovy abundance and availability. This situation makes pelicans sensitive to changes in these fish, due to environmental stochasticity and its variation in anchovy carrying capacity and to a reduced carrying capacity for pelicans through increased anchovy harvests. The relationship between mean Southern California Bight (SCB) anchovy biomass and mean pelican reproductive rate in the SCB is emphasized. Productivity (F) is one of the most sensitive productive parameters of brown pelicans as an index to anchovy availability. Anchovy abundance (B) is best related to F by the logarithmic curve,  $F = -1.4 + 0.55 \ln B$ . Minimum levels of anchovy abundance for effective pelican reproduction is defined as  $B_{min}$  and estimated at 40 mi<sup>2</sup> anchovy school surface. It appears that a total biomass level of about 43 mi<sup>2</sup> or  $2.15 \times 10^6$  short tons may be the level in the SCB below which high pelican reproduction is very poor. This is about 78% of the long-term mean of biomass estimated for the central stock of anchovies. Both pelicans and fishermen respond to variations in anchovy biomass as consumers without mutual interference, with the old fishery outpacing pelicans in response to higher levels of abundance. Pelicans require only 0.08% of the mean SCB anchovy biomass, and when migrant birds are added in the fall this requirement increases to 0.33%. The brown pelicans dependency on anchovies is well demonstrated. The management and conservation needs of offshore wildlife add a new dimension to the goals of management of commercially valuable resources. The most effective management will occur when fish populations are maintained above  $B_{min}$ .

Estimating the population dynamics of coho salmon (*Oncorhynchus kisutch*) using pooled time-series and cross-sectional data.

AUTHOR(S): Anderson, J. L., and J. E. Wilen.

YEAR: 1985.

SOURCE: Jour. Fish. Aquat. Sci. Canada 42(3):459-467.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, population trends, life history, wetfish.

ABSTRACT: The population dynamics of coho salmon were estimated using pooled time-series and cross-sectional data from the Washington coast, the Columbia River region, and the California/Oregon coast. The data were incorporated into two population dynamics models: the Beverton-Holt, and the Ricker models, both of which were modified to take into account certain environmental conditions. Both of the models demonstrated that recruitment of natural stock was positively affected by parent stock and river flow, and negatively by hatchery smolt releases. On the other hand, recruitment of hatchery stock was positively affected by smolt release level and oceanic upwelling, and negatively affected by smolt release density.

Timing of postvitellogenic ovarian changes in the ridgeback prawn, *Sicyonia ingentis* (Penaeidae) determined by ovarian biopsy.

AUTHOR(S): Anderson, S. L., E. S. Chang, and W. H. Clark, Jr.

YEAR: 1984.

SOURCE: Aquaculture 42:257-271.

KEYWORDS: *Sicyonia ingentis*, ridgeback prawn, spawning.

ABSTRACT: The states of postvitellogenic ovarian changes for the ridgeback prawn, *Sicyonia ingentis*, have been previously described. The purpose of this paper is to describe the relative timing of changes in the postvitellogenic ovary. Ovarian biopsy did not have a significant effect on survival or number of spawns under experimental conditions employed. There is considerable variability in the amount of time spent in a given oocyte stage. The maximum possible range for the time it takes for an oocyte to develop from the cortical specialization phase (cs) to spawning is 1-9 days. The mean time in two groups of animals subjected to repeated ovarian biopsies were 97 plus or minus 53 h and 84 plus or minus 22 h. Most of this time is spent in the CS phase, while the germinal vesicle breakdown phase (GVBD) may last more than 24 hrs. The follicular changes of ovulation occur within a few hours and spawning requires less than a minute. GVBD does not occur synchronously throughout the ovary; however, at ovulation all oocytes had undergone GVBD.

Size distributions and sex ratios of ridgeback prawns

(*Sicyonia ingentis*) in the Santa Barbara Channels (1979-1981).

AUTHOR(S): Anderson, S. L., L. W. Botsford, and W. H. Clark, Jr.

YEAR: 1985.

SOURCE: CalCOFI Rep. 26:169-174.

KEYWORDS: Ridgeback prawn, *Sicyonia ingentis*, fishery, age, population trends, length/weight.

ABSTRACT: The ridgeback prawn, *Sicyonia ingentis*, was sampled by trawl in the

Santa Barbara Channel over two years (1979-1981). The size distribution ranged from 23-47 mm carapace length. The maximum size of the females were consistently greater than the males. The age structure of the shrimp was not discerned from the evidence. In 1980, a 1:1 sex ratio was noted in all but the fall months when females outnumbered males by 6.4. In 1981, the sex ratio varied

widely with males outnumbering females in 7 of the 12 months.

Multiple spawning and molt synchrony in a free spawning shrimp  
(*Sicyonia ingentis*: Penaeidae).

AUTHOR(S): Anderson, S. L., W. H. Clark, Jr., and E. S. Chang.

YEAR: 1985.

SOURCE: Biol. Bull. 168:377-394.

KEYWORDS: *Sicyonia ingentis*, ridgeback prawn, spawning, reproduction.

ABSTRACT: The duration of molt cycle stages and multiple spawning within a single molt cycle for a Penaeolidd shrimp, *Sicyonia ingentis*, is examined. The gonadosomatic index (GSI) was low from November to April, increased in late April, and was highest during late June, July, August and September. During the former months, 75-95% of the population was ripe. There was a strong indication for potential multiple spawning during the season of reproduction. Females exhibited a bimodal frequency in molt activity while males showed no discernible peaks. A high frequency of molting was exhibited with significant variability in the length of the molt cycle and the relative duration of molt cycle stages. Asynchronous molting was indicated from January through June. The lowest number of sperm present in a spawned female was more than ten times higher than the number of embryos in the largest spawn. Fifty percent of females spawned a second time in the laboratory with no molts before spawning. The shrimp spawning season in the Santa Barbara Channel is from June through October, with a high incidence (75-95%) of ripe animals at anytime. Molt activity varied dramatically, with changes in reproductive status and season, showing molt synchrony in the population. There is an indication of a strong potential for multiple spawning occurring without intervening molt or mating.

A description of laboratory-reared larvae of the yellow crab,  
*Cancer anthonyi* Rathbun (Decapoda, Brachyura), and comparisons  
with larvae of *Cancer magister* Dana and *Cancer productus*  
Randall.

AUTHOR(S): Anderson, W. R.

YEAR: 1978.

SOURCE: Crustaceana 34(1):55-68.

KEYWORDS: *Cancer anthonyi*, *Cancer magister*, *Cancer productus*, market crab, rock crab.

ABSTRACT: Eggs of yellow crab, *Cancer anthonyi*, were maintained in aquaria until hatching. The larval stages were observed and comparison with *Cancer magister* and *C. productus* larvae were discussed. Five zoeal stages and one megalop stage were passed through prior to the first crab stage. In this respect, the larvae were similar to *C. magister* and *C. productus*. No characteristics were noted which would be useful in segregating the larvae taken in net tows. A pre-zoeal stage, not reported in the other species, lasted for 2 hrs. The mean development times to the first crab stage were 35.8 and 44.8 days at 22 deg C and 18 deg C, respectively. Survival was higher (26%) at the elevated temperature than at the lower temperature (17%).

Epizootiology of tumors in a population of juvenile English  
sole (*Parophrys vetulus*) from Puget Sound, Washington.

AUTHOR(S): Angell, C. L., B. S. Miller, and S. R. Wellings.

YEAR: 1975.

SOURCE: Jour. Fish. Res. Board Can. 32(10:1723-1732.

KEYWORDS: English sole, Parophrys vetulus, recruitment, age, growth.

ABSTRACT: Monthly variations in the abundance of tumorous and normal young-of-the-year English sole, tumor incidence, tumori-genesis, sex ratios of tumorous and normal fish, and tumor location are presented. In 1966 and 1969, the incidence of tumorous fish rose rapidly in the summer influx after August, peaking in October. Tumorous fish had from 1 to 12 angioepithelial modules or epidermal papillomas/angioepithelial polyps, but few fish had more than three tumors each. Chi square tests indicated no significant differences in sex ratios between normal fish of the 1966 and 1969 year-classes, nor were there any significant differences in sex ratios between tumorous and normal fish of these year-classes. Chi square test of differences in tumor location between eyed and blind sides revealed no significant differences in the 1965 and 1966 year-classes, but the 1969 year-class had a significantly greater number of tumors on the blind side. This disease appears to be a significant cause of natural mortality in the population studied. Its presence may be an indicator of an environmental carcinogen but no experimental evidence supports this view.

Draft, EIS/Preliminary fishery management plan: Sablefish of the Bering Sea and northeastern Pacific Ocean.

AUTHOR(S): Anonymous

YEAR: 1976.

SOURCE: NOAA/NMFS. 104 pp.

KEYWORDS: Sablefish, Anoplopoma fimbria, groundfish, fishery, fishing gear, regulations.

ABSTRACT: A management plan is proposed for the sablefish, Anoplopoma fimbria, fisheries off the coast of the United States. Its purpose is to obtain an optimum sustained yield of fish and to re-allocate the harvest. The present fishery extends along the continental slope of the Bering Sea, along both sides of the Aleutian Islands, throughout the Gulf of Alaska, and southwards to southern California. The present gear used to exploit sablefish includes trawls, Danish seines, longlines, and traps. A discussion is made of the history and economics of the fishery, and the potential of competition between foreign and U.S. fishermen in certain areas. Stock measurement indices show overall declining catch rates since 1971 (and earlier in some areas) in the Bering Sea, the Aleutian region, and the northeastern Pacific Ocean. Only in area 11 (Eureka-Monterey) has an increase in catch been noted from 1970 to 1974, and this has been interpreted to be due to an increase in U.S. trawlers specifically seeking sablefish in response to increased market demand. Age size data indicated little change in catch composition since 1969 from a fishery average of 47-70 cm (3-9 year old) range fish. The calculated total allowable catch (based on optimal sustained yield) for the fishery for 1977 was 5,000 mt in the Bering Sea, 2,400 mt in the Aleutian region, 22,000 mt in the Gulf of Alaska, and 7,000 mt off Washington-California.

U.S. Albacore landings seen highest in 3 years.

AUTHOR(S): Anonymous.

YEAR: 1982.

SOURCE: Mar. Fish. Rev. 44(2):21.

KEYWORDS: Albacore, Thunnus alalunga, fishery, fishing gear, length/weight.

ABSTRACT: The U.S. albacore fishery was better in 1981 than in the two previous seasons. U.S. landings were estimated at 14,000 metric tons (t) as of mid-October. The total U.S. landings for 1980 were about 9000 t., and for 1979 about 7300 t. Average jigboat scores were 10 - 30 fish/day/boat with top catches of less than 150 fish/day. Fish size averaged 5.5 - 7.3 kg. (range of 2.7 - 22.7 kg.) aboard the jigboats. The sketchy information obtained from pole-and-line boats indicated an average fish weight of 13.6 - 18.9 kg.

Abalone farming boosts production, uses pollutants.

AUTHOR(S): Anonymous.

YEAR: 1980.

SOURCE: Sea Technology 21(8):23-24.

KEYWORDS: Abalone, Haliotis spp., fishery, growth, feeding.

ABSTRACT: Abalone farming along the west coast of North America was increased to meet consumer demands. Production had fallen to 15 to 20% of the level 10 years ago. The abalone were grown, from an almost microscopic size in plastic buckets, until they were transferred to larger containers. Transferring the young abalone involved wiping down the walls which often crushed their delicate shells. Photographic film plates were used in two capacities; as carriers for the abalone (which settled on the plates) and the chemicals were used as nutrients for diatom growth (which the young abalone fed on). The technique developed allowed safe transport of young abalone and provided nutrients for diatom growth effectively boosting production at abalone farms.

Sablefish tagging studies produce results.

AUTHOR(S): Anonymous.

YEAR: 1979.

SOURCE: Mar. Fish. Rev. 41(5-6):72.

KEYWORDS: Anoplopoma fimbria, sablefish, migration.

ABSTRACT: The preliminary results of a sablefish tagging study from the southeastern waters of Alaska are noted. Some sablefish are demonstrated to travel considerable distances, whereas others move very little. A positive relationship is indicated between the length of time that a tagged sablefish is free and the distance traveled before capture.

Spring and summer prey of California sea lions, *Zalophus californianus*, at San Miguel Island, California, 1978-1979.

AUTHOR(S): Antonelis, G. A., C. H. Fiscus, and R. L. DeLong.

YEAR: 1984.

SOURCE: Fish. Bull. 82(1):67-76.

KEYWORDS: Anchovy, *Engraulis mordax*, length/weight, mortality.

ABSTRACT: Sea lion food habit information was obtained by removing fish otoliths and squid beaks from seal lion scat samples. The prey parts were then identified to species and counted. This information was used to calculate the percent frequency of occurrence of each prey, compare annual and seasonal differences in prey selection and estimate the lengths and weights of the most frequently occurring prey species. The frequency of occurrence of the four most abundant prey species were Pacific whiting (48.7%), market squid (46.7%), rockfish (35.9%), northern



anchovy (20%). These four species appear to vary seasonally in the scat samples, indicating that sea lions feed opportunistically on the most abundant species.

Estimated annual food consumption by northern fur seals in the California current.

AUTHOR(S): Antonelis, G. A., Jr., and M. A. Perez.

YEAR: 1984.

SOURCE: CalCOFI Rep. 25:135-145.

KEYWORDS: Merluccius productus, Pacific hake, Engraulis mordax, northern anchovy, Loligo opalescens, market squid, mortality.

ABSTRACT: Estimates of the total annual food consumption by the fur seal, Callarhinus ursinus, population off California and Oregon-Washington was derived by reviewing the data on diet, feeding rates and migrations. Off California, the fur seals consume approximately 48,100 MT of fish and squid. The most important prey species include northern anchovy, Engraulis mordax (20,900 MT), hake, Merluccius productus (8,600 MT), squid, Loligo opalescens (6,200 MT), and Onycoteuthis sp. (6,200 MT). The fur seals consume approximately 33,600 MT off Oregon and Washington. The most important species include herring, Clupea Nerengus pallasie (5,900 MT), rockfish, Sebastes sp. (5,500 MT), northern anchovy (4,000 MT) and market squid (3,800 MT). In both regions their intake comprises approximately 75% fish and 25% squid. The seals annual consumption rates account for 13% of the anchovy fishery, 10% of the hake fishery, 15% of the herring fishery and 50% of the market squid fishery of the Pacific Coast.

Growth and mortality estimates of rockfishes (Scorpaenidae) from British Columbia coastal waters.

AUTHOR(S): Archibald, C. P., W. Shaw, and B. M. Leaman.

YEAR: 1981.

SOURCE: 1977-1979 Can. Tech. Rpt. Fish. Aquat. Sci. No. 1048, 57 pp.

KEYWORDS: Sebastes entomelas, widow rockfish, age, growth.

ABSTRACT: Data collected from port sampling of commercial catches and sampling aboard research cruises during 1977-79 off British Columbia, Canada were used to estimate age (from otoliths), growth, and mortality of 10 Sebastes species. Von Bertalanffy growth curves were fit to the age-length data and the von Bertalanffy growth parameters estimated. A single sample of predominantly male S. entomelas yielded a mortality rate of about 0.05. A mean length-age curve was illustrated for S. entomelas (sexes combined). Parameters for the von Bertalanffy best-fit growth curve were given. The maximum recorded length and age for S. entomelas during this study were approximately 58 years and 56 cm (FL), respectively.

Commentary letter on the 1984 ocean salmon fishing regulations draft.

AUTHOR(S): Arnett, G. R.

YEAR: 1984.

SOURCE: 7 pp.

KEYWORDS: Coho salmon, Oncorhynchus kisutch, chinook salmon, Oncorhynchus tshawytscha, fishery, regulations, wetfish.

ABSTRACT: There has been a declining trend in the stocks of wild salmon along the Pacific Coast over the last several years. In the face of this trend, as well as the drastic impact of El Nino on the

salmon fisheries, the Department of the Interior, Fish and Wildlife and Parks Service has made several suggestions to the Pacific Fishery Management Council on the draft regulations for the 1984 ocean troll and sports fisheries for salmon. These suggestions include increased escapement goals for all salmon, and establishment of escapement goals for king salmon, *Oncorhynchus tshawytscha*, based on major river systems. A complete closure of the ocean troll fishery from Cape Vizcano, California to Cape Blanco, Oregon is recommended, as well as a complete closure of all ocean fisheries from Cape Falcon, Oregon to the Washington/Canada border. Also included is a coastwide two-fish bag limit for the ocean sport fishery for all species of salmon.

Differences in heart size between ocean caught and laboratory grown larvae of the northern anchovy, *Engraulis mordax* Girard.

AUTHOR(S): Arthur, D. K.

YEAR: 1980.

SOURCE: Jour. Exp. Mar. Biol. Ecol. 43:99-106.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, feeding, growth.

ABSTRACT: The heart sizes of ocean caught and lab grown anchovy, *Engraulis mordax*, larvae were compared and found to differ significantly. Lab grown larvae were kept at temperatures of 17 to 19 deg C and raised on dinoflagellates, rotifers and isopods. At 4mm (3 days) lab grown larvae had hearts only slightly larger than ocean caught larvae of the same length. The difference was greatest at 9mm (16 days) when the hearts of lab grown anchovies was 40% larger. The oldest larvae kept were 19mm long and had hearts only 24% larger than ocean caught larvae. Feeding and non-feeding larvae, in the lab, also exhibited differences in heart and body size. The results suggest ocean caught larvae probably fed less often, during the critical first feeding period, than lab grown anchovy larvae.

Food and feeding of larvae of 3 fishes occurring in California current, *Sardinops sagax*, *Engraulis mordax*, and *Trachurus symmetricus*.

AUTHOR(S): Arthur, D. K.

YEAR: 1976.

SOURCE: Fish. Bull. 74(3):517-530.

KEYWORDS: *Engraulis mordax*, northern anchovy, *Trachurus symmetricus*, jack mackerel, feeding, larvae.

ABSTRACT: The gut contents of larvae of Pacific sardine, *Sardinops sagax*, northern anchovy, *Engraulis mordax*, and jack mackerel, *Trachurus symmetricus*, from the California Current were examined. The number of particles were identified to taxa and grouped by size. The predominant food of the three species were eggs and nauplii of small copepodid species. The smallest larvae were the most euryphagous. At first feeding, anchovies fed on slightly larger particles than sardine; however, jack mackerel fed on particles 3x larger than those taken by sardine larvae. During the early larval period, feeding incidence decreased for anchovies and sardines which fed only during the day. Jack mackerel feeding increased. A comparison with lab-grown anchovy larvae showed a decrease in the body depth and weight for ocean-caught larvae. This decrease may be related to poorer food rations, the decline in feeding incidence and the apparent lack

of increase in particle size ingested.

Genetic analysis of North American populations of the pink salmon, *Oncorhynchus gorbuscha*, possible evidence for the neutral mutation-random drift hypothesis.

AUTHOR(S): Aspinwall, N.

YEAR: 1974.

SOURCE: *Evol.* 28:295-305.

KEYWORDS: Migration, population trends.

ABSTRACT: An analysis of the neutral mutation - random drift hypothesis as the cause of maintaining high levels of protein variability in populations. In many of the streams in Alaska, the pink salmon exists as two genetically isolated populations (called odd-year and even-year) because of a rigid two-year live cycle. An analysis of three proteins revealed considerable uniformity within, but major differences between, odd and even year populations of pink salmon. This pattern was discussed in terms of a balancing selection versus the neutral mutation-random drift hypothesis. The data appear to support the latter.

Observations on the growth rate of the spiny lobster.

AUTHOR(S): Backus, J.

YEAR: 1960.

SOURCE: *Calif. Fish Game* 46(2):177-181.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, growth.

ABSTRACT: The growth rate and molt frequency are reported for the spiny lobster, *Panulirus interruptus*, from southern California. Investigations were conducted at fish dealers in Redondo Beach, California. Lobsters molting outside the usual summer period, and thus molting more than once per year, comprised only 4% of the total. Consequently, 96% of the lobsters only molt once per year. Length (carapace length) frequencies for combined sexes showed no obvious growth groups. Plots of separate sexes show fairly distinct growth groups. Female and male carapace lengths increase an average of 6.2 and 5.3 mm per molt, respectively. The ratio of carapace length to total length is 0.31 on average. Thus, the total length increments would be 2.0 cm per molt for females and 1.7 cm per molt for males. These values are equal to yearly growth increments, assuming one molt per year.

The visual feeding threshold and action spectrum of northern anchovy.

AUTHOR(S): Bagarinao, T., and J. R. Hunter.

YEAR: 1983.

SOURCE: *CalCOFI Rep.* 24:245-254.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, feeding.

ABSTRACT: Larval anchovy, *Engraulis mordax*, feeding was observed under several light spectrums and at a number of food concentrations. 97% of the larvae fed under bright conditions. Prey counts ranged from 20-100 rotifers per larvae. An irradiance of 530 nm was required to induce at least 50% of the larvae to feed. The visual acuity of anchovy larvae was suited for feeding in turbid, greenish coastal waters, their typical habitat. On clear days, at noon, larvae could feed at 74 m. They had a 13-hour feeding range during March in southern California. Differences in feeding among various size larvae was related to development of the eye and morphology changes.

Larval transport and recruitment of Pacific hake, *Merluccius productus*.

AUTHOR(S): Bailey, K. M.

YEAR: 1981.

SOURCE: Mar. Ecol. Prog. Ser. 6(1):1-9.

KEYWORDS: *Merluccius productus*, Pacific hake, larvae, recruitment, distribution.

ABSTRACT: The survival and distribution of Pacific hake larvae was studied in terms of offshore transport (advection). The effect of temperature on recruitment was also discussed. The spawning activity of *Merluccius productus* is concentrated in January and February, but may extend until April. The mean distance of larvae from the coast within the area studied was found to be quite variable but positively correlated to Ekman transport. The effect of advection on Pacific hake recruitment was discussed. The early life history of Pacific hake was found to be well adapted to minimize the problem of offshore larval transport. A positive correlation between larval survival and sea surface temperatures may indicate that onshore transport is beneficial to larval survival. However, offshore transport and temperature were considered independent in terms of larval survival.

The early life history of the Pacific hake, *Merluccius productus*.

AUTHOR(S): Bailey, K. M.

YEAR: 1982.

SOURCE: Fish. Bull. 80(3):589-598.

KEYWORDS: Pacific hake, *Merluccius productus*, early life history, feeding, growth, physiology, larvae, reproduction.

ABSTRACT: This paper presents information on the following aspects of the early life history of the Pacific hake (*Merluccius productus*): a) rates of development; b) starvation tolerances; c) growth; d) metabolism; e) the vertical distribution of eggs and larvae; f) predator vulnerability. The time required for hatching of eggs, and for complete absorption of the yolk sac are temperature dependent, with the higher range of temperature increasing the hatching speed. Increasing temperature also decreased the mean and maximum time span to starvation, after complete utilization of the yolk sac. One to two days before complete yolk sac absorption, daily increments began to be added to the otoliths, but after 30 days became unreadable. For the first 30 days after hatching, larvae growth was slow in length/weight, and then grew rapidly. Respiration rates are directly related to size and water temperature. At a temperature of 12 degrees centigrade the respiration rate for first feeding larvae was between 4.8 and 6.8 microliters per mg-dry weight per hour. Eggs and larvae in Puget Sound were located near the bottom of the water column, while those found off California were found about midwater. This is theorized to be due to the different densities of the water in the different locations. California water is more saline and therefore more dense, which causes the eggs to float higher in the column. The daily ration calculated from the data for first-feeding Pacific hake was 0.129 calories. It was theorized that since Pacific hake spend a longer time in the vulnerable larval stage than similar other organisms, predation pressure on their eggs and larvae is probably higher.

Recent changes in the distribution of hake larvae: Causes and consequences.

AUTHOR(S): Bailey, K. M.

YEAR: 1980.

SOURCE: CalCOFI Rep. 21:167-171.

KEYWORDS: Reproduction, spawning, nursery, ichthyoplankton, migration, population trends, fishery, early life history, larvae, recruitment, Pacific hake, *Merluccius productus*.

ABSTRACT: This analysis offers an explanation for why hake (*Merluccius productus*) larvae ichthyoplankton decreased in abundance off Baja California and increased in abundance off central California in the mid-1960s and persisted until 1979. This shift in the fishes early life history abundance coincided with the beginning of a large, intensive fishery for adults off the coasts of Washington and Oregon. The study indicates that since the larger hake migrate farther south than the small ones for reproduction, and the fishery is aiming at the large hake, the smaller individuals spawning farther north are contributing more to the year-class. Since larvae are more susceptible to offshore transport in the north than in the south, this shift of nursery to the north could render the species more susceptible to reduced recruitment in its population trends.

The Dynamics of California sea lion predation on Pacific hake.

AUTHOR(S): Bailey, K. M., and D. G. Ainley.

YEAR: 1982.

SOURCE: Fish. Res. 1(2):163-176.

KEYWORDS: Seasonality, behavior, Pacific hake, *Merluccius productus*.

ABSTRACT: This study was conducted to determine the dynamics, both by year and seasonality, of California sea lion predation behavior on Pacific hake (*Merluccius productus*), and to determine the effect of hake abundance upon the predation. The data on the hake consumed by California sea lions (*Zalophus californianus*) was gathered from otoliths picked from scats and spewings on the Farallon Islands, California from 1974 to 1978. Hake was the major component of California sea lion diet (approximately 90% by number) from April to August, but dropped in importance from September until March. This decline in importance was hypothesized to be due to the migration of hake offshore and to the south for spawning. During the winter months rockfish appeared to replace hake as the major prey item. California sea lions seem to favor 2 to 4 year old hake in their diets. When this age range was reduced in numbers they began to prey more heavily upon older hake, and other fish such as rockfish. The author's calculations concluded that California sea lions are the major pinniped predator upon Pacific hake, consuming approximately 185,000 tons annually.

Predation by a carnivorous marine copepod, *Euchaeta elongata* Esterly, on eggs and larvae of the Pacific hake, *Merluccius productus*.

AUTHOR(S): Bailey, K. M., and J. Yen.

YEAR: 1983.

SOURCE: Jour. Plankton Res. 5(1):71-82.

KEYWORDS: Pacific hake, *Merluccius productus*, early life history, feeding.

ABSTRACT: Feeding behavior of the marine copepod, *Euchaeta elongata*, upon the early life history (eggs and larvae) of Pacific hake, *Merluccius productus*, both in nature and in the lab were studied. The highest rate of copepod predation was on the middle yolk sac stage larvae. The copepod did not feed on the hake eggs, nor did it prey heavily on the early yolk-sac and post yolk-sac larvae. The ability of the larvae to avoid predation increased with increasing age. Starving the hake larvae decreased their ability to escape predation. Equal availability of the larval stage of the copepod genus *Pseudocalanus*, decreased the predation on hake larvae by 60%. Several other invertebrate predators were tested as to their ability to prey on the early life stages of Pacific hake. In a series of tows, it was observed that when hake larvae were abundant, so was *E. elongata*. Copepods were also observed with black material in the gut, and it was theorized that this was in fact hake larvae. It was estimated that when hake larvae are abundant, between 30-40% of the copepods feed on them. Observations indicate that *E. elongata* can have a significant impact on larval hake ichthyoplankton, especially when they are in areas of restricted water movement such as Dabob Bay, Washington.

The life history and fishery of Pacific whiting, *Merluccius productus*.

AUTHOR(S): Bailey, K. M., R. C. Francis, and P. R. Stevens.

YEAR: 1982.

SOURCE: CalCOFI Rep. 23:81-98.

KEYWORDS: Pacific hake, life history, distribution, spawning.

ABSTRACT: An overview of the information available on the life history and population dynamics of Pacific whiting is included. The life history was reviewed in terms of: stocks and distribution, spawning, early life history and adult life history (e.g. migratory behavior, schooling, age and growth, competitors and predators). The population dynamics were discussed in terms of: size of stock, recruitment and mortality. Background information on the fishery and its management is also discussed.

Studies on the metabolism of the migratory squid, *Loligo opalescens*: Enzymes of tissues and heart mitochondria.

AUTHOR(S): Ballantyne, J. S., P. W. Hochachka, and T. P. Mommsen.

YEAR: 1981.

SOURCE: Mar. Biol. Letters 2(2):75-85.

KEYWORDS: Market squid, *Loligo opalescens*.

ABSTRACT: The enzymes of various squid, *Loligo opalescens*, tissues were analyzed and the importance of amino acids and glycogen as oxidative properties was shown. Anaerobic metabolism is highest in the mantle, fins and heart. Brain metabolism utilizes a glucose substrate, while most other tissues utilize glucose and amino acid substrates. Fat was an unsatisfactory substrate for all tissues examined. Squid mitochondria use the malate shuttle to transport electrons between cytosol and the mitochondrion.

Bay fishes of northern California.

AUTHOR(S): Bane, G. W., and A. W. Bane.

YEAR: 1971.

SOURCE: Mariscos Publications, Southampton, New York. 143 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, coho salmon,

Oncorhynchus kisutch, chinook salmon, Oncorhynchus tshawytscha, chilipepper, Sebastes goodei, bocaccio, Sebastes paucispinis, sablefish, Anoplopoma fimbria, California halibut, Paralichthys californicus, petrale sole, Eopsetta jordani, English sole, Parophrys vetulus, distribution, habitat, length/weight, spawning, feeding.

ABSTRACT: Guide to bay fishes of northern California with an emphasis on the Bodega-Tomales Bay area. Information covered includes: technical and common fish names, classification, size, identifying characters, and coloration, distinguishing characters and related species, range and habitat, and other items of biological or economic interest.

Under Alaska seas, the shallow water marine invertebrates.

AUTHOR(S): Barr, L., and N. Barr.

YEAR: 1983.

SOURCE: Alaska Northwest Publ. Co., Anchorage, AL. 208 p.

KEYWORDS: Spot prawn, Pandalus platyceros, Dungeness crab (=market), Cancer

magister, sea urchin, Strongylocentrotus spp., reproduction, feeding, mortality, habitat, distribution, growth, length, physiology.

ABSTRACT: Characteristics of 241 invertebrate species inhabiting the shallow

water marine environment off the Alaska coast are presented in this handbook. Geographic and depth ranges are provided as well as habitat descriptions, feeding behavior, reproduction and morphological characteristics. The species are grouped according to taxonomic classification. The text provides color plates for almost all species discussed and a glossary of unfamiliar terms.

Electrophoretic analysis of hemoglobins of California rockfish (genus Sebastodes).

AUTHOR(S): Barrett, I., J. Joseph, and H. G. Moser.

YEAR: 1966.

SOURCE: Copeia (3):489-494.

KEYWORDS: Sebastes goodei, chilipepper rockfish, S. miniatus, vermillion rockfish, S. paucispinis, bocaccio.

ABSTRACT: Electrophoretic analysis of hemoglobin from blood samples of 27 species of California rockfishes was conducted and the significance of the results are discussed with respect to the identification and separation of rockfish species. Specimens were collected from Monterey and San Diego, California. Typical electrophoretic patterns of the hemoglobins were illustrated for each of 27 Sebastes species, including S. goodei, S. miniatus, and S. paucispinis. Clear genetic polymorphism was not indicated except for possibly S. eos. However, sample sizes for many of the species were small. There was no apparent relationship between the total number of hemoglobin zones and the morphological categories that have been recognized within the genus.

The utilization of shallow marsh habitats by commercially important fishes in Elkhorn Slough, California.

AUTHOR(S): Barry, J. P., and G. M. Cailliet.

YEAR: 1981.

SOURCE: Cal-Neva Wildl. Trans. 1981. D. Koch, (ed.)

KEYWORDS: California halibut, Paralichthys californicus, northern

anchovy, *Engraulis mordax*, English sole, *Parophrys vetulus*, feeding, behavior.

ABSTRACT: This study was conducted in order to determine the extent to which commercially (fishery) important fish utilize the tidal creeks and other shallow habitat in Elkhorn Slough. 29% of the 8,725 fishes caught in the study were directly important to commercial fisheries. In order of abundance, these fishes were: northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasii*), shiner surfperch (*Cymatogaster aggregata*), starry flounder (*Platichthys stellatus*), black surfperch (*Embiotica jacksoni*), leopard shark (*Triakis semifasciata*), California halibut (*Paralichthys californicus*), bat ray (*Myliobatis californica*), and English sole (*Parophrys vetulus*). Northern anchovy and Pacific herring comprised over 70% of these fish by number. Most of these fish appeared as juveniles; however, some species had reproductive adults in the sample. This seasonal occurrence of the fishes' early life history and migration closely coincided with the individual species' spawning season. On the average, the greatest species diversity occurred during the spring and summer. Most species also showed seasonality in their occurrence. Some behavioral observations were made on the different feeding strategies used by the species. Basically, 5 different feeding modes were observed. Stomach fullness was measured and the full stomach occurred in 62% of the individuals tested, with empty stomachs occurring 5.7% of the time.

A biological survey of oil platforms in the Santa Barbara Channel.

AUTHOR(S): Bascom, W., A. J. Mearns, and M. D. Moore.

YEAR: 1976.

SOURCE: Jour. Petro. Tech :1280-1284

KEYWORDS: Platforms, artificial reefs, community, contaminant levels.

ABSTRACT: A survey of fish populations associated with two oil platforms in the Santa Barbara Channel was undertaken and compared to previous surveys by California Fish and Game in 1960 and 1970. Diver surveys included transects and grids in addition to bottom samples, sediment, water and physical samples. Attached biota ranged from 20-90 cm thick and was dominated by *Corynactis* (70%) in addition to thick mussel communities observed on the cutting piles. In all, 200 species were found on or under the platforms. An additional 77 species of polychaetes were found in the mud samples. Fish assemblages had increased to an average of 20,000 individuals (from the 6,000 reported in 1960 and the 12,500 reported in 1970), representing 21 species. Seven species, including olive, brown and blue rockfish, and white surfperch, made up 62.5% of the assemblage and most individuals were found in the midwater depths. Chemical and physical findings showed little difference in the levels of elements and hydrocarbons than naturally encountered. The exception was vanadium in rockfish, which was not toxic at the observed levels.

A study of the yellowtail, *Seriola dorsalis* (Gill).

AUTHOR(S): Baxter, J. L.

YEAR: 1960.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 110: 96pp.

KEYWORDS: Fishery, age, growth, spawning, migration, growth, population, fishing gear, yellowtail, *Seriola lalandei*, life history.



ABSTRACT: The general life history is given for yellowtail (*Seriola dorsalis*), along with a description of the fisheries. A detailed redescription of the yellowtail was based on morphometric measurements and meristic counts taken from specimens captured throughout most of their geographic range. Both the sport fishery and the commercial fishery was described as to areas, seasons, fishing gear, methods, and number of fish landed each year from 1936-1957. The mean fork lengths (mm) of yellowtail at ages I - XII as determined from scale readings are: I-506; II-634; III-706; IV-783; V-831; VI-872; VII-893; VIII-958; IX-1008; X-1035; XI-1082; XII-1127. The rate of growth calculated from tag return data compared favorably with that determined by age analysis data. The weight-length relationship was similar for both sexes and can be described by the formula  $W = 0.00000007439 L^{2.85}$ . Yellowtail are carnivorous, "opportunistic feeders". Squid and pelagic red crabs were the most often observed invertebrate prey. Sardines, anchovies, jack mackerel, and Pacific mackerel were the most important forage fishes. Yellowtail spawning begins in July and continues until October. Older individuals appear to be capable of multiple spawnings. Some fish spawn during their 2nd summer when they are 20 months old and all spawn by their 3rd summer. Fecundity estimates ranged from 458,000 to 3,914,000, showing an increase in egg number with increasing weight of fish. Tagging experiments determined that there is a migration of yellowtail (age II and older) from central and northern Baja California to California waters. Yellowtail move north in the early spring, then south in the late summer and fall. At this date, the yellowtail population appears to be in a healthy state.

Summary of biological information on the northern anchovy,  
*Engraulis mordax* Girard.

AUTHOR(S): Baxter, J. L.

YEAR: 1967.

SOURCE: CalCOFI Rep 11:110-116.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, population trends.

ABSTRACT: Various biological characteristics of the northern anchovy, *Engraulis mordax*, are reported. Anchovies are found from Queen Charlotte Islands, British Columbia to Cape San Lucas, Baja California. Eggs and larvae have been taken up to 300 miles offshore. A separate subspecies inhabits San Francisco Bay. The northern anchovy range is divided into three subpopulations; from British Columbia to central California, off southern California to northern Baja California, and off central and southern Baja California. Anchovies are generally found in coastal waters, being further offshore in fall and winter. During the day they are well below the surface while they move to the upper layers at night. About 50% are mature at 130 mm SL between 2 and 3 years old. Each large female spawns about 20 to 30 thousand eggs annually. They spawn 2 to 3 times per year, every month of the year, with peaks during late winter and spring. Eggs and larvae are pelagic. Eggs require 2 to 4 days to hatch and the yolk sac is entirely absorbed within 36 hrs. Anchovies are short lived, individuals over 7 inches long and 4 years old being rare. They are indiscriminate filter feeders and are chiefly daytime feeders. Their chief competitor is the Pacific sardine (*Sardinops*

caeruleus). Predators include a great many species of fishes, birds, and mammals. The anchovy is probably the number one forage species in the inshore waters of California and Baja California. The commercial and live-bait fisheries are briefly described, including the uses and history of the catch.

Results of tagging experiments.

AUTHOR(S): Baxter, J. L., and R. D. Collyer.

YEAR: 1960.

SOURCE: Pages 52-77 in J. L. Baxter (ed.), A study of the yellowtail, *Seriola dorsalis*. Calif. Dep. Fish Game, Fish Bull. 110.

KEYWORDS: Yellowtail, *Seriola lalandi* (=dorsalis), distribution, age, growth,

feeding, physiology, spawning.

ABSTRACT: The purpose of this section of the study is to report the results of

tagging experiments conducted from 1951 to 1957 in which 15,161 yellowtail were tagged throughout their known range and 532 were subsequently recovered. Approximately 200 fish were measured and detailed descriptions recorded. The yellowtail were aged by means of scales through the seventh year. Feeding behavior, spawning and general conditions of the population as a whole were observed and reported.

Type, quantity and size of food of Pacific salmon (*Oncorhynchus*) in the Strait of Juan de Fuca, British Columbia.

AUTHOR(S): Beacham, T. D.

YEAR: 1986.

SOURCE: Fish. Bull. 84(1):77-89.

KEYWORDS: Coho salmon, chinook salmon, *Oncorhynchus kisutch*, *Oncorhynchus tshawytscha*, feeding, distribution.

ABSTRACT: The stomach contents from four Pacific salmon species, (*Oncorhynchus nerka*, *O. gorbusha*, *O. kisutch*, and *O. tshawytscha*) were examined for volume, number and size of prey. Sand lance, *Ammodytes hexapterus*, and euphausiids were the most important prey in the diets of all four salmon species. Sockeye was the least piscivorous, while chinook was the most piscivorous. The results of the effect of predator size on prey size showed that as predator size increased, the size of prey consumed also increased. In coho and chinook salmon, larger individuals switched prey species from smaller species (sand lance) to larger species (herring and rockfish). Overall, the diets between the four salmonid species show some differences from each other. It appears that the partitioning of the diet between the salmon species is due to morphological differences such as number, length and spacing of gill rakers.

Fecundity of coho salmon (*Oncorhynchus kisutch*) and chum salmon (*O. keta*) in the northeast Pacific Ocean.

AUTHOR(S): Beacham, T. D.

YEAR: 1982.

SOURCE: Jour. Zool. Canada 60(6):1463-1469.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, reproduction, length/weight, population trends.

ABSTRACT: In this study, the fecundities of coho and chum salmon were examined. It was found that there was significant regional and

annual variability for both species. Fecundities of coho salmon (adjusted to a 53.6 cm length) from Vancouver Island ranged from 2,452-2,825 eggs per female, whereas the adjusted fecundity at the same length of coho from Karluck River, Alaska was 4,403 eggs per female. Chum salmon from Vancouver Island and the Queen Charlotte Islands had fecundities which ranged from 2,604-3,244 eggs per female (adjusted to a length of 58.8 cm) compared to the range of 3,236-3,450 eggs per female for equal lengths from mainland British Columbia. Fecundity was significantly related to postorbital-hypural length for most samples. The author suggests that annual variability in fecundity may be the cause for annual variation in the stocks of chum salmon.

New information on the longevity of Pacific Ocean Perch  
(*Sebastes alutus*).

AUTHOR(S): Beamish, R. J.

YEAR: 1979.

SOURCE: Jour. Fish. Res. Bd. Canada 36(11):1395-1400.

KEYWORDS: *Sebastes paucispinis*, bocaccio, age.

ABSTRACT: A comparison of age estimations determined from surfaces of otoliths and from sections of otoliths was performed for a variety of rockfishes (genus *Sebastes*) with particular emphasis on *S. alutus*. The otolith sectioning technique produces age estimates which far exceed previous estimates based on surface counts of annuli. Among those species which are thought to be older than previous estimates based on surface count were individuals of *S. paucispinis* aged as high as 55 to 60 years.

Use of fin-ray sections to age walleye pollock, Pacific cod,  
and albacore, and the importance of this method.

AUTHOR(S): Beamish, R. J.

YEAR: 1981.

SOURCE: Trans. Am. Fish. Soc. 110(2):287-299.

KEYWORDS: Age, growth, *Thunnus alalunga*, albacore.

ABSTRACT: Thin sections of fin rays were used to estimate the age of walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), and albacore (*Thunnus alalunga*). Sections of dorsal, pectoral, pelvic, and anal fin rays all appeared to be acceptable for age determination of walleye pollock. However, sections of pectoral fin rays had the most distinct pattern of alternating opaque and translucent (hyaline) zones. It appears that the widths of the growth zones are related to the size of the fish at the time of annulus formation. The first annulus varies in prominence and is sometimes difficult to identify. For adult Pacific cod it was possible to find distinct annuli on sections of fin rays from the first dorsal fin, particularly for older fish. The fin-ray annuli and checks were similar to those of walleye pollock, but because of the rapid growth of Pacific cod, the first annulus was not as difficult to identify. Ages determined from fin-ray sections appeared to provide higher and possibly more accurate ages than those determined from scales. The sections from the second dorsal or anal fins of albacore were most suitable because of the prominence of zones and absence of bone resorption from the centers of the rays. Growth patterns were similar to those of walleye pollock and Pacific cod, with the first annulus difficult to identify. The advantages of the fin-ray method are in the clarity of the growth pattern,

especially for older fish, and in the ability to determine age without sacrificing the animal or damaging retail value. The disadvantages of the method are the difficulties in determining the position of the first annulus and in identifying growth checks.

Differences in the age of Pacific hake (*Merluccius productus*) using whole otoliths and sections of otoliths.

AUTHOR(S): Beamish, R. J.

YEAR: 1979.

SOURCE: Jour. Fish. Res. Bd. Canada 36(2):141-151.

KEYWORDS: Age, growth, Pacific hake, *Merluccius productus*.

ABSTRACT: This study was conducted to validate the age and growth determinations for Pacific hake in the Strait of Georgia by counting otolith rings both on the surface and by sectioning. Relationships between fish length and otolith size fish length and otolith length, fish length and otolith height, and fish length and otolith thickness were found. Otolith growth, however, was not isometric. The relationship between otolith weight and thickness is probably curvilinear. Evidence showed that, especially for older fish, cross sections may be more accurate than surface estimates since zones tend to be lost on the periphery of the otolith. Differences between surface and cross-sectioning became extremely deviant after age 11, if the cross-sectioning was accepted as the true age. In general, it was apparent that otoliths from older hake increased in thickness more than in length or height. Their recommendation is that otoliths that are larger and thicker than average should be sectioned and read.

Age determination of lingcod (*Ophiodon elongatus*) using dorsal fin rays and scales.

AUTHOR(S): Beamish, R. J., and D. Chilton.

YEAR: 1977.

SOURCE: Jour. Fish. Res. Bd. Canada 34(9):1305-1313.

KEYWORDS: *Ophiodon elongatus*, lingcod, age.

ABSTRACT: Scales and the cross-sections of the 4th-8th rays of the second dorsal fin were used to estimate the ages of lingcod. These features provide reliable age estimates, are easily removed from commercially caught fish, and can be processed quickly. There was some difficulty in estimating ages of 1-2-year-old fish with this method. Fin ray estimates tended to be older than scale estimates, especially after age 7 (or about 75 to 85 cm). After age 5-6, the scale annulus was difficult to identify, so the authors recommend fin ray determination only for fish of age 7 or greater. The oldest fish averaged 8 years by fin ray estimation. Females tended to be larger than males of the same age.

Preliminary evaluation of a method to determine the age of sablefish, *Anoplopoma fimbria*.

AUTHOR(S): Beamish, R. J., and D. E. Chilton.

YEAR: 1982.

SOURCE: Jour. Fish. Aquat. Sci. Canada 39(2):277-287.

KEYWORDS: *Anoplopoma fimbria*, sablefish, age, growth.

ABSTRACT: Age of sablefish was estimated in this study using otoliths subjected to the break and burn method. A partial validation of this method was possible using fish of known age, oxytetracycline

injected fish, and the results of an independent tagging study. The authors concluded that sablefish grow slowly as adults after a fairly rapid initial growth as juveniles. It was estimated that a female of average size in the Pacific Coast and Bering Sea fisheries was between 20 and 30 years of age. Therefore, previous studies have underestimated the age of sablefish when using scale annuli. Based on their preliminary results, the authors suggest a re-evaluation of the management strategies of the sablefish fishery.

Resource partitioning by small-mouthed pleuronectias in Puget Sound, Washington.

AUTHOR(S): Becker, D. S.

YEAR: 1984.

SOURCE: Ph.D. dissertation, Univ. Wash. Seattle, WA. 138 p.

KEYWORDS: English sole, *Parophrys vetulus*, Dover sole, *Microstomus pacificus*, habitat, feeding, distribution.

ABSTRACT: Five target species (English sole, rock sole, Dover sole, rex sole

and C-O sole) were investigated to determine their patterns of spatial, temporal, and trophic resources used in the nearshore region of Puget Sound, WA. Stomach content analysis was used to determine feeding patterns while depth and sediment characteristics were studied for habitat preference. Discussion of the statistical comparisons used to analyze the results is also presented.

Genetic structure of *Genyonemus lineatus*, *Seriphus politus* (Scianidae) and *Paralabrax clathratus* (Serranidae) in southern California.

AUTHOR(S): Beckwitt, R.

YEAR: 1983.

SOURCE: Copeia: 691-696.

KEYWORDS: *Paralabrax clathratus*, kelp bass, population trends.

ABSTRACT: A survey of the genetic characteristics of three species, including *Paralabrax clathratus*, was undertaken in order to determine possible divisions or isolation of populations within the southern California area. Sources of tissue samples were liver muscle, skeletal muscle and eye tissue. Samples were collected from four locations within the Southern California Bight; San Diego, Palos Verdes (Los Angeles), Santa Barbara and Santa Catalina Island. Mean within-sample heterozygosity for *P. clathratus* was  $H = 0.019$ . Four out of 34 loci were polymorphic. Presumed genotype frequencies were in close agreement with Hardy-Weinberg equilibrium. Genetic distances between samples were low (not significantly different from zero). The coefficient of gene differentiation was also low ( $G = 0.010$ ). Allele frequencies at the polymorphic loci were similar in all samples. There was no evidence for population subdivision in southern California or between the mainland and island samples.

Pelagic shark/swordfish drift gill net fishing management information document.

AUTHOR(S): Bedford, D.

YEAR: 1985.

SOURCE: Calif. Dept. Fish Game, Mar. Res. Doc. 74 pp.

KEYWORDS: Shark, *Alopias vulpinus*, swordfish, *Xiphias gladius*, distribution, age, growth, mortality, reproduction, migration.

ABSTRACT: The common thresher, *Alopias vulpinus*, bonito, *Isurus oxyrinchus*, swordfish, *Xiphias gladius*, opah, *Lampris regius* are four species affected by the developing drift gill net fishery in southern California. Thresher shark landings have increased 10-fold from 1977 to 1983 while swordfish landings have seen a 5 times increase in the same period. A review of papers on the distribution, age and growth, mortality, reproduction, migration, stock structure and stock status of these fish is presented. Catch-per-unit-effort data based on wholesale receipt counts and logbook landings show an increasing trend until 1980, followed by a decline through 1983 in thresher shark landings. This can be attributed to the decline in fish availability. The impact of drift gill nets on non-targeted species is also considered. The length/frequency histograms, total catch and CPUE data suggest thresher stock is in a precarious situation.

The pelagic shark fishery off southern California.

AUTHOR(S): Bedford, D.

YEAR: 1983.

SOURCE: Proc. 1983 Western Groundfish Workshop Asilomar, Pacific Grove, CA.

KEYWORDS: Thresher shark, *Alopius vulpinus*, fishery.

ABSTRACT: Off the coast of southern California, the pelagic shark fishery utilized drift gill nets to catch thresher shark, *Alopius vulpinus*, bonito shark, and *Isurus oxyrinchus*. Large numbers of blue shark, *Prionace glauca*, were incidentally trapped in the nets. Between 1976 and 1981, landings increased from 800,000 to 3,500,000 pounds annually, with thresher shark accounting for over 2,000,000 pounds and bonito shark landings 500,000 pounds. Little is known about the thresher sharks distribution; bonito and blue sharks are oceanic. Male threshers mature at 1800 mm and females at 2300 mm (this represents an age of 4 to 7 years). The female gives birth to 4 pups annually. Bonito sharks mature at 1800 mm and blue sharks mature at 2200 mm. They produce between 2 to 10 pups and as many as 82 pups, respectively. It appears unlikely that the limited fleet range would impact the oceanic species. However, the future of the thresher shark is uncertain since the distribution and stock size is unknown.

The billfish fishery resource of the California Current.

AUTHOR(S): Bedford, D. W., and F. B. Hagerman.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:70-78.

KEYWORDS: Swordfish, *Xiphias gladius*, fishery.

ABSTRACT: The swordfish, *Xiphias gladius*, and striped marlin, *Tetrapturus audax*, are both migratory species of a worldwide distribution. Both species are seasonally abundant in southern California. Swordfish are the object of commercial harpoon and gill net fisheries, making up 3% of the overall Pacific catch and averaging 14,000 MT/year. Marlin are an exclusively recreational fishery in California since 1938. The longline fleets of the east Pacific average 21,000 MT/year.

Ambicoloration in the black abalone, *Haliotis cracherodii* Leach.

AUTHOR(S): Behrens, D. W.

YEAR: 1979.

SOURCE: Calif. Fish Game 65(1):54-55.

KEYWORDS: Abalone, *Haliotis* spp., physiology.

ABSTRACT: A live albino, or at least colorless, black abalone (*Haliotis cracherodii*) was collected intertidally in October 1978. The specimen measured 92x69x25 mm and weighed 132 gms and was a female. The epipodium and mantle were white and the eyes lacked color. The mantle cavity and viscera were normal color.

The Pacific Coast black cod, *Anoplopoma fimbria*.

AUTHOR(S): Bell, F. H., and J. T. Gharrett.

YEAR: 1945.

SOURCE: *Copeia* 1945(2):94-103.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, distribution, fishery, fishing gear, age, length/weight, spawning.

ABSTRACT: Facts known about sablefish and its fishery in an effort to draw attention to a need to better assess the current sablefish fishery are reviewed. Topics reviewed include geographical distribution, history of the fishery, the current fishery, size and age, spawning season, condition of stocks, and the relationship between intensity of fishing.

Confirmation of longevity in *Sebastes diploproa* (Pisces Scorpaenidae) from <sup>210</sup>Pb/<sup>226</sup>Ra measurements in otoliths.

AUTHOR(S): Bennett, J. T., G. W. Boehlert, and K. K. Turekian.

YEAR: 1982.

SOURCE: *Mar. Biol.* 71:209-215.

KEYWORDS: Growth, age, *Sebastes* spp.

ABSTRACT: The two methods of counting otolith growth zones (the whole otolith technique and the section otolith technique) were assayed by radionuclide concentrations in the splitnose rockfish, *Sebastes diploproa*. Otoliths examined exhibited a consistent deficiency of <sup>210</sup>Pb activity relative to <sup>226</sup>Ra activity. The deficiency was found to decrease with increasing numbers of growth zones. The ages of fish were effectively analyzed and growth history determined by the <sup>210</sup>Pb/<sup>226</sup>Ra disequilibrium levels. Four age groups of otoliths were identified and agreed between both techniques in the first 3 groups. In the fourth group, the otolith section age exceeded the whole otolith section age. The otolith section age was found to be correct by use of the <sup>210</sup>Pb/<sup>226</sup>Ra disequilibrium. Estimates of longevity in *Sebastes* near 80 years were confirmed.

Age determination of broadbill swordfish, *Xiphias gladius*, from the straits of Florida, using anal fin spine sections.

AUTHOR(S): Berkely, S. A., and E. D. Houde.

YEAR: 1983.

SOURCE: Pages 137-143 in E. D. Prince and L. M. Pulos (ed.), *Proc.*

*Int. workshop on age determination of oceanic pelagic fishes: Tunas, billfishes and sharks.*

KEYWORDS: Swordfish, *Xiphias gladius*, wetfish, age, growth.

ABSTRACT: In this study, the ages of swordfish, *Xiphias gladius*, were calculated from bands present on thin sections of the second anal fin spine. These bands were assumed to be annual, formed primarily during the winter months. From the 439 swordfish examined, 87% of the anal spine sections were considered readable, although the percentage readability declined in males greater than 170 cm lower jaw fork length (LJFL). Other advantages in using the anal spines

included ease of collection and storage. Back calculation of lengths at estimated age, fitted to the von Bertalanffy growth model showed differential growth rates and different maximum sizes between males (217.4 cm LJFL) and females (340.0 cm LJFL). The oldest fish in these samples was age 11, and 61% of the fish were age 3 or less; however, older fish are known to exist in the population.

Fishery and reproductive cycle of the red sea urchin,  
*Strongylocentrotus franciscanus*, in British Columbia.

AUTHOR(S): Bernard, F. R.

YEAR: 1977.

SOURCE: Jour. Fish. Res. Bd. Canada 34:604-610.

KEYWORDS: Sea urchin, *Strongylocentrotus* sp., fishery, reproduction.

ABSTRACT: The reproductive season of a population of red sea urchins, *Strongylocentrotus franciscanus* off Vancouver, British Columbia was examined. There was no difference between male and female gonad indices. Gonadal index and gametogenesis were lowest in September and reached a peak in May. The recovery period following spawning was quite rapid. The gonad index was influenced highly by glycogen content which reached up to 13% of the total weight of the gonad. An urchin roe fishery was active from October to April. Yields constituted up to 25% of the dry weight and were variable due to several environmental factors.

Preliminary investigation on the red sea urchin resources of British Columbia (*Strongylocentrotus franciscanus* (Agassiz)).

AUTHOR(S): Bernard, F. R., and D. C. Miller.

YEAR: 1973.

SOURCE: Fish. Res. Board Can. Tech. Rep. 400. 37 p.

KEYWORDS: Sea urchin, *Strongylocentrotus franciscanus*, population trends, distribution, age, spawning, reproduction, mortality, fishery, feeding, growth.

ABSTRACT: The purpose of this report is to discuss the potential exploitation of the sea urchin as a commercial fishery. The biology and life history of the urchin populations along the British Columbia coast are described. Commercial harvesting and fishing efforts as well as their potential impact on the environment is also discussed.

Stomach contents of albacore, skipjack, and bonito caught off southern California during summer 1983.

AUTHOR(S): Bernard, H. J., J. B. Hedgepeth, and S. B. Reilly.

YEAR: 1985.

SOURCE: CalCOFI 26:175-183.

KEYWORDS: Albacore, Pacific bonito, *Thunnus alalunga*, *Sarda chiliensis*, feeding, northern anchovy, *Engraulis mordax*, distribution.

ABSTRACT: Food habits were determined for three scombrid species caught off southern California during the 1983 El Nino period. Chi square analysis for homogeneity showed highly significant differences in types of prey and proportions consumed. Comparisons of the data with historical (El Nino and non-El Nino year data) suggest that the scombrids are opportunistic feeders, and that prey availability was partly a function of the oceanographic conditions. The index of relative importance (IRI) and mean volumetric ratio measurement of northern anchovy in the diet of albacore is presented.



Eggs and larvae of *Scomber scombrus* and *Scomber japonicus* in continental shelf waters between Massachusetts and Florida.

AUTHOR(S): Berrien, P. L.

YEAR: 1978.

SOURCE: Fish. Bull. 76(1):95-115.

KEYWORDS: *Scomber japonicus*, chub mackerel, early life history, life history, larvae.

ABSTRACT: Descriptive comparative information on two species of *Scomber* larvae (*Scomber scombrus* and *Scomber japonicus*), are presented in order to facilitate their identification and their spawning areas between Massachusetts and Florida. The early stage eggs of these two *Scomber* species are similar and their identification depends upon spawning area and the proximity of older identifiable stages. Four meristic characters were useful in identifying the larvae. *S. japonicus* has 10-11 first dorsal spines in larvae as small as 11.9 mm and *S. scombrus* has 12-17 spines at 18.2 mm and greater. *S. japonicus* has 14 precaudal and 17 caudal vertebrae while *S. scombrus* has 13 precaudal and 18 caudal vertebrae. *S. japonicus* has 13 or 14 pterygiophores with the 1st anal pterygiophore anterior to the 1st haemal spine while *S. scombrus* has 22-25 pterygiophores and the 1st anal pterygiophore is posterior to the first haemal spine. *S. japonicus* are deeper bodied and at 3-15 mm have greater preanus lengths than *S. scombrus*. *S. scombrus* larvae are more heavily pigmented than *S. japonicus*, particularly on the dorsal trunk surface and at the cleithral sympysis. *S. scombrus* eggs were taken from Martha's Vineyard to Chesapeake Bay and out to the edge of the continental shelf off Maryland to North Carolina. The distribution of larvae overlapped that of eggs. Most larvae taken in June were north of the area of larva occurrence in May. By August, larvae occurred only near the northeastern extreme of sampling.

Eggs of *S. japonicus* were taken between Charleston, South Carolina and St. Lucie Inlet, Florida, in January and February. During May they occurred more northerly. Most eggs were found over the outer half of the continental shelf. Larvae were found slightly farther inshore than were the eggs. Spawning appears to occur simultaneously from North Carolina to Florida, over seven months (January to July).

Survey of the pelagic fishes of the California current area.

AUTHOR(S): Berry, F. H., and H. C. Perkins.

YEAR: 1966.

SOURCE: Fish. Bull., U. S. 65:625-682.

KEYWORDS: Northern anchovy, *Engraulis mordax*, Pacific hake, *Merluccius productus*, sablefish, *Anoplopoma fimbria*, Dover sole, *Microstomus pacificus*, life history, distribution.

ABSTRACT: This paper reports the results of trawl surveys conducted off central California to central Baja California between May 1961 and March 1963. The purpose of the survey was to discover what larger pelagic organisms occur in this area and to study certain life history aspects of the Pacific hake, *Merluccius productus*. More than 189 fish species were taken and charts listing their number, size, range and location of capture are provided. Many of the species are synopsisized with remarks on taxonomy, range, ecology, and ontogeny.

Contribution to the biology of the Pacific hake, *Merluccius*

productus (Ayres).  
AUTHOR(S): Best, E. A.  
YEAR: 1963.  
SOURCE: CalCOFI Rep. 9:51-56.  
KEYWORDS: Hake, Merluccius productus, distribution, length/weight, fishery, age, feeding, mortality, growth, seasonality,  
ABSTRACT: The purpose of this paper was to present the literature and previous biology of hake based on a review of the literature and previous data collected by the California Department of Fish and Game. The information covered in this review includes: geographical range, fish size in commercial landings, size by sex, size at maturity, length/weight relationships, age determinations, distribution in space and time, hake as a predator, hake as prey, and commercial uses of hake.

Movements of Petrale sole, Eopsetta jordani (Lockington), tagged off California.  
AUTHOR(S): Best, E. A.  
YEAR: 1963.  
SOURCE: Pacific Marine Fisheries Commission, Portland, Oregon. Bull. 6:23-38.  
KEYWORDS: Petrale sole, Eopsetta jordani, migration, length/weight, growth, fishery, groundfish.  
ABSTRACT: As a part of a West Coast tagging project, Petrale sole were tagged along the California coast then recovered in an effort to determine movements, migration rate, and growth. Fish tagged off northern California were recovered mainly north to Cape Blanco, Oregon, while fewer individuals moved north to Vancouver Island, British Columbia. Fish tagged southwest of San Francisco moved north through the Gulf of the Farallons to Pt. Reyes and Cordell Bank during the summer. The average migration rate was found to be 2 miles per day, with a maximum of 3.8 miles per day for a single fish. Growth of 29 recovered fish at liberty for 11 to 13 months were calculated to have maximum expected lengths of 52 and 63 cm, for males and females, respectively.

Catch localities for Dover sole, Microstomus pacificus (Lockington) landed in California 1950 through 1959.  
AUTHOR(S): Best, E. A.  
YEAR: 1963.  
SOURCE: Calif. Dept. Fish Game, Fish Bull. 121:48-56.  
KEYWORDS: Dover sole, Microstomus pacificus, distribution, fishery  
ABSTRACT: This paper summarizes in graph form the localities (marked by blocks of 10 minutes of longitude by 10 minutes latitude) in which the Dover sole, Microstomus pacificus were caught in California between 1950-1959. Average annual catches per locality are also included. In general, due to technological advances, Dover sole changed its status from a trash fish to an important commercial flatfish fishery in the 1950s. Dover sole landings in California averaged nearly 9 million pounds annually from 1950 to 1959. The fishery is primarily in northern California although central California ports also contribute significantly to the fishery. The important fishing season is between June and August, in which approximately half the annual catch is landed.

The 1985 spawning biomass of the northern anchovy.  
AUTHOR(S): Bindman, A. G.

YEAR: 1985.

SOURCE: Southwest Fisheries Center Admin. Rep. LJ-85-21. 31 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning.

ABSTRACT: The 1985 spawning biomass is reported for the northern anchovy, *Engraulis mordax*, estimated from the egg production method. This uses the ratio of the daily production of eggs and the daily specific fecundity of the adult population. Anchovy eggs were found further offshore this year, compared to the past five years. Spawning was from Baja California to San Francisco Bay. Estimates of the parameters of daily egg production rate, average weight of mature females, female fraction of the population, batch fecundity, and fraction of mature females spawning per day were  $16.95 \times 10^{12}$  eggs per day, 14.4940 grams, 0.6093, 7343 eggs, and 0.1198 per day, respectively. This gives a spawning biomass estimate of 458,025 metric tons, with a coefficient of variation of 18.75%. A Russian cruise reported spawning off San Francisco. Adding this area, the total biomass estimate is 521,742 metric tons. This estimate is up 61% from the 1984 spawning biomass, and appears to be attributed to a 31% increase in egg production and a 21% increase in female weight. The estimate can be compared to the annual acoustic survey which estimates total biomass of anchovies (not spawning biomass) to be 627,000 to 753,000 metric tons in the U.S. waters off southern California.

Impacts on commercial and sport fishing.

AUTHOR(S): Blayney - Dyett and Kendall Associates.

YEAR: 1980.

SOURCE: Prepared for Mendocino County Coastal Energy Impact Program, County

of Mendocino, Fort Bragg, CA., Blayney - Dyett and Kendall Associates.

KEYWORDS: Platform, contaminant level, contaminant susceptibility, economics, fishery.

ABSTRACT: The purpose of this paper was to assess the impact of a program to explore and develop undersea oil and gas resources on commercial and sport fishing industries. Salmon, albacore, rockfish, sole, sablefish, crab, and shrimp are the important fisheries in the area. An analysis of the potential factors which could hamper commercial and sport fishing indicate that oil spills are the least predictable but potentially the most damaging consequence of oil and gas development. The study also examined potential onshore impacts of energy development, including competition for harbor and shore space, marine services, and labor force. The authors concluded that these impacts would be negligible as the oil industry probably would locate and seek support services and employees out of the county.

Fecundity of the widow rockfish, *Sebastes entomelas*, off the coast of Oregon.

AUTHOR(S): Boehlert, G. W., W. H. Barss, and P. B. Lamberson.

YEAR: 1982.

SOURCE: Fish. Bull. 80(4):881-884.

KEYWORDS: *Sebastes entomelas*, widow rockfish, length/weight, reproduction.

ABSTRACT: Fecundity of *S. entomelas* is described as a function of length and weight from samples collected in December 1980 (n=3) and

January 1981 (n=65) during port sampling of commercial midwater trawlers at Newport, Oregon. Linear equations are given for the length-fecundity relationship and weight-fecundity relationship. The length-fecundity relationship differed significantly from the same relationship described by Phillips (1964) for specimens collected from California. Larger individuals exhibited greater fecundities than that described by Phillips. Similarly, the weight-fecundity regression from Phillips (1964) is characterized by a lower slope. It is not clear whether these differences are methodological or geographical. Estimates of the percent nonviable eggs are given for different stages of ovarian development.

Artificial reef research: A review with recommendations for future priorities.

AUTHOR(S): Bohnsack, J. A., and D. L. Sutherland.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):11-39.

KEYWORDS: Habitat, artificial reef, recruitment, colonization, community.

ABSTRACT: This paper presents research undertaken on artificial reefs, their

design, size and placement. Design considerations are discussed as they pertain to increasing larval and juvenile recruitment, survival and growth. Assessment techniques to describe communities and monitor biotic changes as well as maintaining artificial reef data bases are suggested improvements to enhance knowledge of artificial reef habitats. The importance of fish attraction versus fish production, as well as the economics and social impacts of artificial reefs, have been carefully examined. In all, 29 recommendations are presented in this study for future projects.

The abalones of California.

AUTHOR(S): Bonnot, P.

YEAR: 1948.

SOURCE: Calif. Fish & Game 34(4):141-169.

KEYWORDS: Abalone, *Haliotis* spp., fishery, life history.

ABSTRACT: The natural history and taxonomy of the abalones, *Haliotis* spp. of California are reviewed. The species studied included the red (*H. rufescens*), black (*H. cracherodii*), pink (*H. corrugata*), green (*H. fulgens*), threaded (*H. assimilis*), Japanese (*H. kauschatkama*) and the northern green (*H. wallalensis*). Commercial and sport fisheries, uses and conservation of abalone were also considered. The fishery was chiefly based on diving operations. In Monterey, landings varied from a high of 68,249 dozen in 1929 to a low of 2 dozen in 1943. In San Luis Obispo County, the fishery increased steadily from 355 dozen in 1926 to 36,058 dozen in 1946. The intertidal zone suffered from overworking by commercial and sport divers, whereas deep water stocks were relatively untouched.

and M. C. Caldwell.

The Audubon Society field guide to North American fishes, whales, and dolphins.

AUTHOR(S): Boschung, H. T., Jr., J. D. Williams, D. W. Gotshall, D. K. Caldwell,

YEAR: 1983.

SOURCE: Alfred A. Knopf, New York, NY. 848 p.

KEYWORDS: Swordfish, *Xiphias gladius*, albacore, *Thunnus alalunga*, all species,

physiology, habitat, distribution, growth, length.

ABSTRACT: This one-volume field guide covers North America's most common freshwater and salt water fishes as well as the 45 species of whales, dolphins and porpoises known to occur in North American waters. Full color photographs depict each one of the 585 marine or freshwater fish. Also included are photographs of whales, dolphins and various habitats. The guide is organized using a visual key, with arrangement by shape and color for quick and easy identification. Each species characterization includes its common and scientific name, description, habitat, range, similar species, and a comments section with general information which can include: lengths/weights, growth, predator/prey relationships and spawning information.

Effect of individual growth-rates on expected behavior of the northern California Dungeness crab (*Cancer magister*) fishery.

AUTHOR(S): Botsford, L. W.

YEAR: 1984.

SOURCE: Jour. Fish. Aquat. Sci. Canada 41(1):99-107.

KEYWORDS: Market crab, *Cancer magister*, fishery, growth.

ABSTRACT: This paper analyzes the potential effect of individual growth rates (in a mathematical model format) on the northern California Dungeness crab (*Cancer magister*) fishery. It appears that a single year-class of crabs enters this fishery over several years rather than in one year as described by models with only age structure. Including size structure increases the effectiveness of the model. An effective survival rate can be derived from a size-specific model that enables interpretation as an age-specific model.

Behavior of age-specific, density-dependent models and the northern California dungeness crab (*Cancer magister*) fishery.

AUTHOR(S): Botsford, L. W., and D. E. Wickham.

YEAR: 1978.

SOURCE: Jour. Fish. Res. Bd. Canada 35(6):833-843.

KEYWORDS: Market crab, *Cancer magister*, fishery, reproduction, length/weight, age.

ABSTRACT: A continuous time and age model and a model with constant reproduction are presented in order to address two questions: (1) what characteristics of the density-dependent effects are necessary for cyclic fluctuations to occur, and (2) how does fishing affect the cyclic fluctuations. The analytical techniques used with the model are applied to a preliminary model of the Dungeness crab population. The cyclic behavior of the crab population is similar to an unstable mode of the model. Conditions under which this mode arises are derived and potential causes of decreased stability, including fishing, are examined.

Correlation of upwelling index and dungeness crab catch.

AUTHOR(S): Botsford, L. W., and D. E. Wickham.

YEAR: 1975.

SOURCE: Fish. Bull. 73(4):901-907.

KEYWORDS: *Cancer magister*, market crab, fishery, distribution, population trends.

ABSTRACT: Time series analysis is used to examine annual Dungeness crab, *Cancer magister*, catches in relation to upwelling intensity. Large fluctuations in catch have been observed, with lows being some 20% less than highs. Correlation analysis indicates a significant relationship between crab catch and upwelling for several years following upwelling. Catch is of a cyclic nature, while upwelling is not. This suggests that the catch cycles may be due to density dependent biotic factors rather than upwelling. Upwelling does, however, influence the catch. The time lag is short enough to demonstrate that adults are affected. The time lag is shorter in California than in Oregon or Washington. The relationships between crab catch and upwelling provide a basis for predicting catch for following years. Further conclusions regarding the relationships between crab catch and upwelling, and the biological nature for cyclic catches require research in the natural history and ecology of the crab, and the nature of energy transfer from the pelagic to benthic environment.

Cyclic covariation in the California king salmon, *Oncorhynchus tshawytscha*, silver salmon, *O. kisutch*, and Dungeness crab, *Cancer magister*, fisheries.

AUTHOR(S): Botsford, L. W., R. D. Methot, and J. E. Wilen.

YEAR: 1982.

SOURCE: Fish. Bull. 80(4):791-801.

KEYWORDS: Chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, market crab, *Cancer magister*, fishery, population trends, seasonality.

ABSTRACT: Cyclic variations have been noted in the catches of California salmon fisheries. These cycles are similar in period and strength to well-documented cycles associated with the fishery for Dungeness crab. Cross-correlation studies indicate two cyclic co-varying processes with a period of 9-10 years, and a constant lag of about 4 years (salmon leading crab). Separation of king and coho salmon catches still indicates crab co-variation, although the patterns are weaker. Testing discounts the theory that the cycles are caused by the fishermen delaying the switch from crab to salmon during the seasonal overlap in years of high crab abundance. Speculation is offered as to the true cause of the co-variation taking account of limitations imposed by the biology of the three species, however, the authors conclude that the true cause is as yet unidentified.

Effort dynamics of the northern California Dungeness crab (*Cancer magister*) fishery.

AUTHOR(S): Botsford, L. W., R. D. Methot, and W. E. Johnston.

YEAR: 1983.

SOURCE: Jour. Fish. Aquat. Sci. Canada 40(3):337-346.

KEYWORDS: Market crab, *Cancer magister*, fishery, economics.

ABSTRACT: This paper is an in-depth analysis describing the dynamics of response of effort to abundance of the Dungeness crab, *Cancer magister*, fishery, and to determine the effect of that response on the fishery. The Dungeness crab fishery is concentrated in December through June or July, in which males of 159 mm or more carapace width are taken. In order to determine how harvest rates respond to changes in abundance, the actual harvest rate is compared to different bioeconomic mechanisms known to be operating in the fishery. Rapid increases in abundance lead to

low harvest rates, and rapid decreases in abundance lead to high harvest rates. Density-dependent recruitment is one of the possible causes of the observed cycles in the northern California crab population. The lag in response of harvest rate to changes in abundance is caused either by a time lag in fishermen entering and leaving the fishery following changes in abundance, a lag in market expansion and contraction following changes in abundance, or a combination of the two. Mathematical models are included to explain these possible relationships.

The fish connection: A trophic link between planktonic and rocky reef communities.

AUTHOR(S): Bray, R. N., A. C. Miller, and C. G. Geesey.

YEAR: 1981.

SOURCE: Science 214:204-205.

KEYWORDS: Habitat, feeding, behavior, community.

ABSTRACT: This paper presents the results of a study to determine the input of

organic carbon to reef communities made by the blacksmith, *Chromis punctipinnis*. Since blacksmiths return to the same shelter, their nocturnal deposition of feces results in the importation of 8 grams of carbon per square meter per year. This transport of extrinsic organic carbon to a reef is predictable in time and space.

Planktivorous fishes: Their potential as nutrient importers to artificial reefs.

AUTHOR(S): Bray, R. N., and A. C. Miller.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):396.

KEYWORDS: Habitat, feeding, artificial reef.

ABSTRACT: This study explores the importation of nutrients to rocky reefs by

the blacksmith, *chromis punctipinnis*, a planktivorous fish found in southern California waters. The incorporation into the reef food web of organic material excreted by the blacksmith suggests that these planktivorous fishes should have habitat requirements incorporated into artificial reef design.

Spawning in a British Columbia population of northern abalone, *Haliotis kamtschatkana*.

AUTHOR(S): Breen, P. A., and B. E. Adkins.

YEAR: 1980.

SOURCE: Veliger 23(2):177-179.

KEYWORDS: Abalone, *Haliotis* sp., spawning, reproduction.

ABSTRACT: A natural spawning of northern abalone, *Haliotis*

*kamtschatkana*, off Queen Charlotte Island, British Columbia was described. The abalone were loosely attached to the substrate and often attached to one another in small aggregations. Spawning lasted greater than 3.5 hrs. Females released puffs of eggs at 15 to 120 second intervals. Males were less active and released irregular, strong pulses of sperm. Several other invertebrates, including red urchin, limpets and serpulid worms were also observed spawning. The observations extend the known spawning season of *H. kamtschatkana* into mid-summer.

Changes in subtidal community structure associated with British Columbia sea otter transplants.

AUTHOR(S): Breen, P. A., T. A. Carson, J. B. Foster, and E. A. Stewart.  
YEAR: 1982.

SOURCE: Mar. Ecol. Proj. Serv. 7:13-20.

KEYWORDS: Sea urchin, *Strongylocentrotus* sp., feeding.

ABSTRACT: The community structure of coastal waters of British Columbia was studied following reintroduction of the sea otter, *Enhydra lutris*. The algae population increased and colonized the bottom to a depth of 10 meters. Grazers, particularly the red sea urchin, *Strongylocentrotus franciscanus*, were locally scarce and restricted to crevices and sheltered habitat. In areas where otter predation was not apparent, the algae were limited to shallow waters. The differences in habitat were probably due to predation on urchins and the patterns were utilized to delineate the feeding range of the otters.

Reproduction and spawning of northern anchovy, *Engraulis mordax*, in San Pedro Bay, California.

AUTHOR(S): Brewer, G. D.

YEAR: 1978.

SOURCE: Calif. Fish Game 64(3):175-184.

KEYWORDS: *Engraulis mordax*, northern anchovy, reproduction, spawning, seasonality.

ABSTRACT: Northern anchovy (*Engraulis mordax*) reproductive cycles and spawning are looked at in relation to environmental factors for the nearshore southern California population. The highest gonadosomatic index (GSI), both mean and individual, was found in February and March with the lowest values in September. Smallest males and females with developed gonads were 78 and 81 mm SL, respectively. Although spawning was recorded every month, eggs and larvae were encountered most frequently in February and March with occurrences of 61.5% of all eggs and 68.6% of all larvae. The greatest number of eggs taken in one trawl was equivalent to 34,059 per 1000 cubic meters of water, while larvae was 16,079 per 1000 cubic meters of water. Spawning distribution is tied to water temperatures with 90% of anchovy larvae taken in water between 13.0 and 17.5 deg C. Indirect evidence shows that the seasonal reproductive cycle may be dictated by the limitation of food availability. During the first 5 months 81.5% of all anchovy larvae were captured, while 82.1% of all (*Acartia*), the dominant zooplankton, were caught. Although anchovy have the potential to breed year-round, a seasonal cycle is imposed due to the high and low temperatures of the area. Within this cycle, the maximum expression of fecundity may be limited by feeding requirements which outweigh the environmental factors.

Thermal tolerance and resistance of northern anchovy, *Engraulis mordax*.

AUTHOR(S): Brewer, G. D.

YEAR: 1976.

SOURCE: Fish. Bull. 74(2):433-445.

KEYWORDS: Northern anchovy, *Engraulis mordax*, mortality.

ABSTRACT: Aspects of thermal tolerance, resistance, rates of acclimation, and effects of temperature on the development and growth of the northern anchovy, *Engraulis mordax*, are looked at under laboratory conditions. Six acclimation temperatures for juveniles and adults, ranging from 8 deg C to 28 deg C were used, with control survival ranging from 81.3 to 98.3%. Ultimate



upper lethal temperature was estimated to be 29.5 deg C while the lower was 6.5 deg C. Resistance to lethal temperatures was not related to fish size or photoperiod, while females were significantly more resistant than males and fish tested in the morning more resistant than those tested at night. As fish are acclimated to higher or lower temperatures, their resistance is increased. For embryos and larvae control survival ranged from 72.7 to 86.7%. Fifty percent had normal development between 11 deg C and 28.5 deg C. Resistance to temperature change is high when exposure is short, with the blastodisc stage least resistant and yolk-sac larvae most. The highest mean growth was at 18.0 deg C but no significant difference was observed for larvae reared at 14, 17, 18, and 20 deg C. At temperatures above 25 deg C the anchovy mechanism for physiological compensation began to break down. At very low temperatures feeding either ceases or is minimal. Metabolic demands, which outweigh the amount supplied by the environment of the southern population, may dictate the upper environmental temperature and southern distributional limits. The most realistic end point to ensure environmental quality would be that a significant difference occurs between the temperature of lethal response and that of the control. For a range of temperatures encountered in nature (8, 12, 16, 20, and 24 deg C), juveniles and adults can withstand higher temperatures of 23.0, 24.0, 25.5, 26.5, and 27.5 deg C and lower temperatures of 7.5, 10.0, 12.5, 13.5, and 14.5 deg C, respectively. A temperature range of 14.5 to 23.0 deg C can be handled, regardless of acclimation temperature, by yolk-sac larvae, juveniles, and adults. Anchovy embryos should not be allowed to remain in temperatures of 35.5, 30.5, 30.0 and 27.5 deg C for longer than 1, 3, 5 and 60 minutes, respectively. The rate of temperature change, length of exposure, previous thermal experience, effects of other environmental variables, and ontogeny all influence the potential response of the northern anchovy to temperature.

Northern anchovy and Pacific sardine spawning off southern California during 1978-1980: Preliminary observations on the importance of the nearshore coastal region.

AUTHOR(S): Brewer, G. D., and P. E. Smith.

YEAR: 1982.

SOURCE: CalCOFI Rep. 23:160-171.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, reproduction.

ABSTRACT: Estimates of egg and larval abundance are given for the northern anchovy, *Engraulis mordax*, within the nearshore region (43 m isobath) of the Southern California Bight, and compared to the entire Bight. The nearshore zone and the Bight contained an average of 38 and 102 larvae per m<sup>2</sup>. Adjusted to eliminate temporal bias estimates were 82.4 and 61.1 per m<sup>2</sup>, respectively. In the nearshore zone average larval density rises to a near asymptote at the 36 m isobath. At the 43 m isobath density is estimated 2.3 larvae/m<sup>3</sup>. Within-transect variability was in close agreement for the two areas while the variability between transects is a factor of over 10 for the entire Bight and about 5 for nearshore zone transects. Two gradient analysis were performed, one showing a north (low) to south (high) trend with the other showing no pattern. The mean density of eggs decreased between the 22 and 36 m isobaths in the nearshore area, with longshore variability approaching two orders of magnitude. Mean

egg and mean larval abundances corresponded reasonably. The nearshore region is not a preferred habitat for adult spawning biomass of the northern anchovy, with about 2% of all larvae spawned by the central subpopulation. Spawning in this area is indicative of that in the entire Southern California Bight. The importance of the nearshore zone as a nursery ground is not yet clear. Important areas of spawning include the Santa Barbara Channel from Rincon through Ormond Beach and off Playa Del Rey and Seal Beaches. Information on the spawning of the Pacific sardine, *Sardinops sagax caeruleus*, was also reported.

The behavior and reproduction of salmonid fishes in a small coastal stream.

AUTHOR(S): Briggs, J. C.

YEAR: 1953.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 94, 62 pp.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, Chinook salmon, *Oncorhynchus tshawytscha*, reproduction, life history, fishery, early life history, larvae, mortality.

ABSTRACT: This study was undertaken to obtain information on mortality during the egg and larval stages of certain salmonid fishes in a small California stream. The reproductive biology: time and rate of migration, age and size, sexual dimorphism, location and characteristics of spawning areas (redds), and breeding behavior, is discussed in detail for coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*Oncorhynchus tshawytscha*), and rainbow trout (*Salmo gairdneri*). The average natural mortality in the redds of the three species was determined to be 14.8%, 14%, and 13.7%, respectively. Greater average mortalities occurred in certain redds of coho salmon (55.8%), and rainbow trout (55.4%) due to infestation by an unidentified oligochaete worm during February and May. Chinook salmon eggs and larvae apparently developed early enough to avoid the peak population, and high infestations of this worm. The degree of natural fertilization of the three species was calculated at 93.4% for coho salmon, 92.4% for Chinook salmon, and 96.2% for rainbow trout. A crude percentage survival for that portion of the life cycle up to the free swimming fry stage was also calculated for the three species at 58.5%, 65.1%, and 47.8%, respectively.

Fisheries of the North Pacific, history, species, gear and processes.

AUTHOR(S): Browning, R. J.

YEAR: 1980.

SOURCE: Alaska Northwest Publ. Co., Anchorage, AL. 423 p.

KEYWORDS: Fishery, fishing gear, all species, distribution, habitat, feeding, range, mortality.

ABSTRACT: The purpose of this text is to provide a broad view of the major fisheries of the North Pacific Ocean. The history of the fisheries, biology of fishery species, fishing vessels, gear and methods as well as processing of fishery products are discussed in detail. The text is intended and designed as a guide to the fisheries rather than a scientific document.

Biological processes and ecological development on an artificial reef in Puget Sound, Washington.

AUTHOR(S): Buckley, R. M., and G. J. Heuckel.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):50-69.

KEYWORDS: Habitat, feeding, community rockfish, *Sebastes* spp., artificial reef, recruitment, colonization.

ABSTRACT: The purpose of this paper is to report research conducted at the

Gedney Island artificial reef complex in Puget Sound, Washington over an approximate two-year period. The rate of biota development was examined as well as the sustained aggregation and production of recreationally important fishes. The evolution of the reef community was monitored and simulated fishery removals conducted to ascertain threshold densities which could provide workable techniques for managing artificial reef fisheries.

1ST record of jack mackerel, *Trachurus symmetricus*, in Puget Sound.

AUTHOR(S): Buckley, R. M., and I. Erickson.

YEAR: 1977.

SOURCE: Syesis 10:175.

KEYWORDS: Jack mackerel, *Trachurus symmetricus*, distribution.

ABSTRACT: A note that a 580 mm jack mackerel, *Trachurus symmetricus*, was caught while angling in the extreme south of Puget Sound. The fish was in water of about 10 deg C, lower than normal. The fish was probably diverted into the Sound at the entrance to Juan de Fuca Strait, where they are normally line-caught.

Pease, and J. Matthews.

An ecological comparison of artificial and natural rocky reef fish communities in Botany Bay, New South Wales, Australia.

AUTHOR(S): Burchmore, J. J., D. A. Pollard, J. D. Bell, M. J. Middleton, B. C.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):70-85.

KEYWORDS: Habitat, community, economics, artificial reef, recruitment.

ABSTRACT: The subject of this paper is a two-year study undertaken to compare

the ecology of a natural reef versus an artificial reef at a site located in southeastern Australia. Approximately 34,400 fish belonging to 102 species were observed. A total of 93 species were observed at the natural reef site, while 59 were observed at the artificial reef site. Approximately 50% were common to both sites. A list of the species observed, their scientific and common names, zoogeographic affinity, life history stage, residence category and observation site is provided and discussed.

The commercial fish catch of California for the year 1951 with an evaluation of the existing anchovy case pack requirements.

AUTHOR(S): Bureau of Marine Fisheries Staff.

YEAR: 1953.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 89, 68 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery.

ABSTRACT: The total landings of commercial fish and shipments into California in the year 1951 are reported. The Department of Fish and Game determines the percentage of catches of any species that should be canned. Their requirements have been criticized and an

evaluation of them is presented here. It is concluded that existing case pack requirements are reasonable and should not be changed. A series of tables presents the complete available record of the commercial catch of fish, mollusks, and crustaceans landed in California. Also included are tables of shipments by common carrier into California of fresh fish originating in other states or countries. Species covered include jack mackerel, albacore, Pacific mackerel, sole, squid, crab, rockfish, salmon, anchovy, yellowtail, abalone, sablefish, lingcod, white sea bass, and spiny lobster.

The marine environment in the vicinity of Diablo Cove with special reference to abalones and bony fishes.

AUTHOR(S): Burge, R. T., and S. A. Schultz.

YEAR: 1973.

SOURCE: Calif. Dept. Fish Game, Mar. Res. Tech. Rep. 19, 433 pp.

KEYWORDS: Abalone, *Haliotis* spp., community, population trends, distribution, mortality.

ABSTRACT: A baseline evaluation of the intertidal and subtidal community at Diablo Cove, a future warm water discharge site. The information collected emphasized abalones, algal species consumed by the abalones, and bony fishes. Permanent stations were sampled during three periods of 1970 and 1971. Both the intertidal and subtidal surveys collected information on abalone (distribution and abundances, predators, competitors, population structure and morphometrics) and marine plants according to depth zones. Information from fish studies included subtidal fish counts and species accounts for 28 different families. Additional information was also collected on marine mammals, water temperatures, and effects of discharge facility construction.

Developmental stages of three California sea basses, (*Paralabrax*, *Pisces*, *Serranidae*).

AUTHOR(S): Butler, J. L., H. G. Moser, G. S. Hageman, and L. E. Nordgren.

YEAR: 1982.

SOURCE: CalCOFI Rep. 23:252-268.

KEYWORDS: Early life history, larvae, *Paralabrax clathratus*, kelp bass.

ABSTRACT: The early life history of kelp bass, (*Paralabrax clathratus*), barred sand bass, (*P. nebulifer*), and spotted sand bass, (*P. maculatofasciatus*), is described from laboratory reared and field collected specimens. Eggs of *P. clathratus* and *P. nebulifer* have a mean diameter of 0.95 mm with a range from 0.94 to 0.97 mm. While eggs of *P. maculatofasciatus* have a mean diameter of 0.84 mm with a range of 0.80 to 0.89 mm. Yolk-sac larvae of these three species were not distinguishable from each other. Preflexion larvae of the three species can be distinguished by differences in the number and position of the post-anal melanophores. The large ventral melanophore is on the 8th or 9th post-anal myomere in *P. clathratus*, but is on the 6th or 7th post-anal myomere in *P. maculatofasciatus*. Preflexion *P. nebulifer* have a larger number of small post-anal midventral melanophores than the other two species. From early flexion through midflexion, *P. clathratus* may be distinguished from the other two species by the large post-anal pigment patch, the heavy pre-anal abdominal finfold pigment, and the lack of pigment on the lateral line. Flexion larvae of *P. nebulifer* and *P. maculatofasciatus* are indistinguishable at this stage. From late

flexion through the end of the larval phase, *P. clathratus* may be distinguished by the presence of pigment on the upper jaw, the heavy pigment on the 1st dorsal fin, and the absence of pigment on the lateral line. In postflexion larvae of *P. Nebulifer*, pigment forms in a broad saddle under the first dorsal fin, rather than in several discrete saddles as found in *P. clathrtus*. Similar sized *P. maculatofasciatus* are more heavily pigmented over the trunk. At the juvenile stage, vertical bars form on the body of *P. clathratus* and are quite different from the horizontal stripes of juvenile sand basses. The horizontal stripes of *P. nebulifer* are less dense than those of *P. maculatofasciatus*.

Growth and age determination of the Pacific edible crab,  
*Cancer magister* Dana.

AUTHOR(S): Butler, T. H.

YEAR: 1961.

SOURCE: Jour. Fish. Res. Bd. Canada 18(5):873-891.

KEYWORDS: Market crab, *Cancer magister*, growth, age, length/weight, early life history.

ABSTRACT: Post-larval crabs were collected off the Queen Charlotte Islands in an attempt to determine their age and growth. The results show that the 1st and 2nd post-larval instars have modes at 6.9 and 10 mm. Carapace width before molting was regressed against carapace width after molting in order to determine average carapace widths for instars 3 to 15. Width frequency distributions were used to identify age groups. It was estimated that, for males, stage 5 or 6 is reached after one year, stage 11 or 12 reached after 2 years, stage 13 after 3 years, stage 14 after 4 years, and stage 15 after 5 years. Females undergo similar growth the first 2 years then slow down. After 2 years (stage 11 or 12) both sexes reach sexual maturity.

Shrimps of the Pacific Coast of Canada.

AUTHOR(S): Butler, T. H.

YEAR: 1980.

SOURCE: Can. Tech. Rep. Fish. Aquat. Sci. 202:280.

KEYWORDS: Ocean shrimp, *Pandalus jordani*, life history, distribution.

ABSTRACT: The shrimps of the Pacific coast of Canada were reviewed and a key was established. Eighty-five species were noted including one new species and 17 species recorded for the first time. The key included detailed morphometrics, notes on color, distribution and life history information. Sections on sexing of shrimps, parasites, and synonymies were also included. Seven additional unrecorded species were also expected to be noted.

Maturity and breeding of the Pacific edible crab, *Cancer magister* Dana.

AUTHOR(S): Butler, T. H.

YEAR: 1960.

SOURCE: Jour. Fish. Res. Bd. Canada 17(5):641-646.

KEYWORDS: Market crab, *Cancer magister*, reproduction, behavior, fishery length/weight.

ABSTRACT: A description of the breeding procedure of *Cancer magister* collected from the Queen Charlotte Islands, Canada is summarized. Size at maturity, breeding procedure, size of crabs in the pre-mating embrace, and marks on the exoskeleton caused by the pre-mating embrace are analyzed in the paper. The results indicate

that males mature at 110 mm carapace width but the most important breeding activity occurs around 140 mm or about 3 years old. Females appear to mature at around 100 mm or 2 years old. A sample of mating males indicates that individuals of sub-legal size form an important part of the male breeding population. Copulation occurs between a hard shelled male and recently molted female. The male holds the female in a "pre-mating embrace". Abrasions on the carapaces of males and females were used as indicators of sexual activity of legal-sized versus sub-legal-sized males. The results showed that the relative breeding activity of sub-legal-sized males was slightly more than twice that of the legal-sized crabs.

A review of the methods and problems of quantitative assessment of *Loligo opalescens*.

AUTHOR(S): Cailliet, G. M., and D. L. Vaughan.

YEAR: 1983.

SOURCE: Biol. Oceanogr., Vol. 2, number 2-3-4. Crane, Russak & Co., Inc.

KEYWORDS: *Loligo opalescens*, market squid, spawning, distribution, fishery, fishery gear, mortality.

ABSTRACT: A review of the approaches used to sample *Loligo opalescens* and how they can be used to estimate population abundance. The review looks at two different life history stages of squid (spawning versus nonspawning) which occur at different seasons and locations. During spawning *L. opalescens* tend to mate in sheltered bays and often near deep water such as canyons and basins off California. Spawning seasons are distinct, if not predictable, and occur in areas that vary latitudinally. In this review estimates of squid abundance on the spawning grounds were analyzed in terms of information obtained from market surveys, spawning ground surveys, net samples, night lights, tag and recapture, camera surveys, acoustic surveys, acoustics and video surveys and egg and juvenile surveys. The abundance of squid off the spawning grounds were analyzed in terms of net collections, acoustics and net surveys, night-lighting and jigging, and predator stomachs. The results of this review suggest that squid on the spawning grounds are the best source of information on abundance. Monitoring squid in this stage is fairly efficient and cost effective since aggregations are somewhat predictable and occur close to shore. It is suggested that squid in the nonspawning stage be qualitatively sampled using large-scale acoustic surveys, coupled with large midwater trawls.

The biology of three pelagic sharks from California waters, and their emerging fisheries: A review.

AUTHOR(S): Cailliet, G. M., and D. W. Bedford.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:57-69.

KEYWORDS: *Alopias vulpinus*, thresher shark, age, growth, reproduction.

ABSTRACT: The age, growth and reproduction of the common thresher, *Alopias vulpinus*, the bonito, *Isurus oxyrinchus*, and blue, *Prionace glauca*, sharks from southern California were examined. The 167 threshers studied were between 0-15 years old and ranged from 360 to 5733 mm TL. Males mature at 3330 mm TL and females between 2600-3150 mm TL corresponding to a 3-7 year old individual. The bonito sharks studied ranged from 0-17 years old

and were 900-3210 mm TL, maturing at 1800 mm TL or 8 years old. Blue sharks reach maturity at 2200 mm TL corresponding to a 7-9 year old individual. The studied individuals ranged from 0-9 years and ranged from 280-2521 mm TL. The combination of life history traits could make these species susceptible to overfishing, however the relatively early age at first reproductive maturity may counter this argument.

Ecological studies of sablefish in Monterey Bay.

AUTHOR(S): Cailliet, G. M., E. K. Osada, and M. Moser.

YEAR: In press.

SOURCE: In press. Calif. Fish Game.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, seasonality, spawning, feeding, migration, length/weight.

ABSTRACT: From a 1973-1974 baseline study, 3681 sablefish were collected, 2630 of which were from traps set at four regular depths, and the additional 1051 from commercial fishing activities. The traps were very selective at depths greater than 549 meters, but incidental species of both invertebrates and fishes outnumbered sablefish in traps set at 91 meters. Catch rates at this shallow depth were consistently low, and higher catch rates occurred in traps set between 549 and 1372 meters. Sablefish increased in mean size with depth, and the highest percentage of "large" fish (greater than 64 cm SL) was found between 914 and 1372 meters. Seasonality was characterized by elevated catch rate and the presence of larger fish during the summer months in waters shallower than 193 meters, whereas little seasonality in sablefish numbers occurred in deeper waters. Overall, female sablefish predominated with males most numerous among small fish. Sablefish in Monterey Bay spawned between November and February in waters deeper than 549 meters, and more ripe individuals were found in the larger size classes in deeper waters. Stomach content analysis of 314 fish indicated that sablefish shift their diets as they get larger and move to deeper waters from pelagic fishes and cephalopods to more demersal fishes and crustacean prey. Coincident with this dietary shift was an increase in the intensity of infection of larval nematodes. A total of 164 of the 1450 sablefish tagged and released during the study were recaptured during the subsequent 8 years. Accurate information on date and location of recapture for 121 of these individuals indicates that most did not migrate out of the Monterey Submarine Canyon. Of the 10 fish recaptured out of the general area, 9 had moved north, and only one had moved south.

Pelagic assemblages as determined from purse seine and large midwater trawl catches in Monterey Bay and their affinities with the market squid, *Loligo opalescens*.

AUTHOR(S): Cailliet, G. M., K. A. Karpov, and D. A. Ambrose.

YEAR: 1979.

SOURCE: CalCOFI Rep. 20:21-30.

KEYWORDS: Market squid, *Loligo opalescens*, Pacific hake, *Merluccius productus*, *Sebastes* spp., northern anchovy, *Engraulis mordax*.

ABSTRACT: The assemblage of organisms associated with market squid, *Loligo opalescens*, were analyzed utilizing midwater trawl and anchovy purse seine collections from Monterey Bay. Recurrent group analysis showed a similar assemblage with both methods of sampling. Four species associated with squid in shallow waters

were not found in deep water samples. During the winter midwater trawls, market squid lacked significant associated species. The presence of euphausiids seems to be the link between *Loligo opalescens* and *Merluccius productus*, *Porichthys notatus*, *Clupea harengus pallasi*, *Sebastes* sp., *Citharichthys stigmaeus* and *C. sordidus*. The presence of *Engraulis mordax* can probably be explained due to microzooplankton which live in the same general area.

Welden.

Preliminary studies on the age and growth of blue (*Prionace glauca*), common thresher (*Alopias vulpinus*) and shortfin mako (*Isurus oxyrinchus*) sharks from southern California waters.

AUTHOR(S): Cailliet, G. M., L. Martin, J. Harvey, D. Kusher, and B.  
YEAR: 1983.

SOURCE: In: Proc. Intl. workshop on age determination of ocean pelagic fishes. National Marine Fisheries Service.

KEYWORDS: Thresher shark, *Alopias vulpinus*, age, growth.

ABSTRACT: Specimens of the blue, *Prionace glauca*, common thresher, *Alopias vulpinus*, and shortfin mako, *Isurus oxyrinchus*, sharks were collected from Monterey Bay and commercial fisheries in southern California. The lengths of the individuals and number of bands in the vertebral centra were used to construct growth curves based on the von Bertalanffy and logistic growth models. Combined sex asymptotes of 2,655 mm TL, 6,509 mm TL and 3,210 mm TL were calculated for the blues, threshers and makos, respectively. These curves would approximate a maximum life span of 20 yrs and a 435 mm TL size at birth blue shark; 50 yrs and 1,580 mm TL size at birth thresher; and 45 yrs and 605 mm TL shortfin mako. These values may be off due to inherent problems with the growth models. The data suggest these three species of shark have gradual growth rates, long life spans and relatively low but variable fecundities. This could make them susceptible to overfishing, however the estimate of relatively early ages at first reproductive maturity may counter this argument.

Trophic spectrum analysis of fishes in Elkhorn Slough and nearby waters.

AUTHOR(S): Cailliet, G., B. S. Antrim, and D. S. Ambrose.  
YEAR: 1979.

SOURCE: Pages 118-128 in S. Lipovsky and C. Simenstad (eds.). Gutshop '78: Fish Food Habit Studies Proceedings of the Second Pacific Northwest Technical Workshop, Washington Sea Grant Publ. 222 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, English sole, *Parophrys vetulus*, feeding, community, habitat, distribution.

ABSTRACT: Feeding habits of the more common fishes in Elkhorn Slough and nearby waters in relation to the available prey are described. Species were evaluated in an attempt to assess the factors that structure nearshore communities. Trophic spectra of assemblages of the common fish species, based on % volume and % number of prey consumed were determined. Differences in trophic spectra were observed between different locations in the slough and an ocean station. There is an indication that the apparent differences in the food base for fishes between habitats may be due to prey availability.



California sport fishing regulations.

AUTHOR(S): California Department Fish and Game (CDF&G).

YEAR: 1986.

SOURCE: Calif. Dep. Fish Game, Sacramento, CA. 12 p.

KEYWORDS: All species, fishing gear, regulations.

ABSTRACT: This pamphlet lists the 1986 sport fishing regulations issued by the

California Department of Fish and Game for inland waters, ocean fishing, district trout and salmon, and native reptiles and amphibians that became effective March 1st.

Review of some California fisheries for 1985.

AUTHOR(S): California Department Fish and Game.

YEAR: 1986.

SOURCE: CalCOFI Rep. 27:7-15.

KEYWORDS: Thresher shark, *Alopias vulpinus*, swordfish, *Xiphias gladius*, ocean

shrimp, *Pandalus jordani*, chub mackerel, *Scomber japonicus*, northern anchovy, *Engraulis mordax*, market squid, *Loligo opalescens*, California spiny lobster, *Panulirus interruptus*, Dungeness crab (=market), Cancer magister, jack mackerel, *Trachurus symmetricus*, fisheries, economics, groundfish, regulations.

ABSTRACT: This report presents catch statistics for the current year as well

as historical data on tons landed for several commercially important fishery species. Accompanying information includes the regulatory environment and climatological conditions that influence the fisheries.

Review of some California fisheries for 1984.

AUTHOR(S): California Department Fish and Game.

YEAR: 1985.

SOURCE: CalCOFI Rep. 26:9-16.

KEYWORDS: Thresher shark, *Alopias vulpinus*, swordfish, *Xiphias gladius*, ocean

shrimp, *Pandalus jordani*, chub mackerel, *Scomber japonicus*, northern anchovy, *Engraulis mordax*, market squid, *Loligo opalescens*, California spiny lobster, *Panulirus interruptus*, Dungeness crab (market), Cancer magister, jack mackerel, *Trachurus symmetricus*, fisheries, economics, groundfish, regulations.

ABSTRACT: This report presents catch statistics for the current year as well

as historical data on tons landed for several commercially important fishery species. Accompanying information includes the regulatory environment and climatological conditions that influence the fisheries.

Sea urchin recruitment: Effect of substrate selection on juvenile distribution.

AUTHOR(S): Cameron, R. A., and S. C. Schoeter.

YEAR: 1980.

SOURCE: Mar. Ecol. Prog. Serv. 2:243-247.

KEYWORDS: Sea urchins, *Strongylocentrotus* spp., distribution, mortality, migration. migration.

ABSTRACT: Field studies of red, *Strongylocentrotus franciscanus*, and purple, *S. purpuratus*, sea urchin populations indicated juveniles

are found at higher densities near adult urchins. Laboratory and field experiments were designed to test for substrate preference, juvenile mortality or migration as possible reasons for these observations. No preference was noted by juveniles for coated rock surfaces, isolated surfaces, or adult associated surfaces. These results suggested that differential mortality or migrations in these areas was responsible for the observations.

Age and growth of Pacific bonito, *Sarda Chiliensis*, in eastern north Pacific.

AUTHOR(S): Campbell, G., and R. A. Collins.

YEAR: 1975.

SOURCE: Calif. Fish Game 61(4):181-200.

KEYWORDS: Pacific bonito, *Sarda chiliensis*, age, growth, length/weight.

ABSTRACT: The age and growth of Pacific bonito, *Sarda chiliensis*, were estimated from more than 3,000 otoliths. A von Bertalanffy growth curve was constructed from the data and verified using length frequency curves and tag recapture data. An asymptotic length ( $L_{\infty}$ ) of 76.87 cm FL is reached at approximately 6 years, with fastest growth from 1-3 years. Length-weight equations and total length to fork length equations were also derived and compared to catch data.

How to fish the Pacific Coast.

AUTHOR(S): Cannon, R.

YEAR: 1967.

SOURCE: Lane Books, Menlo Park, CA. 3rd edition.

KEYWORDS: All species, habitat, fishing gear, albacore, *Thunnus alalunga*.

ABSTRACT: Descriptions of the coast line, fishing areas, and fishing techniques are discussed for the fishing range extending from the southern tip of Alaska to the Bahia de San Quintin, Baja, California. An index of common and scientific names is provided as well as a brief characterization for each fish.

Pacific seashores: A guide to intertidal ecology.

AUTHOR(S): Carefoot, T.

YEAR: 1977.

SOURCE: Univ. Wash. Press, Seattle WA. 208 p.

KEYWORDS: Sea urchin, *strongylocentrotus* spp., habitat, distribution, feeding.

ABSTRACT: This book presents an ecological study of the marine environment

focusing primarily on the intertidal part of the shore. The evolution of the seashore, water movement, intertidal zonation and the distribution of organisms on the shore are discussed in detail and illustrated where appropriate. The book also contains sections on mariculture, marine pollution and the evolution and ecology of sand dunes. A glossary is also provided to assist in defining unfamiliar terms.

A brain heater in the swordfish.

AUTHOR(S): Carey F. G.

YEAR: 1982.

SOURCE: Science 216(4552):1327-1329.

KEYWORDS: *Xiphias gladius*, swordfish, physiology.

ABSTRACT: An anatomical apparatus is described from the swordfish (*Xiphias gladius*) which conserves metabolic heat in the brain.

The brown tissue is associated with the rectus superior, an eye muscle, and is in two lobes located just behind each of the eyes and below the brain. In a swordfish of about 130 kg, with a brain of about 2.2 grams, the brown tissue weighs about 50 grams. The anatomy of the tissue is similar to that of liver tissue. The carotid artery delivers blood to the tissue through a (rete mirabile), which in turn delivers blood to the veins across a radiating pattern of sinusoids. This process takes place in a countercurrent fashion. The cells are cuboidal and packed with mitochondria, small vacuoles, and a high concentration of cytochromes (Cytochrome concentration was 35 (+/-3) grams per gram). These factors indicate a high metabolic rate for the tissue. Structure of the swordfish's skull is well constructed to utilize and conserve this recycled heat. Experimentation showed a significantly higher brain temperature than that of the surrounding waters. Since the swordfish is a known vertical migrator, such a system as described would have a positive effect on their ability to perform brain functions despite varying external temperatures.

Daily patterns in the activities of swordfish, *Xiphias gladius*, observed by acoustic telemetry.

AUTHOR(S): Carey, F. G., and B. H. Robison.

YEAR: 1981.

SOURCE: Fish. Bull. 79(2):277-292.

KEYWORDS: *Xiphias gladius*, swordfish, migration, behavior.

ABSTRACT: Six swordfish (*Xiphias gladius*), five off Baja California and one off North Carolina, were tagged with acoustic transmitters to determine their habits of horizontal and vertical migration. In addition, some of the swordfish were tagged with temperature sensors which relayed this information to the surface. The experimenters also used XBT's to determine water temperature. Two of the Baja swordfish exhibited an onshore-offshore diurnal pattern. During the daylight hours they slowly moved along the 50 fm contour line, on the bottom, about 4-5 NM from shore. At night they would move approximately 12 NM offshore to various locations. Two of the other Baja swordfish seemed to be migrating south and west at an average speed of 2-5 km/hr. They appeared to be following the bottom topography. The Atlantic swordfish swam in a generally eastward direction at a speed of approximately 1.5-5.5 km/hr. Its course was away from shore which took it across the Gulf Stream into the Sargasso sea. Several variables were observed to affect the movements of the swordfish. All showed an obvious vertical movement in response to light changes. They seemed to be following isolumens. Another factor was the availability of oxygen. The swordfish would either completely avoid the oxygen minimum layer, or would change the behavior to compensate for it. Temperature variations and thermoclines seemed to have little or no effect on the migrations. Swordfish seem to display amazing ability to understand and traverse large temperature gradients.

Food of the jack mackerel, *Trachurus symmetricus*.

AUTHOR(S): Carlisle, J.

YEAR: 1971.

SOURCE: Calif. Fish Game 57(3):205-208.

KEYWORDS: Jack mackerel, *Trachurus symmetricus*, feeding.

ABSTRACT: The purpose of this study was to report on the feeding habits of the jack mackerel, *Trachurus symmetricus*. The range of this species extends from the Gulf of Alaska to Baja California. Samples were collected in 1951 and 1952 by throwing explosives into a school and retrieving the stunned or dead fish. All collections were made at night. Identification of food items in the stomachs of 77 fish indicate that jack mackerel are macroplanktivores, feeding mainly on copepods (33%), pteropods (30%), and euphausiids (27%). Simultaneous plankton tows were not highly correlated with stomach contents. Crustaceans made up 65% of all food items by number, followed by 35% noncrustaceans. Behavioral observations confirm that jack mackerel are selective feeders. A comparison of food studies indicate that jack mackerel do not generally compete with Pacific sardine (*Sardinops caeruleus*) for food items, due to the predominantly filter feeding habits of the latter. On the basis of volume, euphausiids are by far the most significant jack mackerel food, making up about 70% of its diet. Euphausiids account for only about 5% of the total food of sardines and pteropods are eaten only in significant amounts.

Results of a six-year trawl study in an area of heavy waste discharge: Santa Monica Bay, California.

AUTHOR(S): Carlisle, J. G.

YEAR: 1969.

SOURCE: Calif. Fish Game, 55(1):26-46.

KEYWORDS: Contaminant level, contaminant susceptibility, artificial reef.

ABSTRACT: The purpose of this study was to evaluate the effects of waste discharges from the Hyperion Treatment Plant on the marine environment. Six years of trawl samples resulted in collections of approximately 104 species, although most of the catch was made up of 5 species. The abundance of fishes in the catches fluctuated from year to year, but it was impossible to say whether it was due to waste discharge or natural variation. In addition to the trawls, studies on the effects of pollutants on algal growth were also made. Artificial reefs were built in both a sewage discharge site and control site. While the control site developed a luxuriant kelp bed, no kelp grew in the discharge site because of the particulate matter from waste discharges.

Artificial habitat in the marine environment.

AUTHOR(S): Carlisle, J. G. Jr., C. H. Turner, and E. E. Ebert.

YEAR: 1964.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 124:93 pp.

KEYWORDS: Artificial reef, platform, community, colonization.

ABSTRACT: The attractant ability of various types of artificial habitats in the marine environment was assessed. A car body reef at Paradise Cove (southern California) attracted 49 fish species averaging 11,000 individuals and also supported a kelp forest. The streetcar reef off Redondo Beach included 47 species and a maximum of 3000 individuals after 2 years. Five oil platforms (4 near Santa Barbara, and 1 near Seal Beach) were also censused as artificial reefs. Populations of fish grew from a few scattered fish to thousands of semi-residents. Embiotocid perch dominated at all reefs, accounting for up to 80% of the fish populations. The fish species varied from 12 to 53, depending on the site of

the structure. Offshore sites were colonized by pelagic schooling fish, while the inshore structures had populations of kelpfish, croakers and shark. Encrusting invertebrate species rapidly attached to all available surface areas. Kelp attached to guy wires and rubble. Predating gastropods and seastars were abundant at the sites. The cuttings pile, deposited below the platform, neither attracted or repelled fish species.

Artificial reefs along the southern California coast.

AUTHOR(S): Carlisle, J. G., Jr.

YEAR: 1979.

SOURCE: Fisheries 4(1):32.

KEYWORDS: Artificial reefs, California halibut (*Paralichthys californicus*), community.

ABSTRACT: A letter from H. D. Hoese (1978) is answered in part. Hoese feels that artificial reefs placed on sandy bottoms may discriminate against organisms which prefer soft bottoms. He asks if they interfere with flounder production and if it is safe to extrapolate from a tropical reef environment to a temperate level bottom community. California halibut (*Paralichthys californicus*), fantail sole (*Xystreureys liolepis*), and other sole and flounders favor the interface between reef and sand. Artificial reefs are never continuous, placed in discrete piles, they have many spaces of sand between the hard artificial substrate. Flatfish species are not excluded, resident and semi-resident species are merely provided with new habitat.

Seasonal abundance, size composition, and growth of Rock crab, *Cancer antennarius* Stimpson, off central California.

AUTHOR(S): Carroll, J. C.

YEAR: 1982.

SOURCE: Jour. Crustacean Biol. 2(4):549-561.

KEYWORDS: Spawning, migration, behavior, weight, population, distribution, age, rock crab, *Cancer* spp.

ABSTRACT: The seasonal abundance, sex ratio, size composition, molting and spawning periods, growth rates, and migration behavior were investigated for an adult *Cancer antennarius* population at Diablo Cove, California. Seasonal catch per unit effort was greatest during autumn and least during summer surveys, due to increased numbers of females. The number of males was relatively stable and outnumbered females by an overall sex ratio of 1.4:1. Annual peaks in percentages of females were positively correlated with annual maximum water temperatures. Mean body weights of males and females were 497 g and 354 g, respectively. Mean carapace width was 121.5 mm for males and 111.8 mm for females. Both sexes displayed similar patterns in size distribution. Juveniles were not susceptible to the sampling gear. Greatest percentage of molting crabs occurred in autumn and early winter, although recently molted crabs were found throughout the year and also had a low susceptibility to capture. Single-molt size increases for adult females varied from 13-26% in carapace width and 50-70% in body weight. Smaller crabs tended to have proportionately greater width and weight increases than larger crabs. Crabs 80-105 mm carapace width have an intermolt duration of 5-8 months. Crabs >135 mm have an extended molt cycle of 16 months or longer. Ovigerous females were present every month of the year but were most abundant in winter. The smallest ovigerous female observed

was 73 mm. Adult males possess larger chelipeds than females, a secondary sexual characteristic which appears during the pubertal molt at 60-80 mm. Sexual maturity occurs at age 2. Average annual tag-loss rate was estimated to be 14.0%. Population size estimates in Diablo Cove ranged from a maximum of 10,590 crabs to a minimum of 1,060 crabs. No seasonal trends were apparent to indicate an annual migratory pattern. The majority of crabs were recaptured close to original release sites. However, migratory distances up to 7 km were recorded for several individuals.

Tagging studies on the red rock crab, *Cancer antennarius*, in the vicinity of Diablo Cove, central California.

AUTHOR(S): Carroll, J. C., R. E. Phillips, and D. L. Mayer.

YEAR: 1980.

SOURCE: Amer. Zool. 20(4):890.

KEYWORDS: Rock crab, *Cancer* spp., distribution, population trends.

ABSTRACT: Over 9,000 adult rock crabs, *Cancer antennarius*, were captured and tagged during a 4-year period at Diablo Cove. The average growth rate of recaptures was 15.6% in carapace width and 54.7% in body weight. Fall increases in abundance of females, percentage of molts and a subsequent rise in ovigerous females coincided with peak water temperatures. The greatest distance traveled by an individual was 5 km, however several crabs remained in their release site for 8 to 12 months. The observed 4-year decline in catch-per-unit effort was attributed to increased sea otter predation.

Carpenter.

Management of artificial reefs designed to support natural communities.

AUTHOR(S): Carter, J. W., W. N. Jessee, M. S. Foster, and A. L.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):114-128.

KEYWORDS: Artificial reef, community, colonization.

ABSTRACT: The Pendleton artificial reef, off San Onofre (southern California), was the site of algal and faunal transplants to alter the natural succession. Two species of kelp, *Macrocystis pyrifera* and *Pterygophora californica*, were transplanted in various developmental stages. These species did poorly due to intensive grazing by halfmoon and opaleye. Of 143 tagged plants, only 43 remained after 6 months (3 exhibited growing tips). Juvenile red abalone, *Haliotis rufescens*, were also released on the reefs. Few individuals (approximately 15%) remained after 20 days; however, predation (by *Cancer* spp.) or dispersal could not be determined. The studies suggested management is a necessary part of artificial reef planning and physical, chemical and biological aspects of the environment should be considered before construction. Management after installation, including manipulations of predator/prey systems, and addition or renewal of certain species to direct community succession, is necessary for successful development.

Jessee.

Benthic succession on an artificial reef designed to support a

kelp reef community.

AUTHOR(S): Carter, S. W., A. L. Carpenter, M. S. Foster, and W. N.  
YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):86-113.

KEYWORDS: Artificial reef, colonization, community.

ABSTRACT: The Pendleton artificial reef was constructed of eight quarry rock reefs at a depth of 13.1 m off San Onofre, southern California. A point quadrat method was used to sample abundance and vertical distribution of the benthic flora and fauna. Various physical parameters and the biological components of reefs located 5-6 km away were also considered. During the 3-year study, the reef was dominated by early successional species. The foliose and filamentous algal species accounted for 56% of the total cover. These algae were found primarily on crests of reefs where water motion and light were greatest. Algal recruitment on vertical substrates may have been limited by turbidity, light and competition with encrusting ectoprocts and barnacles (which accounted for 66% of the under story cover). Algal cover increased during late fall and early winter (clear water periods). The ectoprocts increased over the course of the study while barnacles decreased over time. The artificial reef was constructed to make up for losses of kelp due to operation of coastal power plants (ie., San Onofre). Timing of reef placement (season and water temperature) and isolation from other reefs are two factors suggested to explain the low recruitment noted.

Effects of burial on the heart cockle *Clinocardium nuttallii*  
and the Dungeness crab, *Cancer magister*.

AUTHOR(S): Chang, B. D., and C. D. Levings.

YEAR: 1978.

SOURCE: Estuar. and Coast. Mar. Sci. 7:409-412.

KEYWORDS: Market crab, *Cancer magister*, contaminant susceptibility.

ABSTRACT: The effects of ocean dumping on a sedentary species *Clinocardium nuttallii* (the heart cockle) and on a mobile species *Cancer magister* (the Dungeness crab) was determined in laboratory experiments utilizing dredge spoil sand. Cockles and crabs buried by less than 5 cm of sand reached the surface in less than 24 hrs. At 10 cm, all crabs reached the surface, however, only 50% of the cockles re-established siphon contact. In 20 cm of sand, neither crabs nor cockles were able to reach the surface within 24 hrs. The results suggest longer periods of sand deposition, than those utilized in the present study (approximately 1 hr), would be required to prevent harm to benthic populations.

Stability of sea urchin dominated barren grounds following  
destructive grazing of kelp in St., Margaret's Bay, Eastern  
Canada.

AUTHOR(S): Chapman, A. R. O.

YEAR: 1981.

SOURCE: Mar. Biol. 62:307-311.

KEYWORDS: Sea urchins, recruitment, *Strongylocentrotus* spp., feeding, mortality, habitat.

ABSTRACT: The purpose of this study was to determine if reforestation of kelp beds is possible in the barren areas of St. Margaret's Bay, Nova Scotia, Canada. Observations of survivorship and recruitment of *Laminaria longicruris* were made in 10 permanent quadrats in areas which had previously been barren. After 10 months none of

the plants recruited in 1977 remained as a result of sea urchin grazing. A second phase of this study was to determine the location of reproductive kelp beds where the new recruits occurred. Only 4 sites had mature subtidal kelp beds. The most distant recruits were 600 m from the perimeter. It is possible that kelp recruitment was absent at Mill Gove and Fox Point because of the limited dispersal of spores. Experimentally induced kelp regeneration failed due to sea urchin grazing of the kelp sori. A further experiment tested the spore dispersal abilities of kelp areas cleared of sea urchins. These cleared areas showed kelp recruitment, whereas none was found in adjacent uncleared areas. In the absence of kelp, sea urchins utilized diatoms and filamentous Phaeophyta and Rhodophyta as food items. The mean annual biomass of benthic microalgae was found to be 2.2 g Cm<sup>-2</sup>, and net primary production was estimated at 15.4 g Cm<sup>-2</sup> yr<sup>-1</sup> 8 m depth. In spite of the possibility of kelp recruitment on the barren grounds, evidence indicates that re-establishment of reproductively mature kelp stands is not possible due to existing sea urchin densities in St. Margaret's Bay. It was concluded that more than 60% of the primary production in St. Margaret's Bay has been lost since the destructive grazing of the kelp forests.

Mission Bay: A review of previous studies and the status of the sport fishery.

AUTHOR(S): Chapman, G. A.

YEAR: 1963.

SOURCE: Calif. Fish Game 49(1):30-43.

KEYWORDS: Paralichthys californicus, Paralabrax clathratus, Sarda chiliensis, Scomber japonicus, Atractoscion nobilis, habitat, fishery, California halibut, kelp bass, Pacific bonito, chub mackerel, white seabass.

ABSTRACT: The purpose of this report was to determine any changes in the fish fauna of Mission Bay in southern California in 1961, as a result of physical development of this area. This report also presents a review of previous investigations and a brief history of the considerable physical development of Mission Bay into a recreation area. A total of 78 fish species have been reported from Mission Bay. Many were caught via beach-seining. During 1961, the 1,024 fishermen interviewed had fished 2,547 hours and caught 397 fish, an average of 0.156 fish per hour. Fishing success was highest during the month of March. Approximately 20 fish species were commonly caught with four species contributing 57.68% of the total catch: spotfin croaker 29.22%, spotted sand bass 13.35%, California halibut 8.06%, and opaleye 7.05%. Various surfperches contributed 8.31%. Fishing success was relatively equal throughout the bay; however, not all species were caught in all areas. The middle and north jetties offered the greatest variety. Opaleye, sargo, California halibut, spotted sand bass, white seabass, kelp bass and sand bass were caught most frequently. Sharks and rays were caught more frequently than the data suggest since most fishermen discarded these species. A previous survey made in 1950-51 reported an average catch per hour of 0.200 fish per hour which is not significantly higher than the 1961 average of 0.156 fish per hour. The previous survey reported higher numbers kelp bass and sand bass and lower numbers of spotted sand bass. Three species reported in the 1961



survey not reported in the 1950-51 survey are bonito, Pacific mackerel and opaleye. Extensive dredging in Mission Bay since 1945, and particularly since 1956, is likely to be the most important factor in the degradation of fishing between 1957 and 1959. Apparently in 1961 bottom conditions were gradually recovering so as to provide for good fish habitat. The reported change in fish fauna may be due to the change in fish habitat provided by the development of this area. Water temperature may, however, be another important factor governing the fish fauna. It may be significant that poorest fishing was reported during the warm-water years 1957 to 1959. A brief survey of the invertebrates in Mission Bay is also included. The mollusks, shrimps and crabs have been seriously depleted due to dredging operations.

The fishery for northern anchovy, *Engraulis mordax*, off California and Baja California in 1975.

AUTHOR(S): Chavez, H., S. Silva, and J. S. Sunada.

YEAR: 1977.

SOURCE: CalCOFI Rep. 21:147-165.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, population trends.

ABSTRACT: The northern anchovy (*Engraulis mordax*) fishery in both Baja California and California is documented. Work by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) agencies and the Instituto Nacional de Pesca are reported. The California fishery is conducted in two geographical areas, Monterey Bay and southern California. A record high catch of 143,786 metric tons was taken in 1975. Two southern California fleets, one in San Pedro and one in Port Hueneme, have combined fleet capacities of 2,540 and 262 mt, respectively. Four processing plants operate in the southern area with two in the Monterey area. Anchovy price fluctuated between \$29 and \$31 per ton. Regulations on the reduction fishery are divided into two zones; the northern, areas north of Point Buchon, and southern, those areas south of the Point. In the northern and southern zones seasons open on August 1 and September 15, respectively, both close on May 15. Fishing is restricted to all waters beyond 3 nm of the coast, with local restrictions of 4 to 6 miles in some areas. A minimum size limit of 127 mm TL with a 15% by weight undersize allowance exists. Fishermen must maintain a daily record of fishing activity. Reduction permits and fishing can be suspended on 48 hrs notice. Fishing in southern California is excellent during spring and fall, but decreases in February to March with the onset of spawning. Central California landings are highest during the fall. Catches in 1975 from southern and central California were dominated by the 1972-73 and 1970-71 cohorts, respectively. Average lengths in the two areas were 125.8 and 137.7 mm SL, respectively. The same type of information is reported for the Mexican fishery off Baja California. Combined catch from the two countries reached over 200,000 mt in 1975, with the U.S. accounting for 72% of the total landings.

Spiny lobster fishing explorations in the Caribbean.

AUTHOR(S): Chislett, G. R., and M. Yesaki.

YEAR: 1974.

SOURCE: Mar. Fish. Rev. 36(9):43-48.

KEYWORDS: Spiny lobster, *Panulirus* spp.

ABSTRACT: The abundance of the spiny lobster, *Panulirus argus*, was assessed through echo sounding, trawling, and pot fishing, south of Jamaica and north of Hispaniola in the Caribbean. Construction and handling of trawl nets and lobster pots are discussed in detail. Lobster catches by trawling were extremely light, being caught only between 16 and 20 fathoms. Pot catches were higher and highest when set in a narrow depth range. The average and highest catches from Pedro Bank were 0.14 and 0.45 lobsters per pot, respectively. Of other banks fished the only significant catches came from Morant Cays with a rate of 0.08 lobsters per pot. Trawls were not applicable in many areas due to bottom type and low catch rate, while the wire mesh pot strings proved to be adequate. The general availability of lobsters on the banks was low, except for some areas of Pedro Bank. Comparison of this area to the continental shelf east of Honduras and Nicaragua shows that Pedro Bank has a much lower concentration of lobsters.

Rock bass (*Paralabrax*) in the California commercial fishery.

AUTHOR(S): Clark, F. N.

YEAR: 1933.

SOURCE: Calif. Fish Game 19(1):25-35.

KEYWORDS: *Paralabrax clathratus*, kelp bass, fishery, fishing gear, population trends, reproduction, spawning.

ABSTRACT: Summarizes the catch statistics, seasonality, gear and regulations of the commercial fishery for *Paralabrax clathratus* from 1916 to 1931. Statistics for "rock bass" include data for *P. clathratus*, *P. nebulifer* and *P. maculatofasciatus* combined. Information on spawning periodicity and the size at first maturity was collected from sampling of the San Pedro wholesale market. The majority of the commercial fishery was conducted from San Pedro, California. Peak catch occurred during the summer months. Ninety-five percent of the vessels landing *Paralabrax* spp. (accounting for 50% of the total poundage) caught *Paralabrax* spp. incidental to other targeted species. *Paralabrax* spp. was fished predominantly (57%) with hand and set lines. Sampling of the San Pedro wholesale market indicated that *Paralabrax clathratus* comprised the majority of the *Paralabrax* spp. catch. Larger *P. clathratus* seasonally mature earlier (late May) than smaller individuals. *P. clathratus* appeared to spawn during the summer months of June, July and August. All fish smaller than 24 cm TL were immature. All fish larger than 26 cm TL were maturing. Presumably, the average size of first maturity is about 25 cm TL or 10 inches. The average size of *P. clathratus* in the commercial catch was approximately 30 cm TL (12 inches).

Size at first maturity of the white seabass (*Cynoscion nobilis*)

AUTHOR(S): Clark, F. N.

YEAR: 1930.

SOURCE: Calif. Fish Game 16(4):319-323.

KEYWORDS: White seabass, *Atractoscion nobilis*, age, length, weight.

ABSTRACT: The white seabass, *Cynoscion nobilis*, was found to be mature from March to August. The lengths of 78 fish were taken and compared to weight and gonad index. All fish larger than 75 cm were found to be mature. Half of the males were mature at 60 cm, which corresponded with the smallest size for mature females, while half of the females reached maturity at 70 cm. No males

smaller than 50 cm were mature. Three distinct size classes were noted: 35 cm, 35-65 cm, and larger than 70 cm, which corresponded with 1, 2 and 3 year-classes. The results suggested males were mature by the second year and females matured by their third year. The average weight of all mature fish (70 cm+) was 10-11 lbs.

California halibut.

AUTHOR(S): Clark, G. H.

YEAR: 1930.

SOURCE: Calif. State Fish. Lab., No. 104:315-317.

KEYWORDS: California halibut, Paralichthys californicus, fishery, reproduction.

ABSTRACT: California halibut, Paralichthys californicus, catches were analyzed to determine the meaning of observed rapid decreases in the landings of this groundfish. Fishing effort per boat remained nearly constant from year to year. It was observed that the average catch per month per boat decreased considerably from 1924 onward. Between 1919-1923, 1924-1929, and 1919-1929, there were decreases of 22, 46, and 50%, respectively. Regulations state that not more than 50 pounds of halibut under 4 pounds each could be in possession at any time. Halibut are being overfished even with existing regulations. More adequate protection is needed to support this fishery. A brief outline of reproductive characteristics is given to aid those who make the laws.

An investigation of the relationship between Oregon coho salmon (*Oncorhynchus kisutch*) hatchery releases and adult production utilizing law of the minimum regression.

AUTHOR(S): Clark, J., and B. McCarl.

YEAR: 1983.

SOURCE: Jour. Fish. Aquat. Sci. Canada 40(4):516-523.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, reproduction.

ABSTRACT: Several models were tested to examine relationships between coho salmon, *Oncorhynchus kisutch*, adult production and hatchery releases. A unique model which evaluated limiting factors was also used and gave the best results. Density dependence was not found, suggesting previous requests for reduction in hatchery smolt releases were uncalled for. A firm conclusion on maximum release rates was not determined, however, the range may be as few as 32 million to as many as 180 million smolt.

Ecological studies during project Sealab II.

AUTHOR(S): Clarke, T. A., A. O. Flechsig, and R. W. Grigg.

YEAR: 1967.

SOURCE: Science 157:1381-1389.

KEYWORDS: Artificial reef, community, behavior, feeding.

ABSTRACT: Abundances, behavior and food habits of organisms observed to be attracted to the sealab site are reported on a day-by-day basis, along with a comparison of fauna attracted to the site with the normal sand-bottom community. During the project, 11 species of larger invertebrates, 43 species of fishes, and one species of mammal were observed. Of these, 2 invertebrates, 17 fishes, and the mammal were attracted to and associated with the lab, while the rest were normal inhabitants of the sand bottom. The most common invertebrates on the open sand were sea stars, the sea pen, and the sea urchin, *Lytechinus pictus*. Fishes

observed to be normal inhabitants included the longfin sanddab, *Citharichthys xanhostigma*; hornyhead turbot, *Pleuronichthys verticalis*; Pacific sanddab, *C. sordidus*; California tonguefish, *Symphurus atricauda*; bluespot goby, *Coryphopterus nicholsi*; and pink sea perch, *Zalembeus rosaceus*. A variety of other fishes were seen occasionally. The high biomass suggests that the higher carnivores depend on a nonresident food supply. Two types of organisms were attracted to sealab, those that were residents and those that were nightly visitors. Fishes included schools of northern anchovy, *Engraulis mordax*; rockfish, *Sebastes* sp.; sand bass, *Paralabrax nebulifer*; jack mackerel, *Trachurus symmetricus*; and California bonito, *Sarda lineolata*. Some species were attracted to sealab's lights in the evening. For most visiting species, the numbers remained nearly constant throughout the project, while the numbers of those which became residents increased steadily. Nineteen days after sealab was raised, very few of the attracted species were observed in the area. Behavior and species interactions for the common animals is reported. The effect of the presence of Sealab II on the biota was almost immediate. The most striking effect was the attraction of rocky-bottom and mid-water organisms. Attraction was more rapid than reported for artificial reefs, with light and noise around sealab being important factors. No food grew on the structure and it seemed to be a point of orientation for organisms. Visitors provided a regular source of food for resident populations.

Catch localities for Pacific albacore (*Thunnus germo*) landed in California, 1951 through 1953.

AUTHOR(S): Clemens, H. B.

YEAR: 1955.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 100:1-28.

KEYWORDS: Albacore, *Thunnus alalunga*, fishery, fishing gear, distribution.

ABSTRACT: Data on the commercial catch of albacore, *Thunnus germo* (now *Thunnus alalunga*) were summarized as to catch localities of each month of the season for the years 1951 to 1953. The majority of albacore landed in California from 1951 to 1953 were caught during July, August, and September between latitude 26 and 36 deg. N, from the coast out to longitude 125 deg. W. Each year as the season progressed, the fishery tended to move northward up the coast and offshore. The time and location of highest catches were different for each year. During June and July, most of the fish were captured relatively near shore (within 150 miles). By August and September the offshore area (outside 150 miles) became the most productive fishing area. A brief description of the albacore fishery is given, describing the vessels, type of fishing gear, and methods of fishing.

The migration, age, and growth of Pacific albacore (*Thunnus germo*), 1951-1958.

AUTHOR(S): Clemens, H. B.

YEAR: 1961.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 115:1-128.

KEYWORDS: Spawning, length/weight, migration, age, growth, fishery, fishing gear, *Thunnus alalunga*, albacore.

ABSTRACT: Tagging experiments, exploratory fishing, and fishing fleet catch data were used to determine migration patterns,

populations, age, growth rates, and environmental requirements of Pacific albacore, (*Thunnus germon\**), for use in improving the fishery. It was found that the coastward albacore migration moves eastward from the central North Pacific into the coastal fishing grounds of southern California or Baja California then the moves northward up the west American coast. After moving offshore migration is back across the Pacific to enter the fisheries of the Hawaiian Islands and Japan. There are shifts of considerable magnitude in the northward movement within season migration and in the locality of the annual offshore (departure) and inshore (approach) migration. Almost 90% of the 1.3 million fish sampled were caught where surface temperatures were 60 - 67 deg F. Also, there is an albacore size-temperature relationship; fish weighing less than 20 lbs. were harvested in 65 deg F and cooler water by trolling fishing gear, while larger fish predominated in warmer water and were taken primarily by live-bait boats. This albacore temperature relationship was used to predict large seasonal changes in the migration route. The growth rate of albacore is relatively rapid, averaging seven lbs. per year for the catch-dominating 13 lb. fish. The natural size groups in the California fishery are the year-classes I, II, III, and IV. The length/weight relationship calculated was  $W = 4.936 \times 10^{-8} / L^{2.99}$ . Albacore are mature by 93 cm. Spawning probably takes place in the spring somewhere in the west - central Pacific. Running ripe albacore have never been recorded from the California landings. now called *Thunnus alalunga*.

An analysis of California's albacore fishery.

AUTHOR(S): Clemens, H. B., and W. L. Craig.

YEAR: 1965.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 128:1-301.

KEYWORDS: Migration, age, behavior, population, fishery, albacore, *Thunnus alalunga*, length.

ABSTRACT: Historical records of California's sport fishery and commercial fishery for albacore (*Thunnus alalunga*), were compiled and analyzed for the years 1916 to 1961. Yearly landings, length-frequencies, catch locations and catch-per-unit-effort are presented for each year. Pacific albacore have been caught from Cape San Lucas, Baja California to Alaska. Annual albacore landings rose gradually from 23 million pounds in 1916 to a high of over 60 million pounds in 1950, and has since moved erratically downward. The location and amount of albacore caught was positively correlated with sea surface temperatures. Albacore appear to be most plentiful on the fishing grounds from July through August, and they travel upcoast each season as the warm isotherms advance north and toward shore. Above average water temperatures cause the albacore to run northward far to sea, while cold water temperatures permits them to move fairly close to shore. Albacore were found to be most plentiful in waters ranging from 62 to 66 deg F. Few inhabit seas cooler than 58 deg F. Examining the catch in numbers-per-day-fishing found that less albacore are caught per-day-fishing in cold water years. The migration behavior of albacore schools depends upon its size or age composition. Larger fish (>20 pounds) are found in warmer parts of the preferred temperature regime and smaller fish are found in the cooler water. If the size of the California migration is any indication of total numbers in the population,

the resource appears to be in good condition.

Fishes of the Pacific Coast of Canada.

AUTHOR(S): Clemens, W. A., and G. V. Wilby.

YEAR: 1961.

SOURCE: Fish. Res. Board Can., Bull. 68:443.

KEYWORDS: All species, albacore, Thunnus alalunga, physiology, distribution.

ABSTRACT: The text covers 272 species of fishes belonging to 83 families found

in the marine fish fauna of the Pacific Coast of Canada. External characteristics are described and a glossary is provided to aid understanding of descriptive terminology. Species are identified using a dichotomous key. Individual characterizations list physiological attributes, lengths and range.

FAO species catalogue. Vol. 2. Scombrids of the world.

AUTHOR(S): Collette, B. B., and C. E. Nauen.

YEAR: 1983.

SOURCE: FAO Fish. Synopsis 125, Food Agr. Org., U. N., Rome, IT. 137 p.

KEYWORDS: Albacore, Thunnus alalunga, chub mackerel, Scomber japonicus, Pacific bonito, Sarda chiliensis, habitat, fishery, distribution, feeding, spawning.

ABSTRACT: This volume, the second in the FAO series of major groups of organisms that enter the marine fisheries, is an annotated and illustrated worldwide catalogue of the 49 species of scombrids known thus far. Characterizations of each species include drawings, scientific and common names, information on habitats, biology, and fisheries. Distribution maps are provided as well as a glossary of technical terms and measurements.

Systematics and morphology of the bonitos (Sarda) and their relatives (Scombridae, Sardini).

AUTHOR(S): Collette, B. B., and L. N. Chao.

YEAR: 1975.

SOURCE: Fish. Bull. 73(3):516-625.

KEYWORDS: Pacific bonito, Sarda chiliensis, jack mackerel, Trachurus symmetricus, physiology.

ABSTRACT: The scombrid tribe, Sardini, was reviewed to compare morphometrics within the 5 genera and 8 species of bonitos. Differences between the higher tunas and more primitive jack mackerels were noted. Morphometric changes within the 5 genera were less severe and tended to show differences in numbers of fin rays, gill rakers, vertebrae and teeth. One Indo West Pacific species was the only member of the Sardini with a swim bladder. Included in the paper were tables on meristics, illustrations and comparative diagnoses. A synonymy, which lists nominal species, distributions and life histories was also included.

Movement and growth of post-larval Dungeness crabs: Cancer magister, in the San Francisco area.

AUTHOR(S): Collier, P. C.

YEAR: 1983.

SOURCE: Pages 125-134 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, Cancer magister, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, Cancer magister, growth, distribution.

ABSTRACT: The purpose of this study was to analyze the movement and growth of post-larval Dungeness crabs in the San Francisco area. During the four years of the study, in which 9,178 crabs were tagged, no crabs tagged in the Bay were caught within 90 days of tagging at the tagging site. Fifty Bay-tagged crabs were recaptured in the Gulf of the Farallons. The farthest distance traveled by an individual crab was 53 miles. Seventy-three recaptured crabs molted while at liberty; of these, 52 molted once, 16 twice, and 5 three times. Only four adult females (of 483 tagged) were recaptured, one of which had molted. Through carapace width-frequency distributions, it was found that crabs of the year enter the Bay complex during May and June and leave by August or September in the following year. Crab tag recovery data show a regular pattern of movement of juvenile crabs out of the Bay complex and a random movement of adult crabs in the ocean. Although growth increments per molt for post-larval instars are similar between British Columbia and central California, crabs in the San Francisco Bay complex molt more frequently and grow at a rate about twice as fast as ocean-reared crabs. In males, a change in growth rate occurs around 100 mm, which corresponds to the onset of sexual maturity. Growth rate change for females was not analyzed.

Age determination of northern anchovies, *Engraulis mordax*, from otoliths.

AUTHOR(S): Collins, R. A., and J. D. Spratt.

YEAR: 1969.

SOURCE: Calif. Fish Game, Fish. Bull. (147):39-55.

KEYWORDS: Northern anchovy, *Engraulis mordax*, age.

ABSTRACT: Otoliths were looked at as an alternative structure to scales for aging northern anchovies (*Engraulis mordax*). This paper develops a technique for determining ages using otoliths, delineates the advantages and disadvantages of each structure, and verifies that age determinations between the two methods are comparable, for this wetfish. In reading otoliths, the frequency of agreement between two readers was about 70%. The birthdate of anchovies using this method was set at June 1st. For the two sampling years, 1966 and 1967, ages estimated by the two methods agreed 79% and 72% of the time, respectively. It was concluded that there was no significant difference between methods, and each could be used with equal confidence. Due to inherent problems in using scales, it is recommended that otoliths be used in age composition studies of the northern anchovy.

Progress report on the kelp bass, *Paralabrax clathratus*.

AUTHOR(S): Collyer, C. D., and P. H. Young.

YEAR: 1953.

SOURCE: Calif. Fish Game 39:191-208.

KEYWORDS: *Paralabrax clathratus*, kelp bass, growth, reproduction, spawning, population trends, fishery, fishing gear, seasonality, distribution.

ABSTRACT: Summarizes catch records for the "rock bass" party boat fishery from 1936 to 1951. *Paralabrax clathratus* is one of three *Paralabrax* species comprising the "rock bass" fishery. The majority of the "rock bass" catch is considered to be *P. clathratus*. Catch statistics are based on records from party boat

operators and are for *P. clathratus* alone. During 1950-1952, 3,980 *P. clathratus* were tagged and released throughout the Southern California Bight to obtain movement, age and growth information. Growth data are based on 40 fish that were at liberty from 16 to 133 days following tagging. The 11-year average catch (1936-1951) is approximately 140,000 fish per year. Size frequency distributions from various locations characterized by differences in fishing effort reflect the impact of fishing effort on reducing the average size of fish caught. 75% of the tagged fishes were recaptured within 60 days of release. The rapid rate of returns indicates heavy fishing mortality in the areas where tagging took place. Of the 500 tagged and recaptured *P. clathratus*, 400 individuals indicated no movement from the site of tagging. Sixteen fish showed movements of five miles or more. The kelp bass fishery is probably based on a series of independent populations. Estimated growth rates are given for an eight inch fish (2.3 inches per year) and a 12 inch fish (1.64 inches per year). Data on size and season of sexual maturity are tabulated and substantiate those patterns described by Clark (1933). Average size of first maturity is approximately 10 inches TL. Main spawning months are May through August.

Council.

Disposal of offshore platforms.

AUTHOR(S): Commission on Engineering and Technical Systems, National Research

YEAR: 1985.

SOURCE: Natl. Acad. Press, Washington, D. C. 76 p.

KEYWORDS: Platform, habitat, economics, community, artificial reef.

ABSTRACT: The purpose of this paper is to report the findings of the committee

on Disposition of Offshore Platforms appointed by the National Research Council to document and assess alternatives for removing, disposing, or reusing fixed offshore platforms that are past their useful service life. The Department of the Interior is considering changing the mandatory removal requirements due to the maturity of the fields and the accompanying increase in platforms to be removed, their depth, and increased removal costs. Included in this report are the committee's recommendations concerning government policy regarding platform disposition.

Council, CETS, NRC.

Drilling discharges in the marine environment.

AUTHOR(S): Commission on Engineering and Technical Systems, National Research

YEAR: 1983.

SOURCE: Natl. Acad. Press, Washington, D. C. 180 p.

KEYWORDS: Contaminant levels, platforms, mortality.

ABSTRACT: The purpose of this report is to present the findings of the Panel

on Assessment of fates and effects of drilling fluids and cuttings in the marine environment convened to establish a credible technical basis for decisions about discharging drilling fluids and cuttings in the marine environment. The panel's report and its conclusions and recommendations are based on its review of the primary and



secondary scientific literature, public comments, additional data sought by the panel and on the professional experience of panel members.

Sharks of the world. Part 1. Hexanchiformes to Lamniformes.

AUTHOR(S): Compagno, L. J. V.

YEAR: 1984.

SOURCE: FAO Fish. Synop. 125(4):249 p.

KEYWORDS: Thresher shark, *Alopias vulpinus*, fishery, distribution, habitat,

spawning, feeding, migration, reproduction, behavior, length/weight.

ABSTRACT: This volume, the fourth in the FAO series of major groups of organisms that enter the marine fisheries, is a worldwide annotated and illustrated catalogue of 342 shark species belonging to 8 orders and 31 families. Characterizations of each species include drawings, scientific and common names, information on habitats, biology, fisheries and distribution maps.

Subtidal abalone populations in an area inhabited by sea otters.

AUTHOR(S): Cooper, J., M. Wieland, and A. Hines.

YEAR: 1977.

SOURCE: Veliger 20(2):163-167.

KEYWORDS: Abalone, *Haliotis* spp., distribution.

ABSTRACT: The densities, population structure and distribution of red, *Haliotis rufescens*, and (flat), *Haliotis walallensis*, abalone were studied in a kelp forest at Hopkins Marine Life Refuge, Pacific Grove, California. The mean density of both species was 0.16/m<sup>2</sup> and equal numbers of each species were present. All individuals were found to dwell in crevices with the smaller reds and all (flats) found in shallow crevices. The size frequency of *Haliotis rufescens* showed no distinct mode, whereas *H. walallensis* showed a single distinct mode at 7.5 cm. No abalone of legal size were located in the present study, presumably due to active foraging by resident otters.

Epizootiology of Neoplasia in English sole, *Parophrys vetulus*.

AUTHOR(S): Cooper, R. C., and C. A. Keller.

YEAR: 1968.

SOURCE: Natl. Cancer Inst. Monogr. 31:173-185.

KEYWORDS: English sole, *Parophrys vetulus*, growth, contaminant susceptibility, population trends.

ABSTRACT: Data was obtained on the epizootiology of papilloma-like tumors occurring on English sole collected from San Francisco Bay. There was no significant difference between the fish length distribution of tumorous and non-tumorous fish. There also was no difference between the length-weight relationship of both groups, indicating there is no debilitation of diseased fish. No tumors are seen in fish much larger than 200 mm, indicating that tumors regress. The tumorous plus non-tumorous fish grow to about the same length the first year, but tumorous fish appear to be born later in the year and grow faster. This may indicate the presence of a subgroup which is more susceptible to tumorous disease. It was also found that the incidence of tumorous fish is greater in the north than south bay, but it is unclear whether it is due to genetic differences (sub-populations) or environmental differences (e.g. increased industrial waste discharge, decreased

salinity and decreased depth in the north bay).

The effect of sheephead (*Semicossyphus pulcher*) predation on red sea urchin (*Strongylocentrotus franciscanus*) populations: An experimental analysis.

AUTHOR(S): Cowen, R. K.

YEAR: 1983.

SOURCE: *Decologia* 58:249-255.

KEYWORDS: *Strongylocentrotus* spp., sea urchin, mortality.

ABSTRACT: The purpose of this study was to assess the importance of sheephead predation on the red sea urchin, *Strongylocentrotus franciscanus*. Sheephead (*Semicossyphus pulcher*) were removed from an experimental site located in San Nicholas Island, California by spearing. Urchins were found to rank 7th in overall relative importance of prey items although they ranked third overall based on volume only. Sheephead were found to have a significant effect on the abundance of urchins. *Strongylocentrotus franciscanus* increased significantly in the experimental area following removal of sheephead. The urchin population was estimated to increase approximately 26% annually in the absence of sheephead predation. The annual consumption of sheephead was estimated based on sheephead density, diet analysis, and feeding observations. It was estimated that 22 urchins are consumed in one hectare per day, or 8030 urchins per year per hectare. This corresponds to a 2015 - 33% standing crop consumed annually by sheephead. Sheephead were also found to affect the spatial distribution of sea urchins; *S. franciscanus* utilized open microhabitat significantly more often after removal of sheephead in the experimental sites. No significant changes were seen in the urchin size frequency either in the control area or in the experimental area. Thus, it was shown that sheephead can successfully regulate sea urchin abundance. Furthermore, there appears to be a threshold level between sheephead density and their effect on urchin populations. Although threshold level from this study appears to be 100-150 sheephead per hectare.

The maintenance of community structure in a central California giant kelp forest.

AUTHOR(S): Cowen, R. K., C. R. Agegian, and M. S. Foster.

YEAR: 1982.

SOURCE: *Jour. Exp. Mar. Biol. Ecol. Canada* 64:189-201.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp, community, habitat, seasonality.

ABSTRACT: Changes in the algal and invertebrate populations were compared between an experimental site where urchins were removed and a control site in order to determine the effects of sea urchin grazing in a giant kelp forest. Storms which occurred during the experiment also allowed a comparison of grazing and storm effects. The results indicated that changes in community structure due to sea urchin removal (e.g. sea otter predation) may vary but in this study area they will be less important than seasonal and year-to-year changes associated with storms.

Review of the abalone in California.

AUTHOR(S): Cox, K. W.

YEAR: 1960.

SOURCE: *Calif. Fish Game* 46(4):381-406.

KEYWORDS: Abalone, *Haliotis* spp., distribution, life history, habitat, growth.

ABSTRACT: The species of abalone (*Haliotis*) found in California were described. In addition to physical descriptions (of shell sculpture and morphological characteristics) notes on distributions, habitat, life histories and field keys for the eight species were provided. Growth was fairly regular during the first few years then slowed substantially after 4-5 years. Tagged abalones exhibited little movement. Red abalone, *H. rufescens*, reached 11 inches in diameter and ranged from Oregon to Baja California. Pinks, *H. corrugata*, were slightly smaller (10 inches) and occurred from central California to Baja California. The remainder of the species could reach 8 inches in length, however rarely exceeded 5 inches. Distributions ranged from central California to the south (*H. fulgens*, *H. sorenseni*, *H. assimilis*); Oregon to Baja California (*H. cracherodii*); British Columbia to San Diego (*H. walallensis*) and Sitka, Alaska to central California (*H. kamtschaticana*).

California abalones, family Haliotidae.

AUTHOR(S): Cox, K. W.

YEAR: 1962.

SOURCE: Calif. Dep. Fish Game, Fish. Bull. 118:133 p.

KEYWORDS: Red abalone, *Haliotis* spp., life history, growth, feeding, habitat,

distribution, mortality, spawning, reproduction, fishery, economics.

ABSTRACT: The intent of this study was to provide information to answer the

question of what effects the commercial offshore fishery had on the shoreside sport fishery. This report discusses the results of over 1,500 underwater hours logged by California Fish and Game divers in their observations of abalone in their natural deep water habitat. This new information is presented along with all other available data obtained from an extensive literature search to provide a comprehensive, up-to-date study of the life history, biology, behavior and general condition of the abalone resource.

Food and feeding.

AUTHOR(S): Craig, W. L.

YEAR: 1960.

SOURCE: Pages 35-46 in J. L. Baxter (ed.). A study of the yellowtail, *Seriola dorsalis* (Gill). Calif. Dept. Fish Game, Fish Bull. 110.

KEYWORDS: Feeding, yellowtail, *Seriola lalandei*, northern anchovy, *Engraulis mordax*, jack mackerel, *Trachurus symmetricus*, chub mackerel, *Scomber japonicus*, market squid, *Loligo opalescens*, mortality.

ABSTRACT: Number, frequency-of-occurrence and volume of prey items were determined from yellowtail stomachs collected by purse sein and "other" gear. The results show that sardines, anchovies, jack mackerel and Pacific mackerel dominated the diet, but market squid and red swimming crab were also important. Although all these prey species had high importance, the diversity of organisms occurring in the diet suggests that yellowtail are opportunistic feeders, and appear to be attracted to the schooling habits of the forage organisms rather than the particular species.

Weight-length relationship.

AUTHOR(S): Craig, W. L.

YEAR: 1960.

SOURCE: Pages 32-34 in J. L. Baxter (ed.), A study of the yellowtail, *Seriola dorsalis*. Calif. Dep. Fish Game, Fish bull. 110.

KEYWORDS: Yellowtail, *Seriola lalandi* (=dorsalis), length/weight.

ABSTRACT: Weight/length relationships were obtained on 3,377 fish, most of

which were sampled at the canneries. Fork length measurements were taken and mean weights were recorded. The data is presented in table format on males and females separately and also combined.

The sport and commercial fisheries.

AUTHOR(S): Craig, W. L.

YEAR: 1960.

SOURCE: Pages 14-22 in J. L. Baxter (ed.), A study of the yellowtail, *Seriola dorsalis*. Calif. Dep. Fish Game, Fish Bull. 110.

KEYWORDS: Fishery, fishing gear, yellowtail, *Seriola lalandi* (=dorsalis).

ABSTRACT: The sport and commercial fisheries section of A Study of the Yellowtail describes both the sport fishery and commercial fishery. Landings for the sport fishery are reported from 1936 to 1959. The commercial landings are also reported with data available from 1916 to 1957. Gear methods used and the composition of the catch is discussed for both the sport and commercial fisheries.

Fish and game code.

AUTHOR(S): Cribbs, H. C.

YEAR: 1982.

SOURCE: Calif. Dep. Fish Game, Sacramento, CA. 397 p.

KEYWORDS: Regulations, fishing gear, all species.

ABSTRACT: The Fish and Game Code is a compilation of all the rules and regulations enacted by the California Fish and Game Commission pursuant to their regulatory powers granted by the State of California. The provisions of the code relate to the taking, processing or use of birds, mammals, fish, mollusks, crustaceans, amphibia, reptiles or plants and, where applicable, apply also to commercial purposes. Revisions or modifications of the code are set forth in Title 14 of the California Administrative Code and then incorporated by reference in the Fish and Game Code.

The ecology of marine fouling. Pages 99-117.

AUTHOR(S): Crisp, D. J.

YEAR: 1965.

SOURCE: Pages 99-117, in: Ecology and the industrial Society. 5th Symposium of British Ecological Society. Blackwell Press, Oxford.

KEYWORDS: Colonization, economics, platform, seasonality.

ABSTRACT: A discussion of marine fouling organisms and their settlement on the outside or easily accessible parts of structures, and their settlement within narrow pipes or in other inaccessible parts of industrial plants. The article discusses the marine fouling community in terms of growth and reproduction of fouling organisms in relation to water currents and suspended matter content, intrinsic rates of growth and reproduction, competition between fouling organisms, and choice of surfaces at settlement. Following successive growth on a new surface indicates that

primary fouling organisms, after a few weeks of growth, change the character of the surface for later fouling organisms.

A study of the yellowtail *Seriola dorsalis* (Gill).

AUTHOR(S): Crooke, S. J.

YEAR: 1983.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 110.

KEYWORDS: Life history, migrate, spawning, feeding, recruitment, fishery, *Seriola lalandei*, yellowtail.

ABSTRACT: The life history and sport catch records of yellowtail, *Seriola lalandei*, are reviewed in this paper. The yellowtail is the largest member of the family Carangidae found in California water. It is one of the most highly prized gamefishes found off southern California. Results of tagging experiments indicate there are two groups of yellowtail off Baja California. These fish migrate north as the water warms in the spring. During the summer (June - September), adults that are about to spawn move offshore, and return nearshore in the fall, then migrate south as the water cools. Yellowtail form spawning aggregations and broadcast their eggs and milt into the water. They are sexually mature at three years of age. Young fish spawn once per season, but those greater than age seven are capable of multiple spawnings. Yellowtail are relatively slow growing and can gain approximately 3 - 4 lbs. a year. They are highly piscivorous and feeding takes place primarily during daylight hours. Yellowtail fishing off southern California is highly dependent upon water temperature, with highest catch rates occurring during warm water periods. Historically, the catch was dominated by four and five year olds. Presently one and two year olds make up the majority of the catch. Data collected from charter boats operating off Mexico suggest a decrease in the yellowtail population. Age composition studies indicate there were a number of year-class failures starting in 1975 and continuing through 1978. However, recruitment of the 1979 and 1980 year classes was relatively good.

Trends in fin erosion among fishes on the Palos Verdes shelf.

AUTHOR(S): Cross, J. N.

YEAR: 1982.

SOURCE: Pages 99-110 in W. Bascom (ed.), Coastal Water Research Project Biennial Report for the years 1981-1982, South. Calif. Coastal Water Res. Proj., Long Beach, CA.

KEYWORDS: Vermilion rockfish, *Sebastes miniatus*, sablefish, *Anoplopoma fimbria*, English sole, *Parophrys vetulus*, Dover sole, *Microstomus pacificus*, contaminant levels, contaminant susceptibility.

ABSTRACT: Synthesis and analysis of data collected by Los Angeles County Sanitation District from 1971 to 1981 during monitoring cruises are reported in this study. Long term and seasonal trends were analyzed to determine the present status of fin erosion among fishes collected by otter trawl on the Palos Verdes shelf. Although the results indicated a decline in the incidence of fin erosion during this 10 year period, the disease still remains a problem.

Optimal foraging and feeding mode shifts in fishes.

AUTHOR(S): Crowder, L. B.

YEAR: 1985.

SOURCE: Env. Biol. Fish. 12(1):57-62.

KEYWORDS: Northern anchovy, *Engraulis mordax*, chub mackerel, Scomber

japonicus, feeding.

ABSTRACT: It is hypothesized that feeding mode shifts (e.g. from particulate feeding to filtering) are predictable based on the costs and benefits of foraging in various modes. It is suggested that use of different feeding modes may be dependent on the relation of prey size to predator size and relative densities of large and small prey as well as the ability to shift feeding modes. Three examples of feeding mode shifts are given; the northern anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicus*), and alewife (*Alosa pseudoharengus*). All three show a striking agreement between feeding mode shifts observed and the relative profitability of each mode. Nearly complete use of patches of small prey encountered will occur due to this behavior. The ability to switch back and forth between feeding modes would be highly advantageous in the patchy environment these fishes live in. Fishes may be able to assess which provides the greatest net energy gains by comparing yields using the two feeding modes. Feeding mode shifts depend on the relative profitability of each mode and that those shifts are graded, in response to feeding in a temporally and spatially patchy environment.

The status of ocean shrimp resource and its management.

AUTHOR(S): Dahlstrom, W. A.

YEAR: 1973.

SOURCE: Calif. Dept. Fish Game, Mar. Res. Tech. Rep. No. 14.

KEYWORDS: Ocean shrimp, *Pandalus jordani*, fishery, life history, migration, age, distribution.

ABSTRACT: An overview of the ocean shrimp fishery, including the history of the fishery, regulation and management, and biological data. The ocean shrimp fishing season begins on April 16 and ends on October 31 or earlier if the quota is reached. This time period corresponds with the time when most of the females are not carrying eggs and forms the basis of the season. In California, ocean shrimp are generally found from depths of 240 to 750 feet over a green mud or mixed mud and sand bottom. Adults from different beds probably do not intermix but the planktonic larvae may be carried long distances and could conceivably intermingle with those of closely associated beds. Most ocean shrimp are protandric hermaphrodites. Growth rates vary according to region, and also by sex and year class. In California ocean shrimp reach an average size of about 9 mm carapace length after 6 months from larval release. Mortality rates appear to vary from year class to year class, as well as from season to season. Predators appear to be a major factor in natural mortality. In years of good recruitment, many fish species, such as hake, sablefish, arrowtooth flounder, spiny dogfish, and skates can be found feeding heavily on young shrimp.

A history of Dungeness crab fisheries in California.

AUTHOR(S): Dahlstrom, W. A., and P. W. Wild.

YEAR: 1983.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 172:7-23.

KEYWORDS: Market crab, *Cancer magister*, fishery, fishing gear, economics, distribution, length/weight.

ABSTRACT: Although Dungeness crabs range from Amchitka Island, Alaska to Pt. Conception, California, they are most abundant along the

northern and central California coast. This paper covers the use of crabs by California Indians and the commercial and sport crab fishery. The history of the commercial fishery is covered from around 1848 to 1983. The development of fishing traps over that period, the changes in regulations, and commercial landings are covered in the review. The sport fishery is covered briefly since it is only a small fraction of the commercial catch.

EIR/EA Union Oil Co. Platform Gina and Platform Gilda Project. Lease OCS P-0202 and OCS P-0216. Offshore Ventura County, California. Volume II.

AUTHOR(S): Dames and Moore.

YEAR: 1980.

SOURCE: Prepared for City of Oxnard, CA. by Dames and Moore.

KEYWORDS: Platform, habitat, distribution, lingcod, kelp bass, California halibut, chub mackerel, bocaccio, northern anchovy, jack mackerel, Pacific bonito, *Ophiodon elongatus*, *Paralabrax clathratus*, *Paralichthys californicus*, *Sarda chiliensis*, *Sebastes paucispinis*, *Engraulis mordax*, *Trachurus symmetricus*, *Scomber japonicus*.

ABSTRACT: This environmental impact report/environmental assessment describes

the environmental setting of the Platform Gina and Platform Gilda projects. This environmental setting is described in terms of geotechnical, atmospheric sciences, oceanography, marine biology, terrestrial biology, land use, socioeconomic, and cultural resources. The marine fishes section has included information on the demersal fishes, shipwreck ichthyofauna, and commercial and sport fisheries. Fish species observed in the area include lingcod, kelp bass, California halibut, chub mackerel, bocaccio, anchovy, jack mackerel, and Pacific bonito.

Environmental report, Santa Ynez Unit Project, Section 3.4:  
Oceanography.

AUTHOR(S): Dames and Moore.

YEAR: 1982.

SOURCE: Prepared for Exxon USA by Dames and Moore, Los Angeles, CA. 29 pp.

KEYWORDS: Platform.

ABSTRACT: A review of the potential impact of activities associated with the placement and erection of new platforms. Several development option plans and information related to the construction of platforms are presented. The topics covered are: platforms; pipelines and power cables, offshore storage and treating vessel expansion, drilling, oil and gas production, mitigation measures, modernized nearshore marine terminal, and accidental oil spills.

Environmental report, Santa Ynez Unit Project, Section 2.5:  
Marine Biology.

AUTHOR(S): Dames and Moore.

YEAR: 1982.

SOURCE: Prepared for Exxon USA by Dames and Moore, Los Angeles, CA. 58 pp.

KEYWORDS: Ridgeback prawn, spot prawn, ocean prawn, sea urchin, abalone, spiny lobster, Dover sole, kelp bass, *Sicyonia ingentis*, *Pandalus platyceros*, *Pandalus jordani*, *Strongylocentrotus* spp., *Haliotis* spp., *Panulirus interruptus*, *Microstomus pacificus*, *Paralabrax clathratus*.

ABSTRACT: A review of the marine biology of the Southern California Bight, and more specifically, the Santa Ynez Unit (SYU) area which occurs between Pt. Conception and Coal Oil Point. The bight and SYU areas were described in terms of the benthos (epifauna epiflora, infauna and epifauna), plankton, marine fishes (demersal and pelagic), commercial and sport fisheries, marine mammals, kelp beds, intertidal habitats; rocky shore; sandy shore; rare, threatened, or endangered species, and areas of special biological interest.

Final environmental impact report. Resumption of drilling operations on the south Ellwood offshore oil field from Platform Holly. Vol. II, Environmental setting.

AUTHOR(S): Dames and Moore.

YEAR: 1974.

SOURCE: Prepared for the California State Lands Commission by Dames and Moore, Los Angeles, CA.

KEYWORDS: Platform, habitat, northern anchovy, jack mackerel, white seabass, Pacific bonito, kelp bass, vermillion rockfish, yellowtail, *Engraulis mordax*, *Trachurus symmetricus*, *Atractoscion nobilis*, *Sarda chiliensis*, *Sebastes miniatus*, *Seriola lalandei*.

ABSTRACT: A description of the existing baseline environmental conditions in the South Ellwood Offshore Oil Field. The purpose of this report is to state and analyze all foreseeable impacts due to resumption of drilling operations in this area. This volume covers information on the geotechnical, meteorology, terrestrial biology, marine biology, physical oceanography, chemical oceanography, geological oceanography, and social environment. An analysis of the sport and commercial catches in this region indicate that sport catches are dominated by rockfishes and rockbass, while commercial landings include a more varied catch. Most of the poundage in the commercial landings is made up of anchovies, jack mackerel, white seabass, rockfishes, bonito, and flatfishes. Although kelp bass, olive, grass and vermillion rockfishes, sheephead and cabezon are considered year-round residents in the Santa Barbara Channel, others including barracuda, yellowtail and bonito occur there only in the summer months.

Age and growth of Pacific hake, *Merluccius productus*.

AUTHOR(S): Dark, T. A.

YEAR: 1975.

SOURCE: Fish. Bull. 73(2):336-355.

KEYWORDS: Age, growth, population trends, recruitment, Pacific hake, *Merluccius productus*.

ABSTRACT: This study was conducted to examine the population trends; the processes of age and growth, to validate the age determination used, to examine the potential sources of variation, and to provide new estimates of the growth rate of Pacific hake. Hake were collected and examined from 1964 to 1969 off the coasts of California, Oregon and Washington. A discussion of the life history and fishery are included in the introduction. Otoliths, which are the accepted method for aging in hake, were found to have one translucent and one opaque zone on the average. Annual variation in age composition was found to occur, and was postulated to be partly due to varying levels of recruitment of



incoming year classes. Little evidence exists that age composition changes significantly during the commercial season; however, more data is needed to verify this. The relative abundance of 7 to 10 year olds tended to increase from south to north, while the opposite was true for 4 to 5 years olds. The age composition for males and females in all years examined were similar, with most significant difference being a greater percentage of females occurring in the older age groups (>8 years). Growth in length and weight of both sexes was rapid in the first 3 years, then slows rapidly. The length of a particular hake within a year class was found to vary as much as 4 cm as compared to other year classes at that age. However, little variation was apparent within year class groups. In general, the equation that best fits hake growth is:  $L_t = 60.85 (1 - e^{-0.30(E - 0.03)})$ .

The distribution, abundance, and biological characteristics of Pacific whiting, *Merluccius productus*, in the California British Columbia Region during July-September 1977.

AUTHOR(S): Dark, T. A., M. O. Nelson, J. J. Traynor, and E. P. Nunnallee.

YEAR: 1980.

SOURCE: Mar. Fish. Rev. 42(3-4):17-33.

KEYWORDS: Pacific hake, *Merluccius productus*, distribution, size, age.

ABSTRACT: Objectives of this 1977 NMFS survey were to determine the distribution, abundance and biological characteristics of a number of species. The information presented here is the data on Pacific whiting, *Merluccius productus*. The survey encompassed the area from Port Hueneme, California to Kyuquot Bay, British Columbia, between the depths of about 91 and 475 meters. The sampling was done by a bottom trawling survey (BTS), and by a hydroacoustic midwater trawling survey (HAMTS). The sampling area was broken up into the five INPFC subareas, the Vancouver, Columbia, Eureka, Monterey and Conception areas. The total Pacific whiting biomass estimate for the area sampled was 1,198,932 metric tons. 94% of the estimate was made from the HAMTS. 58% of the HAMTS and 87% of the BTS were inside the 183 meter isobath. Comparison of this survey with a similar one in 1975 showed a twofold increase in biomass between the two years. This was postulated to be partly due to strong 1973 year class. Younger age groups tended to be more prevalent with increasing depth in the Monterey and Columbia areas, while length tended to increase with increasing depth in the Vancouver area. A broader range of size groups were present in the southern areas, and mean length tended to increase from south to north.

Statistical analysis of the relation between kelp harvesting and sportfishing in the California kelp beds. In: North, W. J. and C. L. Hubbs (eds.) Utilization of kelp bed resources in southern California.

AUTHOR(S): Davis, D.

YEAR: 1968.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 139.

KEYWORDS: *Paralabrax clathratus*, kelp bass, population trends, fishery, habitat.

ABSTRACT: A statistical (correlation) analysis was performed to determine the relationship between changes in local giant kelp, *Macrocystis pyrifera*, abundance and the catch-per-unit-effort of

*P. clathratus* (and other important sport fishes) over a ten year period (1947-1956). Reductions of giant kelp due to natural causes and commercial kelp harvesting were addressed. No correlation between the amount of kelp harvested and the catch-per-unit-effort of *P. clathratus* in the same year was obtained. Therefore, there was no apparent relationship between kelp-bass fishing and the harvesting of kelp.

Juvenile spiny lobster management or how to make the most of what you get.

AUTHOR(S): Davis, G. E.

YEAR: 1980.

SOURCE: Fisheries 5(4):57-59.

KEYWORDS: Spiny lobster, *Panulirus* spp., regulations, fishery.

ABSTRACT: Goals of spiny lobster (*Panulirus* spp.) management include the ensurance of sufficient larval production to sustain harvest, provide for efficient and equitable allocation and harvest among fishermen, and to maximize the yield per post-larval recruit. The ways in which the former goal have been addressed are reported. The most effective and widely applied action is the use of limits on the minimum harvest size, based on size at maturity, growth, and mortality rates. The minimum harvest size is that at which the biomass of the surviving lobsters is maximized. Management to increase growth rates directly is also used, including trap escape vents, regulations restricting the possession of shorts, and the establishment of nursery sanctuaries. Improving growth rates is correlated to a reduction in mortality. As sea grass beds and estuaries are dredged, filled, or otherwise reduced through increased sedimentation by man's well-known destructive activities, the carrying capacities of these important nursery grounds is reduced or eliminated, reversing management's actions to maximize post-larval recruitment.

Spiny lobster series.

AUTHOR(S): Davis, G. E.

YEAR: 1980.

SOURCE: Fisheries 5(4):27.

KEYWORDS: Spiny lobster, *Panulirus* sp., fishery, regulations, economics.

ABSTRACT: A series of papers regarding spiny lobster, *Panulirus* sp., management is presented, ranging from biochemical generics to ecology and economics. Contributors include the National Marine Fisheries Service, National Park Service, Florida Department of Natural Resources, University of Florida, Nova University, and Science Applications, Inc. This interest in lobsters stems from their economic value along with the fact that they are a significant biological entity. Lobsters are widely distributed, specious, large in size, long-lived, enormous in number and ecologically consequential. Thus, understanding how lobsters achieve their biological success is an important scientific contribution.

Man-made structures on marine sediments: Effects on adjacent benthic communities.

AUTHOR(S): Davis, N., G. R. VanBlaricom, and P. K. Dayton.

YEAR: 1982.

SOURCE: Mar. Biol. 70:295-303.

KEYWORDS: Artificial reefs, platforms, community, colonization.

ABSTRACT: The effects of man-made structures, including artificial reefs, oil platforms, and bridge supports, on the infaunal and epifaunal components of adjacent soft-bottom communities is investigated. Bureaucrat reef, an experimental reef, oil-production platform Eva, and the pilings of the Ventura Bridge were all examined. The accumulation of fishes and fouling organisms on artificial reefs are described. First colonizers were low profile algae including diatoms, various hydroids, and a barnacle. Most species common in southern California reefs were present on artificial reefs including a dense kelp canopy. The other artificial structures examined had rich typical faunas. Sea pen (*Stylatula elongata*) populations had significantly declined in areas adjacent to artificial reefs and the oil platform. The loss in sea pens was due to predation by reef-associated fishes. Elevated densities of the polychaetes *Diopatra ornata* and *D. splendidissima* were observed in areas examined. Near artificial reefs infaunal communities were typical for the area, densities ranging from 3,000 to 11,000 individuals m<sup>-2</sup>. Near the oil platform at least 18 species of infaunal polychaetes were in some way altered. Physical effects near structures was also described. Physical effects of structures were confined to their immediate area. Modifications of natural patterns of abundance in sedimentary communities near structures did occur. Infaunal populations are less sensitive to disturbance than sessile epifauna. Structures can have both positive and negative effects on native species. Decisions to construct any structure should consider possible effects on the biota of the bottom.

Homing behavior and population stratification in the central Puget Sound English sole (*Parophrys vetulus*).

AUTHOR(S): Day, D. E.

YEAR: 1976.

SOURCE: Jour. Fish. Res. Bd. Canada 33(2):278-282.

KEYWORDS: English sole, *Parophrys vetulus*, distribution, migration.

ABSTRACT: The recovery of tagged English sole, *Parophrys vetulus*, in central Puget Sound showed a tendency of fish captured at one site and released at another to return to their respective site of capture. Analysis of fish tag records also revealed a tendency for fish not displaced during tagging to remain essentially in the same area. The population stratification appears to extend to a level of individual territories. Catch-per-unit effort data shows migration of some fish out of the area during the fall and winter months.

Experimental studies of algal canopy interactions in a sea otter-dominated kelp community at Amchitka Island, Alaska.

AUTHOR(S): Dayton, P. K.

YEAR: 1975.

SOURCE: Fish. Bull. 73(2):230-237.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., feeding, mortality.

ABSTRACT: The interaction of algal communities of *Alaria fistulosa*, *Laminaria longipes* and *Agarum cribosum* in the presence of foraging sea urchins and urchin predators (sea otter, *Enhydra lutrus*) were studied. By consuming populations of invertebrate herbivores, the sea otter helps maintain the structure of shallow algal communities. However, shallow waters subject to severe storm disturbances are dominated by

Laminaria spp. When larger Laminaria spp. are removed, the space is quickly utilized by Alaria fistula. In deeper water (12-20 m) where there are many sea urchins, Agarum cribosum is one of the dominant algal species. However, Agarum (a prostrate form) loses in competition for light to solid canopies of Laminaria spp. If both Agarum and Laminaria are removed (as they were in this study), there is a bloom of red algal turf and Alaria fistulosa.

Scales as a means of aging Dover sole (*Microstomus pacificus*).

AUTHOR(S): Demory, R. L.

YEAR: 1972.

SOURCE: Jour. Fish. Res. Bd. Canada 29:1647-1650.

KEYWORDS: Dover sole, *Microstomus pacificus*, age.

ABSTRACT: This paper is a summary of results obtained in determining the age of Dover sole (*Microstomus pacificus*) with scales. Scales were removed from the eyed side of fish, one or two rows above or below the lateral line and midway between the head and tail. For 782 scales read, agreement between the first two readings was 50%. After three readings, agreement increased to 80%. Agreement was 85 and 77% for males and females, respectively. The average percentage agreement for fish aged 1 to 10 was 94% for males and 85% for females. For fish older than 10 years, the average percentage agreement was 94% for males and 85% for females. At times, annuli counts from scales underestimated the true age. Between 1962 and 1967, 24 Dover sole were recovered from a tagging program conducted in 1955. The estimated age at tagging, based on scales, ranged from 2 to 10 years. Fish were at liberty between 7 and 12 years. In nine cases, scales underestimated the age estimated from lengths. The migratory nature of Dover sole may explain why certain annuli were not readable. The level of agreement of scale readings of Dover sole in this study is in line with other studies reported in related flatfish.

The sablefish fishery.

AUTHOR(S): Dewees, C. M.

YEAR: 1980.

SOURCE: Univ. of California Division of Agricultural Sciences Leaflet 21155. 10 pp.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, groundfish, fishery, fishing gear, life history, feeding, reproduction, distribution.

ABSTRACT: This leaflet gives an overview of the fishery for sablefish, *Anoplopoma fimbria*. The life history of sablefish is briefly detailed with information drawn from other references on habitat, reproduction, abundance, distribution, and feeding. A short history of the fishery has also been put together from several sources, ranging from incidental catches by halibut fishermen in 1905 to a fishery off southern California of over 5 million pounds in 1978. The gear types used on sablefish are described, including trawls, longlines, rectangular traps, truncated Korean traps, and the most effective methods of using some of the gear types. Management problems with the fishery are briefly discussed. Consumer information is given including the types of processed sablefish - smoked, fillets and steaks, salted, animal food, and pickled, as well as the popular names of these preparations.

Molting and growth in laboratory reared phyllosomes of the

California spiny lobster, *Panulirus interruptus*.  
AUTHOR(S): Dexter, D. M.  
YEAR: 1972.  
SOURCE: Calif. Fish Game 58(2):107-115.  
KEYWORDS: Spiny lobster, *Panulirus interruptus*, larvae, mortality, early life history.  
ABSTRACT: Larvae of the California spiny lobster (*Panulirus interruptus*) were reared through 6 of 11 phyllosomal stages to document the duration of each stage and the number of molts within each stage. One molt occurred between stages I and II, II and III, IV and V, and V and VI, while 4 molts were observed between stages III and IV. Minor morphological changes and a slight increase in size was seen between stage III and stage IV molts. Approximately 50% of all larvae died between each molt. Temperature affected growth, with those raised at 25 deg. C and 20 deg. C growing at 0.5 mm per molt and 0.3 mm per molt, respectively. Variation is high in duration of stages and molting frequencies during different seasons. Duration is also different at the two temperatures. Feeding may have a significant effect on survival and molting frequency. An estimated five months would be required for the phyllosomes to develop completely from stage I to stage XI.

Movements of adult female Dungeness crabs, (*Cancer magister*) in northern California based on tag recoveries.

AUTHOR(S): Diamond, N., and D. G. Hankin.  
YEAR: 1985.  
SOURCE: Jour. Fish. Aquat. Sci. Canada 42(5):919-926.  
KEYWORDS: Migration, market crab, *Cancer magister*, population trends.  
ABSTRACT: Tag recovery data for adult female Dungeness crabs (*Cancer magister*) in northern California were analyzed to evaluate the possibilities of directed movements during winter or spring periods. It was found that 46% of all recovered crabs were recaptured within 2 km of the original release sites with 22% of these having been at large for more than 1 year. The other 59% had moved up to 5 km from the original release locations. There was no significant correlation between distance traveled and number of days at large before recovery (i.e. they did not disperse from the release area(s) in a random fashion.) Based on the application of 2 nonparametric tests for randomness, it was statistically demonstrated that there was no directed movement of female Dungeness crabs during winter. During the spring, fishing effort was distributed in a nonrandom fashion and violated the assumptions for valid application of statistical tests. However, 82% of the crabs were recovered well inshore of original release sites and this is consistent with the hypothesis of spring inshore migration of females for molting, mating, and later extrusion of egg masses. Both winter and spring recoveries showed no significance between crab size and the distance of movement. However, the average distance of travel was greater in the spring than in winter. It was concluded that adult female Dungeness crabs appear to constitute extremely localized stocks in northern California.

Food abundance and territory size in juvenile coho salmon (*Oncorhynchus kisutch*).

AUTHOR(S): Dill, L. M., R. C. Ydenberg, and A. H. G. Fraser.  
YEAR: 1981.

SOURCE: Jour. Zool. Canada 59(9):1801-1809.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, feeding, habitat, early life history, distribution.

ABSTRACT: A study of the territory size of juvenile coho salmon and potential food abundance was carried out in the field in order to test the prediction that the two factors would vary inversely. The results indicated that territory size became significantly smaller with increasing abundance of benthic food, but not with drift food which the authors had previously believed to be more important. Territories became smaller under the impact of higher intrusion rates, however, this did not correlate with higher food abundances. Therefore, the impact of food abundance on territory size was not due to greater intrusion. Laboratory experiments determined that the attack distance of a juvenile coho increased asymptotically with increasing hunger. Hunger may be the mechanism by which territory size is controlled.

Fishing offshore platforms: Central Gulf of Mexico.

AUTHOR(S): Ditton, R. B., and J. Auyong.

YEAR: 1984.

SOURCE: Gulf of Mexico Regional Office, Minerals Management Service, U. S.

Dep. Interior, Meltairie, LA. OCS Monograph, MMS 84-00006. 158 p.

KEYWORDS: Platforms, artificial reef, fishing gear, fishery, economics.

ABSTRACT: This text reports the findings of a study conducted to determine the

public use directly associated with offshore petroleum structures off the Louisiana coast. The one-year study began in 1980 and focused on environmental investigation on fishing as well as fish and marine animals affected by energy development. Data collection was done by oil and gas company personnel who recorded daily fishing activity around the platforms. An estimated 72,000 daily and/or monthly records were obtained and evaluated. Methods used, findings, and future research directions are also discussed.

Minimum swimming speed of albacore, *Thunnus alalunga*.

AUTHOR(S): Dotson, R. C.

YEAR: 1976.

SOURCE: Fish. Bull. 74(4):955-960.

KEYWORDS: Migration, growth, length, albacore, *Thunnus alalunga*.

ABSTRACT: Albacore tuna, *Thunnus alalunga*, being negatively buoyant in seawater, must swim continuously to maintain position in the water column. This investigation 1) estimated the minimum swimming speed of albacore; 2) compared the minimum swimming speed of albacore with those for other scombrids; and 3) compared calculated minimum swimming speeds of albacore with swimming speeds estimated from sonic tracking of albacore at sea and from long distance tag returns. Minimum swimming speed is defined as the speed necessary for the maintenance of hydrostatic equilibrium. The minimum swimming speed of albacore decreases from 57 cm/s when lengths are 50 cm FL to 45 cm/s at 80 cm FL. The decrease is a direct result of the allometric growth of the pectoral fins and the gas bladder. A large and fully developed gas bladder reduces the density of the fish. The gas bladder of albacore does not have significant development when the fish is less than 55 cm FL, but has considerable volume at a length of 65 cm FL, and is completely developed at 80 cm FL. Gas bladder

development combined with the increasing length of the pectoral fins, results in a relatively abrupt drop in minimum speed between 60 and 70 cm FL. Albacore minimum speeds were slower than those for skipjack tuna, *Katsuwonus pelamis*, similar to those of yellowfin tuna, *Thunnus albacores*, and greater than those of bigeye tuna, *Thunnus obesus*. Mean speeds observed during sonic tracking of three albacore near 85 cm FL were 95 cm/s during daylight hours and 2 cm/s during the night. Each of two tagged albacore approximately 80 cm FL, which were caught after a trans-Pacific migration, had a computed minimum speed of 55 cm/s. These speeds are higher than the estimated minimum speed of albacore of these sizes.

Starfish predation and the creation of mosaic patterns in a kelp dominated community.

AUTHOR(S): Duggins, D. O.

YEAR: 1983.

SOURCE: Ecology 64(6):1610-1619.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., community, mortality, feeding, habitat, distribution.

ABSTRACT: In the shallow subtidal communities considered in this paper, algal pattern is characterized by discrete patch types. High urchin density produces and maintains patches of barren substratum, while areas free from urchin grazing are rapidly colonized by fast growing, highly productive kelp. In this study four factors potentially causing the aggregated pattern of urchins (physical factors, food availability, interspecific competition, and starfish predation) are addressed. The results indicate that predation by the seastar *Pycropodia helianthoides* can significantly affect subtidal algal assemblages in this important marine community.

Echinoidea: The sea urchins.

AUTHOR(S): Durham, J. W., C. D. Wagner, and D. P. Abbott.

YEAR: 1980.

SOURCE: Pages 160-176 in R. H. Morris, D. P. Abbott, and E. C. Haderlie (eds.), *Intertidal invertebrates of California*, Stanford Univ. Press, Stanford, CA.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., life history, physiology, reproduction, growth, feeding, mortality, habitat, reproduction, fishery, economics, distribution.

ABSTRACT: This section of *Intertidal Invertebrates of California* includes all

of the species of echinoids that occur in the littoral zone as well as those residing in shallow water. The biology of each animal is discussed as well as its distinctive characteristics, range, habitat, interactions with other species, economic importance and current research.

Day versus night activity of reef fishes in a kelp forest off Santa Barbara, California.

AUTHOR(S): Ebeling, A. W., and R. N. Bray.

YEAR: 1976.

SOURCE: Fish. Bull., U. S. 74(4):703-717.

KEYWORDS: *Sebastes* spp., rockfish, *Paralabrax clathratus*, kelp bass, community, habitat, feeding, behavior.

ABSTRACT: This paper reports the results of a year-long study comparing the

day and night vertical distributions and feeding activities of residential kelp-bed fishes in an area of reef and kelp off Santa Barbara, California. Tables listing the species observed and their vertical zone locations during both day and night, the percent of individuals by season and day/night variation in abundance are provided. Results of the study indicate that night feeding on plankton decreases and most of the foraging by fishes takes place over the bottom; however, kelp fishes appear to show considerable intraspecific variation in vertical distribution and feeding activity.

Severe storm disturbances and reversal of community structure in a southern California kelp forest.

AUTHOR(S): Ebeling, A. W., D. R. Laur, and R. J. Rowley.

YEAR: 1985.

SOURCE: Mar. Biol. 84:287-294.

KEYWORDS: Urchin, *Strongylocentrotus* spp., community, feeding, habitat.

ABSTRACT: The effects of two severe storms, 3 years apart, were analyzed for their different effects on kelp bed community structure. The effects were determined by monitoring four components of the detrital food chain: kelps (both upper and understory species), grazing sea urchins, epibenthic fishes, and algal turf which houses many small invertebrates the epibenthic fishes feed on. The results of the first storm caused urchins to overgraze the kelp forest creating a barren area. The second storm eliminated the urchins and cleared the rock surfaces thus allowing a new kelp forest to mature and form extensive canopies. The results of this study show that severe storms may have different effects on community structure, depending on the state of the community before the disturbance.

Habitat groups and island-mainland distribution of kelp-bed fishes off Santa Barbara, California.

AUTHOR(S): Ebeling, A. W., R. J. Larson, and W. S. Alevizon.

YEAR: 1980.

SOURCE: Pages 403-431 in D. M. Power (ed.), *The California islands: Proceedings of a multidisciplinary symposium*. Santa Barbara Mus. Natur. His., Santa Barbara, CA.

KEYWORDS: Behavior, habitat, distribution, community, kelp bass, *Paralabrax*

*clathratus*, lingcod, *Ophiodon elongatus*, rockfish, *Sebastes* spp.

ABSTRACT: The purpose of this paper is to present the results of a study conducted off Santa Barbara, California at the southern end of a transition zone between a warm-temperate biota to the southeast and a cool-temperate biota at San Miguel Island and north of Point Conception. The objective is to show how assemblages of kelp bed fishes may be classified into particular habitat groups and how structural differences in habitat affects the composition of these assemblages. Sampling was done using underwater movie strips and factor analysis of this data revealed that species were loosely organized into five habitat groups. These groups and their specific characteristics are discussed in the text in detail. Interlocality comparisons, differences and cluster analysis is also presented.

Annual variability of reef-fish assemblages in kelp forests



off Santa Barbara, California.  
AUTHOR(S): Ebeling, A. W., R. J. Larson, W. S. Alevizon, and R. N. Bray.  
YEAR: 1980.  
SOURCE: Fish. Bull. 78(2):361-377.  
KEYWORDS: Paralabrax clathratus, kelp bass, population trends, habitat, distribution.  
ABSTRACT: Depth stratified cinetransects were used to census fishes in various giant kelp (*Macrocystis pyrifera*) forests along the mainland and at Santa Cruz Island in order to assess the annual variability of species composition, diversity, and abundance of fishes associated with kelp forests off Santa Barbara, California. Species assemblages differed markedly between island and mainland sites and between kelp canopy versus bottom samples. Variation in species composition varied less among years than between sites. However, the net annual change of species arrays differed significantly within sites ( $P$  equal to or less than 0.01) but not between sites ( $P$  equal to or more than 0.05), indicating that species abundances varied concordantly at the island and mainland sites. The kelp canopy associated assemblage was more variable from year to year than the bottom habitat assemblage (density, number of species, and species composition). Yearly differences were loosely related to underwater visibility, water temperature, and perhaps, to kelp density in the canopy. At both the island and mainland study sites, *P. clathratus* constituted a larger proportion of the bottom habitat assemblage than the kelp canopy assemblage.

Commercial abalone fisheries of the Pacific Coast of North America.

AUTHOR(S): Ebert, E. E.  
YEAR: 1970.  
SOURCE: Pages 885-889 in Proc. Symposium on Mollusca, Part III.  
KEYWORDS: Abalone, *Haliotis* sp., fishery.  
ABSTRACT: Seven species of abalone, *Haliotis*, occur along the California coast. The red, *H. rufescens* (landed primarily at Morro Bay and Santa Barbara) and pink, *H. corrugata* (landed in Santa Barbara and San Pedro) make up 95% of the commercial fishery. The abalone season extends from March 16 through January 14. The fishery has switched from hardhat dominated gear to light surface free equipment. The landings have stabilized from 4.5 million lbs. ranking 13th to 16th in poundage of California commercial fisheries (dollar values ranked 8th to 12th).

Laboratory cultivation of the Dungeness crab, *Cancer magister*.  
AUTHOR(S): Ebert, E. E., A. W. Hazeltine, J. L. Houk, and R. O. Kelly.  
YEAR: 1983.  
SOURCE: Pages 259-309 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource. Calif. Dep. Fish Game, Fish Bull. 172.  
KEYWORDS: Dungeness crab, (market crab), *Cancer magister*, feeding, mortality.  
ABSTRACT: This paper describes the culture studies conducted with each life stage of the Dungeness crab and covers a period of nine years. The cultivation and observation of the Dungeness crab was initiated primarily to investigate their decline. Methods for collecting and

transporting, holding and feeding as well as results from observations of egg mass, mating, spawning and hatching are reported in detail for each life stage.

Elements and innovations in the cultivation of red abalone,  
*Haliotis rufescens*.

AUTHOR(S): Ebert, E. E., and J. L. Houk.

YEAR: 1984.

SOURCE: *Aquaculture* 39(1-4):375-392.

KEYWORDS: Abalone, *Haliotis* sp., feeding.

ABSTRACT: The methods and equipment used in the cultivation of red abalone, *Haliotis rufescens* were described. Broodstocks, of known ancestry, were maintained and spawnable abalones were available year around. Spawning was accomplished with uv irradiated seawater. Larvae were cultured in a flow-through system that yielded 90% larvae at the settlement stage. Larvae were settled on a diatom slurry and at 5-10 mm were weaned over to kelp (*Macrocystis*). Juveniles, which fed exclusively on kelp, were moved to grow-out tanks where growth rates averaged 2 mm/month for 12-36 mm individuals and slowed to 1 mm/month for 5-8 cm abalone. Potential problems, particularly with bacterial infection (*Vibrio*) were discussed.

Ova fertility relative to temperature and to the time of gamete mixing in the red abalone, *Haliotis rufescens*.

AUTHOR(S): Ebert, E. E., and R. M. Hamilton.

YEAR: 1983.

SOURCE: *Calif. Fish Game* 69(2):115-120.

KEYWORDS: Abalone, *Haliotis* spp., reproduction.

ABSTRACT: Red abalone, *Haliotis rufescens*, ova fertilization success was observed over five temperatures and following gamete mixing delays. The range of temperatures included 9, 12, 15, 18 and 21 deg C. Gamete mixing delays of up to 8 hrs were also tested. Fertilization success was poor at extreme temperatures 9 and 21 deg C) even at short gamete mixing delays. The fertilization rate was inversely proportional to the gamete mixing time delay period. Sperm lost its viability before the ova. Optimal fertilization rate occurred at 15 deg C.

Growth rates of the sea urchin, *Strongylocentrotus purpuratus*, related to food availability and spine abrasion.

AUTHOR(S): Ebert, T. A.

YEAR: 1968.

SOURCE: *Ecology* 49(6):1075-1091.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., growth, feeding.

ABSTRACT: The growth rate of a population of purple sea urchins, *Strongylocentrotus purpuratus*, at Sunset Bay, Oregon was studied. Three subpopulations: a *Postelsia* zone, eelgrass zone, and boulder field were studied and size frequencies were found to differ. In addition, the amount of calcite deposition to the test and spines was significantly different. Environmental factors studied which might affect growth rates included weather and food availability. The amount of food eaten in a 24-hr period was estimated at 0.05 g(dry wt) of algae. During the winter months, ingestion decreased dramatically and results indicate shortage of food limited growth rates. An additional factor, "weathering", which led to breaking spines also limited growth due to energy

expenditure in test repair. The results of this experiment showed the importance of food in winter growth rates and suggested that several other complex factors can act on urchin growth.

Growth and repair of spines in the sea urchin,  
*Strongylocentrotus purpuratus* (Stimpson).

AUTHOR(S): Ebert, T. A.

YEAR: 1967.

SOURCE: Biol. Bull. 133(1):141-149.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., age, growth.

ABSTRACT: The purpose of this study was to determine if spines could be used as a means of aging the sea urchin, *Strongylocentrotus purpuratus*. A strong positive correlation was found between urchin diameter and the number of rings in the spines. The morphology of calcite crystals and echinochrome pigment in the spines is described in detail. In order to determine whether the production of echinochrome was due to light or injury, 2 one gallon glass jars were filled each with 8 urchins; four green and four purple. Spine tips on two green and two purple animals of each group were clipped. One jar was exposed to light while the other was excluded from light with aluminum foil. Under dark conditions, regenerating spine tips were white to greenish in both green and purple urchins. Under light conditions, regenerating spine tips were purples in both green and purple urchins. It was concluded that light is important in echinochrome synthesis or transport and that sharp lines of color in young urchins and new rings in juveniles is a result of regeneration. Although larger animals have more rings, the number of rings in sea urchin spines is not directly related to age, but is a result of regeneration.

An experimental analysis of sea urchin dynamics and community interactions on a rock jetty.

AUTHOR(S): Ebert, T. A.

YEAR: 1977.

SOURCE: Jour. Exp. Mar. Biol. Ecol. 27:1-22.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., growth.

ABSTRACT: Density dependent effects of the purple urchin, *Strongylocentrotus purpuratus*, and the red urchin, *Strongylocentrotus franciscanus*, were examined in Mission Bay, San Diego. Twenty-one experimental plots (each 15 m<sup>2</sup>) were tested with densities of 0, 100, 1000, and 10,000 gms (wet weight) of urchins per meter squared. These treatments were tested monospecifically and with an equal biomass of both species. The results suggested that intraspecific competition was more intense than interspecific competition. Algal biomass in the region was examined and an equation was developed in relation to urchin densities. Total barrenness of algae biomass would require 42 purple urchins or 41 red urchins per meter squared (values much higher than those reported in the literature). Growth rates were density dependent, however the von Bertalanffy parameter K was never higher than previously reported at 0.61 and 0.72 for purple and red urchins, respectively. The densities of sessile invertebrates were also found to be correlated to urchin biomass.

Negative growth and longevity in the purple sea urchin,  
*Strongylocentrotus purpuratus*. (Stimpson)

AUTHOR(S): Ebert, T. A.

YEAR: 1967.

SOURCE: Science 157:557-558.

KEYWORDS: Sea urchin, Strongylocentrotus sp., growth.

ABSTRACT: The growth of purple sea urchins, *Strongylocentrotus purpuratus*, was monitored for 1 year in tidepools at Sunset Bay, Oregon. The urchins were measured (test diameters ranged from 3 to 7 cm) and tagged. The growth of wild stock was observed for 3 years and compared to the marked urchins. After the first year, many urchins had decreased in size, probably due to calcite resorption. Test sizes of 3.02, 3.66 and 4.95 cm, for 2, 3 and 10 year olds, respectively, were estimated from the growth equation derived from the regression of the data. These values compared favorably with the wild stock growth rates. The results suggest test size is an unreliable method of estimating age since urchins may grow in spurts related to favorable environmental conditions. Urchins probably live as long as 10 years.

Preliminary report on the Alaska sablefish fishery.

AUTHOR(S): Edson, Q. A.

YEAR: 1954.

SOURCE: Pac. Mar. Fish. Comm. Bull. 3:73-86.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, fishery, fishing gear, age, length/weight, population trends, reproduction.

ABSTRACT: An overview of the current status of research related to the sablefish fishery. The topics covered include the fishing areas, fishing methods, tagging program, size and age composition, sex ratio and maturity, relative abundance, and current status of the fishery. Alaska sablefish are fished in nearly all of the deep water areas from Dixon Entrance to Kodiak Island. Information from length frequencies supports the assumption that Alaskan sablefish can be separated into separate stocks. From the early years of the sable fish fishery to 1947 there has been a gradual decline in average fish size and catch per unit effort. After 1947, the intensity of the fishing lessened and the catch on the longer fished grounds has ceased its decline.

Thermal behavioral responses of selected California littoral fishes.

AUTHOR(S): Ehrlich, K. F., J. H. Hood, S. Muszynski, and G. E. McGowen.

YEAR: 1979.

SOURCE: Fish. Bull. 76(4):837-848.

KEYWORDS: California halibut, *Paralichthys californicus*, groundfish, behavior.

ABSTRACT: The purpose of this study was to determine the behavioral responses of 16 species of temperate marine fishes from southern California when placed in a horizontal temperature gradient. The temperature gradient differential between the hot and cold extremes was at least 10 deg C. The isotherm position was shifted so as to differentiate between positional and thermal preference within the experimental temperature gradient. The precision with which a group of fish followed an isotherm varied between species and was related to the size of their preferred temperature range. Preferred temperature gradients are given for 15 other littoral fishes. Fish reached their final preferred temperature within several hours after the establishment of the gradient. California halibut, *Paralichthys californicus*, responded slowly to their

preferred temperature of 22 deg C. suggestions for standardizing the experimental design of these types of studies are included.

Some biological observations of billfishes taken in the eastern Pacific ocean, 1967-1970.

AUTHOR(S): Eldredge, M. B., and P. Wares.

YEAR: 1974.

SOURCE: Page 89-101 in Proc. International Billfish Symp., 9-12 August 1972, Kailua-Kolna, Hawaii, Review and contributed papers. NOAA Tech. Rep. NMFS SSRF 675.

KEYWORDS: Feeding, reproduction, spawning, seasonality, swordfish, *Xiphias gladius*.

ABSTRACT: This paper provided biological data on the reproduction, parasites, seasonality, and feeding habits of striped marlin (*Tetrapturus audax*) and sailfish (*Istiophorus platypterus*) taken between Mazatlan, Mexico and San Diego, California. Blue marlin (*Makaira nigricans*) and black marlin (*Makaira indica*) were also sampled but not in sufficient numbers to draw significant conclusions. Seasonal fluctuations appear both in the northern and southern end of the area sampled, with the greater seasonal restrictions being in the north. Off San Diego no fish are caught before July 1, or after December 1. Length at first maturity for striped marlin was 155 and 165 cm, and 160 and 165 cm for sailfish. No indication of multiple spawning was seen in the ovaries. Striped marlin seem to migrate away from the coast during July and August to spawn. Sailfish seem to mature in June and July, and remain closer to shore to spawn. Numbers of *Philichthys xiphae* were found to infect the opercular bone of striped marlin. Caligoid copepods, capsalid trematodes, and isopods were common on the body surface of many billfish. Another trematode was found in the nasal cavities. Nematodes were present in most of the stomachs examined. The feeding habits analysis indicated that anchovies were not as important as previously believed in the diet of striped marlin, while squid was also found to be unexpectedly unimportant in the diet of sailfish.

Food of juvenile chinook, *Oncorhynchus tshawytscha*, and coho, *O. kisutch*, salmon off the northern Oregon and southern Washington coasts, May-September 1980.

AUTHOR(S): Emmett, R. L., D. R. Miller, and T. H. Blahm.

YEAR: 1986.

SOURCE: Calif. Fish Game 72(1):38-46.

KEYWORDS: Feeding, abundance, chinook salmon, coho salmon, *Oncorhynchus tshawytscha*, *Oncorhynchus kisutch*, northern anchovy, *Engraulis mordax*.

ABSTRACT: A description of the food of juvenile chinook, *Oncorhynchus tshawytscha*, and coho, *O. kisutch*, salmon captured in the coastal waters off northern Oregon and southern Washington during the spring and summer of 1980. For chinook salmon, fishes were the most important prey with crab larvae secondary. During late summer, hyperiid amphipods replaced fishes as primary prey. For coho salmon, fishes were the primary prey with crab larvae, calanoid copepods, the gammarid amphipod *Atylus triclens*, the euphausiid *Thysanoessa spinifera*, and other invertebrates being secondary. During late summer, hyperiid amphipods were primary prey for coho salmon, and the pelagic gastropod *Limacina* sp. secondary. Prey fishes for both species of salmon included the

sand lance, *Ammodytes hexapterus*, rockfish, *Sebastes* spp., unidentified *Osmeridae*, northern anchovy, *Engraulis mordax*, and Pacific herring, *Clupea harengus pallasii*. Juvenile chinook and coho salmon showed a large degree of diet overlap for all three sampling periods. During spring and summer chinook and coho salmon utilized similar fish species as primary prey. During late summer chinook salmon consumed proportionally more fish than did coho salmon, which ate more *Limacina* sp. The intensity of feeding in juvenile chinook and coho salmon changed between sampling periods. The lowest percentage of empty stomachs for both species occurred during late summer, while the highest occurred in summer. The food of juvenile chinook and coho salmon changed from spring to late summer off the northern Oregon and southern Washington coasts, which is probably directly related to changes in prey availability and abundance.

Bio-shield: An antifouling system for offshore platforms that works!

AUTHOR(S): Engle, R. F., and J. P. Ray.

YEAR: 1985.

SOURCE: Engel, R. F. and J. P. Ray. 1985. Bio-shield: an anti-fouling system

for offshore platforms that works! Ocean Engineering and the environment conference record November 12-14, 1985. Sponsored by Marine Technology Society and IEEE Ocean Engineering Society. Volume 1, Pages 62-70.

KEYWORDS: Platform, colonization.

ABSTRACT: Testing of an anti-fouling system (Bio-Shield) for offshore oil platforms is described. The system consists of an anti-fouling copper/nickel sheathing. The system was placed on an existing offshore Huntington Beach platform to evaluate its effectiveness, along with lab and field installation tests. The results of field tests show that after more than ten months of exposure on sixty drilling well conductors, the protected sections were still free of any biofouling growth. The Bio-Shield appears to inhibit biofouling growth on offshore platforms while also providing corrosion protection in the splash zone.

Comment on some frequencies of underwater noise produced by fishing boats affecting albacore catch - reply.

AUTHOR(S): Erickson, G. J.

YEAR: 1980.

SOURCE: Jour. Acoust. Soc. Am. 67(3):1065.

KEYWORDS: Fishery, albacore, *Thunnus alalunga*.

ABSTRACT: Frequencies of underwater noise produced by boats participating in the West Coast albacore (*Thunnus alalunga*) fishery are discussed as to their effect in catch-related success. The low frequencies (less than 1000 Hz) were carefully examined. No significant differences in the long-term power spectra of the two classes of boats were observed. The single anomaly was very carefully examined. There were no significant differences between its spectrum and the spectra of the other type-1 boats. If it were the low frequencies which attract the albacore, then they would be attracted to both classes of boats because the spectra are similar except for the peak around 1500 Hz. The relative intensity did not vary much from boat to boat. There are differences in the temporal structure of the two

classes of boats and they are noted as a possible cause of the correlations.

Some frequencies of underwater noise produced by fishing boats affecting albacore catch.

AUTHOR(S): Erickson, G. J.

YEAR: 1979.

SOURCE: Jour. Acoust. Soc. America 66(1):296-299.

KEYWORDS: Fishery, albacore, Thunnus alalunga.

ABSTRACT: The underwater sounds produced by boats engaged in the West Coast albacore fishery were measured and compared to their catch rate of albacore, Thunnus alalunga. Estimations of the relative intensities of the noise produced by the boats were made. Intensity did not vary greatly from boat to boat and was not found to be correlated with catch rate. Peak intensity was approximately 90 dB re 1 micron Pa at one yard. The underwater acoustic output was analyzed from a few Hz to 5000 Hz. Most of the spectra had large low frequency components and low intensities above 1500 Hz. These were defined as type-1 spectra. Spectra with peaks of higher intensities above 1500 Hz were called type-2 spectra. Correlations between spectra and catch rate found that boats with type-2 spectra had below average catch rates. Lower frequencies were carefully examined to see if there was any significant difference between the lower (below 1500 Hz) frequencies on the low catch rate boats and the rest of the group. No significant differences were found in this region of the spectrum. It was concluded that the important difference was the peak of intensity above 1500 Hz. Boats with above average catch rates had no spectral peaks above 1500 Hz; and those with below average catch rates had spectral peaks above 1500 Hz. Since this was a correlational study, it was not possible to determine whether it is simply the long term power spectrum or the temporal structure of the sound which affects the catch rate.

A field guide to Pacific Coast Fishes of North America.

AUTHOR(S): Eschmeyer, W. N., E. S. Herald, and H. Hammann.

YEAR: 1983.

SOURCE: Houghton Mifflin Co., Boston. 336 pp.

KEYWORDS: All species, distribution, habitat, length/weight, feeding, growth.

ABSTRACT: A general guide to the various fish species occurring from the Gulf of Alaska to Baja California. The book is organized into three basic groups - jawless fishes; sharks, rays and chimaeras; and bony fishes. Information is given on the families as well as the individual species. The individual species are described in terms of identifying characteristics, range, and similar species. The species descriptions are accompanied by individual drawings which point out identifying characteristics.

Federal offshore statistics - leasing exploration production revenue.

AUTHOR(S): Essertier, E. P.

YEAR: 1984.

SOURCE: Minerals Management Service Rep. 84-0071.

KEYWORDS: Platform, economics.

ABSTRACT: An account of statistics relating to the Federal portion of the Continental Shelf leased for oil and gas development. The

statistics are meant to be helpful to anyone involved in trends in offshore activity or in predicting future developments; in other words, the trends they reflect as compared to their exact value. Along with the statistical information is a thorough glossary which defines terms used frequently in the oil-and-gas industry.

Sea otter predation and community organization in the western Aleutian Islands, Alaska.

AUTHOR(S): Estes, J. A., N. S. Smith, and J. F. Palmisano.

YEAR: 1978.

SOURCE: Ecology 59(4):822-833.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., distribution, population trends.

ABSTRACT: Islands with and without sea otters (*Enhydra lutris*) are compared to determine if the otters control epibenthic invertebrate populations, mainly sea urchins (*Strongylocentrotus polyacanthus*), and in turn release vegetation from intense grazing. At Amchitka Island sublittoral macroalgae covers the solid rock substratum from the sublittoral fringe to a depth beyond 25 m, while at Attu and Shemya Islands sublittoral macroalgae were essentially absent. Sea urchin abundance increased with depth at Amchitka and decreased with depth at Attu and Shemya. Sea otter populations at Amchitka and Attu-Shemya are at equilibrium and absent, respectively. Sea otter predation seems to be largely responsible for the differences in epibenthic invertebrate associations between islands. They are principal determinants to the structure and abundance of urchin populations. Urchin populations at Attu and Shemya are limited by competition. At Amchitka, urchins are held to a density and size below that which can have a destructive impact on their food. The macroalgal association at Amchitka is dominated by competitive interactions due to the absence of herbivores. The roles of competition and predation are reversed when the sea otter is removed from the system. Macroalgae are limited by predation and the epibenthic invertebrates by competition. Primary production may be greatly reduced in communities lacking macroalgae. The indirect role played by sea otters in maintaining the macroalgal association is of major importance. Communities without sea otters should be depauperate of higher trophic forms. If macroalgae are the limiting resource to faunal elements, then otters may locally and indirectly elevate the carrying capacities of those species.

Pattern in the development of a marine community.

AUTHOR(S): Fager, E. W.

YEAR: 1971.

SOURCE: Limnol. Oceanog. 16(2):241-253.

KEYWORDS: Community, artificial reef, recruitment, feeding, behavior.

ABSTRACT: This paper reports the results of an experiment to determine marine

community development on artificial substrate (cubes) placed at depths of 12-14 m located off La Jolla, California. The cubes were monitored by divers over an appropriate two-year period in an attempt to understand the contribution of five kinds of patterns in marine community development: vectorial, reproductive, social, coactive and stochastic. A list of species found on or around the



cubes is provided as well as a discussion on the large algae, large invertebrates and fishes that frequented the cubes.

An analysis of fish catches obtained with an otter trawl in Santa Monica Bay, 1969-73.

AUTHOR(S): Fay, R. C., J. A. Vallee, and P. Brophy.

YEAR: 1978.

SOURCE: Calif. Fish Game, 64(2):104-116.

KEYWORDS: All species, distribution.

ABSTRACT: This report presents the results of a four-year benthic biota study

conducted in Santa Monica Bay, California. Five hundred ninety-six otter trawl hauls were made from depths ranging from 5 to 198 m. One hundred and nine species were identified, representing three distinctly different assemblages of fishes. A list of the species trawled and their depths is provided as well as trellis diagrams comparing fish catches taken in the four study areas. A test of the otter trawl as a sampling device was also undertaken with the author's conclusions presented.

Gastropod defensive responses and their effectiveness in reducing predation by starfishes.

AUTHOR(S): Feder, H. M.

YEAR: 1963.

SOURCE: Ecology 44:505-512.

KEYWORDS: Abalone, Haliotis spp., behavior.

ABSTRACT: The escape responses of several species of gastropods, including turban (Tegula spp.), limpets (Acmae spp.), abalones (Haliotis spp.), periwinkles (Littorina spp.), and whelks (Acanthina spp.) were studied in a Monterey tidepool. All but the whelks showed significant responses to the seastars utilized (Pisaster ochraceus, P. giganteus and Pycnopodia helianthoides). The active agent of contact appeared to be the epithelial covering of the water vascular system. The gastropods could become desensitized by continual contact or presence of a predatory star. The species studied were not consumed in proportion to their abundance, indicating the escape response was protective to these forms. Abalones were probably only contacted following detachment from the substrate.

Asteroidea: The sea stars.

AUTHOR(S): Feder, H. M.

YEAR: 1980.

SOURCE: Pages 117-135 in R. H. Morris, D. P. Abbott, and E. C. Haderlie (eds.), Intertidal invertebrates of California, Stanford Univ. Press, Stanford, CA.

KEYWORDS: Sea urchin, Strongylocentrotus spp., mortality.

ABSTRACT: This section of Intertidal Invertebrates of California discusses the

sea stars. The biology of each animal is described as well as its distinctive characteristics, feeding habits, habitat and distribution.

Observations on fishes associated with kelp beds in southern California.

AUTHOR(S): Feder, H. M., C. H. Turner, and C. Limbaugh.

YEAR: 1974.

SOURCE: Calif. Dept. Fish Game, Fish. Bull. 160.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., abalone, *Haliotis*, platform, northern anchovy, kelp bass, yellowtail, jack mackerel, chub mackerel, Pacific bonito, white seabass, *Engraulis mordax*, *Paralabrax clathratus*, *Seriola lalandei*, *Trachurus symmetricus*, *Scomber japonicus*, *Sarda chiliensis*, *Atractoscion nobilis*, community, habitat, life history, distribution.

ABSTRACT: A description of the fishes inhabiting the kelp forests off southern California. The kelp beds were discussed in terms of vertical habitat zones: kelp canopy, mid-kelp, and kelp bed bottom (sandy vs. rocky bottom). The bottom zone was found to be the most complex of the 3 major kelp bed environments, with the irregular rocky bottom habitat containing the richest quality and quantity of organisms. Ninety-seven of the most common fish species were described in terms of their key identification features, distribution, size, habitat, behavior, and life history.

The precision of simulated transect surveys of northern anchovy, *Engraulis mordax*, school groups.

AUTHOR(S): Fiedler, P. C.

YEAR: 1978.

SOURCE: Fish. Bull. 76(3):679-685.

KEYWORDS: Northern anchovy, *Engraulis mordax*, population trends, distribution.

ABSTRACT: Northern anchovy (*Engraulis mordax*) populations are patchy on two levels: schools composed of aggregated individuals and school groups composed of aggregated schools themselves. Systematic, random, and stratified systematic survey designs were compared through simulations of model anchovy populations. The effect of patchiness on the precision of population estimates was determined. A consistently lower coefficient of variation or greater precision was observed with systematic sampling compared to random sampling. There was no significant difference between the coefficients of variation of the systematic and stratified systematic surveys. For large sample sizes, unstratified systematic surveys were more precise than stratified systematic surveys, while for smaller sample sizes there was no difference between the two. Stratified systematic surveys were also more precise for highly non-random populations, and no difference was found when populations were of intermediate or low non-randomness. Systematic sampling may result in considerable gains or losses in precision compared with simple random sampling. There were significant interaction effects involving survey design, and the advantage of stratifying the survey will depend on the number of transects and the spatial distribution of the population. These simulations have quantified the sampling error due to the second level of patchiness only. The sampling error due to patchiness can be reduced by properly designing a survey, but never eliminated.

Some effects of El Nino 1983 on the northern anchovy.

AUTHOR(S): Fiedler, P. C.

YEAR: 1984.

SOURCE: CalCOFI Rep. 25:53-58.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, early life

history, growth.

ABSTRACT: This paper analyzed historical records on northern anchovy (*Engraulis mordax*) population growth. The author discussed the consequences of the 1983 El Nino on the anchovy central subpopulation between Point Conception, California, and Baja California. The 1983 anchovy spawning season was unusual in several aspects. The spawners were relatively young and small and spawned over an extended range, with the eggs maturing rapidly. The production of eggs was not unusual and no effect could be detected on the size of the 1983 year class by the end of the year. Juveniles and adults both appeared to be abnormally small in 1983. The El Nino of 1983 seemed to be unfavorable for the growth of larvae, juveniles, and adults, possibly because of reduced food availability.

Satellite remote sensing of the habitat of spawning anchovy in the Southern California Bight.

AUTHOR(S): Fiedler, P. C.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:202-209.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, reproduction.

ABSTRACT: Sensors carried on earth-orbiting satellites are used to provide high-resolution images of sea surface temperature and phytoplankton concentration. These were used to define boundaries that help explain spatial patterns of spawning activity of northern anchovy, *Engraulis mordax*, in the Southern California Bight. Research vessel surveys showed little or no spawning at temperatures less than 13.5 deg C. Spawning of this wetfish occurred most frequently at 14.5 to 17.0 deg C. When temperatures decreased to 14.4 deg C spawning was reduced significantly. In 1982 the modal spawning temperature was about 0.5 deg C colder than in 1980 and 81, but the frequency within that range was generally lower. Satellite images defined boundaries of spatial distributions nearly completely. The northern extent in the Bight and offshore extent north of Santa Catalina Island are limited by cold upwelled water advected south of Point Conception. The southern most range on the other hand is limited by low phytoplankton pigment levels, in waters 20 to 100 km offshore. These two factors alone however probably do not determine the distribution of spawning activity. The advantages of using satellite data in fisheries science is also discussed.

The structure, development, food relations, reproduction and life history of the squid *Loligo opalescens* (Berry).

AUTHOR(S): Fields, W. G.

YEAR: 1965.

SOURCE: Fish. Bull. 131:1-108.

KEYWORDS: Market squid, *Loligo opalescens*, distribution, habitat, feeding, reproduction, fishery.

ABSTRACT: The taxonomy, distribution, habitat, feeding, anatomy, reproduction and fishery of the market squid, *Loligo opalescens*, was considered. The squid ranged from Puget Sound, Washington to San Diego, California. The squid fed primarily at night on fish, crustaceans (primarily euphausiids and mysids), squid and polychaetes. Several spawning areas were recognized including Cadbara Bay, Vancouver Island, southern Monterey Bay and Santa Catalina Island. In Monterey Bay eggs are present year around,

however the spawning season is most intense from April to July. Following a copulatory embrace the females laid between 180 to 300 eggs per capsule which were deposited in clusters on the substrate. Growth rates of the squid were approximately 4 mm/month. The populations consisted of a male to female sex ratio of 1:1. The main fishery began in Monterey before 1863 and utilized torches and small purse seines. The present fishery utilizes Lampara nets. The commercial catches in California have varied over the years with peak catches from 1943 to 1959 (20,000 tons were landed in 1945). These increases were correlated to an increased effort.

A preliminary report on the fishery and on the biology of the squid, *Loligo opalescens*.

AUTHOR(S): Fields, W. G.

YEAR: 1950.

SOURCE: Calif. Fish Game 36:366-377.

KEYWORDS: Squid, *Loligo opalescens*, fishery, population, spawning, life history.

ABSTRACT: The history of the squid, *Loligo opalescens*, fishery in California was reviewed. Aspects of the population's biology, including spawning rate, seasons and weight/length relationship to maturity were considered. Catches ranged from about 2000 tons in 1916 to almost 20,000 tons in 1946 with periodic fluctuations. The majority of the catch was composed of schools of spawning individuals from Monterey Bay. Length frequency studies suggest most males ranged between 146-175 mm and most females ranged from 136-165 mm. Maturity was attained by individuals as small as 72 and 81 mm for males and females, respectively. However, immature individuals as large as 110 and 120 mm for males and females, respectively, were found. Spawning schools contained fat, healthy squid with enlarged gonads. Weight losses of up to 50% were noted during the spawning season. No trends in spawning seasonality were noted. However, average monthly catches were found to peak between April to July with a minor peak in November. These results suggest squid spawn between April and July.

Studies in locomotion and anatomy of scombroid fishes.

AUTHOR(S): Fierstine, H. L., and V. Walters.

YEAR: 1968.

SOURCE: Memoirs So. Calif. Acad. Sci 6:1-31.

KEYWORDS: Swordfish, *Xiphias gladius*, physiology.

ABSTRACT: The swimming movements and anatomy of various scombrid fishes are investigated and compared with related fishes. The maximum acceleration for a rapidly swimming yellowfin tuna, (*Thunnus albacores*) and a wahoo (*Acanthocybium solanderi*) was determined to be 43.1 m/sec/sec and 35.9 m/sec/sec, respectively. The swimming pattern of the wavyback skipjack, (*Euthynnus affinis*), was analyzed and discussed. Caudal fin-ray amputations performed on yellowfin tuna indicates that the caudal rays contribute about 90% of the forward thrust in swimming. Aspect ratios of the caudal fins of 15 species of scombroid fishes ranged from 10.26 (*Istiophorus greyi*) to 4.19 (*Xiphias gladius*). Features of the vertebral column and caudal fin that are related to normal swimming movements were described. There is a minimum amount of intervertebral overlap in the regions where the greatest amount of bending occurs during swimming, and various structures are

present to minimize intervertebral movements in other body regions. There are two main regions of movement, a pre-peduncular joint and a post-peduncular joint with the intervening peduncle held rigid. The lateral musculature of scombrid fishes comprises 56% to 68% of the total body weight. This does not differ from other active fishes, however, the elongation of the myomeres and the hyperdevelopment of red muscle and tendons is unique. The bulk of the musculature bypasses the peduncular region and inserts on the caudal fin rays by means of lateral tendons. Data concerning the shape, length, origin, insertion, and action of the myomeres and tendons is given. The classification of the scombrid fishes is re-evaluated based on features that are related to locomotion. It was concluded that there are three separate suborders; the Trichiuroidei, Scombroidei, and Xiphoidei.

Fishes collected in Morro Bay, California between January 1968 and December 1970.

AUTHOR(S): Fierstine, H. L., K. F. Kline, and G. R. Garman.

YEAR: 1973.

SOURCE: Calif. Fish Game 59(1):73-88.

KEYWORDS: Distribution, feeding, seasonality, community.

ABSTRACT: The fish species that live in Morro Bay were identified and their seasonal and geographical distribution within the bay was determined. Approximately 1,600 specimens belonging to 66 species were collected between January 1968 and December 1970. Thirty-seven percent of the specimens belonged to the family Embiotocidae, of which the black perch and shiner perch contributed 22% of the catch. The bay was divided into five ecological collecting zones. The names, number of individuals, lengths and month of occurrence of fishes collected from each zone are listed in table format. Zone I had a sand bottom. Ten species were collected in this zone with one species restricted to it. Zone II had a mud-sand bottom with scattered, small *Macrocystis* beds, and represents an area greatly altered by man. Of the 35 species collected in Zone II, 16 were restricted species. Zone III represented a transitional area between Zones II and IV with both developed and undeveloped shoreline. Thirty-one species were collected in Zone III of *Zostera* beds and a silty-mud bottom. Of the 30 species collected, 7 were restricted species. Sharks and rays were restricted to Zones III and IV probably due to the large expanses of tidelands which were rich in invertebrates and serve as feeding grounds. Zone V is the estuarine area formed from Chorro and Los Osos creeks. It contained 13 species of which 8 were restricted to the area and were euryhaline.

Interactions of marine mammals and Pacific hake.

AUTHOR(S): Fiscus, C. H.

YEAR: 1979.

SOURCE: Mar. Fish. Rev. 41(10):1-9.

KEYWORDS: Pacific hake, *Merluccius productus*, behavior, distribution, life history, feeding, fishery, seasonality.

ABSTRACT: This paper describes the importance of Pacific hake (*Merluccius productus*) to the feeding behavior of marine mammals inhabiting its range. Also discussed are the biology, feeding habits, seasonal distribution, range, life history and commercial fishery of Pacific hake. The data presented comes from sources

other than the author's own original research. Of the 38 known marine mammal species which inhabit the same range as Pacific hake, only nine species are considered hake predators. This was determined by the presence of hake remains in stomachs, or because they have similar feeding habits as known predators. The nine mammals are the: California sea lion (*Zalophus californianus*), northern sea lion (*Fumetopias delphinus delphis*), Pacific whiteside dolphin (*Lagenorhynchus obliquidens*), northern right whale (*Lissodelphis borealis*), whitehead grampus (*Grampus griseus*), shortfin pilot whale (*Globicephala macrorhynchus*), and the Dall porpoise (*Phocoenoides dalli*). Other aspects of these mammal's biology are also examined. Some of the known fish predators of hake are listed at the end of the paper.

Southern sea otter recovery plan.

AUTHOR(S): Fish and Wildlife Service (FWS).

YEAR: 1984.

SOURCE: Unpubl. ms. Fish Wildl. Serv., U. S., Portland, OR. 139 p.

KEYWORDS: Market squid, *Loligo opalescens*, habitat, mortality.

ABSTRACT: This report is an unofficial technical review draft of the updated

southern sea otter recovery plan. The general ecology of the sea otter is discussed as well as problems of oil spills. Protective legislation and conservation strategies. Although this proposal does not necessarily represent the official position of U. S. Fish and Wildlife Service, it has been prepared by them to delineate reasonable actions required to place the sea otter in the best possible position.

Relationships of epibiotic fouling and mortalities of eggs of Dungeness crab (*Cancer magister*).

AUTHOR(S): Fisher, W. S.

YEAR: 1976.

SOURCE: Jour. Fish. Res. Bd. Canada 33(12):2849-2853.

KEYWORDS: Market crab, *Cancer magister*, early life history, reproduction.

ABSTRACT: Fifty-six unburied female crabs, *Cancer magister*, were held in the lab through egg extrusion and cementing. The individuals were placed in tanks containing raw seawater (no treatment), filtered, UV sterilized seawater (no treatment) and filtered, UV sterilized seawater containing nutrients, malachite green light, malachite green dark, dark, or antibodies. Results showed that nutrient enriched seawater increased the degree of fouling by filamentous bacteria and corresponded to increased mortalities. The UV irradiation and dark treatments had no effect on fouling. Malachite green reduced filamentous growth and mortalities. Antibiotics decreased mortalities, however filaments continued to grow. Filamentous fouling and mortalities showed an exponential decline with depth into the egg mass. The results suggested that antibiotic sensitive filamentous bacteria were responsible for mortalities and had their greatest effect at the surface of the egg mass.

Mortalities and epibiotic fouling of eggs from wild populations of Dungeness crab, *Cancer magister*.

AUTHOR(S): Fisher, W. S., and D. E. Wickham.

YEAR: 1976.

SOURCE: Fish. Bull. 74(1):201-207.

KEYWORDS: Cancer magister, market crab, reproduction, mortality.

ABSTRACT: Egg samples (totaling 105) of Cancer magister, were collected from six locations along the northern California coast. The degree of egg development, level of fouling, and percentage of mortalities/clutch were noted. No visible eyespot was observed in 10.5% of the eggs, while 35.2% showed some development and 54.3% were fully developed. Fouling was observed in all developmental stages but generally was higher in further developed individuals. Fouling was highly variable within an egg mass concentrated mostly on the periphery and on the inner eggs near the fold of the abdomen. The impact of fouling on the California fishery and potential causes were also discussed.

Pacific mackerel.

AUTHOR(S): Fitch, J. E.

YEAR: 1956.

SOURCE: CalCOFI Prog. Rep. 1955-1956:29-32.

KEYWORDS: Chub mackerel, Scomber japonicus, fishery, feeding, economics, mortality, migration, length/weight, age.

ABSTRACT: General information on the Pacific mackerel fishery and a brief description of ongoing research. Pacific mackerel range from southern Alaska to the mainland coast of Mexico. The fishery is centered in southern California with most of the catch delivered to ports in the Los Angeles region (Redondo Beach, San Pedro, Long Beach, and Newport Beach). Although Pacific mackerel grow rather rapidly, they must be around 3 years old before reaching 12 inches long and three-fourths of a pound. Information from this study shows that one, two, and three-year old mackerel have made up most of the catch. Tagging studies have shown that there was considerable interchanges of fish from central and southern California. Stomach samples from fish collected between Point Conception and Baja California revealed larvae and juvenile fish as the most important items.

The decline of the Pacific mackerel fishery.

AUTHOR(S): Fitch, J. E.

YEAR: 1952.

SOURCE: Calif. Fish Game 38(3):381-389.

KEYWORDS: Chub mackerel, jack mackerel, Trachurus symmetricus, fishery, length/weight, age, spawning, Scomber japonicus.

ABSTRACT: The purpose of this report is to summarize the decline of the Pacific mackerel (*Pneumatophorus diego*) fishery from 1928-1951. The decline of this fishery has been obscured by the collapse of the California sardine fishery and by the subsequent expansion of the jack mackerel fishery. Since the switch of the Pacific mackerel fishery from a fresh fish trade to canning, the pressure on the mackerel fishery has steadily increased. The collapse of the sardine (*Sardinops caerulea*) fishery has also contributed to the increased fishing pressure on Pacific mackerel. Since both jack mackerel (*Trachurus symmetricus*) and sardines are fished in the same waters as Pacific mackerel, and all three species are used for canning, fishermen may fish for one of the three species and substitute either of the other two as acceptable to the canneries. Mackerel average 12 inches in length, and weigh about three-quarters of a pound at age two. At six years of age they are 15 inches long and weigh an average of 1.5 lbs. The age

composition of 65% of the fish caught in the 12-season period, 1939-40 through 1950-51, was less than three years of age. Since mackerel do not spawn until their third or fourth year, 65% of the fish caught during a season would not have spawned or would have spawned only once. The 1945 season produced the lowest numbers and pounds caught. Mortality rates are estimated at 74-78% per year for seasons 1940-41 through 1942-43. Mortality rates increase with fish age and were also noted to increase in subsequent seasons for the same age class. These increasing mortality rates indicate that with the present fishing methods, conditions and pressure, it is not possible to build up a reserve stock of mature spawning mackerel to take care of future needs. The total annual catch of Pacific mackerel in California has gone from 5 million lbs in 1927-28 to 56.5 million lbs during the 1929-30 fishing season. With improved canning methods, the catch went from 11 million lbs in 1933-34 to over 146 million pounds by 1935-36. Since this time, the Pacific mackerel fishery has steadily decreased, with small peaks attributed to particularly strong year classes. During all the years covered by this report, efforts at conservation of the Pacific mackerel have been rather narrow and ineffective. A voluntary closing between April and May 1938-41 proved ineffective. A size limitation was imposed in the fishery in 1947-48. The present economic outlook for the Pacific mackerel is bleak. Since the reserve spawning stock (fish over four years old) dwindled until in 1950-51, less than 3% of Pacific mackerel caught were four years of age and older. The California Department of Fish and Game recommends an overall yearly bag limit to alleviate the steady decline of Pacific mackerel fishery.

#### Marine food and game fishes of California.

AUTHOR(S): Fitch, J. E., and R. J. Lavenberg.

YEAR: 1971.

SOURCE: Univ. Calif. Press, Berkeley, CA. 179 p.

KEYWORDS: All species, fishery, distribution, life history, feeding, reproduction, mortality.

ABSTRACT: Species were selected for inclusion in this text based upon their

edibility and/or sport fishery importance. A brief history of California's food and game fishes and fossil records introduces the main body of the text which consists of life history characterizations of each fish species. An index of common and scientific names as well as a glossary completes this volume.

#### Offshore fishes of California.

AUTHOR(S): Fitch, J. E.

YEAR: 1969.

SOURCE: Calif. Fish Game publ. 80 pp.

KEYWORDS: All species, age, growth, reproduction, spawning, larvae, regulations, fishery.,

ABSTRACT: The purpose of this book was to provide basic information to sport fishermen on the biology and management of offshore fishes. The topics covered included general information on habits and habitats, classification and anatomy, locomotion, food and feeding, age and growth, reproduction, dangerous fishes, diseases and parasites, fishery management, fish descriptions, fishing ports, and marine aquaria. Species descriptions are given for 27



of the more common sport fishes.

Review of the movement of albacore tuna off the Pacific Coast  
in 1963.

AUTHOR(S): Flittner, G. A.

YEAR: 1964.

SOURCE: Comm. Fish. Rev. 26(12):13-19.

KEYWORDS: Migration, age, albacore, *Thunnus alalunga*.

ABSTRACT: The U.S. Navy radar picket vessels trolled for albacore, (*Thunnus alalunga*), off the Pacific Coast in 1963. As in previous years, coverage extended from latitude 31 deg N to 50 deg N, and longitude 124 deg W to 136 deg W. The 1963 catch was the highest for any one year since inception of the program in 1960. A total of 1,041 albacore were caught. The estimated weight of the catch was 10,858 pounds, or 5.4 tons. The northward migration of the albacore population was related to the annual northward extension of the 60 deg to 66 deg F thermal zone. This temperature range included 84.5% of the catch. No albacore were taken from waters colder than 55 deg F or warmer than 70 deg F. Station 3, (41 deg N, 134 deg W), off Cape Mendocino logged the highest total catch for the year, and produced 47% of the combined 1960-1963 catch for all stations. Catches were made on 32 of 46 consecutive days from June 16 to July 31. Fishing was also good at Station 2, (46 deg N, 135 deg W), where catches were logged on 35 of 45 consecutive days between September 1 and October 15. Fishing was poorest at Station 5, (31 deg N, 129 deg W). The 1963 season persisted much later in the year than usual, with 247 albacore taken at Station 4, (36 deg N, 131 deg W), between November 1 and December 17. Catches reached a peak in the November 1-15 interval and declined thereafter. The age group representation of the 1963 catch was similar to 1962. Fish 56 cm FL comprised 46% of the catch and those 62-64 cm FL made up 48%.

H. O. Hodgins.

Effects of petroleum exposure on predatory behavior of coho  
salmon (*Oncorhynchus kisutch*).

AUTHOR(S): Folmar, L. C., D. R. Craddock, J. W. Blackwell, G. Joyce, and  
YEAR: 1981.

SOURCE: Bull. Environ. Contam. Toxicol. 27(4):458-462.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, contaminant susceptibility,  
feeding, behavior.

ABSTRACT: The effects of seawater soluble fractions (SWSF) of Cook Inlet crude oil on the predatory behavior of coho salmon (*Oncorhynchus kisutch*) was examined in the laboratory. The results demonstrate a significant reduction in feeding by coho which were exposed to the petroleum solution. One group of coho maintained high feeding activity, regardless of exposure. This group (designated "eaters") possessed a higher level of hydrocarbons in their livers and brains than a group which demonstrated very reduced feeding activity (designated "noneaters"). The authors speculate that some enzyme of the fish may break down the hydrocarbons, and it is these hydrocarbon products which suppress feeding behavior. The variable effect of the SWSF, may then be related to the specific enzyme activity of the different fishes.

Some frequencies of underwater noise produced by fishing boats

affecting albacore catch - comment.

AUTHOR(S): Foote, K. G.

YEAR: 1980.

SOURCE: Jour. Acoust. Soc. America 67(3):1064.

KEYWORDS: Fishery, albacore, Thunnus alalunga.

ABSTRACT: This paper offers an alternative explanation as to why some frequencies of underwater noise produced by boats participating in the West Coast albacore fishery will affect their success at catching albacore, Thunnus alalunga. The alternative interpretation states that it is the low frequency portion of the radiated noise spectrum which is decisive to catch-related success. This assumes that factors extraneous to the causative association of catch with vessel-radiated noise have been precluded by the original analysis. It is suggested that albacore is attracted by low frequency sound and that the catch-related success of the boats is due to differences in the magnitude or quality of the radiated low frequency sound. This hypothesis could be tested by a review of the measured radiated noise spectra.

Distribution, population dynamics and behavior of a bothid flatfish, *Citharichthys stigmaeus*.

AUTHOR(S): Ford, R. F.

YEAR: 1965.

SOURCE: Ph.D. dissertation, Univ. Calif., San Diego, CA. 243 p.

KEYWORDS: *Paralichthys californicus*, California halibut, feeding, distribution, behavior, reproduction, mortality, growth.

ABSTRACT: The distribution, population dynamics and behavior of *Citharichthys*

*stigmaeus* inhabiting the intercanyon shelf in La Jolla Bay was the object of this study. Intensive quantitative underwater sampling involving direct observation and counts of fish was the method employed to study the population of interest. This method allowed detailed observations in the species natural environment.

Bathymetric distribution, food and feeding habits, growth and energetics are discussed as well as reproduction and mortality.

Observations on the effects of oil field structures on their biotic environment: Platform fouling community.

AUTHOR(S): Fotheringham, N.

YEAR: 1981.

SOURCE: Pages 179-208 in B. S. Middleditch (ed.), Environmental effects of offshore oil production. Plenum Press, NY.

KEYWORDS: Platform, artificial reef, colonization, community.

ABSTRACT: The structure and factors regulating the structure of the fouling community on oil platforms in the Buccaneer Field are determined by looking at the fouling community, its planktonic larvae, and its predators. Exclusion experiments were conducted with cages to keep fish from grazing. Sixteen algal and 101 invertebrate species were identified from the structures. The most conspicuous structural feature is the abundance of the barnacle *Balanus tintinnabulum*. In natural quadrants unoccupied habitat was rare. Early colonization is by a variety of sponges, hydroids, and algae. Recolonization patterns show that sponges, hydroids, and the bryozoan *Savignyella lafonti* were first to arrive with the last two growing over the sponges. These were less abundant in caged quadrants, due to lower light levels and

less food, except the bryozoan which was more abundant due to less fish predation. Successful sets by the dominant barnacle does not occur annually. Spatial variation due to stochastic processes were observed between the two structures studied. Among the motile invertebrates three groups were found; distinctly littoral, rather broad vertical distributions, and those largely limited to the bottom. Growth could be followed on very few organisms. *Balanus* (Amphitrite complex) had a minimum growth rate of 0.026 cm<sup>2</sup> per month. A large portion of the taxa observed breed during the winter months.

Production of nonviable oocytes by Pacific hake.

AUTHOR(S): Foucher, R. P., and R. J. Beamish.

YEAR: 1980.

SOURCE: Jour. Fish. Aquat. Sci. Canada 37(1): 41-48.

KEYWORDS: Reproduction, spawning, Pacific hake, *Merluccius productus*.

ABSTRACT: Hake oocytes from a ripening ovary are known to occur in several size-classes. Examinations of ovaries before and after spawning showed that the largest yolked oocytes were released for fertilization while the smallest yolked oocytes were resorbed. The absorbed oocytes may introduce an error in traditional techniques of evaluating fecundity. Fecundity has been defined as "the number of eggs (oocytes) for the generation of that year present in the ovaries, i.e. the number that should be laid that year." In order to reduce the error fecundity should be defined as the number of oocytes actually released to be fertilized. Histological evidence also indicates that the number of gametes is not fixed at the time of first maturity, but instead may be restocked on an annual basis.

1983 Economic status report on the California coastal pelagic species fisheries.

AUTHOR(S): Fougner, S.

YEAR: 1984.

SOURCE: N.M.F.S. Ad. Rep. SWR-84-3:1-12.

KEYWORDS: Fishery, fishing gear, regulations, economics, chub mackerel, *Scomber japonicus*, jack mackerel, *Trachurus symmetricus*, northern anchovy, *Engraulis mordax*, squid, *Loligo opalescens*, Pacific bonito, *Sarda chiliensis*.

ABSTRACT: The economics of the 1983 California coastal pelagic fisheries are reviewed. The principal target species of the California coastal pelagic fisheries are Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), northern anchovy (*Engraulis mordax*), squid (*Loligo opalescens*), and Pacific bonito (*Sarda chiliensis*). Sardines (*Sardinops sagax*), are taken as an incidental catch in the mackerel fishery. The total combined commercial landings of the target species in 1983 were 60,600 mt with an ex-vessel value of \$12.2 million. This was a decline from the 1982 levels of 113,700 mt and value of \$17.5 million primarily because of the disappearance of anchovy and squid, probably due to warm water conditions. The principal components of the fleets in the coastal pelagic species fisheries are described by fishing area and include, type of fishing gear, target species, landings, ex-vessel values, and number of participating vessels. The primary markets of the commercial fishery are domestic and export markets for canned fish for human consumption and pet food, industrial fish products (oil, meal,

solubles), and fresh and frozen products. There is no evidence that the principal target species are overfished, but catches vary each year due to stock fluctuations or environmental changes. The Pacific sardine stock appears to be continuing to rebuild, but there is concern about a decline in Pacific mackerel. Most fishing for coastal pelagic species is under regulation set by the State of California, which includes area and fishing gear restrictions, seasons, size limits and quotas.

Estimation of abalone mortality rates with growth analysis.

AUTHOR(S): Fournier, D. A., and P. A. Breen.

YEAR: 1983.

SOURCE: Trans. Am. Fish. Soc. 112(3):403-411.

KEYWORDS: Abalone, *Haliotis* sp., mortality.

ABSTRACT: The von Bertalanffy growth parameters and total mortality rates of the northern abalone, *Haliotis kantschatkana*, were simultaneously estimated from length-frequency data. Two populations were sampled and model populations were utilized to test the procedure. The survival rates of the two populations were 79-86% and 60-77%. The differences were probably due to the presumed number of age classes utilized in the equation. Various physical factors between the two sites may have also accounted for some of the variability.

Population and trophic dynamics of Pacific hake (*Merluccius productus*).

AUTHOR(S): Francis, R. C.

YEAR: 1983.

SOURCE: Jour. Fish. Aquat. Sci. Canada 40:1925-1943.

KEYWORDS: Pacific hake, *Merluccius productus*, growth, migration, mortality, recruitment, length/weight.

ABSTRACT: An age structured computer simulation model was developed to synthesize, summarize and evaluate the processes of growth, mortality, and migration of Pacific hake. The model also allows bioenergetic calculations based on the age structure and growth of hake occupying a given area. The results from the study show that 1) the two growth relationships (uniform throughout the year and seasonal growth) provide different estimates of trophic demands, 2) between hatching and the critical age, age-specific natural mortality ( $M$ ) is a density dependent function of age and, after the critical age,  $M$  increases with age for 4-5 years, then undergoes irregular fluctuations, 3) there is a latitudinal gradient to hake size with larger fish tending to move farther north than smaller fish, and 4) production due to growth is greater under the seasonal growth option; the average ratio of total annual production to average biomass is 0.35, and average daily production is 0.4%.

Status of the Pacific hake resource and recommendations for management in 1986. PFMC, Status of the Pacific Coast groundfish fishery through 1985 and recommended acceptable biological catches for 1986.

AUTHOR(S): Francis, R. C.

YEAR: 1985.

SOURCE: Pages 1-1 to 1-22 in Fish. Mgmt. Council, Portland, OR.

KEYWORDS: Pacific hake, *Merluccius productus*, fishery, regulations, population

trends.

ABSTRACT: The purpose of this appendix to the Pacific Fishery Management Plan

is to simplify the management model of the hake fishery and to reestimate the production parameters based on the most current data. Methods used to develop the statistical models are discussed as well as the conclusion based on model results. Tables and graphs accompany the discussions.

Status of the sablefish resource of the U. S. west coast and recommendations for management in 1986.

AUTHOR(S): Francis, R. C.

YEAR: 1985.

SOURCE: Pages 2-1 to 2-30 in PFMC. 1985. Status of the Pacific Coast groundfish fishery through 1985 and recommended acceptable biological catches for 1986. Pac. Fish. Mgmt. Council, Portland, OR.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, weight/length, recruitment, age, mortality.

ABSTRACT: The purpose of this appendix to the Pacific Fishery Management Plan

is an expansion and explanation of the data used that formed the basis for the recommendations of the sablefish fishery management. An assessment of MSY, current status of the resource and recommendations for management in 1986 are covered in detail in this report. Model parameters are identified and the methods used to arrive at estimates are also presented. The various statistical models used are explained as well as the conclusions based on model results. Tables and graphs accompany the discussions.

Swartzman, and W. M. Getz.

Status and management of the Pacific hake (*Merluccius productus*) resource and fishery off the west coast of the United States and Canada.

AUTHOR(S): Francis, R. C., G. A. McFarlane, A. B. Hollowed, G. L.

YEAR: 1984.

SOURCE: NWAFC, NMFS/NOAA, NWAFC Processed report 84-18.

KEYWORDS: Pacific hake, *Merluccius productus*, fishery.

ABSTRACT: The history of the hake, *Merluccius productus*, fishery and management plan was reviewed. In addition, the current status of the stock was considered. The fishery, which began in 1966, along the Pacific Coast, ran from April to October. The low market value was attributable to a myxosporean parasite which caused severe degradation of the flesh after death. Catches have varied from 91,000 tons to over 210,000 tons and variations in year class strength were also apparent. Most fish recruited to U.S. waters by 2 to 3 years whereas Canadian recruits appeared at 5 to 6 years. A modification of the Getz-Swartzmen algorithm model was used to assess historical, equilibrium, management and stock projection for the hake fishery. The model showed a large amount of variability in hake production possibly the result of environmental factors affecting early life history stages. The stock suffered more from exploitation in the American zone than in the Canadian zone. The results of this study suggested MSY is attainable around 210,000 tons, however, an optimum yield of 190,000 tons would be less disastrous to the stock and fishery. The older stock appeared to be quite good due to low U.S.

exploitation, however, younger year classes may require protection. Data indicated the 1980 year class was large while the 1981-83 year classes may have been small.

Pacific salmon and the high seas salmon fisheries of Japan.

AUTHOR(S): Fredin, R. A., R. L. Major, R. G. Bakkala, and G. K. Tanonaka.

YEAR: 1977.

SOURCE: Processed Rep., Northw. Alaska Fish. Ctr., Natl. Mar. Fish. Serv.,

NOAA, Seattle, WA. 324 p.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, *O. tshawytscha*, life history,

early life history, mortality, reproduction, age, spawning, growth, spawning, migration, habitat, distribution, fishery, economics, fishing gear, regulations.

ABSTRACT: This text discusses the salmon and begins with its general life history features which include, but are not limited to, distribution, migration, behavior, maturity, age, reproduction, spawning, mortality and physiological phases. Following this discussion is a detailed analysis of the world fishery in general and the Japanese fishery in particular. This discussion covers a variety of topics including regulatory history licensing, catch quotas, economics and trends within the fishery.

The foreign fisheries off Washington, Oregon and California 1977-78.

AUTHOR(S): French, R., R. Nelson, Jr., and J. Wall.

YEAR: 1981.

SOURCE: Mar. Fish. Rev. 43(5):36-44.

KEYWORDS: *Sebastes entomelas*, widow rockfish, *Sebastes goodei*, chilipepper rockfish, *Sebastes miniatus*, vermillion rockfish, *Sebastes paucispinis*, bocaccio, fishery, fishing gear.

ABSTRACT: Data derived from the foreign fisheries observer program on vessel within Washington, Oregon and California waters during 1977 and 1978 was summarized. Catches were incidental to the Pacific whiting fishery. The majority of rockfishes (genus *Sebastes*) taken incidentally were from the "Columbia" area (Oregon and Washington). No rockfish were taken from the "Monterey" area (Fort Bragg to Pt. Conception). Total metric tons of *S. entomelas*, *S. goodei*, *S. miniatus*, and *S. paucispinis* landed was 303.88, 0.86, 1.31 and 24.14, respectively.

California's living marine resources and their utilization.

AUTHOR(S): Frey, H. W. (ed.)

YEAR: 1971.

SOURCE: Calif. Fish Game Publication. 148 pp.

KEYWORDS: All species, fishery, distribution, length/weight, feeding, population trends, economics, fishing gear.

ABSTRACT: A summary of the fishery and current status of the sport and commercially important species in California. The general categories covered in this report were marine plants, crustaceans, mollusks, fishes and marine mammals. Information on the different species include a history of the fishery, status of biological information and status of the population. Economic utilization, foreign fishery, oil pollution, pesticides, and waste discharge are also briefly discussed.

Stauffer, and C. Thomson.

Northern anchovy fishery management plan, final supplementary  
EIS/DRIR/IRFA.

AUTHOR(S): Frey, H., J. Ginter, D. Huppert, A. MacCall, R. Methot, G.  
YEAR: 1983.

SOURCE: Pacific Fishery Management Council. 166 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, population  
trends, regulations, fishing gear, economics, life history.

ABSTRACT: This document is an amendment (#5) to the Fishery Management  
plan for the northern anchovy, *Engraulis mordax*, originally  
implemented in 1978. This plan incorporates advances in  
scientific information to measure population size and shows a  
need to alter commercial harvest quotas. Various alternatives for  
the following management measures are reviewed: optimum yield  
harvest quotas; seasonal and geographical area closures; minimum  
fish size limits or net mesh requirements; allocations of optimal  
yield for the non-reduction fishery; and regulations applying to  
foreign and joint venture fishing. Past controversial issues  
which may reoccur are also discussed. The fishery is described in  
terms of areas and stocks, history of the exploitation,  
management, and research on this wetfish, socio-economic  
characteristics, and finally revenues derived from the fishery.  
Biological descriptions of the northern anchovy are presented, as  
are harvesting and processing capacities. Optimum yield is  
discussed including biological, ecological, social, and economic  
considerations. Management objectives are: to prevent overfishing  
and promote conservation; allow a fishery and achieve optimum  
yield on a continuing basis; maintain populations large enough to  
sustain adequate levels of predatory fish, birds and mammals;  
avoid conflicts between recreational and commercial fishermen;  
and to promote efficiency in utilization. A number of options are  
covered for each objective, and compared under the following  
criteria; biological impact on the population, economic and  
social impacts, information collecting costs in order to  
implement each option, and monitoring, enforcement, and  
compliance costs. The Fishery Management Plan presented here  
represents potential modifications to the existing management  
regime. The Pacific Fishery Management Council presents  
recommendations of the preferred regulations or options.

Development of fishes of the Mid-Atlantic Bight, Vol. 5.

Chaetodontidae through Ophidiidae.

AUTHOR(S): Fritsche, R. A.

YEAR: 1978.

SOURCE: U. S. Fish Wildl. Serv., Washington, DC. FWS/OBS-78/12. 340 p.

KEYWORDS: All species, habitat, migration, distribution, larvae,  
reproduction,

spawning, life history, growth, age, size, albacore, *Thunnus*  
*alalunga*, swordfish, *Xiphias gladius*.

ABSTRACT: This atlas provides a baseline taxonomic information source  
that can

be used by biologists, ecologists and decision makers, enabling them  
to incorporate environmental considerations into resource  
development. A comprehensive review of literature covering fishes of  
the Mid-Atlantic Bight has been completed, synthesized and presented  
in this six volume series. The Mid-Atlantic Bight covers the

geographical area that extends from the northern boundary of New Jersey to the southern boundary of Virginia, from tidal freshwater out to the 100 fathom contour. This work compiles descriptions of the egg, larval, and juvenile stages of over 300 fish species and includes dichotomous keys useful for their identification. Descriptions of spawning migrations and life habits of adult fishes, their geographic range and distribution as well as movements of fish at all life stages are also included.

A preliminary summary of the life history of the Pacific mackerel (*Pneumatophorus diego*).

AUTHOR(S): Fry, D. H., Jr.

YEAR: 1936.

SOURCE: Calif. Fish Game 22(1):30-39.

KEYWORDS: Chub mackerel, *Scomber japonicus*, life history, spawning, feeding, growth.

ABSTRACT: The purpose of this report is to summarize preliminary life history information on the Pacific mackerel (*Pneumatophorus diego*). The range of the Pacific mackerel is from southern Alaska to the tip of lower California. It is also found in disjunct populations along the Pacific Coast of Mexico. The abundance of Pacific mackerel varies throughout its range due to erratic migratory habits and seasonal variations. Generally in the San Pedro area there is a low period from January through April, with a sudden increase in May. Abundance is generally high throughout the summer months, with a slight midseason slump any time from June to September. Abundance decreases in November and December. The difference in catches between periods of abundance and scarcity is comparatively slight at Monterey due to limited demand. Pacific mackerel do not generally spawn until they are at least 12-13 inches long. Yearling fish do not spawn whereas most two-year olds do. Most mackerel spawn two or more times each season. Some young fish which have just matured spawn only once. In southern California spawning is concentrated from the middle of May to early July. Mackerel spawn in the open ocean and the eggs float freely at or near the surface. They hatch in about three days, the hatching time varying with the temperature. Eggs are generally found in water less than 100 fms deep, between 58 deg and 72 deg F surface temperature, and over a level or gently sloping bottom. Most of the eggs are spawned in water under 40 fms deep and between 62 deg and 69 deg F. Mackerel do not appear to spawn in the vicinity of Monterey. North of North of Pt. Conception, the surface waters near shore are nearly always colder than 57 deg, the minimum temperature at which mackerel eggs have been found.

Tagging experiments on the Pacific mackerel *Scomber japonicus*.

AUTHOR(S): Fry, D. H., Jr., and P. M. Roedel.

YEAR: 1949.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 73.

KEYWORDS: Pacific mackerel, *Scomber japonicus*, migration, distribution, fishery.

ABSTRACT: The purpose of this study was to determine the migration pattern of Pacific mackerel (*Scomber japonicus*) along the eastern side of the Pacific ocean. The biological range of the Pacific mackerel extends from the Gulf of Alaska southward into the Gulf of California. Two types of tags were used to mark



individual fish, an opercular tag and an internal belly tag. The tagging experiment demonstrated that mackerel from as far north as Oregon migrate into southern California. Northward migration was also observed in fish tagged in southern California which were recovered in the San Francisco-Monterey area. Attempts to measure abundance through tag returns were not successful. Operator tags and internal belly tags gave differential results, with the latter being significantly more successful as a permanent marker.

Statistics of selectivity.

AUTHOR(S): Gabriel, W. L.

YEAR: 1979.

SOURCE: Pages 62-66 in S. J. Lipovsky and S. A. Simenstad (eds.), Gutshop '78. Fish food habit studies, Proceedings of a second Pacific northwest technical workshop, October 10-13, 1978. Wash. Sea Grant Publ., Univ. Wash., Seattle, WA.

KEYWORDS: Feeding.

ABSTRACT: This paper explores the desirable properties of an index of selectivity which can be used in the study of community trophic structure to determine feeding selectivity. Two traditional indices of selectivity are reviewed, the forage ratio and the Ivlev index, as well as the log of the odds ratio, for comparison with those properties considered most desirable in an index. The results suggest that the log of the odds ratio meets all the criteria for a desirable index of selectivity and is, therefore, superior to the traditional indices of selectivity.

Preliminary analysis of Pacific coast demersal fish assemblages.

AUTHOR(S): Gabriel, W. L., and A. V. Tyler.

YEAR: 1980.

SOURCE: Mar. Fish. Rev. 42(3):83:88.

KEYWORDS: Distribution, habitat, *Sebastes entomelas*, widow rockfish, *S. paucispinis*, bocaccio.

ABSTRACT: Cluster analysis was used to determine fish species assemblages over the continental shelf and slope from the mouth of the Columbia River to Yaquina Head, Oregon. Data analyzed were collected during the 1973 Oregon Department of Fish and Game Otter Trawl Survey and the 1977 Rockfish Survey. Assemblage persistence was addressed by comparing the results from these two sample periods. Major dichotomies between assemblages were segregations by depth. Shelf assemblages were divided into two depth intervals: "intermediate shelf" (90-145m) and "deep shelf" (145-220m). These assemblages were separate from the slope assemblages beginning at 220 m. Species abundance data (percent composition of catch by biomass) and the mean poundage per haul within each assemblage derived by cluster analysis are given for *Sebastes entomelas* and *S. paucispinis*. *S. entomelas* was most abundant within the "intermediate shelf" assemblages. *S. paucispinis* was not abundant within the "deep shelf" assemblages. A total of 12 assemblages were identified. These assemblages were considered primarily applicable to summer conditions since many species undergo seasonal migrations. Some of the assemblages were similar between the two sample periods.

Feeding selectivity of Dover sole, *Microstomus pacificus*, off

Oregon.

AUTHOR(S): Gabriel, W. L., and W. G. Pearcy.

YEAR: 1981.

SOURCE: Fish. Bull. 79(4):749-763.

KEYWORDS: Dover sole, *Microstomus pacificus*, feeding.

ABSTRACT: The food habits of the Dover sole, *Microstomus pacificus*, are investigated. Habits studied included selectivity and the relationship between feeding and location of fish capture, size of fish, and size and depth of prey items in the sediment. In midsummer fish fed mostly on polychaetes followed by ophiuroids. These prey items occurred in 83.6 - 97.3 and 63.0 - 80.0% of the stomachs examined, respectively. Crustaceans and molluscs comprised less than 6% of the biomass consumed. Size-related diet variations were shown at one of the two stations. Five prey frequency patterns were apparent: 1) prey occurring at low frequencies in diets of small fish (11-20 cm); increasing in intermediate-size fish (21-30 cm), and constant in large fish (30-42 cm); 2) a high frequency of prey in small fish decreasing in intermediate and large-size fish; 3) prey taxon occurring in low frequencies in small and large fish, while relatively higher in intermediate-size fish; 4) increasing prey frequency with increasing fish size; 5) and prey patterns where the frequency of occurrence did not change with fish size. The Dover sole selected polychaetes over other foods and molluscs least often. Selectivity patterns were similar to those for changes in the frequency of occurrence of prey items, but taxa found in analogous categories may not have been the same. Prey items showing an increase in frequency in larger fish generally showed an increase in selectivity also. Feeding location or fish size did not explain size-related variations in prey frequency, indicating some other criteria for selection more important than size. Depth of prey taxon was related to selectivity with larger fish eating deeper prey.

Feeding ecology of pelagic larvae of English sole *Parophrys vetulus* and butter sole *Isopsetta isolepis* off the Oregon coast.

AUTHOR(S): Gadomski, D. M., and G. W. Boehlert.

YEAR: 1984.

SOURCE: Mar. Ecol. Prog. Ser. 20(1-2):1-12.

KEYWORDS: English sole, *Parophrys vetulus*, early life history, larvae, feeding, population trends.

ABSTRACT: English and butter sole larvae displayed a typical pattern of diurnal feeding. The butter sole demonstrated an ontogenetic variation in diet composition; the smaller larvae fed primarily on tintinnids, nauplii, and invertebrate eggs, while larger larvae consumed more copepodites and adult copepods. During 1973, English sole larvae consumed appendicularians almost exclusively. In contrast, during 1971 when appendicularian and English sole larval populations peaked at different times, English sole larvae fed more on other sources such as tintinnids, invertebrate eggs, and nauplii. During this time observations indicated increased starvation and mortality among English sole larvae. The authors conclude that larvae of the English sole are more dependent on a specific prey item than butter sole larvae. Hence, a mismatch of English sole larvae and appendicularian abundance peaks may result in significant population mortality related to starvation.

The ecology of petroleum platforms in the northwestern Gulf of Mexico: a community profile.

AUTHOR(S): Gallaway, B. J., and G. S. Lewbel.

YEAR: 1982.

SOURCE: Gulf of Mexico OCS Regional Office, Bureau of Land Management, Metairie, LA. 70002. FWS/OBS-82/27. 91 p.

KEYWORDS: Platform, community, colonization, habitat, recruitment.

ABSTRACT: The purpose of this report is to present the findings from a study

of the structure and ecological function of petroleum platforms in the northwestern Gulf of Mexico. A history of platform installation, structural properties and distribution throughout the study area is presented. Characterizations of the composition and biology of major faunal groups on or around platforms, successional patterns and growth, ecosystem dynamics and carbon flows are also topics of discussion. The report summarizes the benefits of platform communities to man and suggests specific steps be taken to preserve a biological resource endangered by platform removal.

Ingestion of the bacteria on and the cuticle of crustose (non-articulated) coralline algae by post-larval and juvenile abalone (*Haliotis ruber* Leach) from Tasmanian waters.

AUTHOR(S): Garland, C. D., S. L. Cooke, J. F. Grant, and T. A. McMeekin.

YEAR: 1985.

SOURCE: Jour. Exper. Mar. Biol. Ecol. 91(1-2):137-149.

KEYWORDS: Abalone, *Haliotis* sp., feeding.

ABSTRACT: *Haliotis ruber* larvae were cultured and settled on crustose coralline algae. At six weeks, the post-larvae were 692  $\mu\text{m}$  and the population density was 0.9 animals/ $\text{cm}^2$ . These post-larvae actively grazed the cuticle layer (to a depth of 1-2  $\mu\text{m}$ ) of the coralline algae. The bacterial layer (*Vibrio* and *Moraxella*) was also consumed. At 13 weeks the population density had dropped to 0.6 animals/ $\text{cm}^2$  and the post-larvae were 2,435  $\mu\text{m}$ . These animals were observed with bacteria (predominantly *Moraxella*) among the radula teeth. These results suggest that indigenous bacteria are an important component of the post-larval diet.

Just for the Halibut.

AUTHOR(S): Garrison, C.

YEAR: 1981.

SOURCE: South Coast Sportfishing pp 30-31.

KEYWORDS: California halibut, *Paralichthys californicus*, life history, fishery.

ABSTRACT: This paper summarizes briefly a few facts on the life history of the California halibut, *Paralichthys californicus*, with tips on how to bait and hook halibut for the sportfisherman. In order to maintain stocks, a minimum-size regulation of 22 inches is maintained for the halibut fishery. The species ranges from Long Beach, Washington to Magdalena Bay, Baja California. Most sportfish catches are made from March through October, from the surf zone to about 100 feet, with most fish being caught in less than 50 feet. Halibut are known, however, to occur as deep as 600 feet. California juvenile halibut do not generally migrate, although larger adult halibut have been reported to travel as far as 140 miles from a tagging site. Halibut usually spawn from about February to July, with the greatest number spawning from

late April to early June. Female halibut grow larger than males, and both sexes reach 30 years of age.

Review of the early life history of Puget Sound fishes.

AUTHOR(S): Garrison, K. J., and B. S. Miller.

YEAR: 1982.

SOURCE: Fish. Res. Inst., Univ. Washington, Seattle, WA. FRI-UW-8216. 729 p.

KEYWORDS: Early life history, reproduction, spawning, physiology, widow rockfish, *Sebastes entomelas*, English sole, *Parophrys vetulus*, petrale sole, *Eopsetta jordani*, Dover sole, *Microstomus pacificus*.

ABSTRACT: The early life history and reproductive biology of 175 teleost (bony

fish) species found in Puget Sound is summarized in this report.

Accompanying each summary is a list of literature references gathered from published and unpublished bibliographies pertaining to that particular species. The summaries are intended to provide insight into the present state of knowledge regarding the species covered.

Brachyura: The true crabs.

AUTHOR(S): Garth, J. S., and D. P. Abbott.

YEAR: 1980.

SOURCE: Pages 594-630 in: R. H. Morris, D. P. Abbott, and E. C. Haderlie (eds.). Intertidal invertebrates of California. Stanford Univ. Press, Stanford, California.

KEYWORDS: *Cancer magister*, *Cancer productus*, *Cancer anthonyi*, market crab, rockcrab, distribution, habitat, reproduction, feeding, fishery, economics, growth.

ABSTRACT: A description of Brachyura crabs down to the species level.

The chapter begins with a general description of the characteristics of Brachyura crabs which separate them from other decapods. The seven families in Brachyura are then briefly discussed. The final section is a detailed description of the various species in each family. Information is included on habitat, general distribution, distribution of subpopulations, fishery and economics, feeding, reproduction and growth. *Cancer magister*, *C. productus*, and *C. anthonyi* are 3 of the species described.

Designated common names of certain marine organisms of California.

AUTHOR(S): Gates, D. E. and H. W. Frey.

YEAR: 1974.

SOURCE: Calif. Dep. Fish Game, Fish Bull. 161:55-90.

KEYWORDS: All species, scientific and common names.

ABSTRACT: This list of designated common names for certain marine organisms

attempts to include all known shallow water marine and anadromous fin fishes occurring within California waters. The list includes the common name, scientific designation and also other common names by which the species is or has been known. The criteria used for selecting the common names is discussed as well as those situations where the criteria cannot be applied and how these are handled.

Containment culture of abalone on an offshore oil platform.

AUTHOR(S): Gealy, F. D., and J. L. Siva.

YEAR: 1984.

SOURCE: Unpubl. ms Atlantic Richfield Co.

KEYWORDS: Platform, growth, artificial reef, abalone, *Haliotis* spp.

ABSTRACT: Experimental culturing of red abalones on an oil platform in Santa Barbara Channel to test the feasibility of open ocean abalone culture on and in the vicinity of an oil production platform is described. Two studies were addressed: growth and survival as a function of stocking density, and growth and survival as a function of different placement depths. The results of the density study show that up to 50% substrate coverage survival is 100%, from 100-120% substrate coverage average survival was around 84%, and by 137% substrate coverage survival is down to 55%. The results of the effect of different culturing depths indicate that abalone growth was most sensitive to average annual temperature and initial stocking growth.

Assessment of ocean shrimp management in California resulting from widely fluctuating recruitment.

AUTHOR(S): Geibel, J. J., and R. F. G. Heimann.

YEAR: 1976.

SOURCE: Calif. Fish Game 62(4):255-273.

KEYWORDS: *Pandalus jordani*, ocean shrimp, recruitment, population trends.

ABSTRACT: Ocean shrimp, *Pandalus jordani*, population dynamics are reviewed and the failure of the Schaefer stock production model examined. Current management includes regulations on catch quota, mesh size, and season based on the stock production model. The population of ocean shrimp was estimated to be capable of yielding 2.5 million pounds through 1969, 3.4 million in 1970, and 2.9 million pounds in 1971. Estimates were expected to improve as time went on and new data points were added to the model. Data added for 1972 caused problems; however, with maximum equilibrium yield estimated at 6.5 million pounds, it was hoped that parameters would return to pre-1972 levels in 1973-74, but they did not. Estimates of numbers of age 1 females for year classes prior to 1963 have varied between 37 and 65% with a mean of about 50%. Sex composition was related to the size of age 1 shrimp, with the year classes containing larger shrimp having a higher percentage of age 1 females. Weak year classes, which grow more rapidly, have a greater percentage of age 1 females. Thus, fluctuations in spawning biomass will be less than variations in recruitment. In an average year, age 1 females contribute over 74% to the spawning female biomass. Alteration of year classes indicate that the number of older shrimp affects survival of the incoming year class. Landings in 1952, 1962, 1964, 1970 and 1971-72 were 4,000, 3,000,000, 1,200,000, 4,000,000, and 1,800,000 pounds, respectively. Two major periods of favorable recruitment (1955-62, 1965-71) were observed, while two short periods of a significant drop (1963-64, 1972-73) occurred due to poor environmental conditions. In periods of favorable environmental conditions, more biomass will be available than will be computed by the model. Ocean shrimp are sensitive to the environment, and the fishery should be kept under surveillance.

Dispersal of the solitary coral *Balanophyllia elegans* by demersal planular larvae.

AUTHOR(S): Gerrodette, T.

YEAR: 1981.

SOURCE: Ecology 62(3):611-619.

KEYWORDS: Platform, community, colonization.

ABSTRACT: Dispersal in the scleractinian coral, *Balanophyllia elegans*, was observed in laboratory and field experiments. Mean dispersal distances of less than .5 m were noted for the demersal plankton larvae. Corals tend to be spatially aggregated due to the limited dispersal distance. A diffusion model which assumed random movement and settling behavior suggested maximum dispersal rate was .1 m/yr. Various dispersal methods (including adult transport on kelp holdfasts, and currents moving demersal larvae) were considered to explain the range of *Balanophyllia* which would require 29 million years given the calculated dispersal rate.

Age at maturity of the Pacific coast salmon of the genus  
*Oncorhynchus*.

AUTHOR(S): Gilbert, C. H.

YEAR: 1914.

SOURCE: Fish. Bull. 32:1-22.

KEYWORDS: Chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, reproduction, spawning, age, length/weight.

ABSTRACT: An analysis of the structure of scales from five species of Pacific coast salmon (along with other facts from their life history) in order to determine their age at maturity. The surface of a scale is mapped out in a definite succession of areas, a band of widely spaced rings always followed by a band of closely crowded rings, the two together constituting a single year's growth. The general results from this study have shown the age at spawning for the five species to be: fourth or fifth year for sockeye; fourth, fifth, sixth or seventh year for king salmon; generally the third year for coho salmon; third, fourth or fifth years for dog salmon; always the second year for humpback salmon.

Flounders of the genus *Paralichthys* and related genera in  
American waters.

AUTHOR(S): Ginsberg, I.

YEAR: 1952.

SOURCE: U.S. Fish Wildl. Serv. Fish Bull. 71:267-351.

KEYWORDS: *Paralichthys* spp., life history.

ABSTRACT: Three genera of flatfish, *Paralichthys*, *Hippoglossine*, and *Pseudorhombus*, from the Pacific and Atlantic coasts of North and South America were morphometrically analyzed to assess the status of the taxonomy. Since meristics often vary considerably, frequency distributions (from several trawls) were included for gill rakers, anal and dorsal rays, and scale counts. The proportional changes, associated with growth, were also considered. Marked variability was observed in color, size and form among different age classes. The results of the study were used to produce a key of all species from each genera considered. The distribution, color, morphometrics and interspecific differences were presented. A brief review of the biology of the species was presented when literature was available.

A study of reproductive biology of red abalone, *Haliotis*  
*rufescens* Swainson, near Mendocino, California.

AUTHOR(S): Giorgi, A. E., and J. D. DeMartini.

YEAR: 1977.

SOURCE: Calif. Fish Game 63(2):80-94.

KEYWORDS: Abalone, *Haliotis* spp., spawning, reproduction.

ABSTRACT: The reproductive cycle of two populations of red abalone, *Haliotis rufescens*, was studied over two years to determine fecundity and the minimum size at sexual maturity. Spawning, for both populations, occurred in the late spring and early summer although not all individuals spawned during a season. Females matured at a smaller (39.5 mm) size than the males (84.5 mm). Fecundity estimates of females ranging in size from 134 to 198.5 mm, were highly variable and numbered from 619,000 to 12,575,000.

Effects of current velocity on development and survival of lingcod, *Ophiodon elongatus*, embryos.

AUTHOR(S): Giorgi, A. E., and J. L. Congleton.

YEAR: 1984.

SOURCE: Environ. Biol. Fishes 10(1-2):15-27.

KEYWORDS: Lingcod, *Ophiodon elongatus*, mortality, reproduction, larvae, spawning.

ABSTRACT: The influence of current velocity on the development and survival of lingcod was examined. Field studies showed that at sites of low current velocity the interstitial oxygen concentration of egg masses averaged 16% air saturation during tidal flux with an estimated embryo mortality of 59% due to hypoxia. Similar studies at sites of high current velocity conducted during periods of tidal slack showed an average interstitial oxygen concentration of 69% and no embryo mortalities were observed. Egg masses at low current velocity showed retarded development of embryos internally compared with embryos at the periphery. In egg masses kept under hypoxic conditions, embryos hatched first at the periphery and later near the center. Egg masses were found to be deposited at significantly shallower depths at sites of low current velocity than at sites of high current velocity possibly indicating a behavioral adaptation of spawning site selection. Laboratory studies indicated that a current velocity of 10-15 cm/s was required to maintain interstitial oxygen concentrations near that of ambient water conditions.

Distribution and abundance of coho salmon in offshore waters of the north Pacific Ocean.

AUTHOR(S): Godfrey, H., K. A. Henry, and S. Machidori.

YEAR: 1975.

SOURCE: Intl. N. Pac. Fish. Comm. Bull. 31. 80 pp.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, distribution, age, length.

ABSTRACT: The annual catches of Japanese, Russian and North American salmon fishermen were sampled to determine the distribution and abundance of coho age classes. Major production sites for North America ranged from Alaska to the Columbia River, and for Asia the Karchatka Peninsula. From 1962-1970 the catches by Japan and the USSR averaged 4.2 million lbs which was quite similar to the 1954-1961 average. In North America, the catch increased 2.3 million lbs in 1962-1970 from the 1954-1961 average of 7 million lbs. The distribution of juvenile coho was found to extend south from home streams in the fall months. This suggests a downstream current dispersal pattern. Juvenile coho released with fork lengths of 60-70 mm were caught the same year with fork lengths varying from 250-310 mm. This suggests rapid initial growth

rates. Of the three to four age classes noted, the majority (90%) belonged to the first and second year classes.

Reproductive cycle of the Pacific bonito, *Sarda chiliensis* (Scombridae), from northern Chile.

AUTHOR(S): Goldberg, S. R., and D. Mussiott.

YEAR: 1984.

SOURCE: Pacific Science 38(3):228-231.

KEYWORDS: *Sarda chiliensis*, Pacific bonito, reproduction, spawning.

ABSTRACT: Gonads of Pacific bonito, (*Sarda chiliensis*), from northern Chile were histologically analyzed to provide a precise description of the reproductive cycle of the species. Gonosomatic indices increased during spring (September in the southern hemisphere) and reached a maximum in early summer (December). All ovaries from April - August were regressed. The smallest female in spawning condition measured 410 mm standard length (SL). The presence of postovulatory follicles from a recent spawning alongside mature follicles for a subsequent spawning indicated *S. chiliensis* spawns more than once during a reproductive season. The gonosomatic indice data for males was similar to that for females as was the seasonal pattern of testes stages. Testes sizes were largest during late spring - early summer, followed by a size decrease through summer. Testes began to enlarge in late winter (August). The smallest reproductively active male (spermiogenesis in progress) measured 390 mm SL. The Pacific bonito, *S. chiliensis*, spawns from spring to late summer off northern Chile. Their seasonal reproductive cycle is typical of temperate zone fishes, as spawning occurs during half of the year with no reproductive activity in the other half.

Growth of sablefish (*Anoplopoma fimbria*) in marine net pens.

AUTHOR(S): Gores, K. X., and E. F. Prentiss.

YEAR: 1984.

SOURCE: Aquaculture 36(4):379-386.

KEYWORDS: *Anoplopoma fimbria*, sablefish, economics, growth.

ABSTRACT: This investigation was conducted to test the feasibility of net rearing undersized and damaged sablefish in order to increase their market value. There were no short term mortalities related to capture nor did the fish have difficulties adapting to confinement in the net pens. There is a short discussion of some difficulties in net rearing sablefish including speculation on the causes of certain lesions on the fish and also on occasional mortalities. Growth rates for fish in this study reached a maximum of 0.1 kg/month which exceeds the previously reported growth rate of 0.04 kg/month for sablefish in the wild. The mean growth rate of males was always smaller than that of females (though not statistically different). The authors conclude that it is not practical at this time to raise undersized sablefish to a marketable size, however, it may be feasible to hold larger sablefish which have been damaged until they heal.

D. M. Young.

Levels of trace organic compounds in sportfish from southern California.

AUTHOR(S): Gosset, R. W., H. W. Puffer, R. H. Arthur, J. F. Alfafara, and

YEAR: 1982.



SOURCE: Southern California Coastal Water Research Project 1981-1982; 29-37.

KEYWORDS: *Sebastes paucispinis*, bocaccio. *Paralabrax clathratus*, kelp bass, contaminant levels.

ABSTRACT: Total DDT and total PCB levels (mg/wet kg) in edible muscle tissues of important sportfishes collected from various locations near the metropolitan Los Angeles area were discussed. Edible muscle tissue of sportfish in the vicinity of metropolitan Los Angeles contain concentrations of total DDT and total PCB that are above background levels. Observed total DDT levels did not exceed the FDA limits in any of the species sampled. Levels of total DDT and total PCB are given for *S. paucispinis* and *P. clathratus* along with other important sport species.

Catch-per-unit-of-effort studies of northern California Dungeness crabs, *Cancer magister*.

AUTHOR(S): Gotshall, D. W.

YEAR: 1978.

SOURCE: Calif. Fish Game 64(3):189-199.

KEYWORDS: *Cancer magister*, market crab, fishery.

ABSTRACT: Catch-per-unit-effort data for the northern California Dungeness crab, *Cancer magister*, fishery was determined. The data was used to calculate population size, mortality rates and season landings. Catches dropped from 16.4 million lbs in 1969 to 2.4 million lbs in 1971. The mean catch per trap increased as fishing days increased. The instantaneous mortality rates ranged from -0.00490 (1966 to 1967 season) to -0.18300 (1971 to 1972 season).

Northern California Dungeness crab, *Cancer magister*, movements as shown by tagging.

AUTHOR(S): Gotshall, D. W.

YEAR: 1978.

SOURCE: Calif. Fish Game 64(4):234-254.

KEYWORDS: *Cancer magister*, market crab, population trends.

ABSTRACT: Over a 12-year period (1956 to 1967) 6,209 male Dungeness crabs, *Cancer magister*, were tagged and released in northern California. Juvenile and adult crabs were found to have discrete population centers. The crabs were also thought to move with prevailing currents particularly north and south (with the Davidson and California Currents). A total of 1,434 tags were recovered with 19% (204) from 1.8 km of the release area.

Relative abundance studies of Dungeness crabs, *Cancer magister*, in northern California.

AUTHOR(S): Gotshall, D. W.

YEAR: 1978.

SOURCE: Calif. Fish Game 64(1):24-37.

KEYWORDS: Market crab, *Cancer magister*, population trends, fishing gear.

ABSTRACT: Trawling studies were conducted in Humboldt Bay, California from 1966 to 1969 in order to assess the abundance of 0 year class Dungeness crabs, giving clues to the state of the fishery three to five years later. SCUBA transects were also performed to assess the catching efficiency of the trawl. The results indicated that 1966 and 1968 were strong year classes. Comparison of the SCUBA transects to the trawl method, after adjustments were made for relative area covered, indicated that the trawl missed almost 55% of the crabs. Night trawls showed a

significantly higher catch than day trawls.

Stomach contents of northern California Dungeness crabs,  
Cancer magister.

AUTHOR(S): Gotshall, D. W.

YEAR: 1977.

SOURCE: Calif. Fish Game 63(1):43-51.

KEYWORDS: Cancer magister, market crab, feeding.

ABSTRACT: The stomachs of 208 Dungeness crabs, Cancer magister, were examined. The stomachs contained 40 different food items representing six animal phyla and one plant species. The major prey items included clams, crustaceans and fish. The frequency of occurrence of amphipods and fish decreased with depth, while polychaetes, snails, clams, cumaceans, isopods, and echinoderms increased in frequency. The stomach contents of northern California crabs were similar to those from British Columbia waters.

Stomach contents of Pacific hake and arrowtooth flounder from  
northern California.

AUTHOR(S): Gotshall, D. W.

YEAR: 1969.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 55(1):75-82.

KEYWORDS: Pacific hake, Merluccius productus, ocean shrimp, Pandalus jordani, feeding.

ABSTRACT: Stomach contents of Pacific hake and arrowtooth flounder were collected from fish feeding on ocean shrimp beds. Frequency of occurrence and volume of food categories occurring in hake and flounder stomachs indicated that they fed most abundantly on ocean shrimp. Although ocean shrimp appear to be an important prey item, their food habits probably depend on the availability of a particular organism. Studies of Pacific hake off Washington indicate that krill are hake's most important food. Because of their predation on ocean shrimp, the vertical migration of hake and flounder may be affected by the vertical migration of ocean shrimp (upward migration at dark and downward migration at first light).

The use of predator food habits in estimating relative  
abundance of the ocean shrimp, Pandalus jordani Rathbun.

AUTHOR(S): Gotshall, D. W.

YEAR: 1969.

SOURCE: VAO Fish. Rep. 3(57):667-685.

KEYWORDS: Ocean shrimp, Pandalus jordani, mortality, population.

ABSTRACT: The purpose of the project was to obtain reliable estimates of population size, year class composition, and mortality rates for the ocean shrimp, Pandalus jordani. Predator species were used as biological samplers in conjunction with sea surveys. Pacific hake, Merluccius productus, and arrowtooth flounder, Atheresthes stomias, were selected for an initial intensive analysis, while the hake was selected as the final sampler. In the 1965/66 study, the 1964 shrimp year class was most numerous in hake stomachs, commercial catches, and sea surveys, with the 1965 year class represented by fewer shrimp and the incoming 1966 year class in between. Year class composition determined from stomachs and sea surveys were quite similar, while those between stomachs and commercial landings differed. Autumn stomach samples yielded a

more accurate index of abundance for incoming year classes than sea surveys. Pacific hake stomachs yielded a wider range of sizes than did both sea surveys or commercial samples. Generally, the annual mortality rates derived from stomachs were higher than from sea surveys. Several sources of error must be considered when using biological samples, including net feeding, size selectivity, hake and shrimp bed distributions, and the effects of changes in hake abundance. The concept of predator sampling has potential as a fisheries management tool.

Population size, mortality rates, and growth rates of northern

California ocean shrimp, *Pandalus jordani*, 1965 through 1968.

AUTHOR(S): Gotshall, D. W.

YEAR: 1972.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 155: 47 pp.

KEYWORDS: Ocean shrimp, *Pandalus jordani*, population trends, mortality, growth.

ABSTRACT: Population size, mortality rates, and growth rates were determined for the California ocean shrimp, *Pandalus jordani*, for 1965-1968 from a stratified two-stage sea survey sampling plan. Shrimp population estimates off California and southern Oregon ranged from 2.2 to 8.1 million pounds and 114 thousand to 4.6 million pounds, respectively, with a trend towards an increase per standard trawl from 1965 through 1968. The 1964, 1966, and 1968 year classes were considered dominant, with a large portion being females as 1-year olds (non-normal situation). Natural mortality rates and survival rates during their second winter of life for the 1964 and 1965 year classes were 0.384 and 0.68, and 0.604 and 0.55, respectively. The highest mortality rates were found in the 1963 and 1964 year classes during their third winter. Fishing mortality varied, with the highest values found in their third summer in the fishery. Fishing mortality rates calculated from commercial catch per hour data was generally lower than those computed from survey information. The number of spawners is positively related to the number of 1-year olds produced, while population size and incoming year class survival is inversely related. Growth was demonstrated through the Von Bertalanffy equation. In 1964 and 1965 year classes "L oo" and "K" were close, however, "to" was considerably different. The most representative population and mortality rate estimates were found in fall of 1965, spring 1966, and spring and fall 1967 surveys, with the rest being biased due to various reasons which are discussed.

Metabolic rate of the albacore tuna, *Thunnus alalunga*.

AUTHOR(S): Graham, J. B., and R. M. Laurs.

YEAR: 1982.

SOURCE: Mar. Biol. 72(1):1-6.

KEYWORDS: Albacore, *Thunnus alalunga*, physiology.

ABSTRACT: Six albacore tuna (6 - 13 kg) were tested to determine their oxygen consumption rates ( $V_{O_2}$ ). Temperature flux was minimized to 15 - 19 C, and swimming rate averaged about 1.3 body length/s. Average combined  $V_{O_2}$  per unit of body weight was 0.212 ml/g/h, with a range of 0.159 - 0.286 ml/g/h. The weight specific  $V_{O_2}$  is twice that of sockeye salmon under similar conditions, and 60% of that of skipjack tuna at higher temperatures. The exponent relating body weight to  $V_{O_2}$  is 1.18 for albacore tuna, and 1.19

for skipjack tuna. These similarly high metabolic rates seem to be characteristic of the tuna family in general, and to correlate with their continuous swimming activity and endothermal maintenance.

Distribution, relative abundance, and seasonality of swordfish larvae.

AUTHOR(S): Grall, C., D. P. DeSylva, and E. D. Houde.

YEAR: 1983.

SOURCE: Trans. Am. Fish. Soc. 112(2):235-246.

KEYWORDS: Swordfish, *Xiphias gladius*, early life history, spawning, habitat, reproduction.

ABSTRACT: This paper is a review of swordfish (*Xiphias gladius*) larvaedata from around the world. The authors propose to delineate the spawning centers and seasons of adult swordfish based on updated data concerning distribution and relative abundance of larvae. 961 larvae (3-200 mm SL) were included in this study. All specimens were classified as small (<10 mm) or large ( $\geq 10$  mm); with the small specimens presumed to be closer to the center of the spawning grounds. Larvae abundance was adjusted to compensate for sampling effort. In the Atlantic, the larvae were most abundant in the eastern Caribbean near the Lesser Antilles, in the Straits of Florida, and in the western Caribbean near the Straits of Yucatan, which appear to be the primary spawning grounds. Large larvae were more abundant in all areas except in the eastern and southern Gulf of Mexico. The data indicates that adults are pelagic spawners with a year-round spawning season peaking in the late fall and winter. In the Western Pacific, large larvae were most common in the areas east of 140 deg W longitude. Small larvae were common in two areas around 1) the Philippines, Borneo, New Guinea and the north Australia, and 2) approximately 20 deg N latitude, 150 deg E longitude. Only in the former did the small slightly outnumber the large. In the rest of the areas the larger larvae outnumbered the small by 4 to 10 times. No specific spawning grounds were delineated for the Pacific area. While spawning appears to take place year-round, peaks occur in the north Pacific from May to August; and in the south Pacific in December and January. Most larvae taken in the Indian Ocean were in October, with the greatest numbers along the South Equatorial current. The authors conclude their data is weak mostly due to sampling artifacts.

Early development of Pendleton artificial reef.

AUTHOR(S): Grant, J. J., K. C. Wilson, A. Grover, and H. A. Togstad.

YEAR: 1982.

SOURCE: Mar. Fish. Rev. 44(6-7):53-60.

KEYWORDS: Artificial reef, community, habitat, colonization.

ABSTRACT: Pendleton artificial reef was constructed and placed off southern California in an attempt to increase the productivity of an otherwise barren area. The authors were particularly interested in transplanting giant kelp, *Macrocystis pyrifera* and *M. angustifolia*. The reef consisted of light modules made of quarry rock. Four of the modules were covered with cobble-sized rock to enhance abalone recruitment. During separate operations giant kelp and juvenile red abalone were transplanted onto the artificial reef. Natural settlement of fish and invertebrates on the reef was monitored. During the first year of the reef there

was observed a complex assemblage of fishes, invertebrates, and algae. There were observed 19 fish species and 26 invertebrate spp. The kelp transplants did not do as well as hoped because of the abnormally warm water conditions in 1981 which caused a decline in kelp beds along the southern California coast. The results of the first year of this study indicate that the diversities of fishes, invertebrates, and algae are increasing.

Management Plan for Northern Anchovy.

AUTHOR(S): Greenhood, E. C., H. W. Frey, C. E. Blunt, Jr., and Staff.  
YEAR: 1978.

SOURCE: Calif. Dept. Fish Game, Mar. Res. Mgmt. Rep. 1. 62 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, regulations.

ABSTRACT: The northern anchovy, *Engraulis mordax*, management plan, adopted in January 1977, is presented. The plan is formulated for the central stock, and designed so annual reduction quotas could be set automatically, based on an accepted harvest quota, related to the size of the spawning stock estimated each year. The management plan has a number of resource safeguards to prevent overharvesting. A Fish and Game Commission Policy Statement is given listing policies and defining "conservation and management" and "optimum yield". An anchovy Environmental Statement proposes an increase of the 1967-77 reduction quota for the southern permit area of 100,000 tons. A description of the proposed action is presented along with an evaluation. A management plan is proposed along with possible alternatives. Factors considered included aesthetics, scientific and education, recreational uses, commercial, economic, and social. Options are discussed in terms of their control and evaluation. A management option is recommended and justified, and its implementation discussed. Also reported in relation to the above are the status of the stock, potential revenues, status of commercial and recreational fisheries, and past and present research. The production model is discussed along with the background of the anchovy and its biology, including distribution, age and growth, and feeding. Issues regarding the use of the anchovy resource are discussed in detail.

The validity of otoliths as indicators of age of petrale sole from California.

AUTHOR(S): Gregory, P. A. and T. Jow.

YEAR: 1976.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 62(2):132-140.

KEYWORDS: Petrale sole, *Eopsetta jordani*, age.

ABSTRACT: Otoliths of petrale sole (*Eopsetta jordani*) were analyzed to determine age. Otolith margins and length frequencies were compared to actual growth. Seasonal variability in opaque or hyaline margins exists. Hyaline margins are found from November through March, declining to 20% in August. Opaque zones peaked in August (80%) after first appearing in April. A linear relationship between otolith radius (R) and total length (TL) was found ( $TL = -4.3347 + 16.7553R$ ). No significant difference was found between calculated and observed mean total lengths of fishes age I, II, III, and IV. In length frequencies both single and double modes were seen. Hyaline zones were determined to be annuli. Some otoliths have an extended period of hyaline zones on margins and crowding of marginal zones. In the former case, fish

spawned in one winter would not have completely formed annuli with an outer opaque zone until 18 months later. Consequently, an arbitrary birth date of January 1 is given and all fish with hyaline margins from January 1 to September 1 regardless of the presence or absence of an outer opaque zone are considered to have a full annuli. Those from September 1 to December 31 are not considered annuli.

Results of the jack mackerel subpopulation discrimination feasibility study.

AUTHOR(S): Gregory, P. A., and R. N. Tasto.

YEAR: 1976.

SOURCE: Calif. Fish Game, Mar. Res. Admin. Rep. 76-2. 14 pp.

KEYWORDS: Jack mackerel, *Trachurus symmetricus*, fishery, distribution.

ABSTRACT: The purpose of this study was to determine if histochemical, morphometric and meristic characters can differentiate between subpopulations of jack mackerel (*Trachurus symmetricus*) off of the southern California and Baja California coast. Jack mackerel remain inshore for their first 3 to 6 years. As they grow older and larger, they school less and inhabit offshore waters outside the range of the existing commercial fishery. This study was initiated to determine the relationship between inshore and offshore populations. Blood samples were collected for the electrophoresis studies. Of 11 tests conducted, only phosphoglucose isomerase (PGI) showed sufficient polymorphism to be useful in a study of genetic variability as an indicator of subpopulation status. PGI activity was found at only one locus, and was not found to significantly differ between samples. Heterogeneity was found only in anal fin rays counts. Recommendations for future studies are included.

Feeding behavior of three oceanic fishes (*Oncorhynchus kisutch*, *Trachurus symmetricus*, *Anoplopoma fimbria*) from the northeastern Pacific.

AUTHOR(S): Grinols, R. B. and C. D. Gill

YEAR: 1968.

SOURCE: Jour. Fish. Res. Bd. Canada 25(4):825-827.

KEYWORDS: Coho salmon, jack mackerel, sablefish, *Oncorhynchus kisutch*, *Trachurus symmetricus*, *Anoplopoma fimbria*, feeding, behavior.

ABSTRACT: Observations of the feeding behavior and an analysis of stomach contents of three oceanic fish species. Flood lights hung over the side of a research vessel at night attracted saury and blue lanternfish, which in turn attracted the three predatory species (coho salmon, jack mackerel, sablefish). Blue and soupfin sharks were also observed preying on the saury and blue lanternfish. Observations on the feeding behavior of the salmon, mackerel and sablefish showed that a single salmon would circle the concentration of foraging fishes then rapidly charge the concentration churning the surface into a froth until the prey would disappear. Stomach contents from two salmon specimens contained saury, blue lanternfish and euphausiids. Jack mackerel would approach the prey in schools of up to 40 individuals. To attack, each individual would swim swiftly toward the surface, seeking individual prey. Jack mackerel appeared to select and pursue individual prey. The stomach contents from one jack mackerel contained two saury and three blue lanternfish. Sablefish would approach the prey either singly or in groups of up to twelve individuals. Individual sablefish would seek out its

selected prey at the surface. Their predatory activity appeared to be more premeditated toward single individuals than the other two species. Stomachs from fifteen sablefish contained blue lanternfish, euphausiids and saury.

Morphological evidence for starvation and prey size selection of sea-caught larval sablefish, *Anoplopoma fimbria*.

AUTHOR(S): Grover, J. J., and B. L. Olla.

YEAR: 1986.

SOURCE: Fish. Bull. 84(2):484-489.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, feeding, larvae.

ABSTRACT: In this study sea-caught larval sablefish were examined using selected morphological measurements to determine variability in larval condition. Prey size-selection and feeding requirements were also examined to determine if there is a relationship between larval condition and feeding requirements. Larvae were collected from 9 stations off Washington and Oregon. At one of the stations (No. 25) 82% of the larvae (<12.5 mm SL) appeared to be starving. Although starving larvae appeared at only one station, their presence confirms that sablefish larvae do encounter suboptimal environmental conditions in the sea. From an analysis of gut contents smaller sablefish appear limited in the size of prey they can exploit. This limitation, combined with the small larvae (<12.5 mm SL) being associated an unsuitable prey at Station 25, may have been responsible for the high incidence of empty guts and starvation at that station.

Hydrocarbons in Dungeness crabs, *Cancer magister*, and estuarine sediments.

AUTHOR(S): Guard, H. E., L. H. DiSalvo, J. Ng, and P. W. Wild.

YEAR: 1983.

SOURCE: Pages 243-258 in P. W. Wild and R. N. Tasato (eds.), Life history, environment, and mariculture studies of the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, *Cancer magister*, life history, early life history, fishery, contaminant levels.

ABSTRACT: The purpose of this study was to assess the relative importance of hydrocarbon accumulation in Dungeness crabs from San Francisco and Eureka areas in relation to the decline of their fishery. In part one of this study, they compared hydrocarbon levels in various tissues of Dungeness crabs from San Francisco area versus Eureka area where the crab fishery has not experienced a similar drastic decline. The second part of the study involved identifying major hydrocarbons in San Francisco Bay juvenile crabs and the sediments where they occur. Part one revealed no significant difference in hydrocarbon levels in either muscle or hepatopancreas between male and female crabs. However, for total hepatopancreas tissue total hydrocarbon levels for San Francisco crabs averaged more than three times that found in Eureka crabs. These adult San Francisco crabs were also shown to have significantly higher levels of saturates, unsaturates, and total hydrocarbons in hepatopancreas tissue compared with muscle, gonads, and eggs. This same difference was not noted for Eureka crabs. Part two of this study revealed that sediments from the eastern shore of the San Francisco Bay contained appreciable amounts of saturates, unsaturates, and PAH. The sediment

associated oil was rich in unsaturates (33-51% of total hydrocarbon) which may be of petroleum origin. Altogether, 17 PAH were identified, including several mammalian carcinogens as well as a few microbial mutagens. The source of these hydrocarbons was not clearly identified. It is also unclear what long-term sublethal effects these hydrocarbons may have on the Dungeness crab populations.

The reproduction of some species of pelagic sharks from the equatorial zone of the Indian Ocean.

AUTHOR(S): Gubanov, Ye. P.

YEAR: 1978.

SOURCE: Jour. Ichthyo. 18(5):781-792.

KEYWORDS: Thresher shark, reproduction, *Alopias vulpinus*.

ABSTRACT: The reproduction of nine species of shark (comprising 3,897 individuals and 235 pregnant females) from the equatorial Indian Ocean was studied. The species studied included dusky shark (*Carcharhinus obscurus*), oceanic whitetip (*C. longimanus*) blacktip (*C. limbatus*), whitetip (*C. albimarginatus*), blue (*Prionace glauca*), tiger (*Galeocerdo cuvier*), shortfin mako (*Isurus oxyrinchus*), thresher (*Alopias vulpinus*), and the bigeye thresher (*A. superciliosus*). Two types of reproduction were found in these pelagic species; viviparity and ovoviviparity. The fecundity was comparatively low ranging from 2 embryos in the thresher to 50 to 100 in the blue shark. Only the whitetip shark showed a tendency for increased litter size with maternal growth. However, size of the embryos was directly related to size of the mother. The oceanic whitetip exhibited reproductive seasonality (December-January and April-May) while the dusky, blacktip, whitetip, blue and both threshers reproduced year around. More data was needed to determine reproductive periodicity in the tiger and shortfin mako sharks.

The great widow rockfish hunt of 1980-1982.

AUTHOR(S): Gunderson, D. R.

YEAR: 1984.

SOURCE: N. Amer. Jour. Fish. Mgmt. 4:465-468.

KEYWORDS: *Sebastes entomelas*, widow rockfish, fishery, regulations, groundfish, population trends, economics.

ABSTRACT: History of the *S. entomelas* fishery was described. The rapid depletion of the *S. entomelas* resource along the eastern Pacific coast was discussed. This depletion revealed significant weaknesses in the current fisheries management regime and suggested that groundfish management policies need to be reassessed. Management ideas included greater control of harvest limits and long term reduction in the number and capacity of fishing vessels.

Distribution and abundance of rockfish off Washington, Oregon and California during 1977.

AUTHOR(S): Gunderson, D. R., and T. M. Sample.

YEAR: 1980.

SOURCE: Mar. Fish. Rev. 42(3-4):2-16.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Sebastes goodei*, chilipepper rockfish, *Sebastes entomelas*, widow rockfish, habitat, distribution.

ABSTRACT: Estimates of pelagic and demersal rockfish abundance were made



with hydroacoustic/midwater trawls and benthic trawls, respectively at various locations between Pt. Hueneme, California and Cape Flattery, Washington during 1977. Biomass estimates (kg caught per km trawled) for the dominant species caught were illustrated geographically (including *S. paucispinis* and *S. goodei*). *S. paucispinis* and *S. goodei* were most abundant south of Cape Mendicino, California (particularly in the Monterey INPFC area) and were almost most abundant in the Vancouver INPFC area at the shallowest depth interval (50-99 fathoms) sampled. *S. entomelas* was most abundant in midwater samples. Ninety percent confidence estimates are presented and discussed. It is suggested that results from this study be used to make more precise estimates of target species over smaller sample areas.

Maturation and fecundity of four species of *Sebastes*.

AUTHOR(S): Gunderson, D. R., P. Callahan, and B. Goiney.

YEAR: 1980.

SOURCE: Mar. Fish. Rev. 42(3-4):74-79.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Sebastes goodei*, chilipepper rockfish, reproduction, spawning.

ABSTRACT: The length-maturity and length-fecundity relationships of four species of rockfish (genus *Sebastes*) including *Sebastes paucispinis* and *S. goodei* are assessed from samples collected during the 1977 Rockfish Survey extending from Pt. Hueneme, California to Cape Flattery, Washington. The embryo release period for female *S. goodei* encompasses a relatively short period of time. Female *S. paucispinis* exhibited a wide range of maturity states indicating either a single, broad spawning period or multiple spawning. A large proportion of male and female *S. paucispinis* were sexually inactive. Consequently, the length-maturity relationship determined for this species should be considered tentative. This assessment should be conducted somewhat later in the year than July-August. The size composition of oocytes within ovaries of all four species is illustrated. All *S. goodei* oocytes larger than 0.22 mm were considered mature. Geographical trends of the length-maturity relationships for *S. goodei* were calculated for different latitudes within northern California. The length-maturity relationships determined from this study differ from those determined by Phillips (1964). *S. goodei* exhibited a much lower fecundity than the other rockfishes. *S. paucispinis* ovaries were not mature enough to distinguish mature and immature oocytes.

A review of the fisheries of the Gulf of Mexico.

AUTHOR(S): Gusey, W.

YEAR: 1981.

SOURCE: In: United States Environmental Protection Agency before the administrator - Testimony of Frank Hester, Docket IX-WP-80-3. Attachment 13.

KEYWORDS: Fishery, platform, feeding, economics, artificial reef.

ABSTRACT: A detailed description of the commercial fishery in the Gulf of Mexico, along with the development of oil production and associated fishery enhancement. The Gulf of Mexico is a very productive area. Some of the commercial fisheries include red snappers, mullet, sea trout, red drum, sheepshead, shrimp, blue crab, sponges, and turtles. Fresh-water species include catfish and buffalofish. Since 1940, the Gulf fisheries have been in a

period of accelerated expansion. Along with its great biological productivity, the Gulf of Mexico has "the greatest concentration of coastal and offshore oil industry activity in the world." The oil platforms used for accessing the oil have provided millions of square feet of solid substrate which act as artificial reefs. It appears that as the platforms have increased there has been an increase in the number of fish, fishing areas, and fishermen. These "artificial reefs" attract fishes for a variety of reasons, including a food source (encrusting organisms), protection and attraction to a solid object.

Abnormal vertebral development in northern anchovy, *Engraulis mordax girard*.

AUTHOR(S): Haaker, P. L.

YEAR: 1977.

SOURCE: Calif. Fish Game 63(3):182-185.

KEYWORDS: *Engraulis mordax*, northern anchovy, physiology.

ABSTRACT: Eight abnormal northern anchovies, *Engraulis mordax*, with abnormal vertebral development, including lordosis and scoliosis, were collected from the forebay at Huntington Beach Generating Station, Huntington Beach, California. The deformities did not reveal vertebral fusion and discs were deformed from the spinal curvature. The approximate frequency of occurrence was 0.46 fish per 1000 fish collected. The identification of factors involved in causing such deformations was not possible.

The biology of the California halibut, *Paralichthys californicus* (Ayres), in Anaheim Bay, California.

AUTHOR(S): Haaker, P. L.

YEAR: 1975.

SOURCE: Pages 137-151 in E. D. Lane and C. W. Hill (eds.). The marine resources of Anaheim Bay, Calif. Dept. Fish Game, Fish Bull. 165:195 pp.

KEYWORDS: California Halibut, *Paralichthys californicus*, nursery, feeding, growth, age.

ABSTRACT: California halibut, *Paralichthys californicus*, were sampled over two years in Anaheim Bay for use in gut analysis, age and growth, reproductive indices and feeding studies. The guts of 292 halibut of various sizes were examined. Individuals less than 55 mm fed primarily on crustaceans; those from 55 to 230 mm ate large crustaceans and fish, and halibut larger than 230 mm were totally piscivorous. Age and growth was determined utilizing otoliths, scales and length frequencies. Females at 1 and 2 years of age grew faster than males. The sex ratio appeared to approximate a 1:1 ratio. Males matured at about 200 mm and females at about 375 mm. The ovaries contained immature ova (.009 to .120 mm in diameter) supporting evidence that the Anaheim Bay population was composed of immature individuals. Anaheim Bay was used as a nursery ground between April and May. Mature individuals migrated inshore during the spring to spawn.

Bivalvia: The clams and allies.

AUTHOR(S): Haderlie, E. C., and D. P. Abbott.

YEAR: 1980.

SOURCE: Pages 355-411 in R. H. Morris, D. P. Abbott, and E. C. Haderlie (eds.), Intertidal invertebrates of California, Stanford Univ. Press, Stanford, CA.

KEYWORDS: Dungeness crab, Cancer magister, feeding.

ABSTRACT: This section of Intertidal Invertebrates of California addresses

the class Bivalvia, the bilaterally symmetrical mollusks that include the clams, oysters, scallops and mussels. The biology of the animals is discussed as well as its distinctive characteristics, range, habitat, interactions with other species, economic importance and current research.

The biology of the Dover sole, *Microstomus pacificus* (Lockington).

AUTHOR(S): Hagerman, F. B.

YEAR: 1952

SOURCE: Calif. Dept. Fish Game, Fish Bull. 85.

KEYWORDS: Dover sole, *Microstomus pacificus*.

ABSTRACT: This bulletin presents information on the biology of the Dover sole (*Microstomus pacificus*). About 3,200 specimens were collected from July 1948 to October 1949. Their distribution ranged from southern California to Alaska. Refer to paper for extensive description and meristic counts. The sex ratio in the commercial catch was about 3:1. Males mature earlier than females, between 30-39 cm. Females mature between 35-45 cm. The height of the spawning season is throughout December, January and February. Large females are estimated to produce about 230,000 eggs. The distribution of larvae is from California to Mexico. The young become demersal between 50 and 55 mm in length and are found inshore along the bottom. Dover sole appear to feed mainly on mud-inhabiting sedentary invertebrates. There is a differential growth rate between males and females; females have a faster growth rate and the ultimate size is greater. By six years the females average 30 mm longer than males of the same age. Adults appear to migrate to deeper water during the spawning season. In early spring, younger fish migrate to shallower nursery grounds. In summer months the sexes appear to segregate themselves.

Mercury in fish and shellfish of the Northeast Pacific. II. sablefish, *Anoplopoma fimbria*.

AUTHOR(S): Hall, A. S., F. M. Teeny, E. J. Gauglitz, Jr.

YEAR: 1976.

SOURCE: Fish. Bull. 74(4):791-797.

KEYWORDS: Contaminant susceptibility, fishery, regulations, distribution, age, groundfish, sablefish, *Anoplopoma fimbria*.

ABSTRACT: Mercury content was determined for fish collected off the coasts of Alaska, Washington, Oregon and California. The mean mercury levels showed an increase from north to south. An inverse gradient in fish size occurred from north to south with the fish becoming smaller as you go south. There appeared to be a direct relationship between sablefish size and age with the mercury level found in the muscle. Although it would seem logical that the correlation between age and mercury level would be higher than the correlation between weight and mercury, this was not observed. Mercury levels in males compared to females showed a greater correlation in females. Of the sablefish specimens observed for this study approximately 30% exceeded the U. S. Food and Drug Administration action level of 0.5 ppm mercury.

Mercury in fish and shellfish of the northeast Pacific. II.  
sablefish, *Anoplopoma fimbria*.

AUTHOR(S): Hall, Alice S., F. M. Teeny, and E. J. Gauglitz, Jr.

YEAR: 1976.

SOURCE: Fish. Bull. 74(4):791-797.

KEYWORDS: Age, distribution, sablefish, *Anoplopoma fimbria*, contaminant levels, weight/length.

ABSTRACT: The level of mercury in the edible muscle tissue of sablefish, *Anoplopoma fimbria* was investigated and related to geographical distribution, weight and sex. A total of 692 sablefish taken from the Bering Sea, Alaska to San Diego, California were analyzed for individual mercury content. The mean mercury levels showed a general increase from north to south, as did the percentage of fish that exceeded the FDA action level of 0.50 ppm. The mean mercury levels (ppm) and the percentage that exceeded the FDA action level by area are as follows: Bering Sea and Kodiak Island - 0.40 (29%); northern California 0.26 (21%); central California - 0.47 (43%); southern California - 0.60 (72%). The average size of the specimens decreased in size, north to south. The relationship between weight and mercury level was highly significant (0.1% level) in all areas except the Bering Sea - Kodiak Island area. Larger fish had higher mercury levels until at the southern end of the range even small fish exhibited high mercury levels. Females showed a better correlation between weight and mercury than did males, however, correlation coefficients were significant for both sexes. Relationships between age and mercury were significant in all areas except Washington. It was concluded that sable fish can accumulate mercury in amounts that exceed the maximum level permitted in fish by the FDA.

Update of the estimated mortality rate of *Engraulis mordax* in southern California.

AUTHOR(S): Hanan, D.

YEAR: 1981.

SOURCE: Calif. Fish Game 67(1):62-65.

KEYWORDS: Northern anchovy, *Engraulis mordax*, mortality, population trends.

ABSTRACT: Annual mortality ( $a$ ) and instantaneous total mortality ( $Z$ ) are calculated using the Chapman-Robson method, and a time series is plotted to show long term trends in the parameter values. Instantaneous total mortality was estimated to be 0.97 with an annual mortality of 62.1%. A high between-sample variance existed due to high variability in recruitment or relative year class strengths. Prior to 1976, a 10-year decreasing trend existed, while after 1976 a 4-year increase in mortality occurred. This coincides with a decrease in older anchovies in catches and a decline in the total U.S. commercial catch in the central subpopulation area.

Analysis of the common thresher shark, *Alopias vulpinus*, in the California bight.

AUTHOR(S): Hanan, D. A.

YEAR: 1984.

SOURCE: Calif. Fish & Game/Southwest Fisheries Center, NMFS. Admin. Rep. LF-84-10C. 34 pp.

KEYWORDS: Thresher shark, *Alopias vulpinus*, fishery, mortality.

ABSTRACT: The thresher shark, *Alopias vulpinus*, has been the object of a gill fishery since 1977 and data from observations, skippers logs, and DFG landing receipts were used to analyze the impact of the fishery on these elasmobranchs. Catches have increased from 129,522 lbs. in 1977 to 2,192,134 lbs. in 1982. Catch per unit effort data were available for only 1981-82 which indicated a slight shift towards smaller sharks in 1982. Limited entry into the fishery and restrictions on drift gill net size are two of the limits imposed by legislation enacted in 1982 to protect this fishery resource. Little knowledge exists on the life history of threshers. They are ovoviviporous and bear 2 to 4 young. Females reach maturity in 7 to 9 years, while males mature at a slightly earlier age. Some reports indicate the sharks undergo extensive migrations. A model was developed from the available data, which suggested sustainable fishing mortality ranged from .007 plus or minus .049. These low harvest mortality rates were consistent with historical experience with shark fisheries.

Rearing experiments on the California market squid *Loligo opalescens* Berry, 1911.

AUTHOR(S): Hanlon, R. T., R. F. Hixon, W. H. Hulet, and W. T. Yang.

YEAR: 1979.

SOURCE: *Veliger* 21(4):428.

KEYWORDS: Market squid, *Loligo opalescens*, growth, feeding.

ABSTRACT: Market squid, *Loligo opalescens*, were reared in closed, artificial seawater systems in 64 liter rectangular tanks. Two diets were fed to four groups of squid. The first treatment consisted exclusively of brine shrimp nauplii fed to 80 hatchlings (exp. 1) and 90 hatchlings (exp. 2). The other treatment included wild populations of copepods, brine shrimp nauplii and adults, barnacle nauplii, larval fish and *Loligo* hatchlings. Density of food organisms never exceeded 1 organism/ml. In the first two experiments no squid survived longer than 10 days. In experiment 3 11% of the hatchlings survived past day 10 and 1 lasted to day 35. The greatest survival rates were observed in experiment 4, where 15% survived longer than 10 days, 8% longer than 60 days and 1 lasted 79 days. Growth rates averaged from 1.1 to 5.6 mm ml/month. Older individuals tended to grow faster. The largest squid lived 79 days and measured 7.3 mm ML.

Feeding attractants in chemical constituents of brown alga for young abalone.

AUTHOR(S): Harada, K., S. Maruyama, and K. Nakano.

YEAR: 1984.

SOURCE: *Bull. Jap. Soc. Sci. Fish.* 50(a):1541-1544.

KEYWORDS: Abalone, *Haliotis* spp., feeding.

ABSTRACT: One hundred young abalone, *Haliotis discus*, (approximately 2.3 cm long) were tested for attraction by proteins, lipids, amino acids, volatile bases and betaines fractionated from the brown alga *Ishige okamurai*. The attraction index was higher for all fractions (except betaines) than obtained on the control. The fractions were equal to the whole extract. A variety of 2 and 3 extract combinations showed more effective attraction than single constituents. The results suggested that proteins, lipids, amino acids and bases were the constituents of brown algae which caused feeding attraction. In addition, these constituents acted in a

synergistic manner to the abalone.

Indices of the availability of market squid, *Loligo opalescens*, to the Monterey Bay fishery.

AUTHOR(S): Hardwick, J. E., and J. D. Spratt.

YEAR: 1979.

SOURCE: CalCOFI Rep. 20:35-39.

KEYWORDS: Market squid, *Loligo opalescens*, fishery.

ABSTRACT: Four indices were used to predict the availability of market squid, *Loligo opalescens* in Monterey. These included the annual Monterey landings, ratio of Monterey to southern California landings, catch per delivery day, and price paid to fishermen. A cumulative analysis revealed poor availability of squid during 1952, 1958, 1960, 1961, 1966, 1970, 1973 and 1975. The squid availability appears to be affected by the previous year's fourth quarter sea elevation.

The marine environment in Upper Newport and Sunset Bays, Orange County, California.

AUTHOR(S): Hardy, R. A.

YEAR: 1970.

SOURCE: Calif. Dept. Fish Game, Mar. Res. Reg. Publ. 70, 10 pp.

KEYWORDS: Habitat, *Strongylocentrotus* spp., urchin, kelp bass, *Paralabrax clathratus*, *Paralichthys californicus*, contaminant levels, community.

ABSTRACT: Information on the physical and biological characteristics of Sunset Bay (a dredged, concrete-diked residential marina) and Upper Newport Bay (a generally unmodified bay) were recorded and compared. Information on the physical characteristics included substrate type, water temperature, dissolved oxygen, etc., while the biological information included bacteria levels, pesticide levels, and a comparison between three major habitat types. The differences observed between Sunset and Upper Newport Bays suggest that changes would occur in Upper Newport Bay after its development.

Species selective predation on juvenile pink (*Oncorhynchus gorboscha*) and chum salmon (*O. keta*) by coho salmon (*O. kisutch*).

AUTHOR(S): Hargreaves, N. B., and R. J. LeBrasseur.

YEAR: 1985.

SOURCE: Jour. Fish. Aquat. Sci. Canada 42(4):659-668.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, feeding, behavior, early life history, wetfish.

ABSTRACT: Predation by coho salmon smolts has been speculated to be the primary cause of mortality among yearling pink and chum salmon during their first few months of ocean residence. This study was initiated to determine if coho smolts preferred one species over the other. The results showed greater mortality, presumably by coho predation, among pink salmon enclosed with coho and chum salmon, despite the fact that chum were almost three times as abundant. Rechecking the data from an earlier study conducted in Burke Channel, British Columbia, showed clear signs of prey selection by the coho, also indicating a preference for pink salmon. The authors conclude that during early sea-life, prey species may be more important than prey size for coho salmon feeding on mixed populations of pink and chum salmon.

Preliminary report on maturity, spawning season and larvae  
identification of rockfishes (Scorpaenidae) collected during  
1970.

AUTHOR(S): Harling, W. R., M. S. Smith, and N. A. Webb.

YEAR: 1971.

SOURCE: Jour. Fish. Res. Bd. Canada unpubl. ms Rep. No. 1137.

KEYWORDS: *Sebastes entomelas*, widow rockfish, *Sebastes paucispinis*,  
bocaccio, larvae, ichthyoplankton, spawning, reproduction.

ABSTRACT: Description of the stages of maturity, estimated spawning  
season, and description of larvae of rockfishes (genus *Sebastes*)  
collected off British Columbia and southeast Alaska during 1970  
were included. The size of 50 percent maturity for *S. entomelas*  
is estimated to be 43 cm for males and 45-49 cm for females. The  
size of 50 percent maturity for *S. paucispinis* is estimated to be  
57 cm for males and 62 cm for females. Illustrates the pigment  
patterns of larval *S. entomelas* were illustrated.

Preliminary report on maturity, spawning season, and larvae  
identification of rockfishes (*Sebastodes*) collected in waters  
off British Columbia during February 1969.

AUTHOR(S): Harling, W. R., M. S. Smith, D. Davenport, and D. M. Bianchin.

YEAR: 1969.

SOURCE: Jour. Fish. Res. Bd. Canada unpubl. ms. Rep. No. 1055.

KEYWORDS: *Sebastes entomelas*, widow rockfish, spawning, reproduction.

ABSTRACT: Describes the testes and ovary condition of size classes of  
*Sebastes entomelas* collected off British Columbia during February  
1969. The size at 50 percent maturity for *S. entomelas* is 37 cm  
for males and >40 cm for females.

Food availability, sea urchin grazing, and kelp forest  
community structure.

AUTHOR(S): Harrold, C., and D. C. Reed.

YEAR: 1985.

SOURCE: Ecology 66(4):1160-1169.

KEYWORDS: Sea urchins, *Strongylocentrotus* sp., feeding.

ABSTRACT: Red sea urchin, *Strongylocentrotus franciscanus*, grazing off  
San Nicholas Island was uncharacteristically sporadic. Kelp  
forests and barrens existed side by side. The regulating factor  
was found to be the availability of drift algae. In urchin  
barrens, drift abundances were low, urchins grazed the substrate  
and gave up crevice microhabitats. In the kelp forests, drift  
abundances were high and urchins collected drift while staying in  
their crevices. The drift abundances were related to the  
macroflora cover which was regulated by hydrographic conditions.  
This theory was supported by evidence collected during a strong  
algal recruitment to the barrens. Urchins switched over to a  
growing behavior more typical in kelp forest communities.

Pacific fishes of Canada.

AUTHOR(S): Hart, J. L.

YEAR: 1973.

SOURCE: Fish. Res. Bd. Canada, Bull. No. 180. 740 pp.

KEYWORDS: All species, life history, distribution, spawning, feeding.

ABSTRACT: Guide to 325 fish species occurring along the Pacific Coast of  
Canada. Species descriptions include: a physical description of  
the species including information on fins, scales and color,

size, range; characteristics important in making quick identifications; brief account of the life history; total range and distribution in British Columbia; and utilization in industry and/or economic significance.

Distribution of zooplankton in association with Dungeness crab, *Cancer magister*, larvae in California.

AUTHOR(S): Hatfield, S. E.

YEAR: 1983.

SOURCE: Pages 97-124 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, *Cancer magister*, larvae, distribution.

ABSTRACT: This study analyzed the distribution of both holoplankton and meroplankton in the Gulf of the Farallons and northward, along the coast of California. This analysis was conducted in order to determine the effects of ocean currents on the distribution of the Dungeness crab, *Cancer magister*, larvae. Analysis was done by year, from 1976-1979. The distribution of various decapod larvae and other zooplankton are discussed. Refer to paper for species list and recurrent group of zooplankton analysis. Zooplankton distribution is discussed in light of large-scale current systems as well as local phenomenon. Late zoeal stages of *Cancer magister*, as well as *C. productus* and *C. gracilis* were not found close to shore near San Francisco, unlike *C. antennarius*. Dungeness crab zoea appear to move offshore and presumably alongshore during late winter and the winter-spring transition period. The megalopae are found nearshore once upwelling begins, although the mechanism by which they move inshore is unclear. This paper contains little actual data on Dungeness crab larvae.

Intermolt staging and distribution of Dungeness crab, *Cancer magister*, megalopae.

AUTHOR(S): Hatfield, S. E.

YEAR: 1983.

SOURCE: Pages 85-96 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies on the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, *Cancer magister*, feeding, behavior.

ABSTRACT: The purpose of this study was to determine the sequence of epidermal changes occurring during the intermolt period between Stage V larvae and megalopa and the molt of megalopa to first juvenile instar. This information was used to study the relationship between geographic distribution and timing of events during this larval stage. This variability may however be due to laboratory conditions. Distance from shore, date and latitude on intermolt stage explains 76% of the variation in the offshore data and confirms the annual movement of megalopae toward the coast from offshore over a relatively consistent period of time.

Progress report on anchovy tagging off California and Baja California, March 1966 through May 1969.

AUTHOR(S): Haugen, C. W., J. D. Messersmith, and R. H. Wickwire.

YEAR: 1969.

SOURCE: Pages 75-89 in J. D. Messersmith (ed.), The northern anchovy



(*Engraulis mordax*) and its fishery 1965-1968. Calif. Dep. Fish Game, Fish Bull. 147.

KEYWORDS: Anchovy, *Engraulis mordax*, fishery, distribution.

ABSTRACT: This paper reports the results of three years of anchovy tagging

conducted from March 1966 through May 1969. A map depicting the major movements of tagged and recaptured anchovies is provided. Also discussed are the special studies undertaken to assess the cause and rate of tag loss occurring in the reduction plants. The reduction system from the fishing vessel to the grinding mill is diagrammatically illustrated.

Hilda's hidden haven.

AUTHOR(S): Hauser, H.

YEAR: 1974.

SOURCE: Exxon USA 13(4):17-21.

KEYWORDS: Platform, community, artificial reef.

ABSTRACT: Oil production Platform Hilda is located 2 miles offshore in 106 ft of water in the Santa Barbara Channel. Most life was found in 30 to 40 ft of water. On underpillings, hydrozoans were observed within a month after construction. Plant life was also observed in early stages. Barnacles colonized the surfaces in dense clusters, along with mussels. Areas not occupied by mollusks were covered with concentrations of club anemones. Sea perches, including white, black, rubberlip, and pile, were the most numerous fishes around the platform. Next in abundance were the rockfishes. Other fishes observed included sculpins, sea bass, calico bass, cabezon, and treefish. Schools of sardines, mackerel, and bonito were observed around the structure. Offshore oil platforms function as artificial reefs. They provide suitable substrate for larval forms drifting in the ocean to settle on and grow. Commercial fishermen and charter boats visit platforms as the best guarantee of a catch.

Outer Continental Shelf Oil and Gas Information Program - Pacific Summary Report.

AUTHOR(S): Havran, K. J.

YEAR: 1983.

SOURCE: Minerals Management Service Publ.

KEYWORDS: Platform, distribution, habitat.

ABSTRACT: Similar to the previous Pacific Summary Reports, this is organized around four chapters: 1) geologic information, 2) magnitude and timing of offshore development, 3) identification and analysis options proposed for transporting offshore oil and gas to shore-based processing plants, and 4) industry proposal for coastal facilities considering planning and permitting constraints.

Environment and cohort strength of Dover sole and English Sole.

AUTHOR(S): Hayman, R. A., and A. V. Tyler.

YEAR: 1980.

SOURCE: Trans. Am. Fish. Soc. 109(1):54-70.

KEYWORDS: *Microstomus pacificus*, Dover sole, *Parophrys vetulus*, English sole, recruitment.

ABSTRACT: The correlation between environmental factors and cohort strength was analyzed for the Dover sole (*Microstomus pacificus*),

and the English sole (*Parophrys vetulus*). A multiple regression model was constituted to describe observed cohort strength as a function of a few significant environmental (oceanographic or river) factors. Exploratory correlations included: patterns in cohort strength, critical periods, sea surface temperature, barometric pressure, vertical and longitudinal transport, wind magnitude, offshore divergence, river discharge, solar radiation, short-term weather variability and spawning capacity. Ten factors for the Dover sole and eight for the English sole accounted for significant quantities of the observed variation. The population trends of both species was most closely related to environmental, specifically oceanographic factors. Each species is affected by a different set of factors. This is probably because of the differences in habitat of the young of both species. However, variation in age class or cohort strength of both soles can be explained on the basis of factors associated with upwelling occurring in the early life history of these groundfish.

Comparison of cohort analysis and catch per unit effort for  
Dover sole and English sole.

AUTHOR(S): Hayman, R.A., A. V. Tyler, and R. L. Demory.

YEAR: 1980.

SOURCE: Trans. Am. Fish. Soc. 109(1):35-53.

KEYWORDS: Dover sole, *Microstomus pacificus*, English sole, *Parophrys vetulus*, fishery, population trends, recruitment.

ABSTRACT: Catch-per-unit-effort (CPUE) and cohort analysis results were used to calculate year class strength, stock and production of female Dover sole, *Microstomus pacificus*, and female English sole *Parophrys vetulus*, in fisheries off the Columbia River. The CPUE indices for Dover sole showed strong year classes in the 1940s and 50s with a subsequent decline in the late 1950s and a resurgence during the early 1960s. English sole CPUE indices suggest a high recruitment in 1961, followed by a slow decrease. However, no long term trends were apparent. Cohort analysis data for both species shows a gradual decline in the female stock in the 1950s with a leveling in the early 1960s. Surplus production plots suggest slightly higher yields are possible with increased effort. CPUE data suggest stock sines increased in the 1970s. Differences in CPUE and cohort analysis, for the Dover sole, were attributed to unusable effort data. However, both methods worked well on the English sole, presumably due to more valid effort data.

Inter- and intra-population variation in the fecundity of  
chinook salmon (*Oncorhynchus tshawytscha*) and its relevance to  
life history theory.

AUTHOR(S): Healey, M. C., and W. R. Heard.

YEAR: 1984.

SOURCE: Jour. Fish Aquat. Sci. Can. 41:476-483.

KEYWORDS: Chinook salmon, *Oncorhynchus tshawytscha*, life history, reproduction.

ABSTRACT: The purpose of this study was to determine the inter- and intra-population variation in fecundity in chinook salmon (*Oncorhynchus tshawytscha*) and to relate this information to predictions of life history theory. A total of 155 samples from various published and unpublished data were used. The fish ranged in length from 401 to 987 mm. Most of the age composition data

were from samples taken by netting, and the ages were all determined from scales. Variation in length explained only 76% of variation in fecundity and in most (73%) instances explained less than 50%. Variation in age, seasonal timing of subpopulations, and stream or ocean type life history pattern did not significantly contribute to variation in fecundity beyond their correlation with length. The average age of reproducing females varied from 3.94 - 6.04 years. The average total age of reproducing females was positively correlated with average fecundity at 740 mm. Fecundity increased with increasing age of maturity and is consistent with theoretical predictions of the trade-off between fecundity and mortality in fish of reproductive age. Data is analyzed in terms of reproductive life history theory.

Common seashore life of southern California.

AUTHOR(S): Hedgpeth, J. W., and S. Hinton.

YEAR: 1961.

SOURCE: Naturegraph Co., Healdsburg, CA. 65 p.

KEYWORDS: Red abalone, *Haliotis rufescens*, habitat.

ABSTRACT: This text discusses the common seashore life found in the area from

Pt. Conception to the Mexican border. The four zones, splash, high tide, middle tide and low tide, are described and the flora and fauna that inhabit each zone are identified. Sand beaches, coves and bay shores are also discussed as well as their inhabitants. A systematic list of animals and plants using common and scientific names is provided for easy reference, along with a map of the study area.

DDT and PCB in benthic crabs.

AUTHOR(S): Heeson, T. C. and D. J. McDermott.

YEAR: 1974.

SOURCE: Pages 109-111 in W. Bascom (ed.), Coastal Water Research Project, annual report for the year ended 30 June 1974. South. Calif. Coast. Water Res. Proj., Long Beach, CA.

KEYWORDS: Contaminated levels, yellow crab, *Cancer anthonyi*, feeding.

ABSTRACT: DDT and PCB concentrations found in gonad and flesh samples of *Cancer anthonyi* collected in 1971-72. Samples were collected from vicinities of major municipal submarine outfalls and compared with samples collected in control areas. Results of the findings are discussed; however, long-term effects of exposure to these contaminants on the biological processes of *Cancer anthonyi* is not known.

Influence of habitat structure on the fish assemblage associated with two cooling water in-take structures in southern California.

AUTHOR(S): Helvey, M., and R. W. Smith.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):189-199.

KEYWORDS: Artificial reef, community.

ABSTRACT: The fish communities at two cooling water in-take structures and four artificial reefs off Redondo Beach, southern California were studied. Habitat parameters considered included substrate diversity, vertical height, vertical diversity, reef height, and substrate rugosity. Thirty six fish species were observed during

the study; 17 were classified as water column species, and 19 as benthic oriented species. The water column species accounted for the greatest numbers of individuals with the number of individuals similar for all reefs regardless of habitat type. Visual landmarks on the reefs may have been more important than habitat complexity for the water column species. Conversely, substrate diversity appeared to be the important factor for benthic fish assemblages.

The fish population associated with an offshore water intake structure.

AUTHOR(S): Helvy, M., and P. Dorn.

YEAR: 1981.

SOURCE: Bull. Southern California Acad. Sci. 80(1):23-31.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Paralabrax clathratus*, kelp bass, habitat, artificial reef, community, behavior, seasonality.

ABSTRACT: Fish assemblages associated with the water intake structure of a power plant in King Harbor, Redondo Beach, California were described. Underwater cinetransects and visual observations described the seasonal occurrence and response of 40 species of nearshore fishes to water currents at the intake. Observations were made from September 1976 to August 1977. *Paralabrax clathratus* was common and abundant during winter and spring and occasionally observed during fall and summer in the near vicinity of the intake structure. *P. clathratus* displayed a positive rheotaxis toward the water flow of the intake. *S. paucispinis* was recorded as common and abundant during summer, infrequent during fall, and absent during winter and spring. Size classes are not described. Authors conclude that intake structure enhances local fish abundance of these and many other nearshore species.

Commercial fisheries.

AUTHOR(S): Henderson, K.

YEAR: 1982.

SOURCE: Pages 6B-1 to 6B-18 in MBC and CDFG, Marine environmental studies,

Little Cojo Bay, CA., proposed liquefied natural gas terminal, 1981 year end technical report, preconstruction study. MBC Applied Environ. Sci., Costa Mesa, CA, and Calif. Dep. Fish Game, Sacramento, CA.

KEYWORDS: Abalone, *Haliotis* spp., spiny lobster, *Loligo opalescens*, rock crab,

*Cancer* spp., sea urchin, *Strongylocentrotus* spp., fishery.

ABSTRACT: The objective of this study was to assess the impacts of a proposed

liquefied natural gas terminal to be constructed in Little Cojo Bay, CA., on the commercial fishing effort and catch success for abalone, spiny lobster, rock crab and sea urchins. Preconstruction data will be compared with samples taken during construction and operation to assess any impacts. Quantitative data is presented in table and graphic form. A brief discussion of the commercial fishery for each species is also presented.

A progress report on the status of chilipepper (*Sebastes goodei*) off California.

AUTHOR(S): Henry, F. D.

YEAR: 1985.

SOURCE: Pages 5-0 to 5-16 in PFMC. Status of the Pacific Coast groundfish fishery through 1985 and recommended acceptable biological catches for 1986. Pac. Fish. Mgmt. Council, Portland, OR.

KEYWORDS: Chilipepper, *Sebastes goodei*, life history, fishery, regulations, recruitment, mortality, age, length/weight.

ABSTRACT: This progress report discusses the status of chilipepper as it relates to the commercial and recreational fishery. Catch statistics and length composition data are provided for the years 1977 through 1984 for the commercial catches in Eureka, Monterey and Conception areas. Life history characteristics are discussed as well as the materials and methods used for gathering the data and reporting the results.

Metals in marine sediments near a large California municipal outfall.

AUTHOR(S): Hershelman, G. P., H. A. Schafer, and D. R. Young.

YEAR: 1981.

SOURCE: Mar. Poll. Bull. 12:(4):131-134.

KEYWORDS: Contaminant levels, contaminant susceptibility, habitat.

ABSTRACT: Grab samples were taken off the Palos Verdes Peninsula at the Los Angeles County outfall system. Samples were also taken at control stations which were selected by the abundance of certain infauna absent from outfall regions and the low abundance of resistant species found in high numbers in outfall regions. Contamination factors (median outfall/median baseline) were determined for the eight metals detected: silver (27), cadmium (36), chromium (12), copper (20), mercury (approximately 23), nickel (5.4), lead (17), zinc (7.7).

Testimony of Frank Hester.

AUTHOR(S): Hester, F.

YEAR: 1981

SOURCE: United States Environmental Protection Agency before the administrator. County of Ventura, Ventura, CA. Docket No. IX-WP-80-3.

KEYWORDS: Regulations, contaminant level, contaminant availability, mortality, platform, habitat.

ABSTRACT: A testimony by Frank Hester to address charges made by Dr. Mohr,

Scenic Shoreline, and their witnesses, regarding oil development off the California coast. The charges fall into five categories:

- 1.) There is inadequate knowledge about the distribution and species composition of the areas's flora and fauna, the composition of the muds, and the effects of discharges on the environment.
- 2.) Studies are inadequately performed and the people performing the studies are dishonest or incompetent.
- 3.) Discharges of mud and cuttings will result in significant physical damage to the environment.
- 4.) Discharges of muds and cuttings will introduce toxic materials and heavy metals into the environment.
- 5.) Rare or delicate species may be endangered.

Dr. Hester addresses the charges and supports the Environmental Protection Agency's conclusion that "There is sufficient information to support the finding that the proposed (drilling related) activities will not result in significant or long-lasting damage to the ecosystem."

Drilling discharges and demersal fisheries in the Santa Barbara Channel: A historical review.

AUTHOR(S): Hester, F. J.

YEAR: 1984.

SOURCE: (Draft) unpubl. ms. LMR. Inc., San Diego, CA. 23 pp.

KEYWORDS: Ridgeback prawn, spot prawn, English sole, California halibut, rock crab, spiny lobster, sea urchin, *Sicyonia ingentis*, *Pandalus platyceros*, *Parophrys vetulus*, *Paralichthys californicus*, *Cancer productus*, *Cancer anthonyi*, *Panulirus interruptus*, *Strongylocentrotus* spp., fisheries, platform, community, groundfish.

ABSTRACT: Landings of seven bottom-dependent species groups (English sole, California halibut, rockfish (complex), shrimp (complex), spiny lobster, and sea urchin) were estimated from the data files of the California Department of Fish and Game. Changes in annual landings were examined together with the history of Outer Continental Shelf (OCS) activity to see if the estimated 592 exploratory and development wells drilled since 1966 had any apparent relation to changes in fish and shellfish landings. The results show that there is no apparent decline in any fishery related to drilling activity. The decline observed in rockfish may be due to changes in fishing effort rather than drilling discharge. Several positive correlations were found but they were believed coincidental rather than evidence for environmental enhancement due to drilling or platform replacement.

Nearshore production of young anchovy.

AUTHOR(S): Hewitt, R. P., and G. D. Brewer.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:235-244.

KEYWORDS: Northern anchovy, *Engraulis mordax*, population trends, larvae, growth, mortality.

ABSTRACT: Age-specific production estimates are derived for larval northern anchovy, *Engraulis mordax*, from the Southern California Bight and the nearshore zone (portion of the Bight within the 43 m isobath) to determine the importance of the former as a nursery. In the nearshore zone spawning activity is low in the fall followed by an increase in December and a maximum in March. Spawning spread from north to south and by the peak was extensive all along the coast. During the decline in April, May and June, spawning was displaced southward. Little reproduction was evident by July. Production estimates declined with age and initial mortality was great, decreasing as larvae developed. Average egg production in the nearshore area and the Bight were 190 and 230 eggs per day per m<sup>2</sup>, respectively. Initial production of eggs in both areas is equal, early mortality in the nearshore zone higher, and 30-day old larvae production from both areas comparable. Higher early mortality in the nearshore zone may be due to an increase in predation or cannibalism because of the restricted depth range and not yet fully mobile ichthyoplankton. There was no evidence of migrations to or from the two areas. The density of large larvae may be higher in the nearshore zone, but information points to the fact that there is no difference in production between areas. Production in the nearshore zone is representative of that in the Southern California Bight, with the seasonal cycle, the density, and the survival of spawn

comparable.

Distribution and mortality of northern anchovy larvae in 1978 and 1979.

AUTHOR(S): Hewitt, R. P., and R. D. Methot, Jr.

YEAR: 1982.

SOURCE: CalCOFI Rep. 23:226-245.

KEYWORDS: Northern anchovy, *Engraulis mordax*, distribution, mortality, larvae.

ABSTRACT: The distribution, abundance, and mortality of northern anchovy, *Engraulis mordax*, larvae are reported for 1978 and 1979 from ichthyoplankton surveys. Factors affecting survival are also discussed. The geographic distribution of spawning differed between the two years, with the 1979 distribution displaced southward and farther offshore. Temporal distribution also differed. In 1978, spawning peaked in early March, was low by May, and very low in July through August, while in 1979 the peak was also in early March but a moderate level was sustained through May. Larvae were 1.2 times more abundant in 1979. Instantaneous mortality of young larvae in 1978 and 1979 were 0.175 and 0.161, respectively, the difference not significant. Survivorship within 1978 and 1979 was proportional to larval production. The twofold difference in survival between years appears to be as large as survival variability within the years. Temperature patterns, strong storms, and larval transport may be responsible for the significant variations in survival during these two years.

Causes of mortality in young jack mackerel.

AUTHOR(S): Hewitt, R. P., G. H. Theilacker, and Lo Nch.

YEAR: 1985.

SOURCE: Marine ecology progress series 26(1-2):1-10.

KEYWORDS: *Trachurus symmetricus*, jack mackerel, mortality, growth.

ABSTRACT: Field and laboratory experiments were used to quantify some early causes of mortality, predation and starvation. In the Pacific mackerel, *Scomber japonicus*, these fractions were separated by subtracting mortality due to starvation from total mortality and calling this remainder predation. Starvation was determined by histological examination. Growth rate, net retention, and body shrinkage due to preservation were also examined. Data indicated very high initial mortality, leveling off during onset of feeding. There were no indications of starvation in yolk-sac larvae, but starvation became a significant factor when the larvae began to feed. This factor tapers off to insignificance within 10 days. Overall, in terms of numbers removed, predation is the most important factor. Ninety-nine percent of the larvae are removed in the yolk-sac stage, and starvation is only significant for a relatively short time as the larvae begin to feed.

Procedures for calculating the egg production estimate of anchovy spawning biomass.

AUTHOR(S): Hewitt, R., A. Bindman, and N. Lo.

YEAR: 1984.

SOURCE: Southwest Fisheries Center, NMFW, Admin. Rpt. LJ-84-19. 46 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, reproduction.

ABSTRACT: The programs and data files used to generate the egg

production estimate of northern anchovy (*Engraulis mordax*) spawning biomass are documented. Spawning biomass is defined by the egg production method as the quotient of the daily production of eggs and the daily specific fecundity of the adult population. The overall flow of information and the analysis procedures are described along with the data archives; i.e. the raw data files used as the source for data extractions and subsequent analyses. Data extraction and analyses programs as well as secondary data files generated from the data archives are also described. Appendices also document data file formats and content, and the source code for the various programs.

Age of young sablefish, *Anoplopoma fimbria* (Pallas) 1811.

AUTHOR(S): Heyamoto, H.

YEAR: 1962.

SOURCE: Jour. Fish. Res. Bd. Canada 19(6):1175-1177.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, age, groundfish.

ABSTRACT: Descriptions are given of several sablefish, *Anoplopoma fimbria*, captured off the Oregon coast which were younger than any previously recorded specimens. The fork length of these sablefish ranged from 12.3 - 16.4 cm, with scale circuli ranging from 6 - 9 in number. There was no annulus on any of these fishes scales indicating age at about 6 months., Two later caught specimens from Puget Sound were 26.0 and 32.4 cm (fork length), and they had 14 and 16 circuli, respectively. Both fishes scales were forming an annulus at the outer edge.

Distribution, abundance, and size of sablefish (*Anoplopoma fimbria*) found in deep water off the mouth of the Columbia River.

AUTHOR(S): Heyamoto, H., and M. S. Alton.

YEAR: 1965.

SOURCE: Comm. Fish. Rev. 27(11):1-8.

KEYWORDS: sablefish, *Anoplopoma fimbria*, groundfish, population trends, distribution, length-weight.

ABSTRACT: During this study, 189 otter trawls were made at depths ranging from 50 to 1,050 fm. Sablefish, *Anoplopoma fimbria*, were taken at depths up to 650 fm, but were infrequent below 475 fm. Highest catch rates were attained at stations from 200 - 450 fm deep. Over all years sablefish represented over 50% of the catch from trawls at 275 - 450 fm, the highest contribution being 83% of the catch at 325 fm in 1963. Average size of sablefish increased with depth from 15.2 in at 50 - 125 fm to as much as 21.3 in at 350 - 450 fm for 1962. From 50 - 125 fm almost 98% of the sablefish were under 22 in, and from gonads of fishes in spent or spawning condition it has been determined that those under 17 inches are all immature, while those over 22 inches are all mature. The authors indicate that immature smaller fish are found shallower, and they postulate that the fish move deeper with increasing age and size. The authors also conclude that deep living sablefish may represent an untapped fishery resource.

Abalones, shells, and sea otters: Dynamics of prey populations in central California.

AUTHOR(S): Hines, A. H., and J. S. Pearse.

YEAR: 1982.

SOURCE: Ecology 63(5):1547-1560.



KEYWORDS: Abalone, *Haliotis* spp., mortality, growth.

ABSTRACT: Three species of abalones, *Haliotis rufescens*, *H. walallensis*, and *H. kantschatkana* were censused from 1972 to 1981 at Hopkins Marine Reserve, central California. Most live abalones were found in crevices and densities averaged 1.8 animals/10m<sup>2</sup>. The size of shells, within the otter's range, was about 8 cm, approximately half the average size of individuals outside the otter's range. About 20% of the population of live animals (55 empty shells) were taken by otters each month of the study. The feeding rates of otters suggested a high productivity by the abalone. The production rates were the result of high juvenile recruitment and growth. The population turnover time was 1 to 3 years.

Heat tolerance in the black abalone, *Haliotis cracherodii*  
Leach, 1814 - Effects of temperature fluctuation and  
acclimation.

AUTHOR(S): Hines, A., S. Anderson, and M. Brisbin.

YEAR: 1980.

SOURCE: *Veliger* 23(2):113-118.

KEYWORDS: Abalone, *Haliotis* sp.

ABSTRACT: The effects of fluctuating temperatures and continuous submergence on black abalone, *Haliotis cracherodii*, was examined. Abalones maintained at 11 deg C while continuously submerged had a 96-hr ET50 of 26.1 deg C, however the animals subjected to a tidal cycle had a 96-hr ET50 of 26.6 deg C. Abalones maintained at 16.0 deg C without a tidal cycle had a 96-hr ET50 of 27.4 deg C while animals within a tidal cycle had an ET50 of 27.2 deg C. The effect of temperature had a strong impact on the abalones. The change from no mortality to 100% mortality occurred within a range of 1.0 deg C. Sperm, from spawning abalone during the experiment, remained motile up to 27.0 deg C. Only 15.8% of the abalone which exhibited thermal shock were revived.

Seashore life of southern California.

AUTHOR(S): Hinton, S.

YEAR: 1969.

SOURCE: Univ. Calif. Press, Berkeley, CA. 181 p.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., physiology, habitat.

ABSTRACT: This text can be used as a hand-guide to the animal life of California beaches south of Santa Barbara. A discussion of the cause and effects of tidal flow, wave action and seawater chemistry on the intertidal zone inhabitants proceeds brief characterizations describing the species. Illustrations are provided as an aid in identifying the animals as well as color plates depicting the various habitats.

Spawning of twelve groundfish species in the Gulf of Alaska and  
Pacific coast regions, 1975-81.

AUTHOR(S): Hirschberger, W. A., and G. B. Smith.

YEAR: 1983.

SOURCE: NOAA Tech. Memo., NMFS F/NWC-44. 50 p.

KEYWORDS: Spawning, reproduction, distribution, sablefish, *Anoplopoma fimbria*,

Dover sole, *Microstomas pacificus*, Pacific hake, *Merluccius productus*.

ABSTRACT: The eastern Bering Sea, Gulf of Alaska and offshore Washington, Oregon and California were the areas studied for this report. Gonad

maturity stage data collected during fisheries research surveys from 1975-81 provide the basis for this study. Maps showing the geographic locations of fish in spawning condition are included, along with the distribution of these observations.

Term fetuses from a large common thresher shark, *Alopias vulpinus*.

AUTHOR(S): Hixon, M.A.

YEAR: 1979.

SOURCE: Calif. Fish Game 65(3):191-192.

KEYWORDS: *Alopius vulpinus*, thresher shark, reproduction.

ABSTRACT: The common thresher shark, *Alopius vulpinus*, is an ovoviviparous species found worldwide in temperate to subtropical waters. In California the average length is 2.4 m with sharks from the south being larger than the northern sharks. A 4.6 m female, weighing 295 kg, was taken in 13 fathoms approximately 2 miles off Ventura in 1977. Four fetuses which lacked umbilical scars, suggesting they were close to birth, were removed from the mother. Two fetuses were badly mutilated during removal. The remaining fetuses were a 1417 mm TL male weighing 8.8 kg and a 1386 mm TL female weighing 7.7 kg. These specimens fall just short of the 1550 mm TL maximum size reported for a term fetus.

Trophic interactions among fishes and zooplankters nearshore at Santa Catalina Island, California.

AUTHOR(S): Hobson, E. S., and J. R. Chess.

YEAR: 1976.

SOURCE: Fish. Bull., U. S., 74(3):567-598.

KEYWORDS: Feeding, mortality, distribution.

ABSTRACT: This paper presents a study of morphological adaptations of predator-prey organisms brought about by selective pressures which forced changes in zooplankters. This resulted in the subsequent adaptations of their predators to overcome these changes. A detailed discussion is presented covering the development of defensive features of prey and the ensuring modifying offensive features of the predator. A summary of the evolutionary implications of these adaptations is included.

Crepuscular and nocturnal activities of Californian nearshore fishes, with consideration of their scotopic visual pigments and the photic environment.

AUTHOR(S): Hobson, E. S., W. N. McFarland, and J. R. Chess.

YEAR: 1981.

SOURCE: Fish. Bull. 79(1):1-30.

KEYWORDS: *Paralabrax clathratus*, kelp bass, habitat, physiology, behavior, feeding.

ABSTRACT: Describes the occurrence of the scotopic (dim-light sensitive) visual pigments of 27 nearshore marine fishes in relation to their diel activities and feeding periodicity. Observations on the diurnal, crepuscular and nocturnal activities of fishes were made underwater at Santa Catalina Island over a three-year period. Feeding activity was assessed from gut fullness of fishes collected during late afternoon and early morning (before sunrise). The kelp bass passes through three major ontogenetic phases based on trophic relationships. The first phase includes juveniles up to 65 mm SL that feed primarily on zooplankton during the day and pass the night sheltered amid vegetation. The

second phase - subadults ranging in size from 65 to 165 mm, feed mostly on crustaceans (gammarid and caprellid amphipods, isopods, cumaceans, mysids, and carideans) that occur on the bottom during the day and swim close to the bottom during the night. Some (42%) of the subadults exhibited gut fullnesses indicative of nocturnal feeding. Those individuals that fed at night were collected over sand substratum. This habitat was infrequently occupied by subadults during the day. The third phase includes the large (165 mm SL) adults which are increasingly piscivorous with growth. The estimated average (plus or minus 95% C.I.) spectral absorbance maximum of pigments extracted from kelp bass retinae was 498.8 plus or minus 2.0. This value is characteristic of species that shelter at night.

Cephalopoda: The squids and octopuses.

AUTHOR(S): Hochberg, F. G., Jr., and W. G. Fields.

YEAR: 1980.

SOURCE: Pages 429-444 in R. H. Morris, D. P. Abbott, and E. C. Haderlie (eds.), Intertidal invertebrates of California, Stanford Univ. Press, Stanford, CA.

KEYWORDS: Red abalone, *Haliotis rufescens*, market squid, *Loligo opalescens*, mortality, feeding, physiology, reproduction, life history, habitat, growth, distribution, economics, fishery.

ABSTRACT: This section of Intertidal Invertebrates of California addresses the class Cephalopoda to which the squid, *Loligo opalescens*, belongs. The biology of this animal is described as well as its distinctive characteristics, range, habitat, interactions with other species, economic importance and current research.

Results of sablefish tagging experiments in Washington, Oregon and California.

AUTHOR(S): Holmberg, E. K., and W. G. Jones.

YEAR: 1954.

SOURCE: Pac. Mar. Fish. Comm. Bull. 3:103-120.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, migration, growth, length/weight, fishery.

ABSTRACT: Tagging programs were implemented by California, Oregon, and Washington research agencies in order to better understand sablefish migration patterns. These patterns are important to understand because if stocks migrate extensively coastwise, they would have to be managed differently than if the stocks are divided into local groups of fish remaining in one area. The information cover in this report includes a description of the tagging programs, tag returns, migration, length of time at liberty, growth, size of fish tagged, and factors affecting recoveries.

Shrimps and prawns of the world.

AUTHOR(S): Holthuis, L. B.

YEAR: 1980.

SOURCE: FAO Fish. Synop. 125(1):271 p.

KEYWORDS: *Pandalus jordani*, ocean shrimp, habitat, fishery, distribution, *Sicyonia ingentis*, ridgeback prawn, length, spot prawn, *Pandalus platyceros*.

ABSTRACT: This volume, the first in the FAO series of major groups of

organisms that enter the marine fisheries, is an annotated worldwide catalogue of shrimps and prawns of actual or potential fishery interest. The species are identified by scientific name, FAO names and local names. A brief description of habitat and fishery is included for each species. A chart depicting the distribution of the species by major marine fishing areas is also presented.

Alaska's fishery resources ... The Dungeness crab.

AUTHOR(S): Hoopes, D. T.

YEAR: 1973.

SOURCE: U.S. Dept. Commerce, NOAA, NMFS Fishery Facts 6. 14 pp.

KEYWORDS: Market crab, Cancer magister, economics, fishery, life history, mortality.

ABSTRACT: The Dungeness crab, Cancer magister, fishery of Alaska has averaged 9.2 million pounds landed since 1960 and was worth \$1 to 2 million annually. The preferred habitat is a sandy to muddy substrate and the crabs are found in the open ocean, intertidal zone and sheltered water. The female carries up to 1.5 million eggs on its abdomen until they hatch within 7 to 10 months. The planktonic larvae (zoea) undergo five molt stages before settling to the bottom (after 3 to 4 months) as a juvenile. Growth rates vary for males and females and growth only occurs during a molt period (approximately once per year). Males can reach 10 inches whereas females rarely attain the legal maximum size of 6.5 inches. The fishery utilizes baited (squid, clams, or herring) traps set in lines at 50 to 20 fathoms. The catch is processed by either butchering crabs for canning or cooking for the whole crab market. Research by Alaska Fish and Game, has been directed toward stock identification, growth and mortality rates and population size estimates.

Slime films and their role in marine fouling: a review.

AUTHOR(S): Horbund, H. M., and A. Freiburger.

YEAR: 1970.

SOURCE: Ocean. Engng. 1:631-634.

KEYWORDS: Colonization, platform, community, growth.

ABSTRACT: A review of research done on slime films. These films are usually the first form of fouling to appear on a submerged surface, and are composed of bacteria, their by products and detritus. Early researchers observed that the presence of a slime film facilitated the attachment of larger fouling organisms such as erect bryzoa and barnacles. Some of the slime film bacteria are found to produce acids which can corrode metal, while others can destroy organic coatings. Many bacteria produce mucilaginous secretions and all seem to influence the fouling environment. The primarily polysaccharide secretion produced by the bacteria seems to encourage settlement of fouling species by providing a base to which organisms can attach or by providing a food source. Small accumulations of slime films on toxic substances were found to enhance antifouling effectiveness by functioning as toxic reservoirs. In contrast, large accumulations diminish antifouling effectiveness by acting as a barrier thus preventing toxicant from leaching out of the formulation.

Fishes.

AUTHOR(S): Horn, M. H.

YEAR: 1974.

SOURCE: Pages 11-1 to 11-124 in M. D. Dailey, B. Hill, and N. Lansing (eds.), A summary of knowledge of the southern California coastal zone and offshore areas. Vol. II., Biological Environment. Prepared for Div. Mar. Minerals, Bur. Land Mgmt., U. S. Dep. Interior, by South. Calif. Ocean Study Consort., Calif. State Univ., Domingues Hills, CA. Contract No. 08550-CT4-1.

KEYWORDS: All species, early life history, behavior, feeding, distribution, reproduction, seasonality, fishery.

ABSTRACT: This summary of fishes found in the marine environment off California is organized as follows: the shelf of the mainland and offshore islands, deep sea basins, and the general pelagic zone, which includes the epipelagic zone. Discussion for each zone includes summaries on distribution and seasonality, diversity and abundance, principle species, species associations, food habits and trophic relationships, general ecology, reproduction and early life history. A discussion on diseases and environmental stresses, including contaminants, kelp harvesting and fishing is also included.

Ecology of fishes in Upper Newport Bay, California: Seasonal dynamics and community structure.

AUTHOR(S): Horn, M. H., and L. G. Allen.

YEAR: 1981.

SOURCE: Calif. Dept. Fish Game, Mar. Res. Tech. Rep. 45, 102 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, *Paralichthys californicus*, California halibut, distribution, larvae, life history, early life history, length/weight, habitat, nursery, groundfish.

ABSTRACT: Forty-six fish species were collected with six different types of gear (otter trawl), gill net, bag sein, small sein, drop net and square enclosure) in Upper Newport Bay, California. *Atherinops affinis* was the most abundant in the samples while *Mugil cephalus* ranked first in terms of biomass. The upper bay appears to be used by 2 or more life history stages of 6 of the most abundant species, as indicated by a length-frequency analysis. Eggs belonging to 7 taxa, and larvae from 20 taxa, were also collected. Species richness and abundance were positively correlated with temperature and salinity. Of the 11 species greatest in importance, anchovy was eighth in total numbers and accounted for 0.5% of the individuals and 0.1% of the biomass. California halibut was also found to occur in the bay, generally occupying the channel (deep, high salinity water) as an adult and shallower areas as a juvenile.

Distribution and relative abundance of billfishes (*Istiophoridae*) of the Pacific Ocean.

AUTHOR(S): Howard, J. K., and S. Ueyanagi.

YEAR: 1965.

SOURCE: Stud. Trop. Oceanogr. (Miami), 2, 134 pp.

KEYWORDS: Behavior, distribution, early life history, larvae, migration, population trends, seasonality, spawning.

ABSTRACT: This is a synopsis of what was known to date about the distribution and abundance (of the adult form and the early life history of their larvae) of the following species in the Family-Istiophoridae: striped marlin (*Makaira audax*), blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), sailfish (*Istiophorus orientalis*), shortbill spearfish (*Tetrapturus angustirostris*). The first 37 pages of this manuscript are

involved in the discussion of the nomenclature and taxonomy of the above species. Following this, for striped marlin there is a discussion of the distribution, seasonal occurrence, and some notes on the population trends. The discussion of blue marlin centers around its distribution, seasonal occurrence and migratory behavior. The black marlin reference is concerned with the distribution, spawning, and seasonality of occurrence. The sailfish discussion centers around their distribution, spawning, seasonal distribution and migration. There is also a short note on the distribution of the shortbill spearfish.

Racial and seasonal variation in the Pacific herring,  
California sardine and California anchovy.

AUTHOR(S): Hubbs, C. L.

YEAR: 1925.

SOURCE: Calif. Fish & Game Comm. Fish Bull. 8. 23 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, migration, distribution.

ABSTRACT: This study was designed to determine the relationship of fish characteristics to the physical features of their environment.

Emphasis is placed on the correlation between vertebrae number of the northern anchovy and water temperature in central and southern California. The number of vertebrae varied from 44 and 47 (means 45.89 and 45.48) with the central California averages slightly higher (0.10) than the southern. Fishes from the two areas also differed in body proportions. Differences were also noted between southern California fishes, but these appeared to be due to individual anomalies rather than racial mixing. A subspecies (*Engraulis mordax nanus*) in the central population was found in San Francisco Bay. The fish had two fewer vertebrae in both the average and mode. They were also morphologically different with early development accelerated. Habits of the two central forms are discussed including habitat, migration, and spawning grounds. Similar information is also presented for the Pacific herring, *Clupea pallasii*, and the California sardine, *Sardinia caerulea*.

Changes in the fish fauna of western North America correlated with changes in ocean temperature.

AUTHOR(S): Hubbs, C. L.

YEAR: 1948.

SOURCE: Sears Found. J. Mar. Res. 7(3):459-482.

KEYWORDS: All species, distribution, range.

ABSTRACT: The chief emphasis of this paper is the study of fish faunal changes

associated with annual and long-term changes in ocean surface temperature within historic time along the Pacific Coast of North America. A review of the zoogeographical evidence and inferences drawn from faunal evidence regarding prehistoric changes in the sea temperature is discussed, along with data on changes in the distribution of fishes along the Pacific Coast. Correlations between water temperature and shifts in fish fauna are presented when known and when water temperature data is not known. Correlations are drawn using air temperature information.

List of the fishes of California.

AUTHOR(S): Hubbs, C. L., W. I. Follett, and L. J. Dempster.

YEAR: 1979.

SOURCE: Occas. Pap. Calif. Acad. Sci. 133. 51 p.

KEYWORDS: All species.

ABSTRACT: This is a revision of a manuscript list issued in 1953 and enumerates in a single document all marine, euryhaline, and freshwater fishes native to or introduced into California waters. The scientific names used conform to the provisions of the International Code of Zoological Nomenclature, 1964, and the amendments adopted by the Monaco (1972) Congress.

Adaptation of king crab pots for capturing sablefish  
(*Anoplopoma fimbria*).

AUTHOR(S): Hughes, S. E., D. D. Worlund, and F. W. Hopkins.

YEAR: 1970.

SOURCE: Jour. Fish. Res. Bd. Canada 27(10):1747-1755.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, groundfish, fishing gear, economics, fishery.

ABSTRACT: Due to poor financial returns the catch of sablefish, *Anoplopoma fimbria*, in 1969 has decreased dramatically. This study was initiated to test the feasibility of capturing sablefish in pots of the type used for the king crab fishery. Over the course of this study, 18,754 lbs. of marketable sablefish were caught in 112 hauls, averaging 4.7 lb./pot/hour. Testing indicated that pots were most effective when equipped with triggered tunnels, no attractant lights were used, and hauls were made at 12-hour intervals (as opposed to 24 or 48-hour intervals).

Diet and behavioral aspects of the wolf-eel, *Anarrhichthys ocellatus*, on sandy bottom in Monterey Bay, CA.

AUTHOR(S): Hulberg, L. W. and P. Graber.

YEAR: 1980.

SOURCE: Calif. Fish Game. 66(3):172-173.

KEYWORDS: *Cancer anthonyi*, yellow crab, mortality.

ABSTRACT: To obtain information about the biology and natural history of the

wolf-eel, *Anarrhichthys ocellatus*, this study, undertaken in Monterey Bay, CA., focused on their diet and behavior. During examination of stomach contents, it was determined that *Cancer* spp. were among the prey items of the wolf-eel. The methods used for this study are reported and the results discussed and presented in table and diagrammatical format.

Prey availability and the diets of two co-occurring flatfish.

AUTHOR(S): Hulberg, L. W., and J. S. Oliver.

YEAR: 1979.

SOURCE: Pages 29-36 in S. J. Lipovsky and C. A. Simenstad (eds.), Gutshop '78: Fish food habits studies. Proc. 2nd Pacific northwest technical workshop, 10-13 October 1978, Lake Wilderness conf. Ctr., Maple Valley, WA. 222 pp.

KEYWORDS: English sole, *Parophrys vetulus*, feeding.

ABSTRACT: The diets of two species of flatfish, the Pacific sanddab, *Citharichthys sordidus*, and the English sole, *Parophrys vetulus*, were examined by gut content analysis. The diets of each species were quite broad and exhibited a high percentage of overlap. Generally, the major prey for *C. sordidus* were crustaceans (euphausiids and mysids), while *P. vetulus* consumed polychaetes, amphipods and cumaceans. The natural history of the prey species

had a considerable impact on the feeding behavior of both species. Deep burrowing species, which were not active at the surface, were only taken by *P. vetulus*. However, *C. sordidus*, fed actively on hyperbenthic (active swimming) prey which *P. vetulus* rarely preyed upon. The English sole was adept at digging and sifting for prey, while the Pacific sanddab was a poor digger and better at a hunt and peck or sit and wait feeding strategy.

Lengths, weights and ages of 13 southern California marine gamefish.

AUTHOR(S): Hulbrock, R.

YEAR: 1974.

SOURCE: Calif. Fish Game Publication. 32 pp.

KEYWORDS: Albacore, *Thunnus alalunga*, bocaccio, *Sebastes paucispinis*, Pacific bonito, *Sarda chiliensis*, California halibut, *Paralichthys californicus*, kelp bass, *Paralabrax clathratus*, chub mackerel, *Scomber japonicus*, white seabass, *Atractoscion nobilis*, yellowtail, *seriola lalandei*, length/weight, growth, age.

ABSTRACT: Length with corresponding weight and age of 13 species of gamefish is included. Limited discussion of each species includes information on distribution and abundance, growth, length and age at spawning, and size limits for fishery.

Reproductive ecology of western gulls and *Xantus' Murreletes* with respect to food resources in the Southern California Bight.

AUTHOR(S): Hunt, G. L., and J. L. Butler.

YEAR: 1980.

SOURCE: CalCOFI 21:62-67.

KEYWORDS: Northern anchovy, *Engraulis mordax*, mortality, larvae, distribution.

ABSTRACT: The effect of anchovy prey availability on the reproductive ecology of western gulls and *Xantus' murreletes* was evaluated by estimating the number of birds attempting to breed, their reproductive performance (measured by phenology, chick growth rates, and number of chicks surviving to some age or weight criterion), and prey availability or abundance. The results of this study show that western gulls and *Xantus' murreletes* responded to changes in pelagic fish populations in the Southern California Bight. Western gulls responded to decreases in the availability of schooling fish by failing to breed or by switching to alternate foods, while the *Xantus' murrelete* responded to these decreases either by failing to breed or by delaying breeding until larval anchovies became available.

Exploitation of fluctuating food resources by western gulls.

AUTHOR(S): Hunt, G. L., and M. W. Hunt.

YEAR: 1976.

SOURCE: Auk 93:301-307.

KEYWORDS: Northern anchovy, *Engraulis mordax*, mortality.

ABSTRACT: Stomach samples from western gull chicks were collected in order to assess the relative importance of food types. Data on the lengths of foraging trips by adults was also obtained. Of the prey species identified 89% (by weight) were schooling organisms. The prey species were mainly northern anchovy and unidentified species of squid. There was an inverse correlation between the



percentage of chicks with empty stomachs versus chick stomachs containing anchovies. This result indicates that when the birds were able to locate and track schooling species such as anchovies, more of the birds in the colony obtained food than when the prey species didn't school. Apparently the availability of schooling fish is needed for western gulls of Santa Barbara Island to adequately feed their young.

Sustained speed of the jack mackerel, *Trachurus symmetricus*.

AUTHOR(S): Hunter, J. R.

YEAR: 1971.

SOURCE: Fish. Bull. 69(2):267-271.

KEYWORDS: Jack mackerel, *Trachurus symmetricus*.

ABSTRACT: The purpose of this study was to determine the sustained speed threshold of jack mackerel, *Trachurus symmetricus*. A total of 275 individuals, ranging in length from 9 - 17.6 cm, were tested at fixed speeds of 38 - 160 cm/sec for 6 hours or longer after an introductory period of about 30 min. at a low speed. Swimming fatigue occurred in 50% of the individuals at 22.4 plus or minus 1.2 L 0.6/sec at the 95% confidence level. Speed estimates declined exponentially with time for short swimming period (22 min) and linearly with time for longer ones. Juvenile *Trachurus* (average = 14.6 cm) attained the highest speed in this study (160 cm/sec) for 2-6 min, which is the equivalent to 10 L/sec or about 32 0.6/sec. Possible significance of the true speed relationship is discussed.

Swimming and feeding behavior of larval anchovy *Engraulis mordax*.

AUTHOR(S): Hunter, J. R.

YEAR: 1972.

SOURCE: Fish. Bull. 70(3):821-838.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, feeding.

ABSTRACT: The swimming and feeding behavior of northern anchovy (*Engraulis mordax*) larvae is described during the first 30 days of larval life. The observations and results from other studies are combined to form a model for estimation of larval survival in the sea. Little locomotor activity is exhibited during the first two days of larval existence. Occasionally, they executed a brief and intense burst of swimming. Intermittent swimming, consisting of alternate periods of swimming and gliding, became dominant during the third day. This type of swimming coincided with the appearance of feeding. The brief bursts of swimming occurred at a low frequency throughout the rest of larval life. These original bursts have a respiratory function. The structure of continuous and intermittent swimming is examined in detail. Larvae have a maximum speed capability of 25 body lengths per second or faster for bursts lasting 0.1 to 0.2 seconds. The speed of intermittent swimming increased with larval length. The mean proportion of time devoted to intermittent swimming was 82.6+/-1.2%. Feeding behavior is described in detail. The entire feeding sequence from sighting the prey to the strike lasts only 1-2 seconds. Of all feeding sequences begun, 40% were completed, while the cause of the failure to complete a sequence was an inability to closely approach the prey while forming the strike posture. Searching behavior was independent of body orientation. The reactive perceptive field is roughly triangular in vertical cross-section.

The average frequency of feeding strikes was  $1.28 \pm 0.144$  strikes per minute. The success of larval feeding increased over the first week of feeding. The estimate of the volume of water searched per hour increased exponentially with size. Food densities of various prey types required by larvae were estimated. Larval anchovies must ingest 686 rotifers/day/mg dry weight to fulfill their metabolic requirements. Older larvae required much lower food densities due to their increased feeding success. Larval anchovies are more vulnerable to death from starvation just after yolk absorption than at any other time. The absolute number of prey required is not great, but a high concentration is required. Larval anchovies are more vulnerable to death from starvation just after yolk absorption than at any other time. The absolute number of prey required is not great, but a high concentration is required.

Behavior and survival of northern anchovy, *Engraulis mordax*, larvae.

AUTHOR(S): Hunter, J. R.

YEAR: 1977.

SOURCE: CalCOFI Rep. 21:138-146.

KEYWORDS: Northern anchovy, *Engraulis mordax*, behavior, mortality, feeding, larvae.

ABSTRACT: Swimming and feeding behavior of northern anchovy, *Engraulis mordax*, are described and related to survival of larvae.

Predation and starvation are considered to be the dominant factors influencing survival of larvae. Patches of food organisms (dinoflagellates) are found in the sea in sufficient concentrations to support larval life during the first feeding stage. Laboratory studies indicate that larvae have the ability to remain in patches of food once they find them. Swimming behavior accounts for most of the larvae energy expenditure but is important for both prey selection and predator avoidance. Mechanisms that conserve energy include high food density and the reduction of activity associated with colder water temperatures. Larval anchovy survival involves a complex set of interacting variables. Whether or not larvae will find a concentration of food organisms of the appropriate size and whether or not it will be able to avoid predators and remain in the food patch are only a few factors needing further study.

Culture and growth of northern anchovy, *Engraulis mordax*, larvae.

AUTHOR(S): Hunter, J. R.

YEAR: 1976.

SOURCE: Fish. Bull. 74(1):81-88.

KEYWORDS: Northern anchovy, *Engraulis mordax*, length/weight, larvae, growth, feeding.

ABSTRACT: A description of the growth rate of larval anchovy to metamorphosis, and presentation of data on the ability of newly metamorphosed juveniles to withstand starvation. Both the length and weight data from the experiment were fitted to the Laird-Gompertz growth equation. The larvae achieving metamorphosis were fed dinoflagellates, rotifers, harpacticoid copepods, and brine shrimp nauplii at 16 deg C for 74 days. Larvae completing metamorphosis withstood starvation for 12-15 days while those not achieving metamorphosis did not.

Field experiments on the attraction of pelagic fish to floating objects.

AUTHOR(S): Hunter, J. R. and C. T. Mitchell.

YEAR: 1968.

SOURCE: Jour. Cons. Inst. Explor. Mer. 31(3):427-434.

KEYWORDS: Artificial reef.

ABSTRACT: A number of floating objects were evaluated as fish attraction devices in the waters off Costa Rica. More fish were attracted to plastic sheets bent 60 deg at the midline and floated on the surface. Fish showed a strong preference to sheets floated horizontally on the waters surface (as opposed to sheets suspended vertically). The community structure was studied over time (51 days) and a change from juvenile to adult assemblages was noted. Juveniles were present for the first 6 days; after 17 days the population was composed of large juveniles and adults, and after 28 days, a decrease in the total number of individuals was noted. Estimates of residency times ranged from 9 days for black skipjack tuna, 11-13 days for yellowfin tuna to over 32 days for *Sectator ocyurus*.

Sexual maturity, batch fecundity, spawning frequency, and temporal pattern of spawning for the northern anchovy, *Engraulis mordax*, during the 1979 spawning season.

AUTHOR(S): Hunter, J. R., and B. J. Macewicz.

YEAR: 1980.

SOURCE: CalCOFI Rep. 21:139-149.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, reproduction, length.

ABSTRACT: Spawning frequencies and fecundity are reported for the northern anchovy, *Engraulis mordax*, along with female sexual maturity as a function of length, atretic state of ovaries, and female reproductive state related to time of day. In January-February and March-April of 1979, 64 and 91%, respectively, of females were mature. Estimated length at 50% maturity was 96 mm with larger females (105-119 mm) having a higher probability of maturity in March-April. Mean fecundity was 421 +/- 36 eggs/g female weight less ovary weight. The number of hydrated eggs (Y) as a function of female weight less ovary weight (X) is described by  $\ln Y = 4.183 + 1.620 \ln X$ . Females in the Los Angeles Bight spawned an average of once every 7 to 10 days with the frequency declining by June. In Monterey Bay spawning had nearly ended by March. Incidence of ovarian atresia was inversely correlated with the frequency of spawning and the decrease in spawning frequency may be caused by a cessation of spawning. Nightly spawning can be divided into three periods; early spawning (1800 to 2100 hrs), maximum spawning (2100 to 0200 hrs), and post-spawning (0200 to 0600 hrs). The regression equation is preferable in estimating batch fecundity for females over expressing fecundity on a unit weight basis. Spawning frequency during peak periods is about the same for northern and central stocks (once a week), but northern stocks may be limited in the number of spawnings because of the short duration of the spawning season. If appropriate weights were developed for the time of sampling, the number of females with new post-ovulatory follicles or hydrated eggs could be used as a measure of spawning frequency.

Early life history of Pacific mackerel, *Scomber japonicus*.

AUTHOR(S): Hunter, J. R., and C. A. Kimbrel.

YEAR: 1980.

SOURCE: Fish. Bull. 78(1):89-101.

KEYWORDS: *Scomber japonicus*, chub mackerel, early life history, larvae, feeding, growth.

ABSTRACT: Reared and wild larvae were examined to characterize the early life history of the Pacific mackerel, *Scomber japonicus*, including incubation times, yolk absorption, onset of feeding, vulnerability to starvation, swimming and feeding behavior, food catch, growth rate and efficiency, and oxygen consumption. The effects of temperature variation on these characteristics were also examined. At 19 deg C, hatching time was 56 hrs, similar to the east Pacific population. Average size at hatching was 3.1 mm SL, and onset of feeding about 50 hrs later. The effects of starvation were irreversible after 4.5 days. This threshold persisted from onset of feeding through metamorphosis. Growth rapidly accelerated after 6-7 mm SL, and continued through metamorphosis (15 mm SL) at 16-24 days. Swimming behaviors of larvae were unlike adults. The larvae predominantly modulate tail beat amplitude to change speed. Also, relative speed increased with size from 1.3 TL/sec to 3.8 TL/sec. At 8.1 mm 50% of the larvae could eat yolk-sac anchovy larvae. Cannibalism by the larger (mean=10.8 mm) siblings began when the mean size reached 8 mm. This ended as metamorphosis approached and schooling began. Fifty percent of the larvae could capture prey 85% of their mouth-width, and 95% could capture prey 57% of their mouth-width. Three to 5 day old larvae ate 87% of their body weight per day, with a mean growth efficiency of 33%. They consumed 7.4 microliters of oxygen per hour, which converts to 18% of the mean daily ration. Pacific mackerel larvae are comparable to other small-egged pelagic larvae. Growth metabolism and feeding and swimming behavior are of most value in characterizing their early life history. Fast growth, with correspondingly high ration, is characteristic of scombroid larvae. Rapid increase in relative mouth size and cruising speed assist in capturing sufficient food. However, this high metabolism means growth and survivorship is dependent on the availability of larger prey.

Egg cannibalism in the northern anchovy, *Engraulis mordax*.

AUTHOR(S): Hunter, J. R., and C. A. Kimbrell.

YEAR: 1980.

SOURCE: Fish. Bull. 78(3):811-816.

KEYWORDS: *Engraulis mordax*, northern anchovy, feeding, mortality.

ABSTRACT: Field and laboratory studies were used to show that egg cannibalism accounts for a considerable amount of natural egg mortality in the northern anchovy, *Engraulis mordax*. Adults feed on their eggs by filtration both night and day, with 42% and 88%, respectively, of the stomachs sampled containing eggs. The mean number of eggs per stomach was 5.1 for night and day samples combined, while the maximum number of eggs in a single stomach was 730 (32% of all eggs found). Due to the patchiness of the eggs in their natural environment and the selective filtering of fish, the mean number of eggs in the stomachs increased exponentially with the mean egg abundance in surrounding water. From plankton tows taken in front and behind schools, it was estimated that as many as 48% of the eggs in the water may be

consumed. An estimate of the daily ration yields 85.8 eggs consumed per fish. The amount of daily egg production filtered by a school was 17.2% per day which is approximately equal to 32% of the total natural egg mortality. Egg filtering is intensified when egg patches are encountered and account for a major source of egg mortality. This cannibalism may help in the regulation of northern anchovy population size. Larval cannibalism may also be significant, although evidence to date does not support this.

Association of fishes with flotsam in the offshore waters of Central America.

AUTHOR(S): Hunter, J. R., and C. T. Mitchell.

YEAR: 1966.

SOURCE: Fish. Bull. 66(1):13-29.

KEYWORDS: Artificial reef, community, behavior, feeding.

ABSTRACT: The ecology and behavior, including frequency, size, and abundance of fishes associated with floating objects is reported. Findings are related to the location and size of the object. Fishes captured under flotsam represented 12 families and 32 species, with little seasonal variation. Nearly all fishes observed or captured were juveniles. Adults were not as close to the objects nor did they remain there as long. The mean and minimum length of some species increased with distance offshore. This may be because individuals caught offshore were recruited to the object inshore, and the larger size is attributed to growth while associated with the object. The ranges of sizes of other fishes under flotsam varied widely, while some were extremely restricted. Flotsam associated fish aggregations are characterized by rapid recruitment in no particular sequence. Schooling and the association with drifting materials may be related, the object representing a point of reference. Two mechanisms are postulated; fishes are attracted to a drifting object because it functions as a schooling companion and drifting materials may function as a substitute for a reef or other substrate.

Thresholds for filter feeding in northern anchovy, *Engraulis mordax*.

AUTHOR(S): Hunter, J. R., and H. Dorr.

YEAR: 1982.

SOURCE: CalCOFI Rep. 23:198-204.

KEYWORDS: Northern anchovy, *Engraulis mordax*, feeding.

ABSTRACT: Prey densities needed to initiate filter feeding in the northern anchovy, *Engraulis mordax* were estimated. Prey items included *Artemia nauplii*, anchovy eggs, and the dinoflagellate *Gymnodinium*. Density thresholds for the onset of filtering behavior for *Artemia*, anchovy eggs, and *Gymnodinium* were 5-8 nauplii, 1-2 eggs, and 151-328 cells per liter, respectively. When no food was present 2% of fish exhibited filtering behavior, while at the highest densities nearly all fish filtered continuously. During any 2-second period, 70-80% of all fish were feeding. Percentages increased with the addition of food. The strongest responses were observed for anchovy eggs and nauplii when more than 50% of the fish were filtering at 4 eggs and 20 nauplii per liter, respectively. Similar responses to different foods occurred at the same density of biomass. The lowest concentrations of food that stimulated filtering were inversely

related to particle size or mass. The density of biomass is an important factor in regulating the intensity of filter feeding in anchovy schools, with a high concentration of biomass needed to initiate filtering. Threshold density may also be a function of the cost of filtering relative to biting the prey. Evidence points to natural anchovy egg densities large enough to stimulate filter feeding, but they are probably also taken when feeding is stimulated by other prey. Selective feeding may also exist, accomplished through varying intensity of filtration, and acting mainly on larger preferred prey.

Swimming speed, tail beat frequency, tail beat amplitude, and size in jack mackerel, *Trachurus symmetricus*, and other fishes.

AUTHOR(S): Hunter, J. R., and J. R. Zweifel.

YEAR: 1971.

SOURCE: Fish. Bull. 69(2):253-266.

KEYWORDS: *Trachurus symmetricus*, jack mackerel, physiology.

ABSTRACT: The purpose of this study was to determine the relationships between swimming speed, fish length, tail beat amplitude, and tail beat frequency in a pelagic marine fish, jack mackerel, *Trachurus symmetricus*. Tests were also run on three other marine fish for comparative purposes: chub mackerel, *Scomber japonicus*; Pacific sardine, *Sardinops sagax* and a shark, *Triakis henlei*. Fish were photographed from above with a 16 mm high-speed motion picture camera at speeds of 62 - 200 fps. Fish speed was analyzed by use of a coordinate reader and digitizer. A total of 176 speed tests (ranging from 15-212 cm/sec) were analyzed for 19 jack mackerel, varying in total length from 4.5 to 27.7 cm. The tail beat amplitude of *Trachurus* did not change with speed but was constant at all speed levels and was directly related to length on the order of 0.21 L. Tail beat frequency did change with speed and was, therefore, the only speed modulator measured in these experiments. The relationship between tail beat frequency and velocity was linear throughout the range of test speeds for all species examined. The slope and intercept of the regression line varied with fish length. Fish have a minimum tail beat frequency and a minimum swimming speed below which they cannot swim by movement of the caudal fin and these minima were a function of body length. There appears to be a common length coefficient among different species. The regression coefficient differed for the species examined, being the highest in *Trachurus* and the lowest in *Salmo*. Since amplitude was a constant, these results implied that the speed output per beat of the caudal fin was greater in *Trachurus* and *Scomber* than it was in *Salmo* and *Corassius*. Water speed is measured in body lengths per second, the relationship between it and frequency is nearly the same in all fish. A simple mathematical model for estimating swimming speed from tail beat frequency and fish length is included.

The onset of schooling in northern anchovy larvae, *Engraulis mordax*.

AUTHOR(S): Hunter, J. R., and K. M. Coyne.

YEAR: 1982.

SOURCE: CalCOFI Rep. 23:246-251.

KEYWORDS: Northern anchovy, *Engraulis mordax*, behavior, larvae.

ABSTRACT: The minimum larvae size when schooling begins is determined

for the northern anchovy, *Engraulis mordax*, to better understand the effects of predation, cannibalism, and food abundance on size-specific mortality rates. Larval densities when schooling began ranged from 1.7 to 4.3 larvae per liter. Signs of parallel orientation were first observed at lengths of 11 to 12 mm SL, with an increased frequency as larvae grew. The sharpest increase was between 12 and 14 mm and by 15 mm all fish showed a strong schooling behavior. Schooling was not obvious until 1 to 1.5 hrs after feeding, but if food was insufficient schooling did not occur. Larvae achieve the ability to school at 11 to 12 mm but some type of fright response may be needed to trigger the behavior. Anchovies between 12 and 15 mm are characterized by rapid structural and behavioral changes. The onset of schooling may be related to the fishes locomotor efficiency and improvements in the visual system, while actual initiation may result from environmental events. The observed increase in patchiness in the sea at larger larval lengths is probably due to the onset of schooling.

The spawning energetics of female northern anchovy, *Engraulis mordax*.

AUTHOR(S): Hunter, J. R., and R. Leong.

YEAR: 1981.

SOURCE: Fish. Bull. 79(2):215-230.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, reproduction.

ABSTRACT: The developmental and energy requirements of the northern anchovy, *Engraulis mordax*, to have a high frequency of spawning are examined, along with an estimate of the annual reproductive energy costs and effort. During peak spawning months, 14% of mature females spawned per day, the highest fraction found, indicating individual spawnings every 6-7 days. Individuals spawned an average of 15 times from February to September and 5 times between October and January. Egg size distributions are continuous and have one or two modes, with batch sizes for spawned and nonspawning females of 9110 and 13120 eggs, respectively. Four spawning batches of eggs exist in the ovary of females near spawning condition, with the mean size of the most mature batch 0.71 mm. It was demonstrated that a rate of egg maturation allowing for continuous production of egg batches at 7 to 10 day intervals occurs. Spawning does not cease due to a lack of yolked eggs. The mean number of eggs per spawning batch is independent of past spawning history for the first few months of spawning. Over the entire spawning season, the dry weight of eggs varies about 20%, with the largest produced in February to April, indicating an adaptive significance due to cooler water temperatures at that time. At any one spawning about one-half the calories in the ovary are lost, showing a relatively small amount of calories invested considering the cost of 20 spawnings in a mature ovary. Energy stored in other tissues and food income are used for reproductive energy, with about two-thirds of the annual cost of egg production accounted for by a decline in fat stores. The annual spring bloom may regulate reproductive potential, the effect having a 1-year lag time. A reproductive effort of 8-11% (egg calories/ration calories) sustained by a daily ration of foods of 4-5% of the fishes wet weight per day, support the estimate of 20 spawnings per female per year in the northern anchovy central subpopulation. The annual reproductive effort and egg production

probably changes in a complex manner in relation to food, growth, temperature, population size, and age structure.

Spawning incidence and batch fecundity in northern anchovy, *Engraulis mordax*.

AUTHOR(S): Hunter, J. R., and S. R. Goldberg.

YEAR: 1979.

SOURCE: Fish. Bull. 77(3):641-652.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning.

ABSTRACT: A postovulatory follicle detection period was determined for laboratory reared northern anchovy, *Engraulis mordax*, in order to estimate spawning frequency of natural populations, batch fecundity, and the maturation rate of the next egg group. Postovulatory follicles over 48 hrs were unusable due to their rapid degeneration, while those classified as 0 day or 1 day old were aged with an accuracy of 76 to 84%. Using 1-day-old postovulatory follicles as the preferred estimator, spawning incidence during a two-week period in February occurred at a rate of 16% (+/-4%) of the population per night. In March a rate of 12% was determined. These rates are equivalent to a spawning periodicity of 6-7 and 8 days, respectively, during the two peak spawning months. Sex ratio of the schools is related to spawning incidence with schools containing mostly males having a higher percentage of spawning females (40%) than schools dominated by females (10%). Spawning begins when the largest eggs have reached a diameter between 0.6 and 0.7 mm. At this time the next size class of eggs is approximately 0.46 mm. Consequently the eggs remaining in the ovary must increase at a rate of 0.04 mm/day over the next 6-7 days. Batch fecundity is estimated at 389 (+/-59) hydrated eggs/g ovary-free female weight. The amount of food available and the fishes energy reserves may play a role in the limit of spawning activity and total fecundity as indicated by the high spawning frequency and long breeding season.

J. A. McMillan, and H. W. Frey.

California's northern anchovy fishery: Biological and economic basis for fishery management.

AUTHOR(S): Huppert, D. D., A. D. MacCall, G. D. Stauffer, K. R. Parker,  
YEAR: 1980.

SOURCE: NOAA Tech. Memo NMFS, NOAA-TM-NMFS-SWFC-1.

KEYWORDS: Northern anchovy, *Engraulis mordax*, age, growth, life history, distribution, fishery, regulations, reproduction.

ABSTRACT: The basis of northern anchovy, *Engraulis mordax*, management plans in California are discussed. Included are a description of who is in authority over the fishery, who developed the Fishery Management Plan, and what is needed for successful implementation of this plan. The fishery is described in terms of the areas and stocks involved, a history of exploitation, California's management regime, a history of research, socio-economic characteristics, interactions between and among user groups, and revenues derived from the fishery. The biology of the anchovy is also reported including life history, catch-effort data, survey and sampling data, habitat, and current stock status. The capacity of both the fishing fleet and processing plants are discussed. The optimum yield formula is presented and described in terms of biological, ecological, social, and economic



considerations. The current management regime is also detailed including all options considered. Finally, a series of appendices presents a review of anchovy biomass estimation procedures, the anchovy population growth model, fishery regulations, instantaneous biomass growth rate of a cohort, yield per recruit, and the economic aspects of the fisheries.

School structure of squid, *Loligo opalescens*.

AUTHOR(S): Hurley, A. C.

YEAR: 1978.

SOURCE: Fish. Bull. 76(2):433-442.

KEYWORDS: Market squid, *Loligo opalescens*, behavior.

ABSTRACT: The schooling behavior of squid, *Loligo opalescens* was studied in the laboratory. The stimulus regulating schooling appears to be visual orientation. Schools typically consist of similar sized individuals. There is a tendency for larger squid (13-15 cm dmL) to school more cohesively than smaller squid (7-9 cm dmL). Disturbance tended to group the individuals more tightly and increase the degree of parallel orientation. The squid schools show much similarity to obligate schooling fish aggregations.

Mating behavior of squid *Loligo opalescens*.

AUTHOR(S): Hurley, A. C.

YEAR: 1977.

SOURCE: Mar. Behav. Physiol. 4(3):195-203.

KEYWORDS: Market squid, *Loligo opalescens*, reproduction, behavior.

ABSTRACT: The mating behavior of squid, *Loligo opalescens* is reported for both laboratory and field situations. In the laboratory, clear dominance hierarchies were observed. Aggressive displays were exhibited by males guarding egg masses. However, all females were allowed to enter the "territory". The initiation of a dominance hierarchy seemed to depend on the presence of egg masses. Observations made while diving in Monterey Bay did not include dominance patterns. This could be due to the size of the spawning aggregations.

Feeding behavior, food consumption, growth, and respiration of squid *Loligo opalescens* raised in the laboratory.

AUTHOR(S): Hurley, A. C.

YEAR: 1976.

SOURCE: Fish. Bull. 74(1):176-182.

KEYWORDS: Market squid, *Loligo opalescens*, feeding, growth.

ABSTRACT: The daily caloric requirements of squid, *Loligo opalescens*, were determined by studying the feeding behavior, consumption rates, growth and respiration in a laboratory situation over 100 days. Newly hatched larvae were fed *Artemia*, copepods and larval anchovy. A slight preference for the larval fish was noted. Growth rates were variable and values ranged from 0.5-4.5 mm/month. Respiration rates varied according to temperature, and may have been biased due to crowding, however an average of 3 ul oxygen/mg dry wt/hr seems realistic. This translates to 0.22 calories for respiration in 24 hrs suggesting squid require 23 nauplii or 2 anchovy larvae per day for sustenance.

The anchovy crisis.

AUTHOR(S): Idyll, C. P.

YEAR: 1977.

SOURCE: Pages 223-230 in H. W. Menard (ed.), Ocean science. W. H. Freeman and Co., San Francisco, CA.

KEYWORDS: *Engraulis mordax*, northern anchovy, Pacific bonito, *Sarda chiliensis*, mortality, feeding, distribution, fishery.

ABSTRACT: The anchovy fishery and conditions that impact upon it is the subject

of this paper. The anchovy fishery, the world's largest, is located in the Peru current. The periodic ecological forces that have had and are currently having an effect on this fishing industry are discussed in detail. Also discussed is the impact of heavy commercial fishing which, combined with natural phenomenon, threatens to destroy the industry. Suggestions are made to moderate the human use of this fishery to enable its recovery.

Active animals of the deep-sea floor.

AUTHOR(S): Isaacs, J. D., and R. A. Schwartzlose.

YEAR: 1975.

SOURCE: *Sci. Amer.* 233(4):84-91.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, feeding.

ABSTRACT: This paper presents the findings of a study undertaken in 1975 to

photograph animals on the deep-sea floor. Bated cameras were dropped to the ocean floor at depths between 400 and 7,000 meters and photographs were taken of the feeding animals. The paper reports a surprising variety and abundance of active animals at unusual depths.

Albacore food habits.

AUTHOR(S): Iverson, I. L. K.

YEAR: 1971.

SOURCE: *Calif. Dept. Fish Game, Fish Bull.* 152:11-46.

KEYWORDS: Albacore, *Thunnus alalunga*, feeding.

ABSTRACT: Stomach contents of albacore (*Thunnus alalunga*) were examined and analyzed by volume, number, and frequency of occurrence and by Index of Relative Importance. Fish were found the most important food in the albacore diet. They comprised by volume 86.0% of the stomach contents in 1968 and 92.7% in 1969. The northern anchovy, *Engraulis mordax*, and saury, *Cololabis saira*, contributed the greatest volume of all food sources. Analysis of frequency of occurrence found 81.8% of the stomachs contained fish in 1968, and 76.5% in 1969. Again, the individual species of fish occurring most often were anchovies and sauries. In the Eastern Pacific in 1968, analysis by Index of Relative Importance ranked northern anchovy as the predominant food item of albacore. Saury were second, followed by euphausids, *Sebastes* spp. and *Sergestes similis*. For 1969, individual rankings shifted: saury were first; anchovy second; two cephalopods ranked third and fourth, and a euphausid was fifth. The composition of stomach contents differed in albacore sampled from southern California and those from the north. In southern California, anchovies and sauries predominated, cephalopods followed next in importance and crustaceans occurred occasionally. In central California, the importance of anchovies and sauries decreased with a corresponding increase in myctophids, paralepids, and rockfish. Cephalopods and crustaceans also became more important in this region. In Oregon and Washington, anchovies were the most important food in 1968, but in 1969, sauries were found most often. Cephalopods contributed a small amount in 1968 but were of

considerable importance in 1969. Crustaceans contributed significantly both years in northern waters. Food items in albacore stomachs included representatives of 21 fish families, 14 cephalopod families, and 3 crustacean subclasses.

Ontogenetic changes in behavior performed during interactions between crab instars of the Dungeness crab, *Cancer magister* Dana (1852).

AUTHOR(S): Jacoby, C. A.

YEAR: 1980.

SOURCE: Amer. Zool. 20(4):888.

KEYWORDS: *Cancer magister*, market crab, behavior.

ABSTRACT: Observations of juvenile and adult Dungeness crabs, *Cancer magister*, indicated all instars were nocturnal. The crabs performed 33 behavioral patterns often for more than one functional situation. More forceful behavior was noted in younger crabs with older individuals providing more stereotypical displays. Adult male and female crabs exhibited fewer behavioral patterns and fewer interactions.

Behavioral responses of the larvae of *Cancer magister* Dana (1852) to light, pressure, and gravity.

AUTHOR(S): Jacoby, C. A.

YEAR: 1982.

SOURCE: Mar. Behav. Physiol. 8:267-283.

KEYWORDS: Market crab, *Cancer magister*, behavior.

ABSTRACT: Ontogenetic and vertical movements in crab, *Cancer magister*, larvae were observed in laboratory PVC tubes. The responses to light, pressure and gravity were noted. During day and night larvae consistently oriented with respect to gravity. The zoeal larvae exhibited increased activity and a positive phototaxis when subjected to increased pressure. At night, pressure had various effects on the instar stages. The first two instars held positions with increased pressure to 2.5 and 1 atm. for stage 1 and 2, respectively. The fourth stage moved down at all pressure gradients except 1.5 atm. The fifth instar moved up for pressures of 1.0, 1.5 or 2.5 atm. All instar stages were positively phototactic at directional light levels of 0.06 to 0.3 W/mE<sup>2</sup>. The results of the experiments suggested that early instars should be found at 20 m, later instars in the upper 2 m and megalop larvae at 20 m.

Ontogeny of behavior in the crab instars of the Dungeness crab,

*Cancer magister*, Dana 1852.

AUTHOR(S): Jacoby, C. A.

YEAR: 1983.

SOURCE: Jour. Comp. Ethol. 63(1):1-16.

KEYWORDS: Age, feeding, behavior, *Cancer magister*, market crab.

ABSTRACT: The ontogeny of behavior in juvenile and adult Dungeness crab, *Cancer magister*, is examined, with emphasis on analysis of aggressive interactions between conspecifics of similar ages. Most non-mating interactions between crabs involve exclusion of one crab from an area. Juvenile instars perform escape oriented behavior more than adults and use more presentations (less definitive threats) during encounters. First and second instar juveniles display less diverse behavior than other instars. Adult

male-male and adult female-female encounters are characterized by performances of spread pushes, behaviors with coordinated and controlled pushing between two crabs. Adult crabs interacting with members of their own sex perform more action patterns per encounter than juveniles interacting with juveniles or males interacting with females. Females perform the fewest behaviors during interactions with males. Interactions between instars one and two often are restricted to contact between two crabs and then separation. Juvenile instars three through six have more intense encounters. Male-male interactions are not as intense as female-female interactions. While male-male interactions tend to involve contact action patterns by both crabs, but not the forceful strikes and grabs displayed in female-female encounters. Instead males perform more controlled contact action patterns. Interactions between two juvenile crabs tend to be less intense than encounters between adult crabs of the same sex. More encounters are lost by crabs that initiate an interaction, except females lose more male-female encounters regardless of which crab initiates the interaction. The same repertoire of action patterns is performed by all age classes. The potential to perform a complete repertoire of behavior immediately following metamorphosis is viewed as adaptive for *Cancer magister* because all of the action patterns are important for defense, feeding, and grooming.

California salmon landings 1952 through 1965.

AUTHOR(S): Jensen, P. T., and P. G. Swartzell.

YEAR: 1967.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 135:43-57.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, Chinook salmon, *Oncorhynchus tshawytscha*, fishery, regulations.

ABSTRACT: The data for commercial troll and recreational catch salmon fisheries is recorded for the years 1952 through 1965. These include only data on coho salmon (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tshawytscha*). The data are presented by port-areas identified by the major city-port in that area: Crescent City, Eureka, Fort Bragg, San Francisco, and Monterey. Discussion is made of the changing fishery regulations (both commercial and sport) for these years.

Distribution patterns and density estimates of fishes on a southern California artificial reef with comparisons to natural kelp reef habitats.

AUTHOR(S): Jessee, W. N., A. L. Carpenter, and J. W. Carter.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):214-226.

KEYWORDS: Artificial reef, community.

ABSTRACT: The assemblage of fish species and their utilization of space on the Pendleton artificial reefs were compared to densities and distributions of similar species in a neighboring kelp forest (San Onofre) and a natural reef (Las Pulgas). The densities of fish on the artificial reef were significantly higher for most species considered. These differences were attributed to the physical and vertical relief on the artificial reef. The distance to hard bottom habitats and neighboring reefs may also have been important. Transects of the reef showed bottom substrate the preferred habitat for the barred sand bass, black perch and sheephead and reef crest substrate preferred by the blacksmith,

garibaldi and halfmoon. No preference of substratum was determined from the kelp bass and opaleye density estimates. The substrate preferences noted on the artificial reef were consistent with the behavioral and biological needs of the individual species.

Larval development and bioenergetics of rock crab (*Cancer irroratus*) larvae reared under optimal and suboptimal conditions of temperature and salinity.

AUTHOR(S): Johns, D. M.

YEAR: 1980.

SOURCE: Amer. Zool. 20(4):844.

KEYWORDS: Rock crab, *Cancer* sp., larvae.

ABSTRACT: Energy budgets for rock crab, *Cancer irroratus*, larvae cultured in various salinities and temperatures were described. Growth was maximized at 15-18 deg. C and a salinity of 30-35‰. When survival was low, most energy was utilized in maintenance. Conversely, when survival was high, more energy was used for new tissue growth.

Ecological effects of an artificial island, Rincon Island, Punta Gorda, California.

AUTHOR(S): Johnson, G. F., and L. A. de Wit.

YEAR: 1978.

SOURCE: Prepared for U. S. Army, Corps of Engineers. Miscellaneous Report 78-3.

KEYWORDS: Artificial reef, platform, distribution, habitat, community.

ABSTRACT: The purpose of this study was to better understand the ecological consequences of artificial island construction. The objectives were to compare biota around Rincon Island with the natural bottom between the island and shore, describe the shell debris beds around the island, seasonally survey the major benthic organisms along permanent transects on each side of the island, survey fishes around the island with gill nets, and expand the existing species list of the area. The results showed that the high-relief solid substrate of Rincon Island has a rich and varied flora and fauna compared to the more depauperate natural bottom habitats in the area. Data from the permanent transects indicate that some species undergo significant seasonal variability. The gill net survey obtained 23 fish species with rockfish, surfperch, toadfish and swell sharks dominating the catch.

Seashore animals of the Pacific Coast.

AUTHOR(S): Johnson, M. E., and H. J. Snook.

YEAR: 1927.

SOURCE: Dover Publ., Inc., New York, NY. 659 p.

KEYWORDS: Market squid, *Loligo opalescens*, spiny lobster, *Panulirus interruptus*, life history, behavior, physiology, habitat, feeding, mortality, range.

ABSTRACT: This text represents a non-technical, illustrated study of the structure and habits of the common seashore animals of the West Coast of the United States. Material has been gathered from many sources and illustrated in such a way to facilitate use by non-scientific individuals. Life histories, habitats, and other general information is provided for each species along with illustrations and physiological descriptions.

The offshore drift of larvae of the California spiny lobster,  
*Panulirus interruptus*.

AUTHOR(S): Johnson, M. W.

YEAR: 1960.

SOURCE: CalCOFI Rep. 7(Jan 58-Jun 59):147-161.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, larvae.

ABSTRACT: What happens to a floating population of spiny lobster, *Panulirus interruptus*, larvae is discussed. Movement is documented by reporting the distribution of 11 phyllosoma stages over time. The total larval life lasts about 7.75 months with Stage I found only from mid-June to mid-November. The source of larvae is at the immediate coast or in the area of islands. Later larval stages occur in diminishing numbers and usually farther from the coast. In restricted areas there is evidence of flushing of larvae. When considering the whole area there is little flushing, probably due to coast counter-currents, long back swirls, and eddies that retain large numbers of larvae up through the later stages. Larvae drift about at the mercy of prevailing water currents for a long period of time. In general, the drift of larvae is to the south and southwest. Larvae flushed to waters far from shore are probably lost, a percentage of the population which cannot be estimated with any certainty.

*Paramoeba invadens* n. sp. (Amoebida, Paramoebidae), a pathogenic amoeba from the sea urchin, *Strongylocentrotus droebachiensis*, in Eastern Canada.

AUTHOR(S): Jones, G. M.

YEAR: 1985.

SOURCE: Jour. Protozool. 32(4):564-569.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., mortality.

ABSTRACT: The purpose of this paper was to provide a description of *Paramoeba invadens* n. sp. from urchin tissues and from cultures, for comparison with other members of the genus. Amoebae are 20-40 um in length with one parasome per cell. Descriptions are given for the locomotive, floating, semifloating and tissue-dwelling forms. Although *P. invadens* have only been recovered from diseased *Strongylocentrotus droebachiensis*, the ease with which it can be cultured on malt-yeast or non-nutrient agar, with marine bacteria as a food source, suggests that it is a facultative parasite and may occupy a typical free-living habitat in oceanic waters or sediment. Sea urchin disease shows characteristic symptoms such as muscle necrosis, particularly in tube feet, and invasion of tissues by coelomocytes. Healthy urchins injected with the pathogen show a high degree of mortality.

A review of the longline fishery for billfishes in the eastern Pacific ocean.

AUTHOR(S): Joseph, J., N. L. Klawe, and C. J. Orange.

YEAR: 1974.

SOURCE: Joseph, J., N. L. Klawe, and C. J. Orange. 1974. A review of the longline fishery for billfishes in the eastern Pacific Ocean. Pages 309-331 in R. S. Shomura and F. Williams (eds.), Proceedings of the International Billfish symposium, Kailua-Kona, Hawaii, 9-12 Aug. 1972. Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS SSRF-675.

KEYWORDS: Population trends, economics, fishery, seasonality, distribution, *Xiphias gladius*, swordfish.

ABSTRACT: Information from the Japanese, Korean and Chinese longline fleets is used to analyze the distribution, seasonality, relative abundance, population trends, fishing effort and catch of swordfish (*Xiphias gladius*), shortbill spearfish (*Tetrapturus angustirostris*), striped marlin (*Tetrapturus audax*), blue marlin (*Makaira mazara*), black marlin (*Makaira indica*), and sailfish (*Istiophorus platypterus*) in the eastern Pacific ocean. Also discussed is the history of the fishery and the economics behind it. Finally, some recommendations are made for scientific research and proper management of these species. From about 1962, when the catch rates for tunas dropped off, the catch rate of billfishes began to increase, and by 1972 was about 600,000 fish per year. Striped marlin are widely distributed throughout the eastern Pacific ocean all year long, ranging from shortbill spearfish are more abundant seaward. Swordfish are abundant between 35 degrees north and 40 degrees south latitudes in the eastern Pacific. Because of the similar habitat, lifestyle, behavior, and their inter-relationship with one another, some ecological aspects of tuna are included in this paper on billfishes.

Progress report on the status of English sole in California-Monterey and Eureka areas.

AUTHOR(S): Jow, T., and J. J. Geibel.

YEAR: 1985.

SOURCE: Pacific Fishery Management Council - Status of the Pacific Groundfish Fishery through 1985 and Recommended Acceptable Biological Catches for 1986. Appendix 8.

KEYWORDS: English sole, *Parophrys vetulus*, fishery, regulations, economics, recruitment.

ABSTRACT: Trends in English sole landings from 1924-1984 are presented. The results show that landings have fluctuated since 1929, although a declining trend has occurred since 1980. During the most recent years, recruitment has been below average, as reflected in the cohort analyses and in the resulting annual fisheries.

California's view of anchovy management.

AUTHOR(S): Kaneen, R. G.

YEAR: 1977.

SOURCE: CalCOFI Rep. 21:25-27.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery.

ABSTRACT: Current views of the management of the northern anchovy, *Engraulis mordax*, fishery in California by the Marine Resources Region (MRR) are given. The MRR is responsible for field work, public contact, catch monitoring, and other activities related directly to management. It is their job to make management recommendations to the Sacramento headquarters. The Operations Research Branch (ORB) is responsible for conducting research. It is the direct responsibility of the Fish and Game Commission (FGC) to set rules and regulations, including closing the season on 48 hrs notice, on the reduction fishery. The Director of the MRR makes recommendations to the FGC guided by information from his department, the National Marine Fisheries Service, and general policy statements in the Fish and Game Code. The

management of this wetfish must "walk in the shadow" of the poorly managed sardine fishery of years ago. Working biologists, sportsmen, commercial fishermen, and processors are all dissatisfied with previous anchovy management. It is the policy of the FGC to foster and encourage the development and expansion of the industry so that the resource may be fully developed in the public interest without endangering the resource. Consequently, current public opinion appears to have improved. In the future the MRR would like to see an opportunity for increased production in a manner consistent with other beneficial uses and a cooperative management program with Mexico. Future combined landings of Mexico and California will soon exceed 200,000 tons with the continued authorization of reasonable quota increase requests.

Feeding dynamics of *Loligo opalescens*

AUTHOR(S): Karpov, K. A., and G. M. Cailliet

YEAR: 1978.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 169:45-65.

KEYWORDS: Squid, *Loligo opalescens*, feeding.

ABSTRACT: The diet of market squid, *Loligo opalescens*, was examined with respect to location, depth, size and sex of individuals, diet behavior and digestion rates. The samples were collected from the Monterey Bay and adjacent areas using bottom and underwater trawls. Squid fed mostly on crustaceans (primarily euphausiids) and to a lesser extent on fish, cephalopods, gastropods and polychaetes. There was little difference in the diets of large (101-180 DML) versus small (21-100 DML) squid. Euphausiids were a predominant prey item in deeper waters, while a more balanced prey composition was consumed in shallow water. On the spawning grounds megalop larvae were more important than euphausiids and cannibalism increased; however, there was little difference in diet between sexes. Feeding activity was highest during the daylight hours with little to no feeding after dark. Stomachs of squids were emptied within 5 to 7 hours after feeding.

Prey composition of the market squid, *Loligo opalescens* Berry, in relation to depth and location of capture, size of squid, and sex of spawning squid.

AUTHOR(S): Karpov, K. A., and G. M. Cailliet.

YEAR: 1979.

SOURCE: CalCOFI Rep. 20:51-57.

KEYWORDS: Market squid, *Loligo opalescens*, feeding.

ABSTRACT: The prey of market squid, *Loligo opalescens* from the Monterey Bay region were identified and crustaceans were found to dominate the diet. Offshore the squid fed almost exclusively on euphausiids, while inshore, other prey items (mysids, megalope larvae, fish and cephalopods) became more important. The feeding behavior was highly variable at the spawning grounds; euphausiids were absent from the diet and many demersal species were taken. No significant difference in prey type taken by sexes was noted at the spawning grounds. Larger squid (101-180 mm DML) fed more specifically on euphausiids, cephalopods and fish than the small (21-100 mm DML) squid.

Possible morphological indicators of population structure in the market squid, *Loligo opalescens*.



AUTHOR(S): Kashiwada, J., and C. W. Recksiek.

YEAR: 1978.

SOURCE: Fish. Bull. 169:99-112.

KEYWORDS: Market squid, *Loligo opalescens*.

ABSTRACT: Market squid, *Loligo opalescens*, were collected at locations between Puget Sound, Washington and Rosario Bay, Baja California. Several morphological characteristics were examined and measurements were collected from the mantle, fins, arms, tentacles, gill filament, and funnel cartilage. Sexual dimorphism was evident from the first and second arm lengths. Some degree of difference was also noted in adult and immature squid. The data suggested three separate stocks of squid were found along the coast. These included Puget Sound, northern and central California and Baja. The differences in observed morphological variations could have been due to environmental factors at the various geographic locations.

Beaks of the market squid, *Loligo opalescens*, as tools for predator studies.

AUTHOR(S): Kashiwada, J., C. W. Recksiek, and K. Karpov.

YEAR: 1979.

SOURCE: CalCOFI Rep. 20:65-71.

KEYWORDS: Market squid, *Loligo opalescens*.

ABSTRACT: The market squid, *Loligo opalescens*, were captured in southern California and central California (Monterey Bay) to look at beak dimensions and body size. A regression of the dorsal mouth (body) length on various beak dimensions (of the upper and lower beaks) were thought to be useful in determining size, age, sex and geographic location of the squid taken from various predator's stomachs. The data would also elucidate the question of subpopulation presence. The results of the experiment showed no significant difference between regression lines of southern and central California squid. In addition, no difference was noted between males and females. The experiment quantified relationships between beak sizes and body length.

Shark tagging in the eastern Pacific Ocean, 1962-65.

AUTHOR(S): Kato, S., and A. H. Carvallo.

YEAR: 1967.

SOURCE: Pages 93-109 in P.W. Gilbert, R. F. Matewson, and D. P. Rall (eds.), sharks, skates and rays. Johns Hopkins Press & Amer. Inst. Biol. Sci.

KEYWORDS: Thresher shark, *Alopias vulpinus*, growth, distribution.

ABSTRACT: Preliminary data on the effectiveness of various tags on 16 species of sharks from the eastern tropical Pacific Ocean was presented. The data was evaluated by movement and growth studies. Sharks were tagged in three habitats; offshore (California to Peru), coastal (near the Gulf of California), and insular (at Revillagigedo Islands). Sharks were tagged with Peterson discs, Rototags, straps, or darts. Several sharks were tagged with a combination of tags to check for losses. Of the 860 tagged sharks, 10% were recovered within 1 to 2 years. Few sharks were recovered in the offshore areas (4) with 49 caught at the Islands and 30 caught inshore. The time at liberty and distance traveled was variable within and between species. Growth rates appeared to be inconsistent and suggested errors in measurements. Average growth rates of juvenile *Carcharhinus galapagensis* and C.

albmarginatus were 41 mm and 31-54 mm, respectively. Peterson and dart tags were shed at faster rates than Rototags and strap tags. Roto tags were preferred since they caused less fin damage.

Field Guide to Eastern Pacific and Hawaiian Sharks.

AUTHOR(S): Kato, S., S. Springer, and M. H. Wagner.

YEAR: 1967.

SOURCE: U.S.F & W. Serv. Bull. Comm. Fish. circ 271.

KEYWORDS: Thresher shark, *Alopias vulpinus*.

ABSTRACT: A guide to 15 families (>70 species) of sharks from the eastern Pacific (Alaska to Cape Horn) and Hawaii was presented. The descriptions and illustrations (of most species) were included in the text. The families represented included: Frill sharks (F. chlamydoselacidae), 1 species from southern California, deep water (>500m). Six and seven gill sharks (F. hexanchidae), 3 genera, coastal. Bullhead sharks (F. squalidae), at least 10 species in cool and deep water. Angel sharks (F. squatinidae), 2 species, temperate waters. Nurse sharks (F. orectolobidae), 1 species from the Gulf of California to Peru. Basking sharks (F. cetorhinidae), 1 species in cool northern and southern waters. Sand sharks (F. odontaspidae), may be 2 species from southern California. Thresher sharks (F. alopiidae), 2 species, pelagic to cool inshore waters. Whale sharks (F. rhiniodalidae), 1 species from warm waters. Mackerel sharks (F. lamnidae), at least 5 species found inshore and offshore throughout eastern Pacific. Cat sharks (F. scyliorhinidae), 10 species from deep waters. Hammerhead sharks (F. Sphrynididae), 6 species in warm waters, occasionally in cooler subtropical waters. Smoothhounds (F. Carcharhinidae), 7 species, coastal temperate and tropical waters. Requiem sharks (F. Carcharhinidae), 7 genera and at least 20 species, most diverse family from warm tropical to cool temperate inshore and offshore waters.

Mariculture potential of the spot prawn, *Pandalus platyceros*  
Brandt.

AUTHOR(S): Kelly, R. O., A. W. Haseltine, and E. E. Ebert.

YEAR: 1977.

SOURCE: Aquaculture 10:1-16.

KEYWORDS: *Pandalus platyceros*, spot prawn, growth, feeding, early life history.

ABSTRACT: Mariculture potential is discussed for the spot prawn (*Pandalus platyceros*) in terms of fecundity, molting frequency and growth, nutrition, salinity and temperature tolerances. Hatching periods averaged 19 days and occurred between February and June at temperatures of 8, 9 - 11.9 deg. C. Fecundity ranged from 2,628 to 4,669 larvae per female. Molting from state I to II occurred 7 days after hatching while subsequent molts were not synchronous. Larvae size varied in each stage but mean sizes progressed increasingly with stage. Mean lengths and weights ranged from 1.5 - 29.9 mm and 0.032 - 16.95 g, respectively. A length/weight relationship was calculated as:  $\log W = -3.0843 + 2.9308 \log L$ , where W = weight in grams and L = carapace length in millimeters. Highest growth rates were found in prawns fed *Phaeodactylum tricornutum* and *Artemia salina*, while lowest rates were found in those feeding only on the *P. tricornutum*. Highest survival was found in those fed only *A. salina*. Growth and

survival in prawns fed diced food was maximized with combined mussel and sea urchins. A food conversion ratio of 5.5:1 was achieved. Prawns exposed to an elevation in temperature showed no increase in mortality. The LD50 temperature was 22.9 deg C. At salinities of 16 and 18 0/000, 100% mortality occurred, while at salinities of 22 0/000 or greater, mortality was less than 20%. The LD50 salinity was 20.4 0/000. Monoculture of spot spawns would be economically questionable, yet a potential in a polyculture system may exist.

Alaska's saltwater fishes and other sea life.

AUTHOR(S): Kessler, D. W.

YEAR: 1985.

SOURCE: Alaska Northw. Publ. Co., Anchorage, AK. 358 p.

KEYWORDS: Sea urchin, strongylocentrotus spp., physiology, distribution, length, Sebastes spp.

ABSTRACT: To simplify identification of Alaska's saltwater fishes and other

sea life, this field guide emphasizes distinguishing features of the living animals. Written descriptions that include both scientific and common names, size and occurrence, diagrams and photographs are provided to assist in positive identification.

Population dynamics of the Petrale sole, *Eopsetta jordani*, in waters off western Canada.

AUTHOR(S): Ketchen, K. S., and C. R. Forrester.

YEAR: 1966.

SOURCE: Jour. Fish. Res. Bd. Canada, Bull. 153. 195 pp.

KEYWORDS: Petrale sole, *Eopsetta jordani*, fishery, growth, age, length/weight, mortality.

ABSTRACT: Two stocks of Petrale sole, *Eopsetta jordani*, were recognized off British Columbia. Local fisheries had severe effects on both populations; average size and age decreased in both stocks until 1947. The 1940-1943 year classes contributed strongly to the fishery, and this trend was noted in the 1958 year class. Asymptotic lengths of 49.0 cm and 58.6 cm were noted for male and female fish, respectively. Half the male fish matured at 38 cm length (age 7), while females matured at 44 cm (age 8). Mortality estimates and fishing pressure results suggest an increased yield of 2-12% could be achieved by a reduction in the minimum size fish marketed, or by increased fishing pressure. However, variations in the vulnerable spawning concentrations weren't considered. Seawater temperatures and wind patterns appeared to have the greatest effect on the pelagic eggs and larvae.

Technical study on artificial spawning of abalone, genus *Haliotis*. No. 1: Relation between water temperature and advancing sexual maturity of *Haliotis discus hannai* Ino.

AUTHOR(S): Kikuchi, S., and N. Uki.

YEAR: 1974.

SOURCE: Bull. Tohoku Reg. Fish Res. Lab. 33:69-86.

KEYWORDS: Abalone, *Haliotis* sp., growth, spawning, length/weight.

ABSTRACT: Laboratory experiments were done to analyze the relationship between temperature and advancing sexual maturity. The main purpose of the study was to find a technique to artificially spawn abalone outside of the natural spawning season. Experiments were done under six different temperature conditions from 8 to 22

deg C. As the adults mature sexually, the increasing Gonad Index (Y) is related to temperature as follows:  $Y = 0.00597 T - 0.04527$  ( $T < 20$  deg C). The theoretical lowest water temperature at which sexual maturity occurs is at 7.6 deg C. The best growth (shell length, weight, and sexual maturity) occurred with adults kept at 17 deg C.

Notes on larvae, juveniles, and spawning of bonito (*Sarda*) from the eastern Pacific Ocean.

AUTHOR(S): Klawe, W. L.

YEAR: 1961.

SOURCE: Pac. Sci. 15(4):487-493.

KEYWORDS: Pacific bonito, *Sarda chiliensis*, larvae, spawning, seasonality.

ABSTRACT: This report summarizes a few notes on the description of bonito (*Sarda*) larvae and comments on their spawning season. The range of *Sarda chiliensis* extends from southern British Columbia to northern Chile. Evidence indicates that spawning of the Pacific bonito occurs in June off of southern California, and from December through February off the coast of Peru. Planktonic larvae caught off Baja California have between 43 and 45 myomeres. Three spines are found along the posterior edge of the preoperculum. Other larval characteristics are included. Juveniles of *S. chiliensis* and *S. orientalis* may be differentiated in the bars of gill raker counts, even at a relatively small size.

Pacific mackerel: A resurgent resource and fishery of the California current.

AUTHOR(S): Klingbeil, R. A.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:35-45.

KEYWORDS: Pacific mackerel, *Scomber japonicus*, fishery, regulations, population trends, age, length/weight, jack mackerel, *Trachurus symmetricus*.

ABSTRACT: The purpose of this paper was to describe management efforts during the years of Pacific mackerel depletion (1965-1975), and to document Pacific mackerel fishery and management developments during the years of resurgence (1975-1980). Regulation of the fishery after the initial depletion was slow but culminated with a moratorium in 1970. The moratorium law provided for quota management and closely monitored jack mackerel landings for signs of increased incidental catches. Management during the years of resurgence was hectic and complicated by the incidental catch of Pacific mackerel in the jack mackerel fishery, and by the difficulty of accurately assessing the biomass of Pacific mackerel.

Sex ratios of northern anchovy, *Engraulis mordax*, off southern California.

AUTHOR(S): Klingbeil, R. A.

YEAR: 1978.

SOURCE: Calif. Fish Game 64(3):200-209.

KEYWORDS: *Engraulis mordax*, northern anchovy, population trends.

ABSTRACT: Female to male sex ratios of the northern anchovy, *Engraulis mordax*, were calculated from the southern subpopulation using commercial catch statistics and scientifically collected data.

Sex ratios from both sample types varied greatly. There was no apparent seasonal or cyclic trend. Commercial catches always favored females over males with ratios ranging from 1.14:1 to 2.02:1 (1968-69 to 1974-75 seasons). This could be explained by differential mortality or growth rates affecting females and males. Scientific cruises on the other hand varied from favoring females (24:0), males (0:25), or approached 1:1 (1.03:1). The scientific cruises covered a more extensive area than the commercial vessels and appeared to be the most important difference in the two sampling types. The information suggests a temporal and spatial difference in the sex composition of the population. The overall sex ratio of the southern subpopulation is expected to be close to 1:1.

Maturation and growth of Pacific mackerel, *Scomber japonicus*  
Houttuyn.

AUTHOR(S): Knaggs, E. H., and R. H. Parrish.

YEAR: 1973.

SOURCE: Calif. Fish Game 59(2):114-120.

KEYWORDS: Chub mackerel, *Scomber japonicus*, age, growth, length/weight, seasonality, reproduction, spawning, mortality.

ABSTRACT: The maturity state of 3397 female Pacific mackerel, *Scomber japonicus* were determined by visual inspection. Spawning was found to occur between March and October with the majority between April and August. Female mortality for the 1, 2, 3, 4, 5 and 6+ was 22.5%, 65.7%, 75.1%, 84.7%, 84.2% and 87.0%, respectively. 100% of the males over 3 years were found to be mature; the first year class was 88% mature and the second year class was 96.6% mature. A von Bertalanffy weight-length curve was produced for the Pacific mackerel. Lengths ranged from 272.96 mm FL for age 1 to 406.64 mm FL for age 8 fish.

Some peculiarities in the reproduction of the black cod  
(*Anoplopoma fimbria* (Pall)).

AUTHOR(S): Koldolov, L. S.

YEAR: 1968.

SOURCE: Proc. Pacific Scientific Research Institute of Marine Fisheries and Oceanography 8(4(51)):662-668.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, groundfish, reproduction, early life history.

ABSTRACT: This study was initiated to give a detailed description of the reproduction of sablefish, *Anoplopoma fimbria*, in the Bering sea, and the Vancouver-Oregon area. According to the data, 50% of the black cod in the Bering Sea are mature at the age of 5 - 6 years (60 - 62 cm). Black cod spawn from September to February with peak spawning in the autumn. Female sablefish caught in the Bering Sea had fertilities ranging from 438,000 to 503,000 eggs in fish lengths from 725 to 825 mm, respectively. Larvae and juveniles keep to the upper layers of water at temperatures of 9-16.7 deg C. The authors propose a life history model based on many observations. The black cod rises from the bottom when mature and moves out to sea away from the continental slope to spawn. The eggs are thought to be carried out to the Aleutian Islands and perhaps to the Gulf of Alaska. Then the young juveniles at an age of 5-7 months (60 - 62 cm), after becoming more temperature tolerant, return to the upper slope and shelf areas. Another possibility suggested is a migration of the black

cod out to the Aleutian Islands and the Gulf of Alaska. The authors can find no data to support the migration hypothesis and consider it unlikely, however, they also cannot disprove it.

Uptake, distribution, and depuration of <sup>14</sup>C-benzene in northern anchovy, *Engraulis mordax*, and striped bass, *Morone saxatilis*.

AUTHOR(S): Korn, S., N. Hirsch, and J. W. Struhsaker.

YEAR: 1976.

SOURCE: Fish. Bull. 74(3):545-551.

KEYWORDS: Northern anchovy, *Engraulis mordax*, contaminant susceptibility.

ABSTRACT: The uptake, distribution, and depuration of benzene in the northern anchovy, *Engraulis mordax*, was determined to evaluate the importance of long-term sublethal effects of low levels of oil in inshore areas. Accumulations of benzene was greatest in the gall bladder, followed by the intestine, liver, brain, gill, and muscle. Concentrations in the gall bladder were 53.4-8,450 times the initial water concentration while the muscle was 1.11-135 times greater. Maximum concentrations were obtained 0.25 to 4 days after first exposure, with the gall bladder and liver maximums occurring later than the other tissues. After cessation of exposure the residues rapidly depurated, with gall bladder, liver, and gill residues lasting longest. Benzene and/or metabolites accumulate predominantly in tissues with a high lipid content. They are absorbed across the gills, translocated to the tissues by the blood, and either accumulated in tissues or metabolized. The fish are capable of excreting or metabolizing benzene, and the major depuration route is through the liver, gall bladder, intestine and colon. Similar results are reported for the striped bass, *Morone saxatilis*. The observations indicate a rapid uptake rate over a wide range of concentrations. Contaminant susceptibility is high and fish could accumulate significant benzene levels after brief exposure during an oil spill. Because of rapid depuration it does not appear that bio-amplification will occur.

Economic status of the California Dungeness crab fishery in 1983-84.

AUTHOR(S): Korson, C. S.

YEAR: 1985.

SOURCE: NOAA Tech. Mem. NOAA-TM-NMFS-SWR-008. 8 pp.

KEYWORDS: Market crab, Cancer magister, fishery, economics.

ABSTRACT: The Dungeness crab, *Cancer magister*, fishery off California is harvested from five sectors (Avilla-Morro Bay, Monterey, San Francisco-Bodega Bay, Fort Bragg, and Eureka). Landings were up slightly from the 1982-83 year to 5.6 million pounds still well below the state average of 9.9 million pounds. The San Francisco landings for 1983-84 (875,000 pounds) represented a 15-year high and a 50% increase over 1982-83. Approximately 400 vessels remain in the fishery, down from 557 vessels in 1982-83. The value of the fishery was \$9,566,000, a 96% increase over the 1982-83 value or 87% (corrected for inflation). Wholesale prices of crab have risen to \$2.45 to \$2.85 per pound with retail prices as high as \$9.00 per pound.

Economic status of the California pink shrimp fishery in 1984.

AUTHOR(S): Korson, C. S.

YEAR: 1985.

SOURCE: U. S. Dept. of Commerce Tech. Memo.,  
NOAA-TM-NMFS-SWR-009. 10 pp.

KEYWORDS: *Pandalus jordani*, ocean shrimp, economics, fishery.

ABSTRACT: Annual landings (thousands of pounds) and exvessel values (thousands of dollars) of ocean shrimp have been decreasing from 1978 to 1984. California landings did undergo a slight increase from 1983 to 1984, which was attributed to the return of larger shrimp to the normally productive beds off Eureka/Crescent City. Landings in the Eureka/Crescent City area, generally the most productive beds, recovered to over 1.3 million pounds, an increase of over 300% from 1983. Although the California landings made a slight increase, the exvessel values declined from 1983 to 1984 because of a drop in the price per pound. Wholesale prices for the vacuum-packed product were \$3.60 to \$4.50 per lb in 1983 compared to \$3.50 to \$4.25 per lb in 1984.

Economic status of the Washington, Oregon, and California groundfish fishery in 1984.

AUTHOR(S): Korson, C. S.

YEAR: 1984.

SOURCE: NOAA Tech. Memo. NOAA-TM-NMFS-SWR-010:1-22.

KEYWORDS: Rockfish, *Sebastes* spp., Dover sole, *Microstomus pacificus*, sablefish, *Anoplopoma fimbria*, flatfish, groundfish, economics.

ABSTRACT: The economics of the Washington, Oregon and California groundfish fishery in 1984 is examined as to total catch, total ex-vessel revenue, and the landings, revenue per vessel, and number of operating vessels for each harvesting sector of the groundfish fleet. In addition, price ranges for processed products, and factors affecting groundfish markets are examined. The California groundfish catch consists of several different species, which includes rockfish (*Sebastes* spp.), Dover sole (*Microstomus pacificus*), sablefish (*Anoplopoma fimbria*), and other flatfishes and groundfishes. Total landings in 1984 were 168,635 mt (including joint-venture deliveries) compared to 169,808 mt in 1983. The ex-vessel value of these landings declined 2.4%, from \$62,417,000 in 1983 to \$60,931,000 in 1984. Sablefish, rockfish and flatfish landings all declined in 1984. This also produced a decline in fresh and fresh-frozen domestic groundfish in west coast markets. The decline in rockfish landings was the result of regulations imposed by the Pacific Fishery Management Council. Pacific whiting, (*Merluccius productus*), landings increased in 1984, with 78,889 mt harvested by the joint-venture fishery. The otter trawl and pot and trap fleets saw a decline in both revenue and number of boats in 1984, while the gill net fleet landings increased. Ex-vessel prices for major groundfish species were slightly higher in 1984.

Economic status of the California dungeness crab fishery in 1982-1983.

AUTHOR(S): Korson, C. S.

YEAR: 1984.

SOURCE: NOAA/NMFS NOAA-TM-NMFS-SWR-006.

KEYWORDS: Market crab, Cancer magister, fishery, economics.

ABSTRACT: The Dungeness crab, *Cancer magister*, fishery in California operates from five sectors (Avilla-Morro Bay, Monterey, San

Francisco-Bodega Bay, Ft. Bragg and Eureka). Landings in 1982-83 were only 5.3 million pounds, almost 50% below 1981-82 season. Landings for San Francisco recovered to 570,000 pounds up from the record low 200,000 pounds caught in 1981-82. The number of vessels fishing for crab increased to 557 in 1982-83 (up from 532 in 1981-82). The value of the 1982-83 catch was approximately \$5,714,000 (1.08/lb) a decrease of 42% from the 1981-82 value of \$9,870,000. Adjusted for inflation, the 1982-83 landings represent a net loss of 45%. The wholesale prices of whole-live and hole-cooked crab ranged from \$1.80-\$1.95 and \$2.05-\$2.35, respectively. These prices may have accounted for the decline in consumer demand.

Economic status of the California groundfish fishery in 1983.

AUTHOR(S): Korson, C. S.

YEAR: 1984.

SOURCE: NOAA Tech. Memo. NMFS-SWR-004:1-18.

KEYWORDS: Groundfish, *Sebastes* spp., Dover sole, *Microstomus pacificus*, sablefish, *Anoplopoma fimbria*, economics, fishing gear, Pacific hake, *merluccius productus*, fishery, regulations.

ABSTRACT: This report reviews the economics of the California groundfish fishery in 1983. It provides summarized data on total catch, total ex-vessel revenue, landings, revenue per vessel, and number of operating vessels, for each harvesting sector of the groundfish fleet. The California ground fish catch consists of several different species, which includes rockfish (*Sebastes* spp.), Dover sole (*Microstomus pacificus*), sable fish (*Anoplopoma fimbria*), and other flatfishes and groundfishes. They are harvested with a variety of fish gear, which includes otter trawls, pots and traps, longlines, set nets (gill and trammel), jigs, and hook-and-line. In California total groundfish landings were an estimated 39,500 mt in 1983, down 25% from 1982 landings (52,600 mt) and 3.8% below the 1978-82 annual average (41,100 mt). The ex-vessel value of the 1983 landings was \$22.0 million compared to \$27.9 million in 1982. The decline in production was mainly due to a sharp drop in landings of rockfishes with trawl gear. The California groundfish fishery was impacted by several restrictive harvest regulations that were adopted by the Pacific Fishery Management Council in 1983. The coastwide optimum yield for widow rockfish, (*Sebastes entomelas*), was lowered from 26,000 mt in 1982 to 10,500 mt in 1983, and trip limits were set at 30,000 pounds. A 40,000 pound trip limit was imposed on all other rockfish species. Joint-ventures with the Soviet Union for Pacific whiting, (*Merluccius productus*), continued to expand in 1983. A total of 72,100 mt of Pacific whiting, estimated to have an ex-vessel value of \$10.2 million, was harvested in 1983. This compares to 67,500 mt worth \$10.4 million in 1982. Groundfish processors, wholesale prices, and factors affecting groundfish markets, including changes in imports and exports are also examined and discussed.

Economic status of the California salmon fishery in 1983.

AUTHOR(S): Korson, C. S.

YEAR: 1984.

SOURCE: NOAA-TM-NMFS-SWR-005. 19 pp.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, chinook salmon, *Oncorhynchus tshawytscha*, economics, fishery, population



trends.

ABSTRACT: The catches from the commercial ocean troll and sports fisheries for salmon were drastically down in 1983 for the entire California, Oregon, and Washington (WOC) coastal region. The California commercial fishery landings in 1983 were about 2.4 million pounds; almost 70% below the 1982 landings, and the worst year on record. The decline included both silver salmon, *Oncorhynchus kisutch*, and king salmon, *O. tshawytscha*. The ex-vessel value of the commercial catch was only about \$4.3 million, which after adjusting for inflation was 76% lower than the revenues for 1982. This encouraged a four-fold increase in fishermen attaining license to sell salmon wholesale, rather than selling to processing plants. The market prices for fresh WOC salmon remained low due to an influx of frozen Alaska salmon. The decrease in the fishery is attributed to three separate factors: altered ocean conditions due to El Nino, reduced stock sizes, and poor market conditions which led to reduced fishing effort. Many fishermen in the face of reduced market price of salmon switched to the more lucrative albacore fishery. The effects of fishery management policies were overshadowed by the poor fishing conditions.

Economic status of the Washington, Oregon and California commercial groundfish fishery in 1984.

AUTHOR(S): Korson, C. S., and W. Silverthorn.

YEAR: 1985.

SOURCE: Pacific Fishery Management Council - Status of the Pacific Groundfish Fishery through 1985 and Recommended Acceptable Biological Catches for 1986, Appendix 9.

KEYWORDS: Dover sole, English sole, petrale sole, widow rockfish, sablefish, Pacific hake, *Microstomus pacificus*, *Parophrys vetulus*, *Eopsetta jordani*, *Sebastes entomelas*, *Anoplopoma fimbria*, economics, fishery.

ABSTRACT: An overview of the economic performance of the West Coast groundfish industry in 1984. Developments in the fisheries for the main groups in the groundfish catch (sablefish, widow rockfish, other rockfish, flatfish, and Pacific whiting) are discussed. Landings/yield and revenue from the otter trawl fleet, pot/trap vessels and other gear vessels are also presented. Total landings and exvessel values were about the same as in 1983. A decline in rockfish and flatfish landings combined with reduced fresh and frozen groundfish imports resulted in a decreased groundfish supply to the West Coast markets.

Feeding selectivity of schools of northern anchovy, *Engraulis mordax*, in the Southern California Bight.

AUTHOR(S): Koslow, J. A.

YEAR: 1981.

SOURCE: Fish. Bull. 79(1):131-142.

KEYWORDS: *Engraulis mordax*, northern anchovy, feeding.

ABSTRACT: The feeding of five schools of northern anchovy, *Engraulis mordax*, under various conditions was examined in the Southern California Bight in 1976. The meristics of the fish and their gut contents were recorded. Larvae were separated into a 1 year (98-99 mm) and 1+ year (115-123 mm) size class. The biomass of the schools ranged from 25-100 tons. The school's feeding was primarily a function of prey size; density did not appear to

affect selectivity. At concentrations of 10-40 mg/C/m<sup>3</sup> schools consumed 35-50% of the available prey and 90% of the largest zooplankton available. In only one tow, the anchovies fed preferentially on a particular species, *Calanus pacificus*. No significant difference was found in feeding selectivity of the two age classes. The northern anchovy apparently adjusts its feeding to select for the largest prey available, over a hundred-fold range of sizes.

Seashore life of the northern Pacific Coast.

AUTHOR(S): Kozloff, E. N.

YEAR: 1983.

SOURCE: Univ. Wash. Press, Seattle, WA. 370 p.

KEYWORDS: Market squid, *Loligo opalescens*, habitat, physiology, life history, behavior.

ABSTRACT: Approximately 650 species of plants and animals found in marine and

maritime habitats from British Columbia to San Mateo County, CA. are presented in this text as a guide for amateurs and professional biologists. The emphasis is placed on invertebrates and seaweeds with a few fishes included. Physiology of each species is discussed as well as habitat and areas of distribution. The text is illustrated with photographs and drawings to aid in species identification.

Synopsis of the biological data on the Pacific mackerel, *Scomber japonicus* Houttuyn (northeast Pacific).

AUTHOR(S): Kramer, D.

YEAR: 1969.

SOURCE: U.S. Fish Wildl. Serv. FAO Species Synopsis 40.

KEYWORDS: Pacific mackerel, *Scomber japonicus*, distribution, feeding, length/weight, growth, fishery, fishing gear.

ABSTRACT: This paper is a synopsis of extant biological data on the Pacific mackerel, *Scomber japonicus*, through 1969. A taxonomic synonym and description of morphological characteristics is included. The range of Pacific mackerel has been noted from southeast Alaska to Baja, Mexico. Data on the distribution of Pacific mackerel larvae is also included. Little or no data is available on the fecundity, hardiness, competitors, predators or parasites of wild Pacific mackerel populations. Pacific mackerel are heterosexual and do not display any apparent sexual dimorphism. Spawning does not take place until 2+ years of age. Their eggs are pelagic and are often associated with jack mackerel or Pacific hake. Eggs may be distributed from the surface to 176 m, although abundance falls off drastically at about 23 m. Most of the fish taken commercially are less than 6 years old, with most being between 0 and 3 years old. Pacific mackerel are indiscriminate particulate feeders that feed at any time of day. Relative length/weight data as well as information on growth rates and condition factors is also included. The behavior of tagged *S. japonicus* indicate that fish migrate extensively up and down the eastern Pacific shoreline. They school by size and may be found mixed with jack mackerel and Pacific sardine. The fishing gear most employed by commercial fishermen are purse seines and lampara nets. The fishery does not however, extend over the fish's entire range, being limited largely

to southern California. There are no limitations on the catch of Pacific mackerel, although protection of certain portions of the population is suggested.

Development of eggs and larvae of Pacific mackerel and distribution and abundance of larvae 1952-56.

AUTHOR(S): Kramer, D.

YEAR: 1960.

SOURCE: U. S. Fish Wild. Serv. Fish. Bull. 60(174):393-438.

KEYWORDS: Chub mackerel, *Scomber japonicus*, growth, distribution, early life history.

ABSTRACT: Development of Pacific mackerel eggs is described for the early, middle and late stages. Development of the larvae through the juvenile stage are analyzed in terms of variations in development, pigmentation changes, changes in body form, and sequence of ossification (teeth, branchiostegal rays, gill rakers, fin formation, caudal keels, interspinal systems, and vertebral column). Larval distribution is described in terms of vertical distribution and the occurrence of larvae in relation to temperature. Areal and seasonal abundances are determined from census estimates.

Food of five species of co-occurring flatfishes on Oregon's continental shelf.

AUTHOR(S): Kravitz, M. J., W. G. Pearcy, and M. P. Guin.

YEAR: 1976.

SOURCE: Fish. Bull. 74(4):984-990.

KEYWORDS: English sole, *Parophrys vetulus*, petrale sole, *Eopsetta jordani*, feeding, habitat, groundfish, community.

ABSTRACT: Five species of flatfish (*Parophrys vetulus*, *Glyptocephalus zachirus*, *Lepidopsetta bilineata*, *Eopsetta jordani*, and *Citharichthys sordidus*) were collected at one specific time and place from the central Oregon continental shelf. Stomach samples were identified and counted. From this information, flatfish were categorized into two basic feeding types. *Parophrys vetulus*, *G. zachirus*, and *L. bilineata* were benthophagous, feeding on benthic infaunal and epifaunal invertebrates, mainly polychaetes, amphipods and ophiuroids. No fish species occurred in the stomach of these species except two fishes found in *G. zachirus*. *Eopsetta jordani* and *C. sordidus* were piscivorous and fed on pelagic animals, consuming mainly fishes in addition to shrimp, mysids, euphausiids, and cephalopods.

Laboratory study of behavioral interactions between the American lobster, *Homarus americanus*, and the California spiny lobster, *Panulirus interruptus*, with comparative observations on the rock crab, *Cancer antennarius*.

AUTHOR(S): Krekorian, C. O., D. C. Sommerville, and R. F. Ford.

YEAR: 1974.

SOURCE: Fish. Bull. 72(4):1146-1159.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, behavior.

ABSTRACT: The social interactions between the California spiny lobster (*Panulirus interruptus*) and the American lobster (*Homarus americanus*) are compared to that between the spiny lobster and the rock crab (*Cancer antennarius*), in an attempt to determine the effect of introducing the American lobster to the West Coast. When no shelter was present, the American lobster displaced the

spiny lobster 63% of the time when it initiated a behavioral interaction. When shelter was added, the number of interactions was decreased. The spiny lobster was never seen to threaten or attack the American lobster. Little aggression was shown between the spiny lobster and the rock crab. The American lobster had a strong displacement effect on the spiny lobster in the laboratory. In the field, the behavioral actions of the American lobster would be largely aggressive toward the spiny lobster. The effect of a large introduction of American lobsters would probably have an adverse outcome.

Simulation of temperature and upwelling effects on the English sole, *Parophrys vetulus*, spawning season.

AUTHOR(S): Kruse, G. H., and A. V. Tyler.

YEAR: 1983.

SOURCE: Jour. Fish. & Aquat. Sci. Canada 40(2):230-237.

KEYWORDS: *Parophrys vetulus*, English sole, spawning.

ABSTRACT: A relationship is theorized between water temperature and spawning in the English sole. To test this theory, a FORTRAN computer model driven by records of the bottom temperature index was used. The following hypotheses were described the the computer model: the rate of maturation varies inversely with summer temperatures; little or no spawning occurs attemperatures less than 7.8 deg C; and spawning is delayed by increases in bottom temperature greater than 0.95 deg C. The authors suggest that these hypotheses should be tested with controlled laboratory experiments.

Size composition and sexual maturity of billfish caught by the Japanese longline fishery in the Pacific Ocean east of 130o West.

AUTHOR(S): Kume, S., and J. Joseph.

YEAR: 1969.

SOURCE: Bull. Far. Seas. Fish Res. Lab. (Shimuso) 2:15-162.

billfish by Japanese longline fishery

KEYWORDS: Swordfish, *Xiphias gladius*, age, growth, distribution, population trends.

ABSTRACT: The data presented in this paper is from the years 1963 to 1967. This data on size composition and sexual maturity is analyzed in order to draw conclusions concerning the population trends and structure of swordfish (*Xiphias gladius*), shortbill spearfish (*Tetrapturus angustirostris*), striped marlin (*Tetrapturus audax*), blue marlin (*Makaira mazara*), black marlin (*Makaira indica*), and sailfish (*Istiophorus platypterus*) inhabiting the eastern Pacific. Many of the conclusions drawn here are presented in terms of yearly quarters. During the first quarter striped marlin congregate in coastal waters. During the rest of the quarters they appear to migrate seaward towards the equator. The size composition of striped marlin unimodal around the 170 cm size class. During the second quarter there is a tendency for average size to increase in a southerly direction. Generally, the proportion of females increases as size increases. The modal sizes for females is generally larger than males during the first semester, while they are super imposed during the second semester. It seems from the data that striped marlin spawn in two isolated areas during opposite times of the year. For blue marlin the size frequency curve is bimodal, with the dominant

mode at about 200 cm. Ratios of males to females varied widely over the different sub-areas studied. Spawning seasonality appears to occur during January and December in the southwest portions of the east Pacific. Swordfish are most abundant throughout the year in the central eastern Pacific coastal waters. The frequency curve is multi-modal. The male to female ratio is about equal. Swordfish between 62 and 165 cm grow on the average about 38 cm per year. Spawning seems to be year-round, while peaks occur from March to July in the northern latitudes, and January in the southern latitudes. No sexually mature sailfish were found in this study, indicating they do not spawn in this area from December through February. The size-frequency curve was multi-modal. Shortbill spearfish sampled ranged in length from 110-170 cm. Of 12 specimens examined for sexual maturity, only one was found to be mature.

Florida's spiny lobster fishery: An historical perspective.

AUTHOR(S): Labisky, R. F., D. R. Gregory, and J. A. Conti.

YEAR: 1980.

SOURCE: Fisheries 5(4):28-37.

KEYWORDS: Spiny lobster, *Panulirus* spp., economics, fishery, regulations, fishing gear.

ABSTRACT: In Brazil, Cuba, and the United States, the spiny lobster, *Panulirus argus*, accounts for 90% of the commercial lobster catch. In the United States, Florida-based fishermen account for 98% of the total landings, and the bulk of that comes from the Florida Keys. To date, the highest ex-vessel value and high catch are \$13.4 million (1974) and 11.4 million pounds (1972), respectively. There is now concern over the future stability of the domestic fishery due to declining landings and reduced profitability of fishing. In this paper, the development of the lobster fishery in Florida is traced, from its crude beginnings to the valuable industry of today. Included are economics, gear types and fishing technology, regulations, catches, and the uses and processing of the catch.

Stomach contents of salmon and steelhead trout in the Northeastern Pacific Ocean.

AUTHOR(S): LaBrasseur, R. J.

YEAR: 1966.

SOURCE: Jour. Fish. Res. Bd. Canada 23(1):85-100.

KEYWORDS: *Oncorhynchus kisutch*, coho salmon, feeding, distribution.

ABSTRACT: Stomach contents from four species salmon: *Oncorhynchus gorbusha*, *O. kisutch*, *O. keta*, and *O. nerka*, and one species of trout, *Salmo gairdnerii*. The main prey species were amphipods, copepods, euphausiids, squid and fish. A comparison of stomach contents of immature versus mature chum and sockeye salmon showed no significant difference for the chum, but a significant difference for the sockeye. A comparison of stomach contents between spp. showed a similarity in terms of what spp. occurred but a wide variation in terms of quantity of each species. A comparison of stomach contents of fish from different oceanographic domains showed a greater difference than differences observed between species. These results indicate that feeding may be associated more with availability rather than preferences for specific organisms.

The marine resources of Anaheim Bay.

AUTHOR(S): Lane, E. D. and C. W. Hill.

YEAR: 1975.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 165, 195 pp.

KEYWORDS: Nursery, California halibut, *Paralichthys californicus*.

ABSTRACT: The history and hydrography of Anaheim Bay, a saltmarsh associated with the San Gabriel and Santa Ana rivers of Orange County, are described. The biology is reviewed through checklists of plants (vascular and algae) invertebrates, elasmobranchs and teleosts. A quantitative analysis of the polychaete fauna showed some variation between Anaheim Bay and the recently dredged Huntington Harbour. The life histories of several resident fish species are also considered. The California killifish, *Fundulus parvipinnis*, resident of the tidal channels, has a life span of approximately 18 months. The killifish spawn from April to September and feed on annelids, gastropods and arthropods. The shiner surfperch, primary *Cymatogaster aggregata*, born in May at Anaheim Bay, feed primarily on zooplankton and benthic invertebrates. The staghorn sculpin, *Leptocottus armatus*, is a resident prior to 1 year (when it spawns) and feeds on several invertebrates (primarily crustaceans). The California halibut, *Paralichthys californicus*, uses Anaheim Bay as a nursery area. Young of the year arrive in April to May and move offshore in February. The diamond turbot, *Hypsopsetta guttulata* was the most common flatfish encountered. The turbot feeds in the substrate, reducing competition with the halibut which feeds above the surface. The studies indicate that Anaheim Bay is an extremely specious area and has a high productivity rate.

Changes in sea urchin populations after the destruction of kelp beds.

AUTHOR(S): Lang, C., and K. H. Mann.

YEAR: 1976.

SOURCE: Mar. Biol. 36:321-326.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., growth, reproduction, population trends.

ABSTRACT: Study sites in St. Margaret's Bay, Nova Scotia, Canada were identified where kelp beds had been destroyed by urchin overgrazing at varying times in the past 4 years. The population dynamics of sea urchins (*Strongylocentrotus droebachiensis*) were studied to determine whether, after destroying kelp beds, urchin populations starve and die or migrate away. The results show that, at least within 4 years, the urchins showed decreased growth rate and reduced gonad size, but an increase in numbers resulting from high recruitment rates in the first two years after kelp bed destruction. These populations appear to feed on encrusting algae, and on detritus from the nearest seaweed beds, while preventing the regeneration of kelp. The urchin populations do not appear to be dying or dispersing so that kelp beds can regenerate.

Lingcod, *Ophiodon elongatus*, spawning and nesting in San Juan Channel, Washington.

AUTHOR(S): Lariviere, M. G., D. D. Jessup, and S. B. Mathews.

YEAR: 1981.

SOURCE: Calif. Fish Game 67(4):231-239.

KEYWORDS: *Ophiodon elongatus*, lingcod, spawning.

ABSTRACT: Concern over the decreased stocks of lingcod (*Ophiodon*

elongatus) in Puget Sound and in Hood Canal, Washington, led to limited closures of the fisheries in certain areas and at certain times to protect the lingcod's spawning and nesting season. This study was conducted to determine if these closures were optimum, and to make certain observations on the nesting behavior of lingcods. This study was conducted in the San Juan Channel, Puget Sound, Washington. Male lingcods showed traditional territorial and nest defensive characteristics toward the observers and other organisms, precluding observations closer than about 2 m from the nest. Nests were observed from December 16, 1979 until early April, 1980, with the mode around late February to early March. Nest depth ranged from 2.4 to 19.8 m below MLLW. Nesting substratum was rock crevices with openings for water circulation, and where the current was relatively high (up to 4.6 km per hr). Predation on nests was mostly by vertebrates, particularly gastropods. The males seemed to be selective in their defense of the nests, chasing off other fish, while ignoring most of the invertebrates. High current flow is postulated to be for proper aeration of the egg masses. Depth did not seem to be a factor in nest site selection, but was rather limited to substratum type. Loosely attached or unguarded nests were susceptible to destruction (i.e. being swept) away or being preyed upon). A hatching success rate of 40% was postulated as a minimal estimate.

Reproduction of northern anchovy, *Engraulis mordax*, off Oregon and Washington.

AUTHOR(S): Laroche, J. L., and S. L. Richardson.

YEAR: 1980.

SOURCE: Fish. Bull. 78(3):603-618.

KEYWORDS: Northern anchovy, *Engraulis mordax*, reproduction, age, length/weight.

ABSTRACT: Reproductive biology for the northern anchovy, *Engraulis mordax*, was looked at for the Oregon-Washington population. Fecundity, length and age at sexual maturity, sex ratio, spawning frequency, ovarian maturation, seasonal gonad condition, and patterns in geographic distribution were all evaluated. In the northern subpopulation sexual maturity is reached by the third summer (age II), with 31, 95, 98, and 100% mature fish of lengths 85-100, 101-120, 121-128, and greater than 128 mm SL, respectively. Gonadal condition, expressed by the gonad index (GI) showed some development occurring in immature fish, while the gonads of mature fish increased from March through July, with the lowest values in October. The highest and lowest values for mature individuals were found in July showing the presence of running ripe and spent fish. Throughout most of the year sex ratios did not deviate significantly from 1:1, except during spawning when overall males outnumbered females 2.6:1. At this time 33 to 46% of ripe females were about to spawn or spawning, whereas when a ratio of 1:1 is found only 2% of females were in this condition. Mean relative fecundity was estimated at 720+/-40 oocytes per gram total body weight, indicating a higher fecundity than central or southern subpopulations. The number of times females spawn could not be determined, but the conditions observed indicate a limit to subsequent spawnings due to insufficient time for egg maturation given the environmental conditions of that area. Sexually mature and immature fish are geographically separated, with adults offshore in small surface

schools at night and deeper during the day, and young fish in nearshore coastal areas and bays. This segregation infers a spawning migration of adults during summer, with their return to bays around mid-September. The distinct geographic segregation along with higher fecundities of the northern subpopulation may represent additional racial differences among the three anchovy subpopulations.

Winter-spring abundance of larval English sole, *Parophrys vetulus*, between the Columbia River and Cape Blanco, Oregon during 1972-1975 with notes on occurrences of 3 other pleuronectids.

AUTHOR(S): Laroche, J. L., and S. L. Richardson.

YEAR: 1979.

SOURCE: Estuar. Coas. Mar. Sci. 8(5):455-476.

KEYWORDS: *Parophrys vetulus*, English sole, larvae, distribution, spawning.

ABSTRACT: English sole, *Parophrys vetulus*, larvae were examined in relation to year-to-year variations in relative abundance, distribution, and size composition. Fluctuations are related to age of larvae at capture and associated spawning time of adults, hydrographic phenomena and weather conditions. A greater number of larvae were captured in bongo samples than neuston tows, with an indication of increased availability of larvae in surface waters at dusk. There was a greater variance among the six sampling periods than within. The highest frequency of *Parophrys vetulus* larvae occurrence (64%) and percent of all fish larvae taken (41%) was found in March 1973. Other sampling periods were lower (March 1972, April 1973, and March 1975) with April 1972 and March 1974 the lowest, *Parophrys* larvae comprising less than 1% of all fish larvae taken. Distribution was greatest in March and April 1973 and March 1975. The farthest offshore larvae were found (beyond 200 m) along transects where the continental shelf is widest. Two distinct size groups of larvae were evident. Sizes differed markedly among the four years, with a wide difference in the estimated ages. Duration of pelagic life was estimated to be about 18-22 weeks. Year-to-year variations observed may be due to differences in the time of peak spawning, which ranged from early fall (1971-72 season) to January 1971. Differences in survival may also have contributed to the wide fluctuations. Other explanations include physical transport of larvae out of the survey area and temperature variations influencing the rate of larval development.

Age and growth of a pleuronectid, *Parophrys vetulus*, during the pelagic larval period in Oregon coastal waters.

AUTHOR(S): Laroche, J. L., S. L. Richardson, and A. A. Rosenberg.

YEAR: 1982.

SOURCE: Fish. Bull. 80(1):93-104.

KEYWORDS: English sole, *Parophrys vetulus*, early life history, life history, growth, age, length/weight, larvae.

ABSTRACT: This paper documents the existence and characteristics of daily growth rings in the otoliths of laboratory reared and field caught larvae of the English sole, *Parophrys vetulus*. Both the field larvae, and the eggs from which the lab reared larvae were produced, were taken off the Oregon coast in 1977 and 1978. In the laboratory specimens, the first daily ring was observed between 5 and 6 days after hatching. After 16 to 25 days the



rings on the otoliths became faint on the lab reared fish. In general, the daily rings were much clearer in the field specimens than the lab specimens. From the lab results, daily periodicity of otolith growth increments was inferred. A total of 331 field specimens between 3.1 and 20.0 mm SL were analyzed and their length plotted against their estimated age. Regression analysis revealed the following equation to describe the growth during the early life history of hake:  $L_t = 2.073e^{2.354(1-e^{-0.045t})}$ .

Development of larvae and juveniles of the rockfishes *Sebastes entomelas* and *S. zacentrus* (family Scorpaenidae) and occurrence off Oregon, with notes on head spines of *S. mystinus*, *S. flavidus*, and *S. melanops*.

AUTHOR(S): Laroche, W. A., and S. L. Richardson.

YEAR: 1981.

SOURCE: Fish. Bull. 79(2):231-258.

KEYWORDS: *Sebastes entomelas*, widow rockfish, larvae, ichthyoplankton, seasonality, distribution, early life history.

ABSTRACT: The development series of larvae and juveniles of *S. entomelas* (9.9-74.5 mm SL) and *S. zacentrus* are described and illustrated. The descriptions include literature review, identification criteria, distinguishing features, general development, morphology, fin development, spination, scale formation and pigmentation. Spatial and temporal occurrences are described. The ability to distinguish these species from other previously described *Sebastes* larvae is discussed. The transition stage from pelagic to benthic juvenile *S. entomelas* occurred around 40-44 mm SL. Larval and transforming juveniles were collected at stations approximately 9-306 km offshore Oregon. Pelagic juveniles appeared to range as extensively as larvae. Benthic juveniles were taken close to shore at depths of 9-37 m. Larvae <15 mm long were taken from March through June.

Territorial behavior of the black-and-yellow rockfish and gopher rockfish (Scorpaenidae, *Sebastes*).

AUTHOR(S): Larson, R. J.

YEAR: 1980.

SOURCE: Mar. Biol. 58:111-122.

KEYWORDS: Behavior, distribution, habitat, feeding, platform.

ABSTRACT: Three general patterns of space use for shelter holes and feeding areas were observed for *Sebastes carnatus* and *S. chrysomelas*. The three patterns were territorial (which was further subdivided into exclusive, nearly exclusive, and shared shelter but exclusive feeding area), discontinuous home range, and nonterritorial. Territorial characteristics included well-defined, relatively exclusive home ranges in which the shelter hole was located either within or at the edge of the feeding area. In discontinuous home ranges the sheltering and feeding areas, though well-defined, were located some distance apart. The nonterritorial category consisted of fish which moved about a great deal in areas larger than similarly-sized territorial fish. Most of these fish had little or no exclusive area, but did wander between specific places.

Abundance and vertical distribution of fishes in a cobble-bottom kelp forest off San Onofre, California.

AUTHOR(S): Larson, R. J. and E. E. DeMartini.

YEAR: 1984.

SOURCE: Fish. Bull. 82(1):37-53.

KEYWORDS: Paralabrax clathratus, kelp bass, habitat, distribution, nursery, community.

ABSTRACT: A comparison of the species composition, vertical distribution, and standing stock of noncryptic fishes associated with a giant kelp forest and a nearby kelp-depauperate area is made off San Onofre, California. Vertically stratified visual transects and cinetransects are used to estimate fish abundance and biomass. Species which depend on high relief rocky substratum were rare or absent in these areas of low relief cobble-bottom. The fishes associated with the kelp forest were distributed among three groups defined by their vertical position in the water column ("canopy", "cosmopolites", and "bottom"). Despite the absence of reef-dependent species, the estimated biomass of fishes in the low relief kelp forest studied (388-653 kg/ha) was as large as published estimates of fish biomass in high relief kelp forests. The kelp forest areas at San Onofre supported a larger standing stock of fishes than the adjacent areas without kelp. The presence of kelp per se contributed to the greater standing stock of fishes. Paralabrax clathratus of various sizes was common throughout the water column within the kelp forest. Numerical density and biomass was generally greater in the lower strata. Young P. clathratus concentrated in the upper water column of the kelp forest indicating use of the upper kelp canopy as a nursery habitat. Juveniles occurred throughout the water column. Numbers of subadults and adults were greatest on the bottom. P. clathratus constituted a substantial portion of the density and biomass of fishes throughout the water column within the kelp forest. Mean density of P. clathratus per 100 m<sup>2</sup> was far greater in the kelp forest (3.6608.04) than in the habitat void of kelp (0.25). Mean biomass per 100 m<sup>2</sup> was also greater in the kelp forest (0.67-1.83) than the kelp-depauperate habitat (0.12).

Fishing for anchovies off California.

AUTHOR(S): Lasker, R.

YEAR: 1978.

SOURCE: Mar. Poll. Bull. 9:320-321.

KEYWORDS: Northern anchovy, Engraulis mordax, fishery, spawning, larvae, reproduction, recruitment.

ABSTRACT: Northern anchovy (*Engraulis mordax*) egg and larval surveys for 1975 to 1978 showed a decline in the total spawning biomass, from 3.3 million metric tons to 1.2 million metric tons. Poor year classes in 1974 and 1975 contributed to the decline. The catch in 1975 was approximately 163,000 tons and in 1977 with the advent of a Mexican fishery it rose to a total of 257,000 tons. Mexico fishes without restriction. No spawning biomass estimate was made in 1977, but if it was known to be low, this much fishing would have been restricted. It is not known whether 257,000 tons should be considered 'heavy fishing'. Two questions are asked: What major factors control reproduction and larval survival, and what is the impact of reduced stock size on the strength of future recruitment? Several conditions must be met in order for first-feeding larvae to survive. There is no evidence that pollutants of any kind affect reproductive success. Increased ultraviolet radiation, a consequence of reduced ozone layers, may be extremely deleterious to anchovy larvae.

Field criteria for survival of anchovy larvae: The relation between inshore, chlorophyll maximum layers and successful first feeding.

AUTHOR(S): Lasker, R.

YEAR: 1975.

SOURCE: Fish. Bull. 73(3):453-461.

KEYWORDS: Northern anchovy, *Engraulis mordax*, feeding, behavior, distribution, larvae.

ABSTRACT: Laboratory-spawned anchovy larvae were used to detect larval feeding grounds at sea. Seawater from the surface and from the chlorophyll maximum layers were pumped aboard ship into tanks of first-feeding anchovy larvae. Minimal feeding occurred in the surface water, while extensive feeding occurred in water from the chlorophyll maximum layer. The results also showed that phytoplankton aggregations with over 20 cells/ml must be available within 2 1/2 days after the larvae are ready to feed, and individual phytoplankton cells must be around 40  $\mu$ m in diameter, in order for first-feeding anchovy larvae to successfully feed in the ocean.

Nominal catch-per-unit-effort of albacore, *Thunnus alalunga* (Bonnaterre), caught by U. S. jig vessels during 1961-70.

AUTHOR(S): Laurs, R. M., H. B. Clemens, and L. H. Hreha.

YEAR: 1976.

SOURCE: Mar. Fish. Rev. 38(5):1-32.

KEYWORDS: Albacore, *Thunnus alalunga*, fishery.

ABSTRACT: The albacore (*Thunnus alalunga*) fishery off the west coast of North America catch-per-unit-effort data for 1961-70 was examined. The fishery was centered in southern (south of San Francisco) waters from 1961-65 and in the northern (north of San Francisco) waters from 1966-70. These results suggest the fish are not contiguous over their entire range (Baja California to British Columbia, Canada), but are restricted to certain regions during various seasons. The fishery was concentrated offshore approximately 200-250 miles, however, the greatest catches often occurred within 100 miles off shore. The estimates of annual catch-per-unit-effort doubled over the 10-year period examined.

Small-scale movements of albacore, *Thunnus alalunga*, in relation to ocean features as indicated by ultrasonic tracking and oceanographic sampling.

AUTHOR(S): Laurs, R. M., H. S. H. Yuen, and J. H. Johnson.

YEAR: 1977.

SOURCE: Fish. Bull. 75(2):347-355.

KEYWORDS: Albacore, *Thunnus alalunga*, distribution, behavior, feeding.

ABSTRACT: Tracking studies with ultrasonic tags and oceanographic sampling indicate that oceanographic conditions have a major effect on the distribution and abundance of albacore. Tagged fish were found to spend very little time in water with a sea-surface temperature less than 15 deg C. The oceanographic studies indicated that albacore concentrate in the vicinity of upwelling fronts, presumably to feed, then they move away when the upwelling ceases. The average swimming speed of tagged albacore was estimated at about 1.6 knots (82 cm/s). Average daytime swimming speeds always exceeded those at night, and moonlight seemed to influence nighttime activity.

Albacore tuna catch distributions relative to environmental features observed from satellites.

AUTHOR(S): Laurs, R. M., P. C. Fiedler, and D. R. Montgomery.

YEAR: 1984.

SOURCE: Deep sea research Part A - Oceanographic research papers 31(9):1085-1099.

KEYWORDS: Thunnus alalunga, albacore, growth.

ABSTRACT: The North Pacific albacore, Thunnus alalunga, growth parameters were estimated from tag/recapture data. In addition to meristics, longitude and latitude of release and recapture sites were recorded. Data on growth increment, length at tagging, and time at liberty were used to calculate growth rate (K) and asymptotic length (L) for the standard von Bertalanffy model. An extended von Bertalanffy model was also used to allow for changes in growth rate due to capture stress. Growth rate variation in albacore from different water masses was estimated by sequential analysis of K and L. The albacore recaptured off Japan and north of latitude 40 deg in the U.S. exhibited significantly lower growth rates than those caught south of latitude 40 deg in the U.S. These findings are consistent with current reports that suggest two distinct subpopulations of north Pacific albacore exist.

Observations on swimming depth and ocean temperature telemetered from free-swimming albacore.

AUTHOR(S): Laurs, R. M., R. C. Dotson, A. Dizon, and A. Jemison.

YEAR: 1980.

SOURCE: Pages 33-34 in: A. Wild (ed.), Proc. 31st Tuna Conf., 11-14 May 1980, La Jolla, California. Inter-American Tropical Tuna Commission.

KEYWORDS: Distribution, albacore, Thunnus alalunga, migration, behavior.

ABSTRACT: The effects of oceanographic conditions on local concentrations and

movements of albacore were examined by ultrasonic tracking of free-swimming albacore and concurrent oceanographic sampling. The results showed that the fish spent much of their time in the thermocline and were often observed below the thermocline. The majority of their time was spent in waters 2 deg - 5 deg below the low end of the published optimum temperature preference range. Vertical distribution of fish varied between migrating fish and ones which did not seem to be migrating. Migrating fish made small vertical excursions with little day-night depth difference. Nonmigrating fish showed the opposite. Swimming speeds of tracked fish ranged from 50-175 cm/sec.

Frequency of increment formation on sagittae of north Pacific albacore (Thunnus alalunga).

AUTHOR(S): Laurs, R. M., R. Nishimoto, and J. A. Wetherall.

YEAR: 1985.

SOURCE: Jour. Fish. Aquat. Sci. Canada 42(9):1552-1555.

KEYWORDS: Thunnus alalunga, albacore, age.

ABSTRACT: The purpose of this study was to estimate the rate of increment deposition on sagittae of North Pacific albacore (Thunnus alalunga), a temperate water migratory tuna, with the ultimate objective of developing an accurate aging method. Detectable increments were formed on the otoliths at an average

rate of 0.954 per day. The slight departure from a 1:1 relationship could be due to systematic undercounting of indistinct increments, or to periodic interruption of increment deposition. The physiological basis of increment formation in sagittae has not been studied in albacore. The observed variability in increment width could be due to changing growth conditions such as patchiness of food supply. There was no evidence found that maturation and reproductive activity caused interruption in increment deposition in albacore. Harvested albacore can be aged accurately by counting the number of increments on the sagittae and expanding the increment count by the conversion factor, (C = 1.05).

Estimates of rates of tag shedding by north Pacific albacore,  
*Thunnus alalunga*.

AUTHOR(S): Lours, R. M., W. H. Lenarz, and R. N. Nishimoto.

YEAR: 1976.

SOURCE: Fish. Bull. 74(3):675-678.

KEYWORDS: Albacore, *Thunnus alalunga*, fishing gear.

ABSTRACT: Estimates of tag shedding rates are given for albacore, *Thunnus alalunga*, that had been double tagged. Two types of tag shedding were estimated: Type-I (immediate) and Type-II (instantaneous). The rate of Type-I shedding is estimated to be about 0.12 and Type-II to be between 0.086 and 0.098 on an annual basis. This means that if no mortality occurs, 8.2 to 9.3% of all unrecovered tags can be expected to be lost through shedding annually. However, it was illustrated that the estimation of Type-II shedding could be considerably lower than the true value because the number of tag returns available for this study was too low for an accurate estimate. Also, there may be a possible bias due to fishermen reporting double tag recoveries as single tag recoveries, but this bias was estimated to be low. A chi-square test indicated that gear type did not have a significant effect on the proportions of single and double tag returns. It is important to know the rate of tag shedding because the loss of tags through shedding can cause estimates of mortality in population studies to be biased upwards unless corrected for.

On the relationships between marine plants and sea urchins.

AUTHOR(S): Lawrence, J. M.

YEAR: 1975.

SOURCE: Oceanogr. Mar. Biol. Ann. Rev. 13:213-286.

KEYWORDS: *Strongylocentrotus* spp., sea urchins, growth, feeding.

ABSTRACT: The diets of echinoids feeding in the wild were reviewed. Marine plants were found to dominate gut contents; however, animals and the substrate may also be important in the diets. The degree of dietary preference as opposed to food limitations was unmeasurable. The evolution of food assimilation seemed likely based on the high degree of morphological change. Most echinoids were characterized as "scrapers"; however, dissolved and particulate organic material, detritus and plankton were other possible sources of nutrition. Growth rates were shown to be affected by the algae species consumed, assimilation efficiency and a number of environmental factors. The evidence available suggests echinoid grazing pressure can have a strong impact on community ecology at various densities.

McAllister, and J. R. Stauffer, Jr.

Atlas of North American freshwater fishes.

AUTHOR(S): Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E.

YEAR: 1980.

SOURCE: North Carolina State Mus. Natur. His., Raleigh, NC. 854 p.

KEYWORDS: Coho salmo, Oncorhynchus kisutch, chinook salmon, O. tshawytscha,

distribution, habitat, migration, spawning, reproduction.

ABSTRACT: The available distributional and some biological information on all

the freshwater fishes of the U. S. and Canada is summarized in this "first approximation" atlas. Descriptions of each fish and maps illustrating their distribution are also included.

Early growth of green abalone in hatchery and field.

AUTHOR(S): Leighton, D. L.

YEAR: 1985.

SOURCE: Proceedings of Joint International Scientific Diving Symposium, La Jolla, California.

KEYWORDS: Abalone, Haliotis spp., growth, habitat, mortality, distribution, recruitment.

ABSTRACT: The green abalone is a hardy species which has proven amenable to culture in closed sea water systems as well as open systems. In this study growth rates of both hatchery-reared and hatchery-reared then released into the field abalone were calculated. A sheltering substrate made of stacks of corrugated plastic was designed for the field-released young in order to reduce the high mortality following planting. The results show that the growth of juvenile green abalone in nature appears to be superior to that achieved under hatchery conditions. In contrast, it also appears that growth rates of hatchery-reared young released in San Diego waters have closely matched those of natural recruits.

The influence of temperature on larval and juvenile growth in three species of southern California abalones.

AUTHOR(S): Leighton, D. L.

YEAR: 1974.

SOURCE: Fish. Bull. 72(4):1137-1145.

KEYWORDS: Abalone, Haliotis spp., larvae, growth.

ABSTRACT: The red, *Haliotis rufescens*, pink, *H. corrugata*, and green, *H. fulgens*, abalone were spawned and larvae were raised over a broad range of temperatures. Hatching of eggs occurred within 18-24 hrs, for all species, at 14 to 16 deg C. Upon hatching, the effects of suboptimal temperatures were very pronounced. The red larvae grew fastest, with highest survival at 15-18 deg C. The growth rate was 77u/day. The pink larvae exhibited a growth rate of 64u/day at optimal temperatures of 18-21 deg C. The green abalone's optimal temperature range was 20-23 deg C and shell increases of 88u/day were recorded. At the notch stage (approximately 3 months) the juveniles were less sensitive to temperature and tolerant to a broader temperature range.

Ecological relationships between giant kelp and sea urchins in southern California.

AUTHOR(S): Leighton, D. L., L. G. Jones, and W. J. North.

YEAR: 1966.

SOURCE: Proc. 5th Int. Seaweed Symp., Halifax, 25-28 August 1965.  
141-153. Pergamon Press, NY.

KEYWORDS: *Strongylocentrotus* spp., sea urchin.

ABSTRACT: One of the major grazers of giant kelp, *Macrocystis pyrifera*, is the sea urchin. The southern California kelp beds have sustained the most damage from three species of sea urchins, *Strongylocentrotus franciscanus*, *Strongylocentrotus purpuratus*, and *Lytechinus anamesus*. 1-10 urchins/m<sup>2</sup>) are significant enough to prevent vegetation from developing on cleared substrate. Several natural predators are documented, including sheephead, sea otters, and two species of sea stars. Application of quick lime is the most effective chemical control with the concentrations varying according to depth, wave surge, topography and population densities. The lime costs 2-3 cents/m<sup>2</sup> treated and is absolutely necessary in controlling areas larger than 5000 m<sup>2</sup>.

E. Morse.

Acceleration of development and growth in young green abalone (*Haliotis falgens*) using warmed effluent seawater.

AUTHOR(S): Leighton, D. L., M. J. Byhower, J. C. Kelly, G. N. Hooker, D.  
YEAR: 1981.

SOURCE: Jour. World Maricult. Soc. 12(1):170-180.

KEYWORDS: Growth, abalone, *Haliotis* spp., early life history, spawning, larvae.

ABSTRACT: Observations on the influence of temperature on survival and growth of larvae, postlarvae and juveniles of the green abalone. The abalone were cultured in thermal effluent from coastal power plants. This water temperature ranged from 20-28 deg C compared to 14-20 deg for ambient seawater. Growth rates of juveniles in the heated water were at least 1.5 times greater than those at ambient temperature. Young abalone sufficiently large to be planted efficiently for fishery augmentation or for mariculture (1-2 cm) may be produced in about one-half year.

Diet and growth in the black abalone, *Haliotis cracherodii*.

AUTHOR(S): Leighton, D., and R. A. Boolootian.

YEAR: 1963.

SOURCE: Ecology 44(2):227-238.

KEYWORDS: Abalone, *Haliotis* sp., growth, feeding.

ABSTRACT: The growth of black abalone, *Haliotis cracherodii*, in laboratory feeding experiments was measured by weight gained and increased shell length. Gut content analysis revealed a preference for brown and red macroalgae. Highest growth rates were exhibited by the abalones fed *Macrocystis pyrifera*, *Pelvetia fastigiata* or *Gigartina canaliculata*. The greatest preference was for *Egregia laevigata* although this species had a lower weight promoting value. Growth in the field was highly variable and dependent on feeding and season. Growth in the lab was fast during the first year (26-30 mm/year) and slowed during the second year (20 mm/year). Growth rates were much slower for abalone larger than 130 mm.

Status of the widow rockfish fishery.

AUTHOR(S): Lenarz, W. H., and J. E. Hightower.

YEAR: 1985.

SOURCE: Pages 3-1 to 3-23 in PFMC, Status of the Pacific Coast groundfish fishery through 1985 and recommended acceptable biological catches for 1986. Pac. Fish. Mgmt. Council, Portland, OR.

KEYWORDS: Widow rockfish, *Sebastes entomelas*, fishery, economics, regulations, age, population trends, recruitment.

ABSTRACT: This is an update of the 1984 status report on the widow rockfish

and a review of recent events in the fishery. The report also includes a discussion of the methodology used to obtain the reported data and results of the new assessment, and presents results of explorations of several harvest policies. Widow rockfish landings for 1979 through 1984 are provided for Vancouver, Northern/Southern Columbia, Eureka, and the Monterey/Conception areas.

Growth of jack mackerel, *Trachurus symmetricus*, in captivity.

AUTHOR(S): Leong, R.

YEAR: 1984.

SOURCE: CalCOFI Rep. 25:146-150.

KEYWORDS: *Trachurus symmetricus*, jack mackerel, growth, weight/length.

ABSTRACT: A school of jack mackerel, *Trachurus symmetricus*, was held in captivity to better understand its growth potential. Observations on maturation and the accumulation of energy reserves were also made. Results are compared to observations made on wild fish. In the laboratory fish grew 165 mm in two years, while in the wild they grew only 61 mm. The captive fish put on more than 6 years growth in 2 years. Estimates of von Bertalanffy growth parameters  $L_{\infty}$ ,  $K$ , and  $t_0$  for captive and wild fish were 463.9, 0.6836, -1.08 and 602.9, 0.0935, -3.25, respectively. Captive fish grew significantly larger than those in the inshore southern California fishery. The weight/length equation for captive fish was  $W = aL^b$ , where  $a = 0.000000176$  and  $b = 3.75670$ . Captive fish gained weight five times faster than wild fish. Laboratory fish contained on average less water but more fat per unit wet weight than sea-caught fish. Captive fish were much heavier and fat, water, and fat-free dry weight accounted for 65.2, 8.4, and 26.4%, respectively of the difference. Red muscle, white muscle, and viscera all contained more fat in laboratory fish, and the increase was not distributed proportionately (viscera highest). The water content was higher in sea-caught fish for all three tissues. Gonads of both sexes were most highly developed in June. Contributing factors to the higher laboratory growth rates were abundant food supply, lack of predators, higher temperatures, and absence of spawning. The small jack mackerel in the inshore waters off southern California have the potential to reach 450 mm FL.

Maturation and induced spawning of captive Pacific mackerel, *Scomber japonicus*.

AUTHOR(S): Leong, R.

YEAR: 1977.

SOURCE: Fish. Bull. 75(1):205-211.

KEYWORDS: Chub mackerel, *Scomber japonicus*, spawning, reproduction.

ABSTRACT: The purpose of this study was to develop procedures for routinely spawning mackerel on demand throughout the year.

Mackerel were held under four different photoperiod regimes (4



hrs light [L], 20 hrs dark [D], 8L 16D, 16L 8D and ambient day length) and three temperatures (15 deg C, 18 deg C and ambient 12.8 deg to 19 deg C). Three hormones were studied for the induction of spawning: ground salmon pituitary (SP), human chorionic gonadotropin (HCG) and gonadotropin from pregnant mare serum (PMS). Pacific mackerel normally spawns between March-October, with the height of the season between March-October. The mackerel held under ambient light conditions in this study spawned at the end of April. All female mackerel held under the four light regimes at 19 deg C, became sexually mature. Spawning was not detected in the 8L 16D tank although it contained sexually mature individuals. In those tanks in which mackerel did spawn, spawning occurred in the dark period. Mackerel captured towards the end of the spawning season redeveloped their ovaries more rapidly at 18 deg C than at 15 deg C or ambient temperature. The fish maintained under the 16 deg C, 14L 10D photoperiod remained sexually mature beyond the normal spawning season. All female Pacific mackerel injected with 5-25 mg of SP died within 40 hrs of injection. All injections of 1-25 mg of SP facilitated the stripping of milt in male mackerel. None of these males died. Hydration and ovulation were stimulated in females that received 12.5-500 IU of HCG. The number of larvae produced was negligible because the females were not easily stripped of their eggs. All of the females that received 50 or more IU of a HCG died within 40 hrs after injection. All dosages of HCG facilitated the stripping of milt without killing the male. All females injected with 300-1000 IU of PMS survived 40 hrs after injection. Injections of 750-1000 IU PMS stimulated ovulation after 40 hrs, but few eggs were viable. None of the males injected with PMS died and the stripping of milt was facilitated by the injections. The three combinations of hormones tested were all successful in stimulating hydration, ovulation and spawning. The recommended spawning procedure is 1 mg SP + 17.5 IU HCG for the first injection followed in 24 hrs by 1 mg SP + 12.5 IU HCG and 200 IU PMS for females. Males can be induced to spawn with a 5 mg SP injection. Spawning fish are maintained at 16 deg C, 14L 10D photoperiods. This method has been successful in inducing spawning during every month of the year.

Fish life in the kelp beds and the effects of kelp harvesting.

AUTHOR(S): Limbaugh, C.

YEAR: 1955.

SOURCE: Univ. Calif. Inst. Mar. Res., IMR Ref. 55-9, 158 pp.

KEYWORDS: *Paralabrax clathratus*, kelp bass, community, behavior, food, maturation, spawning, early life history, habitat, growth, movement, northern anchovy, *Engraulis mordax*.

ABSTRACT: A description of the giant kelp (*Macrocystis pyrifera*) forest habitat and the effects of commercial kelp harvesting activities on the fishes associated with kelp forests in southern California during 1952 and 1953. Observations on the natural history and effects of kelp harvesting on *Paralabrax clathratus* were made. 1,500 *P. clathratus* were tagged in the La Jolla area for growth and movement information. *P. clathratus* exhibits an affinity with algal or rocky structures. Depth distribution ranges from the surface to 130 feet. Most of the population occurs shallower than 70 feet. Larger individuals tend to live deeper than smaller conspecifics. *P. clathratus* feeds on crustaceans (including

benthic and algal associated species), squid, and smaller fish (including sardines, anchovies, topsmelt, tube-nose, kelp clingfish, and kelpfish (clinidae). Maturity is reached at the end of the second year at a length of about 180-230 mm. Spawning was observed to occur from early May through August. Large aggregations of *P. clathratus* form during spawning. The young-of-year are common throughout the inshore seaweeds, including the eelgrass in bays, shallow patches of ribbon kelp (*Egregia*), and throughout the length of giant kelp (*Macrocystis*) plants. Young occur in the late summer through December. They grow to a length of 90-115 mm by the end of their first year. *P. clathratus* does not require giant kelp as a habitat as evidenced from the occurrence of individuals in areas where giant kelp is absent. Kelp harvesting has no apparent effect on *P. clathratus*. Movement of tagged individuals between cut and uncut areas of kelp forest was negligible.

Food habits of Pacific whiting, *Merluccius productus*, off the west coast of North America, 1967 and 1980.

AUTHOR(S): Livingston, P.A.

YEAR: 1983.

SOURCE: Fish. Bull. 81(3):629-636.

KEYWORDS: Pacific hake, *Merluccius productus*, feeding.

ABSTRACT: The purpose of this paper was to determine several aspects of the predatory behavior of the Pacific whiting (*Merluccius productus*): a) the major prey items, b) whether or not size-selective predation occurs, c) the diel feeding behavior, and d) the daily ration. To do this, stomach contents were analyzed on Pacific whiting collected off California, Oregon, Washington and Vancouver Island. Euphausiids, including *Thysanoessa spinifera* and *Euphausia pacifica*, were the dominant food item in 1967. They were also a major item in the diets of the fish taken in 1980. Schooling fish, including northern anchovy, Eulachon, and Pacific herring were a secondary item. Other items which Pacific whiting ate to a lesser extent included flatfish, rockfish, other shrimp species, and crab megalops larvae. A switch in food preference from shrimp to fish as the Pacific whiting increased in size was apparent. The only distinct difference between the diets of the different years was that there was a greater consumption of fish in 1980 by whiting >450 mm in length. The data indicates that size preference ranges of size class whiting may be extremely narrow, and yet bimodal. Stomach content weight per fish weight was highest at 1800 hrs with a value of 2.5%, and slightly increased between 0100 and 0300 hrs and 0400 and 0900 hrs. The calculated daily ration for Pacific whiting was 2.5% body weight per day for an average Pacific whiting of 500 mm in length.

California ocean shrimp mesh experiment.

AUTHOR(S): Lo, N. C. H.

YEAR: 1978.

SOURCE: Calif. Fish Game 64(4):280-301.

KEYWORDS: Ocean shrimp, *Pandalus jordani*, fishery.

ABSTRACT: The effect of mesh size on escapement of ocean shrimp, *Pandalus jordani*, is investigated in response to sharp landing declines in 1973. Predicted 50% selection lengths for mesh sizes 1.37, 1.43, 1.50, and 1.60 inches are 16.20, 17.39, 18.79, and 20.78 mm, respectively. Carapace lengths of one-year-olds

averaged from 16-17.8 mm while two-year-olds ranged from 20.35 to 21.64 mm, through the season. The percentage of shrimp smaller than the 50% selection length by any mesh size was estimated for age groups using the normal approximation. The average escapement rate (AER) is a function of mesh size and length relative frequency (LRF). Larger mesh nets do not cause a decrease in fishing efficiency. The current shrimp fishery issue is whether 1.50 inches is a proper legal mesh size or not. Due to a short life span, high natural mortality of one-year-olds, and processing wastage, it is reasonable to protect the one-year-olds. Nets with a mesh size of 1.37 inches will catch 65 and 77% of the one-year-olds in May and September, respectively, while a mesh of 1.50 inches will catch 16% and 31%. A 1.55 inch mesh net will capture 6% of one-year-olds in May and 14% in September; however, two-year-olds will have a 65% AER in May and 32% in September. This is a high loss to the fishery and should be prevented. A mesh size of 1.50 inches insures good escapement of one-year-olds through the season and a harvest of most two-year-olds.

Recurrent groups of larval fish species in the California Current area.

AUTHOR(S): Loeb, V. J., P. E. Smith, and H. G. Moser.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:152-164.

KEYWORDS: *Sebastes paucispinis*, bocaccio, ichthyoplankton, habitat, distribution, early life history, larvae, community.

ABSTRACT: Recurrent group analysis of larvae of nearshore and offshore fishes collected from plankton tows during the 1975 CalCOFI sampling were compared. Recurrent groups were identified so that future sampling could examine species interactions within these groups. *S. paucispinis* was associated with recurring group (V) which included *Engraulis mordax*, *Leuroglossus stilbius*, *Merluccius productus*, *Stenobranchius leucopsarus*, and *Paralichthys californicus*. Group (V) was distributed predominantly in nearshore waters from Pt. Conception to the northern extreme of Baja California (CalCOFI regions 7 and 8) and in nearshore areas off central California and further seaward off southern California.

Geographical and seasonal patterns of larval fish species structure in the California Current area, 1975.

AUTHOR(S): Loeb, V. J., P. E. Smith, and H. G. Moser.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:132-151.

KEYWORDS: *Sebastes paucispinis*, bocaccio, ichthyoplankton, larvae, distribution, seasonality, early life history.

ABSTRACT: Plankton tow data were analyzed from 1975 CalCOFI samples. Seasonal and local abundances of larvae as related to their water mass affinities were described. *S. paucispinis* and *S. jordani* occurred in greatest abundance off central and southern California and were apparently absent or rare off Baja California. *S. paucispinis* ranked as the second and third most abundant of larvae identified to species in the central California regions, and varied from the first to the sixth most abundant species of identified larvae in four regions of southern California.

Ichthyoplankton and zooplankton abundance patterns in the California current area, 1975.

AUTHOR(S): Loeb, V. J., P. E. Smith, and H. G. Moser.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:109-131.

KEYWORDS: Ichthyoplankton, seasonality, geographic, spawning, northern anchovy, hake, jack mackerel, *Engraulis mordax*, *Merluccius productus*, *Trachurus symmetricus*.

ABSTRACT: Data from CalCOFI plankton tows taken in 1975 were analyzed for zooplankton and ichthyoplankton abundances in order to identify major seasonal and regional features within the California current system. Conditions affecting zooplankton and ichthyoplankton abundance may be quite different. Zooplankton spend their entire life cycle as plankton, and are greatly affected by advective processes within oceanic regions. In contrast larval fishes are in a temporary planktonic stage whose abundances reflect spawning locales and suitability of conditions for larval survival. The results of the abundance patterns show no relationship between zooplankton and ichthyoplankton. Some of the patterns observed showed a trend of increasing zooplankton from south to north, and offshore to inshore, which appeared to be related to surface nutrients. Ichthyoplankton abundances were greatest off southern California and northern Baja California because of the large spawning stocks of migrating species (anchovy, hake, and jack mackerel).

Science for Canada's fisheries rehabilitation needs.

AUTHOR(S): Loftus, K.

YEAR: 1976.

SOURCE: Jour. Fish. Res. Bd. Canada 33:1822-1857.

KEYWORDS: Chinook salmon, coho salmon, *Oncorhynchus tshawytscha*, *Oncorhynchus*

*kisutch*, fisheries, fishing gear, spawning, life history.

ABSTRACT: A review of the status of salmonid communities on the east and west

coasts, and of fish communities in selected freshwater areas. Most fishery abundances include overexploitation, excessive nutrient loading, contaminant loading, modified waterflow patterns, new species invasions, and shoreline modification. The rehabilitation of fish stocks (discrete spawning populations), versus fish-farming is argued by the author as the best method of regaining former levels of fish abundance. Rehabilitation will require additional research in areas such as hatching, rearing and selective breeding, fisheries engineering, and in the more precise definition of natural productive capacity of waters.

Larval dynamics of Dungeness crab, *Cancer magister*, off the central Oregon Coast.

AUTHOR(S): Lough, R. G.

YEAR: 1976.

SOURCE: Fish. Bull. 74(2):353-376.

KEYWORDS: *Cancer magister*, market crab, larvae, distribution.

ABSTRACT: Larvae of Dungeness crab, *Cancer magister*, were collected in plankton nets both inshore and offshore near Newport, Oregon. The larval period extended from January to May (130 days) with peak densities of 8,000/1,000m<sup>3</sup> 15 miles from shore. Currents and

larval behavior in the water column were proposed as reasons for onshore patchiness. Sampling during the second year initially yielded similar results. Significantly lower densities later in the season may have been due to mortalities associated with severe weather in February and March. Laboratory rearing experiments, which looked at larval reactions to physical factors (salinity and temperature) and gut-fullness did not help explain the cause of the second year mortalities. Hydrographic data and suggestions for future research were also presented.

On biology of the market squid, *Loligo opalescens*, a contribution toward the knowledge of its food habits and feeding behavior.

AUTHOR(S): Loukashkin, A. S.

YEAR: 1976.

SOURCE: CalCOFI Rep. 18:109-111.

KEYWORDS: Market squid, *Loligo opalescens*, feeding.

ABSTRACT: Gut content analysis of 1000 market squid, *Loligo opalescens*, was studied in different months over a 4-year period. In central California 73.4% of the stomachs were empty, and in southern California 49.2% were empty. Only 33.1% of the stomachs examined (from both regions) contained food. The amount of food present varied from "gorged" (17.2%), 3/4 full (7.8%), 1/2 full (10.3%), 1/4 full (20.9%), 1/8 full (20.0%), and less than 1/8 (23.8%). Crustacean remains (largely indeterminate) comprised the majority of food items at 42%. Remains of fish and indeterminate fleshy material accounted for 19.6% and 21.5%, respectively. Polychaete worms, cephalopods, and unidentified fluids accounted for the remaining 16.9%.

Evidence of movements of some deep water rockfishes (*Scorpaenidae*: genus *Sebastes*) off southern California.

AUTHOR(S): Love, M. S.

YEAR: 1981.

SOURCE: Calif. Fish Game 67(4):246-249.

KEYWORDS: *Sebastes goodei*, chilipepper rockfish, *Sebastes miniatus*, vermillion rockfish, *Sebastes paucispinis*, bocaccio, *Sebastes entomelas*, widow rockfish, migration, distribution.

ABSTRACT: Evidence for the movement of deep dwelling (>70m) rockfishes (*Sebastes entomelas*, *S. miniatus*, and *S. paucispinis*) is presented. This evidence is based on fluctuations in catch-per-unit-effort of these three species by party boats from a single rocky reef. Sampling was conducted from April 1975 to July 1978 off Santa Barbara, California. Further evidence for movement was collected by hydroacoustically tracking one aggregation composed of the above mentioned species along with *S. goodei*. This aggregation moved 2.4 kilometers over a 7 hour period.

Isolation of olive rockfish, *Sebastes serranoides*, populations off southern California.

AUTHOR(S): Love, M. S.

YEAR: 1980.

SOURCE: Fish. Bull. 77(4):975-983.

KEYWORDS: Vermillion rockfish, *Sebastes miniatus*, platform, distribution, habitat.

ABSTRACT: Movements of olive rockfish occurring around shallow reefs and

oil platforms were monitored using artificial tags (plastic tube placed in dorsal musculature) and biological tags (gill parasite, *Microcotyle sebastis*). The rockfish were also measured and the lengths compared between reefs where there was light versus heavy fishing pressure. The results of the study showed that of the 1,847 fish artificially tagged, 11.2% were returned. Information from the artificially and biologically tagged fish showed that olive rockfish rarely moved between shallow water reefs. Stretches of sandy bottom inhibited inshore movements but did not affect movements between oil platforms. Tagged fish appeared to travel across at least 0.8km of sand to an adjacent platform. Fish lengths were observed to be significantly shorter at the heavily fished sites, with most of the fish pre-reproductive. Because of this, mature fish at lightly fished sites may contribute to most of the recruitment for all areas.

Food and habitat of three switch-feeding fishes in the kelp forests off Santa Barbara, California.

AUTHOR(S): Love, M. S., and A. W. Ebeling.

YEAR: 1978

SOURCE: Fish. Bull. 76(1):257-271.

KEYWORDS: *Paralabrax clathratus*, kelp bass, habitat, food, community.

ABSTRACT: A study of the spatial distribution and prey composition of three

morphologically similar fishes (including *P. clathratus*) inhabiting a kelp (*Macrocystis pyrifera*) covered rocky reef off Santa Barbara, California was determined. Gut fullness, prey taxon and volume and frequency of occurrence of each prey type were measured and determined for each fish sampled. Prey were categorized as to habitat type (planktonic, nektonic, or substrate oriented). Seasonal variation in diet based on oceanographic regimes was addressed. Spatial distribution was determined from underwater cinetransects sampled just under the kelp canopy near the surface and just over the bottom. Breadth and overlap of spatial and prey resource use was calculated. *P. clathratus* foraged primarily in midwater, but occasionally ate bottom organisms. *P. clathratus* ate mostly fish, which ranked highest of prey types in both total volume and frequency of occurrence. Fish prey included juvenile rockfishes, pipefish, kelp greenling, topsmelt, and jack mackerel. Adult fish prey included anchovy and agonids. Tunicates (*Salpa*) contributed the largest volume of plankton consumed. Copepods and benthic crustaceans were also important. On the same day, 60% of 72 kelp bass sampled had the same item dominating their stomach contents. Seasonal variation in prey composition differed significantly, particularly between winter and all other portions of the year. *P. clathratus* was most abundant in the lower portion of the water column in areas with greater kelp density and water clarity.

A correlation between annual catches of Dungeness crab, *Cancer magister*, along the West Coast of North America and mean annual sunspot number.

AUTHOR(S): Love, M. S., and W. V. Westphal.

YEAR: 1981.

SOURCE: Fish. Bull. 79(4):794-796.

KEYWORDS: Market crab, *Cancer magister*, fishery, population trends.

ABSTRACT: A comparison is made between the total annual landings of Dungeness crab (*Cancer magister*) off the West Coast of North

America (TAL) and mean annual sunspot number (SS). Both of these phenomenon follow approximately 11-yr cycles, and the cycle periods were strongly correlated (1955-1964,  $r=0.90$ ; 1965-1975,  $r=0.87$ ). Following a suggestion that Dungeness crab landings were influenced by water temperature four years before, with temperatures at that time being inversely correlated to landings, a comparison was made between the catch, and sunspot activity four to five years before. The results showed a higher correlation for the second cycle, and a lower correlation for the first cycle (1955-1964,  $r=0.82$ ; 1965-1974,  $r=0.95$ ). The authors acknowledge that there is no proof that these correlations have meaning, however, since sunspot activity has been shown to affect many physical and biological phenomena, there may be a direct or indirect (through some other factor, i.e. temperature) effect by sunspots on crab abundance.

Abalone and sea urchins in an area inhabited by sea otters.

AUTHOR(S): Lowry, L. F., and J. S. Pearse.

YEAR: 1973.

SOURCE: Mar. Biol. 23:213-219.

KEYWORDS: Abalone, *Haliotis* spp., sea urchins, *Strongylocentrotus* spp., habitat, mortality.

ABSTRACT: The purpose of this study was to report the long-term effects of intense sea otter foraging on sea urchin and abalone populations. During October and November 1972, 30 rock crevices were sampled at water depths ranging from 6 to 11 m in the kelp bed off Hopkins Marine Station, Pacific Grove, California. Most of the sea urchins and abalones were found clustered in crevices and cracks. An estimate of species densities was given as follows: *S. purpuratus*, 0.21/m<sup>2</sup>; *S. franciscanus*, 0.01/m<sup>2</sup>; *H. rufescens*, 0.15/m<sup>2</sup>; and *H. walallensis*, 0.07/m<sup>2</sup>. The red abalone, *H. rufescens* was the most abundant abalone in shallower depths (less than 10 m), while *H. walallensis* was relatively more numerous in deeper areas. There was a significant negative correlation between numbers of abalones and numbers of sea urchins found within the crevices sampled. The largest crevices were inhabited by *H. rufescens*, while intermediate size crevices were inhabited by *Strongylocentrotus purpuratus*. Although abalone and sea urchins were found in a wide range of sizes, their numbers are probably much lower than before the return of the sea otters.

Catalog of the benthic invertebrate collections of the Scripps Institution of Oceanography: Echinodermata.

AUTHOR(S): Luke, S. R.

YEAR: 1982.

SOURCE: Scripps Inst. Oceanog., Univ. Calif., San Diego, La Jolla, CA. SIO

Ref. 82-5.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp.

ABSTRACT: This is the third in a series of catalogs of holdings of the Benthic

Invertebrate collections of the Scripps Institution of Oceanography and contains 2,747 entries covering the Echinodermata. The entrants are systematically arranged and include a catalog number and relevant field data.

The mortality rate of *Engraulis mordax* in southern California.

AUTHOR(S): MacCall, A. D.

YEAR: 1974.

SOURCE: CalCOFI Rep. 17:131-135.

KEYWORDS: Northern anchovy, *Engraulis mordax*, mortality.

ABSTRACT: Catch curves were used to estimate instantaneous and annual mortalities of the northern anchovy, *Engraulis mordax*, in southern California waters. Three assumptions to the method must be met; year classes must not vary in strength, survival must be constant over all ages, and survival must not vary on a seasonal or yearly basis. Estimates of instantaneous mortality (Z) for scientific cruises and commercial catches were 1.09 and 1.16, respectively, with annual mortality rates (a) of 66.5 and 68.0%, respectively. Plots of respective ages of year class pairs versus catch ratio show the 63-64 plot with a peculiar peak between the third and fifth year, while the 64-65 plot shows a sudden rise from low catch ratio at age 3 to a higher ratio around ages 4 and 5. An exceptionally large catch ratio exists in 66-67, indicating a strong year class. Recruitment varies year to year by as much as 50%. Increasing with age was found with mean log catch ratios of 0.9, 1.3 and 1.9 for ages 2/3, 3/4, and 4/5 and 5/6, respectively. With a mean annual catch of this wetfish in southern California of 40,000 tons, instantaneous fishing mortality was estimated as 0.026, corresponding to an annual fishing mortality of 2.6%. Consequently, instantaneous natural mortality and annual natural mortality are 1.06 and 65%, respectively. Assumptions of this analysis are met very poorly by northern anchovies in southern California. Due to collections over many reproductive seasons being combined, the effects of this are minimized. The future exploitation of this fishery is discussed briefly.

The mortality rate of *Engraulis mordax* in southern California.

AUTHOR(S): MacCall, A. D.

YEAR: 1973.

SOURCE: Calif. Fish & Game Mar. Res. Tech. Rep. 4. 23 pp.

KEYWORDS: *Engraulis mordax*, northern anchovy, mortality.

ABSTRACT: Instantaneous (Z) and annual natural mortality rates (a) are estimated for the northern anchovy, *Engraulis mordax*, in southern California waters. Estimates are made using sea survey cruises and commercial landings. From sea survey cruises 'Z' and 'a' were estimated at 1.09 and 66.5%, respectively, while from commercial landings 'Z' is 1.16 and 'a' is 68%. The 63-64 year class shows a strong peak between the third and fifth year and the 64-65 year class indicates a sudden rise from age 3 to ages 4 and 5. The 1967 year class seemed to be exceptionally strong. The assumptions on which this analysis is based are poorly met. The data at present is insufficient to estimate definitive mortality rates-at-age. An estimate of instantaneous fishing mortality comes out to 0.026, and this yields an instantaneous natural mortality of 1.06. The northern anchovy has a mortality rate which increases with age. The annual mortality rate is 66.5% and can be separated into a natural component and fishing component of 65% and 2.6%, respectively.

Biology and fishery potential of jack mackerel, *Trachurus symmetricus*.



AUTHOR(S): MacCall, A. D., and G. D. Stauffer.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:46-56.

KEYWORDS: Jack mackerel, *Trachurus symmetricus*, fishery, distribution, population trends.

ABSTRACT: The distribution of jack mackerel, *Trachurus symmetricus*, extends from the Gulf of Alaska southward to Baja California with a large portion of the range lying outside the 200 mile fishery jurisdiction zones of U. S. and Mexico. A study of the maturation of jack mackerel indicates that most females become sexually mature at the end of their first year. The height of the spawning season appears to be between March through September. Nothing is known of the maturity cycle of the large offshore fish. Jack mackerel eggs and larvae are distributed widely in the northeastern Pacific, with a tendency for larval abundance to progress northward from late winter to late summer. Year-class strengths are highly variable, with strong year classes typically separated by several relatively weak ones. Little is known of spawning rates of pelagic fish, and nothing is known for jack mackerel. Spawning biomass is estimated to be between 0.64 to 1.3 million metric tons from CalCOFI surveys. Mortality rates are likely to be higher for young jack mackerel inhabiting a predator-rich nearshore environment than for large offshore fish. Estimates were made for overall potential yield as they may be applicable for commercial fisheries.

Southern California recreational and commercial marine fisheries.

AUTHOR(S): MacCall, A. D., G. D. Stauffer, and J. P. Troadec.

YEAR: 1976.

SOURCE: Mar. Fish. Rev. 38(1):1-32.

KEYWORDS: Fishery, population trends, regulations, wetfish, *Engraulis mordax*, northern anchovy, *Sarda chiliensis*, Pacific bonito, *Trachurus symmetricus*, jack mackerel, *Seriola lalandei*, yellowtail, chub mackerel, *Scomber japonicus*.

ABSTRACT: This article examines the population trends of several California recreational and commercial fisheries. The current status of the following species are examined and recommendations are made on areas of necessary research and fishery regulations: northern anchovy (*Engraulis mordax*), California barracuda (*Sphyraena argentea*), Pacific bonito (*Sarda chiliensis*), jack mackerel (*Trachurus symmetricus*), white seabass (*Cynoscion nobilis*), yellowtail (*Seriola dorsalis*), Pacific mackerel (*Scomber japonicus*), and Pacific sardine (*Sardinops caeruleus*). Also examined are the historical aspects of the fisheries and some trophic interactions which have a bearing on the fishery. Wetfish stocks of Northern anchovy and jack mackerel are both considered underexploited, while Pacific sardine and Pacific mackerel are thought to be overexploited. Yellowtail resources are only moderately exploited, but no increase in catch allowances is suggested. The white seabass populations appear to be slightly depleted, and could be partly blamed on overestimations of the populations. The present population trends of the California barracuda is difficult to assess, but recommendations are made that the 28 inch bag limit is a rational course of action. Pacific bonito appears to be at or slightly above its maximum sustainable yield. Present trends in rockfish and squid exploitation are lightly analyzed.

Recent increased abundance and potential productivity of Pacific mackerel (*Scomber japonicus*).

AUTHOR(S): MacCall, A. D., R. A. Klingbeil, and R. D. Methot.

YEAR: 1985.

SOURCE: CalCOFI Rep. 26:119-129.

KEYWORDS: Chub mackerel, *Scomber japonicus*, fishery, range, mortality.

ABSTRACT: This report presents the results of simulation models used to investigate potential productivity and stock recruitment compensation. A isopath diagram is used to summarize average annual yields for linear harvest formulas. Results of the simulations and formula calculations are discussed along with suggestions on how this information could be used for successful management of the Pacific mackerel fishery.

Catch composition and reproduction of the spiny lobster, *Panulirus versicolor*, at Palau.

AUTHOR(S): MacDonald, D. C.

YEAR: 1982.

SOURCE: Trans. Am. Fish. Soc. 8(6):694-699.

KEYWORDS: Spiny lobster, *Panulirus* spp., reproduction, growth, population trends.

ABSTRACT: The size and sex composition of commercial catches, size at sexual maturity, and reproductive seasonality of females are reported for a virtually unexploited population of spiny lobster, *Panulirus versicolor*, at Palau. The mean carapace lengths of males and females were 9.8 and 93 cm, respectively. Smaller lobster populations were composed of a majority of females, larger lobster populations were primarily males, and overall, males and females were equally abundant. Juveniles were observed only in the same habitat as adults. Post-larval lobsters were found in interstices at the eroded base of limestone islands and among rubble on reef top and back reef areas adjacent to adult habitat. Females attained reproductive maturity at about 8.2 cm. This is well above the size at which this species enters the fishery. It appears that the level of reproduction was fairly constant throughout the year, with an average of 43% of females in an ovigerous condition at anytime. This does not eliminate the possibility that seasonal variations in reproductive activity occur. Data also suggests repetitive mating.

Natural history of marine animals.

AUTHOR(S): MacGinitie, G. E., and N. MacGinitie.

YEAR: 1949.

SOURCE: McGraw-Hill Book Co., Inc., New York, NY. 473 p.

KEYWORDS: Market squid, *Loligo opalescens*, spiny lobster, *Panulirus interruptus*, habitat, range, physiology, feeding, behavior.

ABSTRACT: At least one representative animal from every major group of marine

invertebrates has been selected for inclusion in this text. The Pacific coast of North America comprises the area of study largely because animals inhabiting this region have been neglected in literature prior to this date. The material in this text has been generalized to provide an understandable, easy reference for the layman and includes information on invertebrate behavior, food, habitat, range, and interrelationships with other species. Photographs and drawings illustrating the animal's physiology

are also provided.

Fecundity of the northern anchovy, *Engraulis mordax* Girard.

AUTHOR(S): MacGregor, J. S.

YEAR: 1968.

SOURCE: Calif. Fish Game 54(4):281-288.

KEYWORDS: Northern anchovy, *Engraulis mordax*, early life history, reproduction, spawning.

ABSTRACT: Fecundity data is presented for the northern anchovy, *Engraulis mordax*, and applied to the problem of estimating adult population size. A brief description of the gonads and ovarian eggs is presented. The relationship between the number of ripe ova (E) and standard length in mm (L) is  $E=2,175+7.700L$ , while the weight-fecundity relationship is described by  $E=574W$  in which W=fish weight in grams. This estimate has a standard error of +/-10%. The male biomass available to the fishery equals about 75% of the female biomass. We should expect about  $3.0 \times 10^8$  eggs per ton of adult anchovies. Egg ratios suggest that anchovies may spawn one or more times per year, with peaks in January through March. The actual spawning frequency cannot be determined at present, but the above estimate of  $3.0 \times 10^8$  eggs assumes one spawning. Considerable error is introduced not knowing the average number of spawnings per year.

Fecundity of the Pacific hake, *Merluccius productus*.

AUTHOR(S): MacGregor, J. S.

YEAR: 1966.

SOURCE: Calif. Fish Game 52(2):111-116.

KEYWORDS: Spawning, reproduction, Pacific hake, *Merluccius productus*.

ABSTRACT: Diameters of eggs containing yolks from 22 female hake showed a bimodal frequency distribution. The numbers of advanced yolked eggs increased with both length (although there is considerable spread of values about the line fitted to the data) and weight of the fish. Although there are two sizes of yolked eggs in an ovary indicating multiple spawning seasons, a combination of the short spawning season, the correlation between eggs per gram of fish and percentage of yolked eggs in the advanced mode and poor condition of the fish indicate that the hake spawn once a year.

Pesticide research at the Fishery-Oceanography Center.

AUTHOR(S): MacGregor, J. S.

YEAR: 1972.

SOURCE: CalCOFI Rep. 16:103-106.

KEYWORDS: *Sebastes paucispinis*, bocaccio. *Sebastes miniatus*, vermillion rockfish, contaminant levels.

ABSTRACT: An assay of total DDT concentrations in the liver and muscle of many sport and commercially important nearshore fishes collected at various locations from Baja California and southern California during 1969 and 1970 is described. Total DDT concentrations increased along a gradient from Baja California north to the metropolitan Los Angeles area. Concentrations are given for liver and muscle tissue of *S. paucispinis* and *S. miniatus*.

Fecundity, multiple spawning, and description of the gonads in *Sebastes*.

AUTHOR(S): MacGregor, J. S.

YEAR: 1970.

SOURCE: U. S. Fish. Wildl. Serv. Spec. Sci. Rep. Fish. 596:12.

KEYWORDS: *Sebastes paucispinis*, bocaccio, reproduction, spawning.

ABSTRACT: Examination of the ovaries of nine rockfish species showed evidence of two spawnings per spawning season. Evidence of multiple spawns were based on co-occurrence of eggs and/or embryos in different stages of development in the ovaries. Specimens were collected 20, 40, and 100 nautical miles offshore San Diego, California during 1961. Upon examination of 13 individuals, average relative fecundity (number of eggs or embryos of a single spawning batch per gram of fish) of *S. paucispinis* was estimated to be 211 eggs/gr. Also included were similar fecundity estimates for ten other rockfish species. Six of 13 individuals of *S. paucispinis* contained remains of larvae from previous spawning (same season) in their ovaries. Therefore, at least some individuals of *S. paucispinis* and two other rockfishes spawn two batches of larvae per season; these three species generally produced distinctly fewer eggs per batch than the rockfish species that appear to spawn only once per season. Development of the second batch appears to be inhibited until the first batch is fertilized. 0.06 per cent of a pooled sample of embryos from several *S. paucispinis* were unfertilized or undeveloped. Preservation in formalin causes swelling of ripe unfertilized eggs and fertilized eggs of stages preceding blastopore closure. The weight of eggs containing embryos increases as the embryos develop. Size of ripe testes of male rockfish are greatly reduced relative to other fish species.

Additional data on the spawning of the hake.

AUTHOR(S): MacGregor, J. S.

YEAR: 1971.

SOURCE: Fish. Bull. 69(3):581-585.

KEYWORDS: Pacific hake, *Merluccius productus*, spawning, length/weight, growth, distribution.

ABSTRACT: Information from female hake collected off northern, central and southern Baja California was used to determine if there were geographic differences in fecundity. The results showed 1) there was a distinct cline in the size of maturity for hake in this study, 2) there was no significant difference in the eggs/gram of fish compared between the three areas: northern Baja, 192 eggs/gram of fish; central Baja, 243 eggs/gram; and southern Baja, 229 eggs/gram, 3) multiple spawning seems unlikely because of the great variation of large to small-yolked eggs observed, and 4) average size of first maturity for female hake varied from 133 mm standard length off southern Baja to 340 mm off northern Baja and southern California.

Age-composition changes in the anchovy, *Engraulis mordax*, central population.

AUTHOR(S): Mais, K. F.

YEAR: 1981.

SOURCE: CalCOFI Rep. 22:82-87.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, age, growth.

ABSTRACT: Prior to 1977-80 no major changes in northern anchovy, *Engraulis mordax*, age composition from the reduction fishery were detected. From 1965-76 a typical season catch/age composition of ages 0, 1, 2, 3, 4 and 5 were 10, 27, 37, 20, 5 and 1%,

respectively. Catches fluctuated greatly with a maximum of 156,000 short tons in 1975. In the 1976-77 season, 2-year olds comprised only 16% of the catch with a higher percentage of age 3, while in the 1977-78 season there was a higher percentage of 4 year olds than 3 year olds. Three and 4 year olds nearly disappeared from the fishery by the 1978-79 season. Age 0 fish became dominant representing 64% of the total catch. By the 1979-80 season nearly 90% of the catch was composed of ages 0 and 1. Between 1977 and 1980 catches also fluctuated greatly, between 110,000 tons (1977) and 11,000 tons (1978). The Mexican catch showed similar trends, but fluctuated less in tons captured. The highest combined catch of 386,000 tons occurred in 1980, with the Mexican fishery surpassing the California fishery. The strongest and weakest year classes were found in 1972 and 1977, respectively. Mean catches of age 0 fish from the 1968-75, 1976, and 1977 year classes were 9.4, 45 and 36%, respectively, age 3 fish from the 1968-74 and 1975-77 year classes were 22.5 and 2.4%, respectively, and there were essentially no age 4 and 5 fish in the 1974-77 year classes. During the years of 1977-80 there was a significant shift to a much higher proportion of young age groups and fewer large old fish. Of the five year classes prior to 1979, three were weak (74, 75 and 77), and one was strong in Mexico while mediocre in California (76). The relative weakness of the 1974, 75, and 77 year classes, together with mortality from fishery and predation are the most likely causes of age-structure shift and population size. Results show that the northern anchovy central subpopulation should be watched very closely and age structure along with population levels over the past three years should be viewed as a danger sign.

Pelagic fish surveys in the California current.

AUTHOR(S): Mais, K. F.

YEAR: 1974.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 162, 79 pp.

KEYWORDS: Distribution, fishery, population trends, Northern anchovy, *Engraulis mordax*, jack mackerel, *Trachurus symmetricus*, Pacific hake, *Merluccius productus*, market squid, *Loligo opalescens*.

ABSTRACT: This report covers the years 1966-1973 of acoustic surveying, by means of the California current system for some of the schooling pelagic fish resources. These surveys were conducted by the California Department of Fish and Game. The purpose of the surveys was to determine certain biological and commercial information, including distribution, abundance availability, and population trends of northern anchovy (*Engraulis mordax*), jack mackerel (*Trachurus symmetricus*), Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), Pacific saury (*Cololabis saira*), Pacific hake (*Merluccius productus*), squid (*Loligo opalescens*), and pelagic red crab (*Pleuroncodes planipes*). Results of the surveys show that the northern anchovy stock far surpasses all the other stocks in biomass. Fishery availability of the stock is variable due to the behavior of the schooling fish. Jack mackerel abundance was limited to rocky banks and island coasts. Pacific mackerel and Pacific sardine population levels off California were apparently too low to estimate accurately. The squid and pelagic crab population levels appeared to be suitable for future exploitation.

Seasonal growth patterns of California stocks of northern anchovy, *Engraulis mordax*, Pacific mackerel, *Scomber japonicus*, and jack mackerel, *Trachurus symmetricus*.

AUTHOR(S): Mallicoate, D. L., and R. H. Parrish.

YEAR: 1981.

SOURCE: CalCOFI Rep. 22:69-81.

KEYWORDS: Northern anchovy, *Engraulis mordax*, chub mackerel, *Scomber japonicus*, jack mackerel, *Trachurus symmetricus*, growth, age, seasonality.

ABSTRACT: Age structure and seasonality were considerably different between the two populations. Southern anchovy growth begins in February and continues until April or May, while central California anchovy growth period starts 3 to 4 months later. Jack mackerel show little seasonality until age 3, when they begin to lose weight in late winter to early spring, and gain during the rest of the year. Pacific mackerel grow even more rapidly than jack mackerel, but settle in the same seasonal pattern after the first year. Fishing regulations protecting the young northern anchovy and jack mackerel would be beneficial, but would not be appropriate for the faster-growing Pacific mackerel.

Destruction of kelp beds by sea urchins: a cyclical phenomenon or irreversible degradation?

AUTHOR(S): Mann, K. H.

YEAR: 1977.

SOURCE: Helgolander mics. Meeresunters 30:455-467.

KEYWORDS: Sea urchin, *Strongylocentrotus* sp., feeding.

ABSTRACT: Grazing pressure by the sea urchin, *Strongylocentrotus droebachiensis*, reduced a stable kelp bed system in Nova Scotia to a barren ground. The beds were initially protected by predation on urchins by crabs and lobsters. In 1968, when the beds were decimated, lobster biomass was found to decrease from almost 2 million lbs. in 1964 to about .5 million lbs. in 1968. The data suggested the decrease by lobster in predation led to an increase in the urchin population and increased grazing pressure. The barren community was thought to represent a stable system, rather than cyclic phenomenon between peaks in kelp harvest and would act to reduce primary and secondary productivity within the nearshore waters.

Food habits of demersal fish in Santa Monica Bay.

AUTHOR(S): Manzanilla, E., and J. N. Cross.

YEAR: 1982.

SOURCE: Pages 119-124 in W. Bascom (ed.), Coastal water research project biennial report for the years 1981-1982. Southern California Coastal Water Research Project, Long Beach, California.

KEYWORDS: Dover sole, *Microstomus pacificus*, English sole, *Parophrys vetulus*, groundfish, feeding, behavior.

ABSTRACT: A comparison was made between the stomach contents of certain demersal fish species and prey taxa caught in benthic grabs in Santa Monica Bay, California. Invertebrate prey taxa were classified into motility modes based on their life history. The results indicate that the longspine combfish, and the Dover sole, *Microstomus pacificus*, fed primarily on surface-motile crustaceans. The dominant prey taxa of the Dover sole included

the ostracod *Euphilomedes* sp., and gammarid amphipods. Pacific sanddab, and speckled sanddab also consumed surface-motile prey, but concentrated more on organisms in the overlying water. California tonguefish preyed mainly on burrowing crustaceans, and hornyhead turbot ate primarily tubicolous polychaetes. Yellowchin sculpin and English sole, *Parophrys vetulus*, ate a variety of taxa from many motility groups, however, tubicolous prey predominated in the diet of English sole, particularly the polychaete *Cistena* sp., and *Tellina* sp., a bivalve. The English sole was second only to the Dover sole in numbers of prey taxa consumed. Most of the dominant organisms found in stomach contents were also dominant in the grab samples. Notable exceptions were gammarid amphipods which occurred at a lower frequency in the grab, indicating positive selection, and bivalves which occurred at a higher frequency in the grab, indicating negative selection.

California commercial and sport fisheries oil toxicity studies on California halibut, northern anchovy, and California mussel.

AUTHOR(S): Marine Biological Consultants and Science Applications, Inc.  
YEAR: 1983.

SOURCE: Vol. II: Synthesis of findings. Prepared for Minerals Management Service, December 1983. Contract 14-12-0001-29105 pp 257.

KEYWORDS: Life history, contaminant levels, contaminant susceptibility, *Engraulis mordax*, northern anchovy, California halibut, *Paralichthys californicus*.

ABSTRACT: The purpose of this study was to test for chronic sublethal effects of oil exposure on various life history stages of selected marine species. In an attempt to simulate natural conditions, the species selected were ones likely to encounter the toxicant in their natural habitat during some developmental state. A naturally occurring petroleum hydrocarbon and a complex mixture of this oil in water were chosen for testing. The species used for the long-term chronic exposure studies were the California halibut, northern anchovy and California mussel.

Working paper on yellowtail (*Seriola dorsalis*) with emphasis on schooling and related behavior in general.

AUTHOR(S): Marine Biological Consultants, Inc.  
YEAR: 1979.

SOURCE: Prepared for Southern California Edison Company, Rosemead, CA. 21 pp. plus addendum.

KEYWORDS: Yellowtail, *Seriola lalandei* behavior, migration, age.

ABSTRACT: The current literature on schooling and related behavior was reviewed, and related to yellowtail (*Seriola dorsalis*). This study was initiated to provide an explanation for the massive kill of yellowtail when they swam into the discharge conduit at Southern California Edison Company's Redondo Beach Generating Station. The yellowtail is the largest member of the jack family (Carangidae) found in California waters, reaching a length of up to 5 ft and weight of 80 lbs. They are schooling fish that are characteristically found close to shore, around islands and offshore banks. Their migration leads them north into southern California in the early spring and then south again in late summer and early fall. Individuals between the ages of three and

eight years appear to school with others of similar size and move throughout much of their geographical range. It was estimated that a school of 58 cm long yellowtail would space themselves with a distance of 34.0 cm between each fish and its nearest neighbor. Related subjects included in the literature review were: Why fish school; how vision, chemical and acoustic responses, and other sensory reception affects schooling behavior; and how fish respond to current flow.

Physical and biological categorization process for selection of Southern California Edison company representative 316(b) study sites.

AUTHOR(S): Marine Biological Consultants, Inc.

YEAR: 1979.

SOURCE: Southern California Edison Company Research and Development Series

79-RD-69. 32 pp. Rosemead, Ca.

KEYWORDS: Distribution, seasonality, *Engraulis mordax*, northern anchovy.

ABSTRACT: The purpose of this paper was to determine the offshore pattern of

distribution, catch-per-unit-effort, and depth/season variability in the Southern California Bight and in the vicinity of Southern California Edison generating stations for five fish species. The trawl data used was from trawls made from the early 1970s until 1980. White croaker (*Genyonemus lineatus*) was found most frequently in shallow waters (<40 ft.). It also appeared to be most common during spring-summer. Queenfish (*Seriphus politus*), occurrence was in depths less than 90 ft. Bight wide seriphus occurrence was highest during fall-winter, but at particular generating stations it was highest during spring-summer. The concentration of northern anchovy (*Engraulis mordax*) was highest in shallower depths, except in the spring-summer period around generating plants where the concentration was lower in the shallowest depths (<30 ft.). Anchovy abundance was greatest in spring-summer near the generating plants. White surfperch (*Phanerodon furcatus*) was most abundant during the winter Bight wide, while it was most abundant during the spring-summer near the generating plants. Abundance was greatest at depths less than 60 ft. Little seasonality abundance could be discerned for Walleye surfperch (*Hyperprosopon argenteum*), but the greatest abundance was restricted to depths less than 30 ft.

Age, length, and weight studies of three species of Columbia River salmon (*Oncorhynchus keta*, *O. gurboscha*, and *O. kisutch*).

AUTHOR(S): Marr, J. C.

YEAR: 1943.

SOURCE: Stanford Ichthy. Bull. 2(6):157-197.

KEYWORDS: *Oncorhynchus kisutch*, growth, age, length/weight, distribution, coho salmon, migration.

ABSTRACT: Samples of scales, length, weight and sex of 518 chum, 6 pink, and 885 silver salmon were collected from the Columbia River in 1914. Chum and pink salmon went to sea in their first years. All pinks returned during their second year, whereas 70.8% and 28.7% of the chum returned in their third and fourth years, respectively. The majority of the silvers (83.9%) went to sea during their second year and returned in their third year. Growth curves were presented for all age groups of chum and silver salmon. The sex ratio of males to females appeared to increase



with increased age. In addition, changes in abundance were correlated to size differences at various latitudes.

Copper toxicity experiments in relation to abalone deaths observed in a power plant's cooling waters.

AUTHOR(S): Martin, M., M. D. Stephenson, and J. H. Martin.

YEAR: 1977.

SOURCE: Calif. Fish Game 63(2):95-100.

KEYWORDS: Abalone, *Haliotis* spp., contaminant susceptibility.

ABSTRACT: The impact of acute and chronic effects of copper on adult and larval red *Haliotis rufescens*, and adult black *Haliotis cracherodii*, abalone was examined. The 96-hr LD50 for black abalone was 50 ppb copper and 65 ppb copper for red abalone. A 48-hr LD50 for red abalone larvae was 114 ppb; however significant levels of mortality were observed at 80 ppb and higher. The mean level of copper accumulation increased with increased concentrations in solution. At 56 ppb, copper had accumulated in the gills and digestive glands of the red abalone with evidence of histopathic damage.

Sexual maturity, fecundity, spawning, and early life history of sablefish (*Anoplopoma fimbria*) off the Pacific coast of Canada.

AUTHOR(S): Mason, J. C., R. J. Beamish, and G. A. McFarlane.

YEAR: 1983.

SOURCE: Jour. Fish. Aquat. Sci. Canada 40(12):2126-2134.

KEYWORDS: *Anoplopoma fimbria*, sablefish, spawning, early life history, ichthyoplankton.

ABSTRACT: Trawls of spawning sablefish and ichthyoplankton surveys were conducted in order to determine important aspects of the spawning activities and early life history of the sablefish along the Pacific Coast of Canada. Sablefish spawn all along the coast of Canada from January to March with peak spawning in mid-February. Spawning occurred at depths greater than 300 m along the continental slope. There was no noticeable spawning migration. The ichthyoplankton surveys suggest that the period of embryo development lasts several weeks. The largest catches of eggs and larvae occurred below 400 m, and the lack of late stage embryos in the trawls suggests that the eggs sink to below 500 m before hatching. Mean lengths at 50% maturity showed very little variation among several sampling stations for the male, and on the average, females were larger than males (56.8 cm and 52.5 cm, respectively). Mean ages at maturity were 4.8 for males and 5.1 for females. The fecundity of an average female in the fishery (70 cm) was estimated as 195,000 eggs during the spawning season. After hatching, post larvae migrated to the surface waters and were found as much as 175 km offshore in late March. Juvenile sablefish were observed in waters inside of British Columbia in July and August, by which time they attain lengths of up to 9 cm.

Factors affecting Puget Sound coho salmon (*Oncorhynchus kisutch*) runs.

AUTHOR(S): Mathews, S. B., and F. W. Olson.

YEAR: 1980.

SOURCE: Jour. Fish. Aquat. Sci. Canada 37(9):1373-1378.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, fishery, habitat, early life history, population trends.

ABSTRACT: Previous studies as early as 1955 have demonstrated a positive relationship between streamflow and Puget Sound coho production. The purpose of this study was to document the continuing relationship between summer stream flow and coho production. Also studied was a model which included hatchery production showing that hatchery reared coho as well as stream reared coho may be affected by summer flow. The results indicate a positive effect of streamflow on both hatchery and stream reared coho. The authors speculate that there is no direct effect of streamflow on hatchery coho, but that increased survival of stream coho with increased streamflow affects survival value of hatchery coho through compensatory mortality. Other indices of environmental conditions during important life stages of coho salmon (streamflows and estuary temperatures during smolt outmigration, fish growth, ocean seawater temperatures, ocean upwelling during spring of outmigration) did not appear to affect significantly the size of the Puget Sound net catch.

Marine mortality of Puget Sound coho salmon (*Oncorhynchus kisutch*).

AUTHOR(S): Mathews, S. B., and R. Buckley.

YEAR: 1976.

SOURCE: Jour. Fish. Res. Bd. Canada 33(8):1677-1684.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, length/weight, life history, population trends, mortality.

ABSTRACT: A weight-dependent model of mortality was constructed for the 18 month period of marine life of Puget Sound coho salmon. The model incorporates a decreasing rate of natural mortality within increasing size, and also takes into account the ocean troll and sport fishing mortality. This model could explain a recent occurrence of high survival by a group of hatchery coho which were released at a larger than normal size. Based on this model the authors suggest an optimal release size for coho salmon of 70 g/fish.

Occurrence of young billfish in the central Pacific ocean.

AUTHOR(S): Matsumoto, W., and T. K. Kazama.

YEAR: 1974.

SOURCE: Matsumoto, W. M. and T. K. Kazama. 1974. Occurrence of young billfish in the central Pac. Ocean. Pg. 238-251 in R. S. Shomura and F. Williams (eds.). Pro. of the Int. Billfish Symp., Kailua-Kona, HA, Aug 1972. Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS SSRF-675.

KEYWORDS: Distribution, ichthyoplankton, larvae, seasonality, spawning, *Xiphias gladius*, swordfish.

ABSTRACT: Using 342 billfish larvae collected on cruises by the National Marine Fisheries Service (NMFS) in Hawaii and the central Pacific, identification of species made by previous authors is verified, and new information on the distribution of the ichthyoplankton is revealed. The species identified are the sailfish (*Istiophorus platyterus*), shortbill spearfish (*Tetrapturus angustirostris*), blue marlin (*Makaira nigricans*), and swordfish (*Xiphias gladius*). Analysis of the data shows that most of the larvae were taken during the day from the top one meter of water. Reduced catches from the surface at night suggests that the larvae migrate downward at that time. Larval distribution southward is difficult to define, but it is

hypothesized not to extend south of latitude 25 degrees south due to the configuration of the 24 deg C surface isotherm. The widest range of blue marlin and shortbill spearfish larvae is examined, along with distribution by seasonality. No blue marlin larvae were found in less than 23.8 deg C water, while no shortbill spearfish larvae were found in waters less than 22.3 deg C water. Only 20 specimens of swordfish were taken in the samples examined. Although this does not generate much in the way of definitive generalities, it did allow for some inferences to be made. The distribution of swordfish larvae was extended to include waters east of Hawaii. Also, some aspects of the differences in the spawning seasons in various parts of the Pacific could be deduced. The lowest temperature in which swordfish larvae were found was 23.3 deg C. The lack of striped marlin and the capture of only 2 sailfish larvae suggests that spawning does not occur in the areas sampled.

Species similarity and movement of fishes on natural and artificial reefs in Monterey Bay, California.

AUTHOR(S): Matthews, K. R.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):252-270.

KEYWORDS: Artificial reefs, recruitment, community.

ABSTRACT: Fish assemblages on artificial and natural reefs, fishing pressure and fish movement between reefs are compared in Monterey Bay, California in an attempt to understand the effects of a newly constructed artificial reef on natural reefs. The blue rockfish (*Sebastes mystinus*), olive rockfish (*S. serranoides*), and white surfperch (*Phanerodon furcatus*) were the three dominant species of the 25 total observed on all natural reefs, with species composition among reefs being similar. After one year the artificial reef species composition was similar to that of natural reefs. Only adult and subadult rockfish (>6 cm) were seen on the artificial reef for the first three seasons. Higher mean densities were observed on the artificial reef in six of the eight seasons. Fishing pressure underwent seasonal changes, with the highest in spring and summer. Highest overall sport fishing was on the marked artificial reef. Of all recaptured fish 79.5% had moved from the natural reefs to the artificial reef, with movement demonstrated two years after the installation of the reef. Only 20.5% of recaptures on the reef were tagged. All but one tagged fish observed on underwater surveys had not moved. The artificial reef fish assemblage was comparable to the natural reefs, with the similarity becoming greater over time. Densities were up to three times greater on the artificial habitat than natural reef. Initial colonization of the artificial reef is not the result of creating new biomass, rather via moving biomass from one location to another. One source of recruitment is from nearby natural reefs, representing as much as 48% of the reef population. Once fish move to the artificial they stay there. It is not known whether movement was due to better food, space, or quality of habitat. Fish movement from an area of low to high exploitation means fish are more susceptible to fishing. When investigated over longer periods of time, artificial reefs do increase total production. Locating reefs too close to natural ones may be counterproductive and actually reduce fish populations.

Movement of two nearshore, territorial rockfishes previously reported as non-movers and implications to management.

AUTHOR(S): Matthews, K. R.

YEAR: 1986.

SOURCE: Calif. Fish Game 72(2):103-109.

KEYWORDS: Artificial reef, rockfish, *Sebastes* spp., habitat, distribution, fishery.

ABSTRACT: This paper reports the results of a tagging experiment conducted

using two species of nearshore, territorial rockfish located on four natural reefs off the coast of Capitola, Connecticut and their subsequent recapture on the Capitola artificial reef. The results of this experiment appear to indicate that rockfish must be roaming about more than previous studies have reported. It is suggested that this factor be investigated as an aid to reef management.

S. Pearse.

Movement and feeding activity of red sea urchins

(*Strongylocentrotus franciscanus*) adjacent to a kelp forest.

AUTHOR(S): Mattison, J. E., J. D. Grent, A. L. Shanks, T. B. Akin, and J.

YEAR: 1977.

SOURCE: Mar. Biol. 39:25-30.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., feeding.

ABSTRACT: Movements of red sea urchins, *Strongylocentrotus franciscanus*, as related to feeding in a kelp forest were studied along transect lines off Santa Cruz, central California. Urchins within the kelp forest were found to move an average of 7.5 cm/day and approximately 66% were feeding when examined. These results were significantly different from data collected 15 and 100 m outside the kelp forest. The urchins averaged 50 cm/day movement and the percentage feeding was reduced to 16 and 15% for the 15 and 100 m stations, respectively. The results suggested movement was in response to low food densities.

Progress report of research on white seabass, *Cynoscion nobilis*.

AUTHOR(S): Maxwell, W. D.

YEAR: 1977.

SOURCE: Mar. Res. Admin. Rep. 77-14. 14 pp.

KEYWORDS: White seabass, *Atractoscion nobilis*, migration, population trends, life history.

ABSTRACT: The white seabass, *Cynoscion nobilis*, population (off California) was examined to determine the feasibility of studying life histories. Subpopulations were noted using electrophoresis, however sample size was not sufficient for significance. Of the 58 juvenile fish tagged and released from partyboats, none were returned. Migration remained poorly understood due to the low numbers of fish and erratic fishery. Little data on maturity was provided by the present study due to sample size. There was some question of the validity of previously published maturity results suggesting management could be impaired.

Kelp, abalone and sea otters.

AUTHOR(S): May, R. M.

YEAR: 1976.

SOURCE: Nature 260(5549):284.

KEYWORDS: Abalone, *Haliotis* spp.

ABSTRACT: The sea otter, *Enhydra lutris*, historically occupied a range from the Aleutians to Baja California. At present, the range is somewhat disjunct with isolated groups in Washington, Oregon and central California. A decrease in the abalone fishery, following the comeback of the sea otter in central California, has been reported. Previous studies suggest the cropping of benthic grazers (particularly abalone and urchins) would lead to increases in kelp productivity. Caution must be exercised in describing evolutionary ecosystems based on these present works because the impact of extinct organisms cannot be defined.

The ecology and thermal sensitivity of the Dungeness crab, *Cancer magister* and related species of its benthic community in Similk Bay, Washington.

AUTHOR(S): Mayer, D. L.

YEAR: 1973.

SOURCE: Ph.D. dissertation, University of Washington. 185 pp. plus appendices.

KEYWORDS: Market crab, *Cancer magister*, life history, distribution, feeding, mortality.

ABSTRACT: Surveys of Dungeness crab, *Cancer magister*, stocks in the Kiket Island vicinity of Washington, were made utilizing taggings, recreational and commercial fishing censuses and scuba transects. The abundance, distribution and diversity of benthic epifauna and infauna were assessed with otter trawls and core samples. The catch per unit effort data showed peak success rates in the summer months. The mark recapture study suggested that high annual mortality was offset by immigration of adults into the area. The growth rates recorded in the study were lower than for crabs outside the study area. The population of the study site was estimated at 14,500 (+/-5,500). The gut contents of crabs and five local fish species were analyzed. The crabs fed almost exclusively on infaunal crustaceans, amphipods and tanaids. *Lumpenus saggita*, *Platichthys stellatus* and *Lepidopsetta bilineata* exhibited a high degree of dietary overlap. Crab predation was important in increasing diversity and reducing abundance of the local infauna. The thermal tolerances of the species were quantified by lethal dose experiments ranging from 25-30 deg C, 10-30 deg C and 5-20 deg C. Increases in egg mortality (of crabs) was significant above 10 deg C and bacterial growth was also enhanced. Thermal avoidance of crabs was also observed. During summer, crabs were not seen in waters warmer than 15.5 deg C while in winter their tolerance appeared to be 15.1 deg C. The results of this study suggested thermal discharges would have little effect on the crab populations and slight increase might enhance juvenile survival.

National pollutant discharge elimination system: 1983 receiving water monitoring report for Huntington Beach Generating Station, Orange County, California, summer 1983 survey.

AUTHOR(S): MBC Applied Environmental Sciences.

YEAR: 1983.

SOURCE: Prepared for Southern California Edison Company, Rosemead, CA.

R&D Rep. 83-RD-145.

KEYWORDS: Platform, northern anchovy, *Engraulis mordax*.

ABSTRACT: An evaluation of the thermal effluent discharged from the Huntington Beach Generating Station. The physical, chemical, oceanographic and biological qualities of waters surrounding the intake and discharge conduits of the facility were studied. In summarizing the result from the study, water column profiling in August 1983 indicated that thermal addition from the discharge was only detectable in the immediate vicinity. Sediment regimes at all stations in August 1983 were generally coarser than in August 1982. Organic carbon levels of the sediments in 1983 were considerably lower than those recorded in 1982. Chemical analysis of sediments revealed higher concentrations of cadmium, chromium, copper, mercury, zinc and iron, but lower concentrations of lead, silver and phenols. Major changes observed in the macrofauna community seem to be associated with the exceptionally heavy storm activity of March 1983, or with the physical changes in nearshore sediments which resulted from them. This storm activity appears to have also had an effect on the infauna community. In most past August surveys, while croaker, queenfish, and northern anchovy have been the dominant members of the demersal fish community. Overall, the conclusions from this study show that the results in 1983 were generally comparable to those encountered in prior surveys, and that the combined influences of the generating station are very localized.

Marine Biology Technical Appendix I for Chevron USA, Point Arguello Field/Gaviota Processing Facility, Texaco Platform Harvest and Southern Santa Maria.

AUTHOR(S): MBC Applied Environmental Sciences.

YEAR: 1984.

SOURCE: Unpubl. ms for Arthur D. Little, Inc.

KEYWORDS: All species, platform, habitat, distribution, migration, contaminant levels, contaminant susceptibility.

ABSTRACT: A description of the environmental setting of the coastline near Pt. Conception and the environmental consequences and mitigation of the proposed oil field development is described. Topics covered under the description of the environmental setting include the intertidal, benthic communities, kelp communities, plankton community, pelagic fishes, demersal fishes, seabirds, marine mammals, artificial habitats, sensitive areas, and rare, endangered, or threatened species. In the consequences and mitigation section, the topics addressed are related to the impacts of proposed projects, the impacts of area buildout scenario, impact of alternative, and mitigation measures.

National pollutant discharge elimination system: 1985 receiving water monitoring report from Huntington Beach Generating Station, Orange County, California, summer 1985 survey.

AUTHOR(S): MBC Applied Environmental Sciences.

YEAR: 1985.

SOURCE: Prepared for Southern California Edison Company, Rosemead, CA R&D Rep. 85-RD-99.

KEYWORDS: Platform, community, habitat.

ABSTRACT: Marine monitoring program for the Huntington Beach Generating Station. The receiving waters and underlying sediments were

monitored for physical and chemical changes. The infaunal, macrofaunal and fish assemblages were also monitored. Observations of the macrofauna community near the generating station indicated that the tube-building polychaete *Diopatra splendidissima* has returned to its pre-El Nino level. It appears to have re-established itself as the community dominant at the greatest density ever observed locally for this species. In general, the results of this study indicate that the only noticeable impact was immediately adjacent to the discharge. This minor alteration of the benthic infauna and macrofauna were attributed to water motion and its effects on sediment grain size and level of organic carbon.

Ecology of oil/gas platforms offshore California.

AUTHOR(S): MBC Applied Environmental Sciences.

YEAR: 1984.

SOURCE: Rep. 86-0093 prepared for Minerals Management Service, U.S. Dep. Interior, Washington, D.C. MMS contract No. 14-12-0001-30294.

KEYWORDS: Artificial reef, community, fisheries, feeding, platform, habitat,

recruitment, economics, regulations, contaminant levels, colonization, behavior.

ABSTRACT: In light of increased concern for potential conflicts between offshore oil and gas operations and the conduct of commercial and sports fisheries in the Pacific OCS, the Minerals Management Service required a summary of the ecology of fishes and attached epifauna that associate with offshore oil and gas platforms of California and an evaluation of actual and potential use of the platforms for mariculture. A summary of this information is presented that is based on an extensive literature review as well as personal contacts with platform operators and scientists who have worked on such platforms offshore California. A plan is also recommended for future field studies which would help fill the large data gaps and allow alternative hypotheses concerning the role of platforms in fish population dynamics to be tested.

Ecology of important fisheries species offshore California.

AUTHOR(S): MBC Applied Environmental Sciences.

YEAR: 1984.

SOURCE: Rep. 86-0093 prepared for Minerals Management Service, U.S. Dep. Interior, Washington, D. C. MMS contract No. 14-12-0001-30294

KEYWORDS: All species, age, behavior, biology, community, life history, contaminant, distribution, ecology, economics, feeding, fishery, groundfish, growth, habitat, ichthyoplankton, larvae, length, migration, mortality, nursery, population, physiology, recruitment, regulations, reproduction, seasonality, spawning, weight, wetfish.

ABSTRACT: This report summarizes the biology and fisheries of 32 fish and invertebrate species of commercial and recreational importance in the marine waters of California. Each species characterization is accompanied by maps of the southern, central and northern California coast which depict the distribution of the species, its spawning grounds and migratory pathways. The species which were examined are as follows: red abalone (*Haliotis rufescens*), ridgeback prawn (*Sicyonia ingentis*), spot prawn (*Pandalus platyceros*), yellow crab (*Cancer anthonyi*), red sea urchin (*Strongylocentrotus franciscanus*), northern anchovy (*Engraulis mordax*), chinook salmon (*Oncorhynchus tshawytscha*), widow rockfish (*Sebastes entomelas*), vermilion

rockfish (*Sebastes miniatus*), sablefish (*Anoplopoma fimbria*), kelp bass (*Paralabrax clathratus*), jack mackerel (*Trachurus symmetricus*), Pacific bonito (*Sarda chiliensis*), albacore (*Thunnus alalunga*), California halibut (*Paralichthys californicus*), Dover sole (*Microstomus pacificus*), market squid (*Loligo opalescens*), ocean shrimp (*Pandalus jordani*), California spiny lobster (*Panulirus interruptus*) Dungeness crab (*Cancer magister*), thresher shark (*Alopias vulpinus*), coho salmon (*Oncorhynchus kisutch*), Pacific hake (*Merluccius productus*), chilipepper (*Sebastes goodei*), bocaccio (*Sebastes paucispinis*), lingcod (*Ophiodon elongatus*), yellowtail (*Seriola lalandi*), white seabass (*Atractoscion nobiis*), chub mackerel (*Scomber japonicus*), swordfish (*Xiphias gladius*), petrale sole (*Eopsetta jordani*), English sole (*Pleuronectes vetulus*). Each species characterization includes information on the geographic range, habitat requirements, reproduction, migration, age and growth, general ecology, physiological ecology, population trends, fishing regulations and economic value of the species. The document is accompanied by an annotated bibliography of over 950 entries, including all citations referenced in the document as well as other related material which was too general or too specific for inclusion in the species characterizations. The annotated bibliography was prepared in hard copy and in magnetic media for use with SCI-MATE and SCI-SEARCH software.

Widow rockfish, *Sebastes entomelas*, new to British Columbian waters.

AUTHOR(S): McAllister, D. E., and S. J. Westrheim.

YEAR: 1965.

SOURCE: Jour. Fish. Res. Bd. Canada 22(6):1559-1561.

KEYWORDS: *Sebastes entomelas*, widow rockfish, distribution.

ABSTRACT: Description of the first *S. entomelas* specimens ever collected from British Columbia waters (Rivers Inlet, central B.C. and Quatsino Sound, west Vancouver Island). These descriptions extend the northern limit of the range of *S. entomelas* to these locations.

W. Brown, and J. H. Vandermeulen.

Bioavailability of crude-oil from experimentally oiled sediments to English sole (*Parophrys vetulus*), and pathological consequences.

AUTHOR(S): McCain, B. B., H. D. Hodgins, W. D. Gronlund, J. W. Hawkes, D. YEAR: 1978.

SOURCE: Jour. Fish. Res. Bd. Canada 35(5):657-669.

KEYWORDS: *Parophrys vetulus*, English sole, contaminant susceptibility, growth, feeding, larvae.

ABSTRACT: Bioavailability and contaminant susceptibility to crude oil in the English sole, *Parophrys vetulus*, are examined. Preliminary data on both growth deterioration and liver pathology are also presented. Concentrations of alkanes and aromatics were found in the skin, muscle and liver of oil-exposed fish, declining with time. A range of aromatics were found with 1, 2, 3, 4 - tetramethylbenzene and the 1-and 2- methyl-naphthalenes most abundant. Aromatics were first removed from skin and muscle



tissue and later from the liver. Tetramethylbenzene was the most persistent with 13% of the original concentration detectable at the end of the experiment (51 days). Concentrations were of the same order of magnitude as those in the oiled sediments. A significant uptake of alkanes was also found, with a decrease with time. Oil-exposed fish were less active, fed less, and had a greater weight loss and weight recovery than non-exposed fish. Higher values of hematocrit and hemoglobin levels were found in oil-exposed fish. After 51 days no difference was found. No histological differences were observed except for severe liver abnormalities in oil-exposed fish. Sediment-bound petroleum hydrocarbons are taken up by flatfish and are distributed throughout their tissues. Significant contaminant levels are bioaccumulated through a very active uptake mechanism, while simultaneous biodegradation occurs. Although biodegradation is effective and efficient, the persistence of two aromatic compounds suggests a potential long-term concern. Compositional changes of hydrocarbons in the sediment over time, in a controlled situation is also discussed.

Mearns.

Metal contamination of flatfish around a large submarine outfall.

AUTHOR(S): McDermott, D. J., G. V. Alexander, D. R. Young, and A. J. Mearns.  
YEAR: 1976.

SOURCE: Jour. Water Poll. Contr. Fed. 48(8):1913-1918.

KEYWORDS: Dover sole, *Microstomus pacificus*, contaminant susceptibility.

ABSTRACT: The levels of trace metals in the flesh, gonads, kidneys, liver, brain, heart and gill arches of Dover sole taken near municipal water works discharges were monitored and compared with uncontaminated fish. No clear uptake pattern of the seven trace elements was noted when the two test populations were compared. The liver and gonads showed increased levels of chromium, while the flesh displayed elevated silver levels. Significant depressions were observed in the gonads for silver and in the liver for cadmium. In Dover sole's exhibiting fin erosion, chromium levels were significantly different in the gonads, liver, kidney and heart than in fish with healthy fins.

Young, and A. J. Mearns.

Chlorinated hydrocarbons in Dover sole, *Microstomus pacificus*, local migrations and fin erosion.

AUTHOR(S): McDermott-Ehrlich, D. J., M. J. Sherwood, T. C. Heesen, D. R. Young, and A. J. Mearns.  
YEAR: 1977.

SOURCE: Fish. Bull. 75(3):513-517.

KEYWORDS: Dover sole, *Microstomus pacificus*, contaminant susceptibility.

ABSTRACT: Observations were made suggesting that Dover sole, *Microstomus pacificus*, found with fin erosion near the Orange County outfall may have migrated from the Palos Verdes shelf, an area with the highest contaminant levels of PCB and DDT in sediments of the Southern California Bight. The area of the origination of fin erosion is investigated along with the role of chlorinated hydrocarbons in fin erosion. No significant difference was found between total DDT concentrations in diseased fish from Orange County and Palos Verdes, while there was a difference between the

levels in unaffected fish from the two regions. DDT levels in diseased fish from both areas and nondiseased fish from Palos Verdes were at least 10 times greater than levels from unaffected Orange County fish. PCB levels in Dover sole from both areas, diseased and nondiseased, were not significantly different. Fish with fin erosion from Palos Verdes had significantly higher levels of DDT and PCB ( $P < 0.05$  and  $P < 0.10$ ) than those without fin erosion. Results support the hypothesis that Dover sole with fin erosion caught in Orange County came from the Palos Verdes population. A significant association also exists between DDT levels and fin erosion and a possible association exists between PCB and the disease. Chlorinated hydrocarbon uptake could be enhanced in diseased fish, thus the higher levels may be a result rather than a cause. It is also possible that affected fish may have been exposed longer than non-affected fish.

Observations on the sexual behavior and spawning of the squid,  
*Loligo opalescens*, at La Jolla, California.

AUTHOR(S): McGowan, J. A.

YEAR: 1954.

SOURCE: Calif. Fish Game 40:47-54.

KEYWORDS: Market squid, *Loligo opalescens*, reproduction, spawning, behavior.

ABSTRACT: The spawning and behavior of mature squid were observed in the laboratory and in the field. Prior to spawning the school moved offshore to shallow sandy bottom habitats. Males assumed an aggressive precopulation behavior. Sperm were transferred during the linking between males and females. Females attached egg capsules either to the sandy substrate or to an existing egg mass. Some masses were up to 40 feet in diameter. Eggs hatched within 30-35 days at 13.6 deg C. Both males and females died after spawning.

Correlations between squid catches and oceanographic  
conditions in Monterey Bay, California.

AUTHOR(S): McInnis, R. R., and W. W. Broenkow.

YEAR: 1978.

SOURCE: Fish. Bull. 169:161-170.

KEYWORDS: Market squid, *Loligo opalescens*, fishery, growth.

ABSTRACT: Delivery receipts for the market squid, *Loligo opalescens*, fishery from 1960 to 1974 were compared with the annual hydrographic conditions of Monterey Bay. When temperature profiles were superimposed on catch data, a lag period of 18 months was observed. These results were consistent with spawning age records for the squid. It was unclear if the lower temperatures were directly affecting the juvenile squid growth rates. Further research would be required to determine if the temperature anomalies were indirectly affecting growth (i.e. through prey species availability, etc.).

Food habits of the white sturgeon, *Acipenser transmontanus*, in  
San Pablo and Suisun Bays, California.

AUTHOR(S): McKechnie, R. J., and R. B. Fenner.

YEAR: 1971.

SOURCE: Calif. Fish Game 57(3):209-212.

KEYWORDS: Market crab, *Cancer magister*, mortality.

ABSTRACT: The purpose of this study was to determine the food habits of

the white sturgeon, *Acipenser transmontanus*. Stomach and esophagus samples were collected from 213 specimens in San Pablo Bay, and from 142 specimens in Suisun Bay and Carquinez Strait. Benthic invertebrates dominated the diet of sturgeon. Clams were consistently the most important food item, with their contribution to total food volume ranging seasonally from about 12-41%. Crabs, *Rhithropanopeus harrisi*, made a less consistent but seasonally more important contribution than clams, making up a third of the diet in the winter. Cancer magister also made up a significant contribution to the diet in the fall. Barnacles constituted about 44% of the food in the summer. Eggs of the herring, *Clupea harengus*, made up about a 20% of the diet in the winter and 80% in the spring. Several species of fish made up about 18% of the diet in the winter and about 6% in the fall. Although shrimp occurred frequently, it never contributed more than 7% of the total volume. The kinds of organisms eaten are qualitatively similar to the invertebrate fauna found in the region. The principal exception is annelids, which are numerous in the area, but seldom eaten. These principal sturgeon food items are abundant in the mudflat communities which shows that these areas are vital habitat to the white sturgeon.

Stable cycles in multistage recruitment models - An application to the northern California Dungeness crab (*Cancer magister*) fishery.

AUTHOR(S): McKelvey, R., D. Hankin, K. Yanosko, and C. Snygg.

YEAR: 1980.

SOURCE: Jour. Fish. Aquat. Sci. Canada 37(12):2323-2345.

KEYWORDS: Cancer magister, market crab, fishery, recruitment.

ABSTRACT: The northern California Dungeness crab, *Cancer magister*, fishery provided a model population for study of multistage density-dependent recruitment mechanisms. The landings of Dungeness crab have shown a highly cyclic pattern since 1940 (with major crashes in 1955, 1963 and 1973). The increased fishing pressure and amplitude of the cycle swing suggest an inevitable crash of the fishery. Several biological and exogenous factors were considered to explain the cyclic pattern and destabilization due to the fishery. A multistage dynamic equilibrium model, with 48 variants, was utilized to assess exploitation and survival by the crab population. Diagnostic tests of the individual variants to the model supported the hypothesis that recruitment was determined in the early life (egg or larval) stages.

Assigning trophic levels to marine animals.

AUTHOR(S): Mearns, A. J.

YEAR: 1982.

SOURCE: Pages 125-141 in: W. Bascom (ed.) Southern California Coastal Water Research Project Biennial Report 1981-1982.

KEYWORDS: Feeding, community, contaminant levels.

ABSTRACT: The purpose of this paper was to produce an objective and repeatable means of assigning trophic levels to different species in a given ecosystem. Trophic level assignments (TLA) were calculated for 3 different ecosystems sampled: 1) the benthic macrofaunal community of the Palos Verdes Shelf near a large municipal outfall; 2) the coastal pelagic fauna of the Southern California Bight, and 3) the remote ocean pelagic fauna of the

Eastern Tropical Pacific. TLA values were calculated in 3 steps: 1) enumerate prey and compute some measure of importance of each prey item (In); 2) determine prey trophic level (Kn), and 3) sum the products of In and Kn. This method was applied to determine TLA's of 32 species of invertebrates, fishes, sharks and mammals representing food webs of the three different ecosystems. The TLA assignments appeared to compare favorably with more subjectively derived assignments for these and similar species used in previous studies.

Trophic structure and pollutant flow in a harbor ecosystem.

AUTHOR(S): Mearns, A. J. and D. R. Young

YEAR: 1980.

SOURCE: In, W. Bascom (ed.) Coastal Water Research Project Biennial Report

1979-1980. Southern California Coastal Water Research Project. Long Beach, Ca. Pages 287-308.

KEYWORDS: Northern anchovy, *Engraulis mordax*, California halibut, *Paralichthys*

*californicus*, contaminant levels.

ABSTRACT: The purpose of this study was to determine what relationships exist

between tissue concentrations of trace metals, chlorinated hydrocarbons, a potent carcinogenic petroleum hydrocarbon constituent (benzo(a)pyrene), and trophic levels of target organisms in the western end of the Los Angeles Harbor. Five target organisms representing the widest possible range of trophic levels were chosen for analysis. This included primary producers (Trophic Level I), herbivores (Trophic Level II) and primary, secondary and tertiary carnivores (Trophic Levels III, IV and V). Analysis was done on giant kelp, gaper clam, northern anchovy, white croaker and California halibut. Analysis of feeding habits indicated that there is some overlap in the apparent diets of the animals but very little overlap when only the most important, (e.g. high percentage, IRI) values are examined. California halibut were found to feed mostly on fish, whereas, northern anchovy fed mainly on crustaceans (ca. 30%) other zooplankton (68.2%). Northern anchovy were assigned to intermediate Trophic Level II-III with a bias of toward III. Halibut were assigned to intermediate Level IV-V with a bias toward VI, because of the dominance of the anchovy in the diet. Young California halibut shift from a benthic or epibenthic feeding toward a nekton feeding mode with an increase in size. This study revealed two principle routes of material flow from primary producers; one path through the benthos to white croaker and a second through the water column via anchovy to the halibut and California pelican. The median cs/k ratio increases from a factor of 5.0 between Level I and Level IV-V, indicating substantial "chemical structure" in this ecosystem. Non-volatile trace metals (cadmium, chromium, copper, iron, manganese, zinc) were found to decrease in concentration with increasing trophic position. Mercury was found to be an exception to this trend. Total concentrations of DDT and PCB were found to increase with trophic level. Levels of benzo(a)pyrene decreased with increased trophic level and is believed to be due to the increasing ability of higher organisms to metabolize this substance.

Age, length and weight relationships in southern California populations of Dover sole.

AUTHOR(S): Mearns, A. J., and L. Harris.

YEAR: 1975.

SOURCE: Southern California Coastal Water Research Project, El Segundo, Ca. TM219 17 pp.

KEYWORDS: Dover sole, *Microstomus pacificus*, length/weight, age.

ABSTRACT: The purpose of this paper is to summarize new information on the local variations of age, length and weight relationships of Dover sole (*Microstomus pacificus*). A total of 681 individuals were measured and tagged. The range in age was from 1-8 years and from 30-355 mm TL in size. The weight range was 1.5 to 291 grams. In comparing the age/length relationships of Dover sole from different areas in California, it was found that northern California fish attained a larger size than those southern conspecifics at the same age. Growth rates also showed that fish from coastal localities grew faster than offshore populations. However, Palos Verdes fish (in the vicinity of a sewage outfall) appeared to grow slower than fish from coastal sites to the north and south. Age/body weight comparisons were also made for various southern California localities. Comparison of liver weight plotted against age showed a trend for diseased fish from Palos Verdes to have larger livers than apparently healthy fish from either Palos Verdes or Catalina. In fact, Dover sole severely affected with fin erosion disease had the largest livers for their age group. Similarly, a comparison of liver weights with body weight showed that diseased Dover sole were some three to five times heavier than those in healthy Catalina or Santa Monica Bay fish.

Distributions of neoplasms and other diseases in marine fishes relative to the discharge of waste water.

AUTHOR(S): Mearns, A. J., and M. J. Sherwood.

YEAR: 1977.

SOURCE: Ann. N. Y. Acad. Sci. 298:210-224.

KEYWORDS: *Sebastes minatus*, vermillion rockfish, contaminant susceptibility.

ABSTRACT: Fishes collected from trawl surveys throughout the southern California Bight were examined for external disease symptoms, including fin and tail erosion, tumors, abnormal coloration and attached macroparasites. Thirty of the 555 *S. minatus* examined (5.4%) exhibited fin erosion. Histologic examination of affected and unaffected *S. minatus* suggested that the lesions in these species were not the result of an infectious process, and no associated microorganisms were found. Fin erosion was the only disease that appeared to be directly related to the discharge of municipal waste waters.

Biological study of oil platforms Hilda and Hazel, Santa Barbara Channel, California.

AUTHOR(S): Mearns, A. J., and M. Moore.

YEAR: 1976.

SOURCE: Southern California Coastal Water Research Project, El Segundo.

KEYWORDS: Platforms, contaminant levels, contaminant susceptibility, community.

ABSTRACT: A summary of the results of a series of field surveys and laboratory analyses made at platforms Hilda and Hazel in the Santa Barbara Channel is described. The purpose of the study was

to assess the abundance, health and diversity of marine life at the two platforms. The results showed a rich diversity of fish and invertebrates (benthic and infauna) surrounding the platforms. In the case of fish, there were 20 to 50 times more fish under the platforms than at the soft bottom control area, and species diversity was similar to a hard bottom control site. Chemical analyses of fish and invertebrates at the platforms showed no increase in contaminant levels over control areas. Sediments were found to have low amounts of petroleum hydrocarbons but had slight elevations in sediment zinc and hydrocarbons.

Environmental aspects of fin erosion and tumors in southern California Dover sole.

AUTHOR(S): Mearns, A. J., and M. Sherwood.

YEAR: 1974.

SOURCE: Trans. Am. Fish. Soc. 103(4):799-810.

KEYWORDS: *Microstomus pacificus*, Dover sole, life history, distribution.

ABSTRACT: Spatial and temporal distributions of the southern California Dover sole, *Microstomus pacificus*, with fin erosion and skin tumors are examined. Relationships between the life history, diseases, and distributions are discussed. Specimens with eroded fins were concentrated off the Palos Verdes Peninsula, while those with tumors were evenly distributed throughout the study area. In the Orange County outfall system abundance fluctuated seasonally, with peaks in May and August. Dover sole with tumors followed a cyclical pattern. Fish with fin erosion did not appear until two years after those with tumors. Fin erosion and tumors were generally found in fish >120 mm and 60-120 mm SL, respectively. Off Palos Verdes tumor-bearing fish were 90-130 mm, and in Santa Monica Bay, 110-150 mm SL. Physical characteristics of each disease were discussed in detail, along with frequency of occurrence. The two diseases are distinct and operate at different growth stages in the life cycle of Dover sole. Fin erosion probably originates in the Palos Verdes Peninsula and fish found in other areas most likely migrated there. The disease is external and not systemic in nature, the cause not known at this time, but any number of agents in the sediment are possible. These substances may come from wastewater outfalls. Skin tumors are a widespread phenomenon and characteristic of juvenile populations. The fate of the tumor-bearing fish has not been determined. Growth anomalies may be associated with metamorphosis and early summer conditions of rapid temperature and food availability changes.

Distribution, abundance and recruitment of softbottom rockfishes (Scorpaenidae: *Sebastes*) on the southern California mainland shelf.

AUTHOR(S): Mearns, A. J., M. J. Allen, M. D. Moore, and M. J. Sherwood.

YEAR: 1980.

SOURCE: CalCOFI Rep. 21:180-190.

KEYWORDS: Rockfish, *Sebastes* spp., distribution, recruitment, growth.

ABSTRACT: Variations in the abundance, recruitment and growth of prominent rockfishes (*Sebastes* spp.) during the 1970s are summarized. Twenty-seven species of rockfish were collected. Catches were dominated by the striptail rockfish (*S. saxicola*),

calico rockfish (*S. dalli*), and halfbanded rockfish (*S. semicinctus*). The number of rockfish per individual haul was relatively constant (1.7-3.2), and abundance was highest inshore (80 fish/haul) at 18-73 meters, moderate between 132-305 m, and low beyond 458 m. Three major breaks in depth distribution were observed; the inshore group dominated by *S. saxicola*, an outer shelf assemblage dominated by *S. saxicola* and *S. diploproa*, and a slope assemblage dominated by *S. diploproa*, *S. goodei*, and *S. elongatus*. In general, more species were found in the north and central areas than in the south. A long-term trend of decreasing "baseline" catch is apparent from 1971-1972 off Orange County. Highest catches were observed during or just after the month of lowest sea-surface temperatures. Peak catches occurred during conditions of increased turbidity. In the waters of southern California a diverse assemblage of rockfish exists, with *S. saxicola* and *S. dalli* most important. *S. saxicola* is a more northerly cooler water species than *S. dalli*. There was a disappearance of *S. saxicola* and influx of *S. dalli* in 1975, and the cause may be related to oceanographic conditions.

The larval recruitment problem of the spiny lobster.

AUTHOR(S): Menzies, R. A., and J. M. Kerrigan.

YEAR: 1980.

SOURCE: Fisheries 5(4):42-46.

KEYWORDS: Spiny lobster, *Panulirus* spp., early life history, life history, larvae, reproduction, recruitment.

ABSTRACT: In spiny lobster (*Panulirus* spp.) management, the most difficult parameter to determine is the identification of the management unit due to their long-lived pelagic, planktonic stage. This stage lasts from 6 to 12 months depending on the species. During this portion of the early life history, larvae develop through 10-12 stages, ending with the puerulus marking the onset of benthic existence. The following three years are spent in bays or nearshore nursery grounds, after which the young lobsters move out to the offshore reef tracts. Here they spend the rest of their lives. Counter-currents or gyres may act to retard loss of larvae from their spawning areas, although a large percentage may be lost. The scope of management strategies called for depends upon recruitment patterns. If recruitment is from many "upstream" populations the genetic structure should differ very little, while if influence from distant populations is slight, gene frequencies would reflect response to local conditions and genetic structure from outside the realm of the larvae would be significantly different. Some population centers may be set off as distinct management units due to local hydrographic conditions influencing recruitment.

Food habits of the king salmon, *Oncorhynchus tshawytscha*

(Walbaum) in the vicinity of San Francisco, California.

AUTHOR(S): Merkel, J. J.

YEAR: 1957.

SOURCE: Calif. Fish Game 43(4):249-270.

KEYWORDS: Feeding, food, chinook salmon, *Oncorhynchus tshawytsche*.

ABSTRACT: The food habits of troll-caught king salmon, *Oncorhynchus tshawytscha*, from the San Francisco area is reported for the first time. A total of 1004 stomachs were examined from fish ranging in fork length from 13.50 to 41.00 inches. Composition

and percentage of prey found were northern anchovy, 29.1%; rockfishes, 22.5%; euphausiids, 14.9%; Pacific herring, 12.7%; squid, 9.3%; other fishes, 7.3%; and crab megalops, 4.0%. Marked seasonal changes in food composition were observed, with fishes being dominant except in April and May when invertebrates predominated. No single item of food was of major importance in all the monthly samples. During February and March, April and May, June and July, and August to November, the most common prey type was Pacific herring, euphausiids, rockfishes, and northern anchovies, respectively. Some seasonal changes were due to locality of capture. Specific information for each prey type is reported, including volume, frequency of occurrence, and seasonality. The food habits of salmon of small and large sizes were similar in general.

Seasonal variation in survival of larval northern anchovy, *Engraulis mordax*, estimated from the age distribution of juveniles.

AUTHOR(S): Methot, R. D.

YEAR: 1983.

SOURCE: Fish. Bull. 81(4):741-750.

KEYWORDS: *Engraulis mordax*, northern anchovy, larvae, recruitment, seasonality.

ABSTRACT: This study looked at seasonal changes in survivorship of northern anchovy larvae, *Engraulis mordax*, to determine whether annual variation in recruitment could be caused by short seasonal events. Stability of the upper water column and offshore transport were suggested as factors in northern anchovy recruitment. Daily growth increments in otoliths of juvenile anchovy indicated March and April had the highest frequency of births in 1978 and 1979. Temporal distributions of anchovy larvae indicated the maximum abundance occurred in February to March of each year but the peak was greater in 1978. Larval survival was greater during April to May of 1978 than the same period in 1979. This increase in survivorship was sufficient to cause a large increase in recruitment. The larger 1978 year class was consistent with the hypothesis that transport of larvae influences recruitment.

Estimated pre-season abundance in the California Dungeness crab (*Cancer magister*) fisheries.

AUTHOR(S): Methot, R. D. Jr., and L. W. Botsford.

YEAR: 1982.

SOURCE: Jour. Fish. Aquat. Sci. Canada 39(8):1077-1083.

KEYWORDS: Fishery, market crab, *Cancer magister*, age, population trends.

ABSTRACT: Annual pre-season abundance for the central and northern California Dungeness crab (*Cancer magister*) fisheries is estimated from the decline in catch per unit of effort within each fishing season. Also, the time series of annual exploitation rates in the Dungeness crab fishery is examined. The temporal pattern of annual exploitation rate differs between the two regions. In central California, the annual exploitation rate was 92% per year during 1951-56, but declined to 72% following the collapse of the fishery. In northern California the annual exploitation rate has varied with the 10-year cycle of catch. During the latter portion of each high catch period, the annual exploitation rate has averaged 69% and increased to 84% in the



1st year of low catch. During the remaining low catch years and the first high catch year, it decreased to 54%. The size distribution of male crabs indicate substantial escapement during each of the first few years of each high catch period, and provide evidence that a single year-class may dominate the fishery for several years, but not for the entire 6-year high catch period. The results of this study show that the commonly held view that catch is a high, fairly constant fraction of abundance each year, and therefore a good index of abundance and recruitment, is not longer tenable. Annual exploitation rate is lower and more variable than previously thought and appears to vary in response to abundance.

Growth of northern anchovy, *Engraulis mordax*, larvae in the sea.

AUTHOR(S): Methot, R. D., and D. Kramer.

YEAR: 1979.

SOURCE: Fish. Bull. 77(2):413-423.

KEYWORDS: *Engraulis mordax*, northern anchovy, growth, larvae.

ABSTRACT: Northern anchovy, *Engraulis mordax*, larvae were collected from the Southern California Bight (13.0-16.2 deg C) in 1976-77. The region represents the central range of the spawning stock during March. Daily growth increments of the otoliths were counted and growth rates were calculated. The range of growth rates, from the 12 samples collected, falls within the observed ranges of anchovy larvae grown in the lab between 14.0-17.5 deg C. In 9 samples the growth rate, for 8 mm larvae, ranged from 0.34-0.40 mm/day. In the remaining 3 samples the growth rates ranged from 0.47-0.55 mm/day. There was no significant differences in water temperatures of these samples. In no case did sea-caught larvae grow as slowly as ration limited lab larvae. The data suggests larvae which obtain enough food to survive grow rapidly.

In search of spiny lobster larvae.

AUTHOR(S): Middleton, K. C.

YEAR: 1985.

SOURCE: Sea Frontiers 31(2):86-93.

KEYWORDS: Spiny lobster, *Panulirus* spp., larvae, ichthyoplankton, early life history.

ABSTRACT: The early life history of the spiny lobster, *Panulirus argus*, is reported. Larvae were obtained from ichthyoplankton samples aboard the R/V Westward, and described. Lobster larvae are pelagic and travel 6 to 13 months in the open ocean. Evidence indicates that there may be transoceanic transport. Larval design and behavior is well adapted for a lengthy ocean journey. Daily vertical migrations are also reported, with older larvae leaving the photic zone by day. Puerulus larvae swim into shallow waters before transformation to benthic existence.

Guide to the coastal marine fishes of California.

AUTHOR(S): Miller, D. J. and R. N. Lea.

YEAR: 1972.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 157:249.

KEYWORDS: *Sebastes entomelas*, widow rockfish, *Sebastes goodei*, chilipepper rockfish, *Sebastes miniatus*, vermilion rockfish, *Sebastes paucispinis*, bocaccio, *Paralabrax clathratus*, kelp bass, distribution, habitat.

ABSTRACT: A taxonomic guide to the identification of marine fishes along the California coast is presented with descriptions of species' horizontal ranges, depth ranges, maximum known length and relative occurrence (ie. rare, uncommon, or common).

The status of the rockfish resource and its management.

AUTHOR(S): Miller, D. J., and J. E. Hardwick.

YEAR: 1973.

SOURCE: Calif. Dept. Fish Game, Mar. Res. Tech. Rep. No. 17.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Sebastes goodei*, chilipepper rockfish, *Sebastes miniatus*, vermillion rockfish, *Sebastes entomelas*, widow rockfish, feeding, reproduction, nursery, ichthyoplankton, habitat, economics, fishery, fishing gear, regulations, life history, seasonality.

ABSTRACT: History of commercial and sport utilization of rockfishes (genus *Sebastes*) throughout California are described. Biology of rockfish, current regulations, management policies and suggestions for future research directions are included. Large *Sebastes paucispinis* disappear from traditional fishing grounds during winter and return to the fishery in large numbers in March or April. *S. goodei* are commercially important from Fort Bragg to Santa Barbara. Adults are commonly taken from 240 to 1,100 feet deep water over rocky bottom. Young-of-year are found in shallower inshore waters. *S. miniatus* occur over rocky bottoms to a depth of 600 feet, but younger fish occur in shallow water. Small specimens have been taken at or near the surface as far offshore as 350 miles. Young-of-year *S. paucispinis*, *S. entomelas*, *S. miniatus*, and *S. goodei* have been observed in kelp beds. Prior to 1943, the leading species in commercial landings were *S. melanops* in northern California, *S. paucispinis* and *S. goodei* in central California, and *S. miniatus* in southern California. With the introduction of the balloon trawl, *S. pinniger* replaced *S. melanops* as the leading species landed in northern California. Central California has always led the state in commercial rockfish landings. Population sizes and structure are unknown. There is sufficient evidence to ascertain present total catch, or to determine the most desirable harvesting rate. Rockfish resources are not fully exploited. Research needs include: study of juvenile rockfish habitat requirements, assessment of the effects of kelp harvesting on juvenile rockfishes, mapping inshore reefs, life history studies on many shallow nearshore species, development of an aggregate species population dynamic model, determination of movement of deep dwelling species, and assessment of species and age composition of catches.

Summary of blue rockfish and lingcod life histories: A reef ecology study; and giant kelp, *Macrocystis pyrifera*, experiments in Monterey Bay, California.

AUTHOR(S): Miller, D. J., and J. J. Geibel.

YEAR: 1973.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 158.

KEYWORDS: Fishery, habitat, early life history, *Sebastes entomelas*, widow rockfish, *Paralabrax clathratus*, kelp bass, lingcod, *Ophiodon elongatus*.

ABSTRACT: This paper summarizes the central California sport fishery from 1957 to 1971, addressing primarily the life history of the blue rockfish, *Sebastes mystinus*, and the lingcod, *Ophiodon*

elongatus. Occurrences of young-of-year *S. entomelas* in giant kelp forests in Monterey Bay were noted. *Paralabrax clathratus* constituted the highest number of fish within the bottom portion of the water column at one location in the kelp forest/reef studied. This high abundance is considered unusual and consisted of a non-migratory aggregation localized to that site. Of 43 tagged individuals, one was recaptured one month later at the point of release. Included are life history observations on giant kelp, *Macrocystis pyrifera*, and many other nearshore reef fishes.

Results of the 1972 skindiving assessment survey, Pismo Beach to Oregon.

AUTHOR(S): Miller, D. J., J. J. Geibel, and J. L. Houk.

YEAR: 1974.

SOURCE: Calif. Dept. Fish Game, Mar. Res. Tech. Rep. No. 23.

KEYWORDS: *Sebastes miniatus*, vermillion rockfish, *S. paucispinis*, bocaccio, fishery.

ABSTRACT: A survey of skin/scuba divers was conducted from January to December 1972 in order to estimate the number of participants, amount of effort, and species composition of the catch of the central and northern California sport diving fishery. A total of 15,030 divers were interviewed from Pismo Beach, California north to the Oregon-California border. Results were compared with the 1960 skindiving survey. Over 50% of all diving was conducted in the Monterey-Carmel Bay area. General trends in the mode and activities of skin/scuba divers is described. The sport fish catch included *Sebastes paucispinis* (18) and *S. miniatus* (61). These two species constituted 0.1 and 0.3% of the sport diving fish catch.

Sea urchin pathogen: A possible tool for biological control.

AUTHOR(S): Miller, R. J.

YEAR: 1985.

SOURCE: Mar. Ecol. Prog. Ser. 21:169-174.

KEYWORDS: *Strongylocentrotus* spp., sea urchin, mortality.

ABSTRACT: The purpose of this study was to demonstrate the transferability of a biological pathogen host specific for sea urchins for the laboratory to a field population. Diseased sea urchins were transplanted to a healthy population and healthy sea urchins were transplanted to a diseased population. Disease symptoms developed between 4-8 weeks in the healthy area exposed to diseased urchins. The pathogen is spread faster at 12 deg C than at 10 deg C, below which the pathogen cannot spread. No disease occurred at the central site by 8 weeks. The feasibility of transferring a host specific pathogen to sea urchins to increase macroalgae cover was demonstrated.

Entry of *Cancer productus* to baited traps.

AUTHOR(S): Miller, R. J.

YEAR: 1978.

SOURCE: Jour. Cons. Inst. Explor. Mer. 38(2):220-225.

KEYWORDS: *Cancer productus*, rock crab, fishing gear.

ABSTRACT: Gear saturation, the tendency for fishing power to become reduced as catch in it increases, was studied using 60 *Cancer productus* in an observation tank. Observations of crab behavior at the traps indicate a major problem in trap design with the ease of finding an entrance. The position of the trap entrance

and its relation to the current was also important. The highest catch rate (65%) was achieved with a side entry trap with the entrances set parallel to the current. Evidence of trap saturation was noted in both top and side entry traps. It was presumed that crabs inside the trap intimidated the approaches of crabs which would have otherwise entered.

Widespread mass mortality of the green sea urchin in Nova Scotia, Canada.

AUTHOR(S): Miller, R. J., and A. G. Colodey.

YEAR: 1983.

SOURCE: Mar. Biol. 73:263-267.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., mortality, distribution, habitat, population trends.

ABSTRACT: Mortality estimates of urchins (*Strongylocentrotus droebachiensis*) during widespread mass die-offs in the autumns of 1980 and 1981 were calculated from the biomass density, length of shore of suitable habitat, and average width of suitable habitat. Mortality estimates exceeded 84,000 tons live weight or 2,900 tons organic weight. Laboratory experiments were also performed where healthy urchins were put downstream of sick urchins and downstream of healthy urchins. In both cases the healthy urchins became sick. The results suggest that the cause of the sickness was a water borne biological agent.

The origin and development of the life history patterns of Pacific salmonids.

AUTHOR(S): Miller, R. J., and E. L. Brannon.

YEAR: 1982.

SOURCE: Pages 296-309 in E. L. Brannon and E. O. Salo (eds.), Salmon and trout migratory behavior symposium, June 1981. Univ. Wash., Seattle, WA.

KEYWORDS: Chinook salmon, *Oncorhynchus tshawytscha*, life history, larvae, distribution, population trends.

ABSTRACT: Presented in this paper is a conceptual model of the interactive

life history patterns and their development in the Pacific salmonid ecosystem. The hypothesis presented addresses the early partitioning of the North Pacific salmonid fishes and if this partitioning leads to subsequent unique and separate stocks. A discussion in support of this hypothesis and how it could relate to certain fisheries management as well as an attempt to develop a scenario for the evolution of behavior and life history patterns is presented in detail.

Size and stage of development of larval English sole, *Parophrys vetulus*, at time of entry into Humboldt Bay.

AUTHOR(S): Misitano, D. A.

YEAR: 1976.

SOURCE: Calif. Fish Game 62(1):93-98.

KEYWORDS: *Parophrys vetulus*, English sole, larvae, early life history, migration, distribution, nursery.

ABSTRACT: English sole (*Parophrys vetulus*) was the subject of a study to determine the stage of development and size of the young entering Humboldt Bay, a nursery ground. Young sole as small as 26 mm and as large as 177 mm were captured by trawling. The degree of development was found to vary slightly among individuals. The

young English sole enter the bay at later stages of development (19-26 mm) coinciding with completion of metamorphosis and the start of bottom dwelling habits. More larvae were caught during the night than the day hour; however, it is not known whether this represents net avoidance at day or increased migration at night.

Fishes associated with drifting kelp, *Macrocystis pyrifera*, off the coast of southern California and northern Baja California.

AUTHOR(S): Mitchell, C. T., and J. R. Hunter.

YEAR: 1970.

SOURCE: Calif. Fish Game 56(4):288-297.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Paralabrax clathratus*, kelp bass, nursery, early life history, habitat, distribution, behavior.

ABSTRACT: Assemblages of fishes associated with mats of giant kelp that drift at the surface off southern California and northern Baja California are described. *S. paucispinis* collected from drift kelp ranged in standard length from 32-76 mm (categorized as juveniles) and occurred in collections made from June and January. *P. clathratus* ranged in standard lengths from 31-80 mm (juveniles) and occurred in collections made from September, December, and January. *S. paucispinis* and *P. clathratus* remained within a few centimeters of the algal material at all times. Twenty one species of fish were observed associated with drifting kelp. The authors conclude that the algal structure affords refuge from predation.

Observations on the biology and behavior of the California spiny lobster, *Panulirus interruptus* (Randall).

AUTHOR(S): Mitchell, C. T., C. H. Turner, and A. R. Strachan.

YEAR: 1969.

SOURCE: Calif. Fish Game 55(2):121-131.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, life history, reproduction, growth, migration.

ABSTRACT: Life history aspects including molting and reproductive cycle, growth, and migrations are reported for the California spiny lobster, *Panulirus interruptus*. Morphometrics are also covered to enable the determination of carapace length from lobster tails to establish if individuals were of legal size (3.25 inches CL). Male and female lobsters were observed with old hard shells throughout the year, but over 80% and 90%, respectively, of the population were in this condition from December to July. Males with old soft shells were found from July to October, new soft shells from June to November, and new hard shells from January to October. Females with old and new soft shells were found from August to November while those with new hard shells were found from August to January. Those ready to be plastered, plastered, and berried occurred in January to May, January to August, and May to August, respectively. Median carapace lengths for females were significantly greater than those for males. Carapace lengths of males and females increased an annual increment of 3.7 mm and 4.4 mm, respectively. Legal size is reached in 10 years for females and 11 years for males. Inshore-offshore migrations were observed, with males delaying movement to shallower water by a month compared to females. Data indicate that lobsters molt

once yearly immediately after the reproductive cycle, with males beginning two months earlier than females. Females also grow more rapidly than males. Migrations may be caused by temperature, food availability, suitable habitat, and the degree of subsurface wave action.

Outer continental shelf oil and gas information program.

AUTHOR(S): Molajo, D.

YEAR: 1985.

SOURCE: Pacific Index Report. April 1983 - October 1984, Minerals Management Service Publication.

KEYWORDS: Regulations, platform.

ABSTRACT: The purpose of this Outer Continental Shelf (OCS) Regional Index is to list relevant, actual or proposed programs, plans, reports, environmental impact statements (EIS), and other lease sale information. The information covered in this index includes the leasing process and leasing schedule beginning July 1982, lease sales starting in November 1983, steps in the prelease and post lease phases, and ongoing programs that support the OCS leasing process.

Responses of two *Haliotis* gastropods (Mollusca), *Haliotis assimilis* and *Haliotis rufescens*, to the forcipulate asteroids (Echino dermata), *Pycnopodia helianthoides* and *Pisaster ochraceus*.

AUTHOR(S): Montgomery, D. H.

YEAR: 1967.

SOURCE: *Veliger* 9:359-368.

KEYWORDS: Abalone, *Haliotis* spp., behavior.

ABSTRACT: The responses of the abalones, *Haliotis assimilis* and *H. rufescens*, to the asteroids, *Pisaster ochraceus* and *Pycnopodia helianthoides*, was elicited by contact with the tube feet or by exposure to seawater soluble substances released by the stars. The responses for *H. assimilis* and *H. rufescens* were quite similar and included tentacular activity, flight, violent whirling of the shell, and emission of a mucous through the respiratory pores. Responses were more pronounced through physical contact; the mucous secretions were also found to elicit responses. *Pycnopodia* had a greater effect than *Pisaster* on the abalone. *H. rufescens* was found to fatigue after several stimulations, whereas the more sensitive *H. assimilis* did not show fatigue after the same number of stimulations.

Photographic survey of benthic fish and invertebrate communities in Santa Monica Bay.

AUTHOR(S): Moore, M. D., and A. J. Mearns.

YEAR: 1980.

SOURCE: Pages 139-147 in W. Bascom (ed.), Coastal Water Research Project, biennial report for the years 1979-1980, So. Calif. Coastal Wat. Res. Proj., Long Beach, CA.

KEYWORDS: *Cancer* spp., crabs, *Sebastes* spp., rockfish, *Strongylocentrotus* spp., sea urchin, *Anoplopoma fimbria*, sablefish, *Engraulis mordax*, northern anchovy, *Paralabrax clathratus*, kelp bass, *Merluccius productus*, Pacific hake, *Microstomus pacificus*, Dover sole, *Parophrys vetulus*, English sole, distribution, habitat, behavior, community.

ABSTRACT: This paper presents the results of a baited camera survey conducted

during 1978 and 1979 at 61 stations throughout Santa Monica Bay. The objectives of this study were to: 1) use underwater photography to describe the macrofauna; 2) compare the photographic data-to-data collected by trawl and hook and line fishing; and 3) determine the abundance and diversity of hard to sample marine organisms. A map of the site locations is provided as well as tables listing species photographed, comparisons between hard bottom and soft bottom communities and comparisons between sampling methods.

The importance of *Loligo opalescens* in the food web of marine vertebrates in Monterey Bay, California.

AUTHOR(S): Morejohn, G. V., J. T. Harvey, and L. T. Krasnow.

YEAR: 1978.

SOURCE: Calif. Dept. Fish Game, Fish Bull. (169):67-98.

KEYWORDS: *Sebastes goodei*, chilipepper rockfish, *Sebastes paucispinis*, bocaccio, feeding, community, *Loligo opalescens*.

ABSTRACT: Diets of selected species including 19 rockfish species, elasmobranchs, teleosts, birds and mammals were analyzed with specific interest in determining the importance of the market squid (*Loligo opalescens*) to the diet of those species and identifying the various sources of mortality to *L. opalescens*. *Sebastes goodei* were collected from northern Monterey Bay and exhibited an extremely low prey diversity. Parts of other *Sebastes* spp. ranked highest in their diet, followed by parts of other fishes, then squid, and finally euphausiids. *Sebastes* species were found to be important constituents of the diets of king salmon, Petrale sole, Pacific halibut, common murre, elephant seal, harbor seal, California sea lion, Pacific striped dolphin and harbor porpoise.

Stock and recruitment relationships in *Panulirus cygnus*, the commercial rock (spiny) lobster of western Australia.

AUTHOR(S): Morgan, G. R., B. F. Phillips, and L. M. Joll.

YEAR: 1982.

SOURCE: Fish. Bull. 80(3):475-486.

KEYWORDS: Spiny lobster, *Panulirus* spp., recruitment.

ABSTRACT: The interrelationships between the abundances of various stages in the life history, puerulus settlement, and juvenile density for the western Australia rock lobster (*Panulirus cygnus*) are reported. The western rock lobster is considered a single unit stock. Spawning stocks were concentrated in the 20-30 fathom depth range with 86.4 to 92.1% of females taken there. Index of spawning success is reflected in the number of first stage phyllosoma larvae released which is estimated as the total number of spawning females times their average fecundity. Estimates ranged from 37 to 205x10<sup>7</sup> for all coastal areas. The index of annual settlement ranged from 9.7 to 126.3 puerulus per collector. The stock-recruitment relationship of  $R=AS(-BS)$  with  $R$ =recruitment,  $S$ =stock size,  $A$ =coefficient of density-dependent survival, and  $B$ =coefficient of density-independent mortality best estimates the spawning stock and puerulus settlement relationship, with  $A$  and  $B$  equaling 7.645 and 0.026, respectively. Puerulus settlement is a good indicator of subsequent juvenile density, however, beyond 2 years of age density-dependent mortality is evident. The stock-recruitment

curve also describes the relationship between settlement and catch rate of "whites", with  $A=0.48$  and  $B=0.012$ . Spawning stock is comprised of year classes from puerulus settlement six years earlier, with the breeding stock dominated by younger year classes. At an instantaneous mortality rate of 1.54, 21% and 5% of females will survive to a second and third spawning, respectively. The relative index of the spawning stock is related to puerulus settlement six years earlier and can be shown by the stock-recruitment model also with  $A=21.17$  and  $B=0.013$ . During the planktonic larval stage of the rock lobster there is a strong stock-dependent effect. Once settlement occurs, a more density-dependent relationship occurs.

Oil-induced mortalities in juvenile coho salmon and sockeye salmon.

AUTHOR(S): Morrow, J. E.

YEAR: 1973.

SOURCE: Jour. Mar. Res. 31(3):135-143.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, mortality, contaminant susceptibility.

ABSTRACT: In an attempt to better understand the effects of oil pollution on the salmon fishery, laboratory experiments were done exposing juvenile coho and sockeye salmon to varying concentrations of oil at different temperatures. The results from the experiments indicate that mortality is directly related to oil concentration and perhaps inversely related to temperature. Mortality apparently is caused by some component of crude oil that is soluble in water, and is also volatile and/or easily oxidized.

The freshwater fishes of Alaska.

AUTHOR(S): Morrow, J. E.

YEAR: 1980.

SOURCE: Alaska Northw. Publ. Co., Anchorage, AK. 248 p.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, Chinook salmon, *O. tshawytscha*,

distribution, life history, early life history, spawning, reproduction, migration, habitat, physiology, age, growth, fishery.

ABSTRACT: This text provides a detailed key of species characteristics to enable identification of the freshwater fishes of Alaska. Following the key are individual characterizations for each fish which include its physiology, biology, range and abundance, habits and importance to man.

Effects of some components of crude oil on young coho salmon.

AUTHOR(S): Morrow, J. E., R. L. Gritz and M. P. Kirton.

YEAR: 1975.

SOURCE: Copeia 1975:326-331.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, contaminant susceptibility, mortality.

ABSTRACT: The purpose of this study was to determine the effects of various components of crude oils on young coho salmon (*Oncorhynchus kisutch*). Experiments were carried out in artificial sea water at about 30% salinity and 8 deg. C. which simulated natural conditions at Price William Sound. Oxygen saturation ranged between 7-10.5 ppm while pH was a constant 8.1. Salinity varied randomly due to evaporation. Average weight of the fish ranged from about 5 g each in the fall to nearly 40 g



each in May. Blood analyses were made every hour for up to 3 hours and, when possible, at 4 and 24 hours after exposure to test substances. No significant mortalities were observed with exposure to aliphatic compounds. Significant mortalities were observed with the aromatic hydrocarbons. The toxicity of the aromatic hydrocarbons tested appears to increase in the following order: cyclohexane, cyclohexene, 1,3 cyclohexadiene, toluene, xylene, benzene, and ethylbenzene. These compounds probably act by increasing cell membrane permeability of the gills, resulting in ionic imbalance and internal carbon dioxide poisoning. Noticeable behavioral alterations in response to these toxic components was also discussed.

Hydrogen peroxide induces spawning in mollusks, with activation of prostaglandin endoperoxide synthetase.

AUTHOR(S): Morse, D. E., H. Duncan, N. Hooker, and A. Morse.  
YEAR: 1977.

SOURCE: Science 196:298-300.

KEYWORDS: Abalone, *Haliotis* spp., reproduction, spawning.

ABSTRACT: Gravid male and female abalone can be caused to spawn with the addition of hydrogen peroxide. This result may be caused by a direct activation of the enzyme-catalyzed synthesis of prostaglandin endoperoxide. The induction of spawning can be blocked by aspirin added to the seawater 15 minutes before the hydrogen peroxide. The use of hydrogen peroxide or similar inexpensive and easily controlled chemical methods may offer unique advantages for synchronous control of reproduction in large numbers of animals, for both cultivation and genetic-breeding purposes.

[Gamma] - Aminobutyric acid, a neurotransmitter, induces planktonic abalone larvae to settle and begin metamorphosis.

AUTHOR(S): Morse, D. E., N. Hooker, H. Duncan, L. Jensen.  
YEAR: 1979.

SOURCE: Science 204:298-300.

KEYWORDS: Abalone, *Haliotis* spp., reproduction, spawning, habitat, nursery, larvae, recruitment, colonization, behavior.

ABSTRACT: Previous experiments have shown that larvae of abalone (*Haliotis rufescens*) show preferential settlement (substrate-specific recruitment) on crustose red algae. In this study cultured abalone larvae were exposed to potential inducers of settling. The results showed that [Gamma] - aminobutyric acid (GABA), a neurotransmitter in higher animals, and certain of its analog (all found in active algae) are potent inducers of rapid settling. In the experiment 100% of the larvae were induced to settle after the addition of 1 mM GABA. The abalone-settlement inducer system described in this study provides a convenient experimental model for further analysis of the basic molecular mechanisms by which environmental and endogenous factors control the recruitment and development of planktonic larvae.

Reproduction and development of *Sebastes paucispinis* and comparison with other rockfishes off southern California.

AUTHOR(S): Moser, H. G.  
YEAR: 1967.

SOURCE: Copeia (4):773-797.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Sebastes goodei*, chilipepper

rockfish, *Sebastes miniatus*, vermillion rockfish, reproduction, early life history, spawning, distribution, nursery, ichthyoplankton, larvae.

ABSTRACT: Male and female reproductive systems of *S. paucispinis* are described. Monthly collections of individuals in 1964 from Newport Bay, California were used to illustrate seasonal changes in testes and ovaries. The first complete series of life history stages for any rockfish species is described as well as horizontal larval distribution and vertical juvenile and adult depth distributions. Seasonal patterns of gestation are described for *S. paucispinis*, *S. goodei*, and *S. miniatus*. *Sebastes* (species combined) larvae are most abundant in CalCOFI plankton tows taken during the winter and spring (December-April). The horizontal distribution of *S. paucispinis* larvae are described for CalCOFI collections from 1953 and 1956. Spawning in *S. paucispinis* as indicated by male and female gonadal indices occurs from October to February. Transforming individuals and juveniles inhabit shallow coastal waters over rocky bottom in association with laminarian algae and over sand bottoms associated with eelgrass (*Zostera*). Juveniles inhabit waters shallower than 20 m during their first year. Pigment patterns of juveniles are described.

Ontogeny and systematics of fishes.

AUTHOR(S): Moser, H. G. (chief ed.).

YEAR: 1984.

SOURCE: Am. Soc. Ichthyol. Herpotol., Special Publ. 1. Allen Press, Lawrence,

KS. 760 p.

KEYWORDS: Early life history, physiology, all species, larvae.

ABSTRACT: This book represents the edited papers presented at an international

symposium entitled Ontogeny and Systematics of Fishes held at La Jolla, California and dedicated to the memory of Elbert H. Ahlstrom. The intent of this volume is to present the current state of knowledge of early life history of fishes and apply that to systematics. Both marine and freshwater fishes are included. Most papers are accompanied by detailed illustrations of various larvae stages.

Sandknop, B. Y. Sumida, and E. G. Stevens.

Description of early stages of white seabass, *Atractoscion nobilis*, with notes on distribution.

AUTHOR(S): Moser, H. G., D. A. Ambrose, M. S. Busby, J. L. Butler, E. M.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:182-193.

KEYWORDS: Early life history, larvae, distribution, feeding, spawning, white seabass, *Atractoscion nobilis*.

ABSTRACT: The early life history and seasonal distribution of larvae are given for the white seabass, *Atractoscion nobilis*. The eggs of *A. nobilis* are larger (1.24 - 1.32 mm diameter) and contain a larger oil globule (0.30 - 0.36 mm diameter) than those of the six other sciaenid species off California. Larvae hatch at a larger size (ca. 2.8 mm) and are larger at yolk depletion (3.7 mm) than in the other species. First feeding larvae are distinguished by a melanistic sheath that covers the head and trunk to slightly posterior of the anus. Beyond initial feeding stages *A. nobilis*

larvae become deep-bodied, and develop a large broad head and a solid pigment cloak that gradually covers the entire body. After notochord flexion the paired fins become enlarged and heavily pigmented and a characteristic banding pattern develops on the body. Measurements, morphometry and specimen drawings of larvae and early juveniles are included. Meristics are noted for larvae only. The early life stages are compared with related genera. Distributional data were obtained from CalCOFI tows made during 1950-78. *A. nobilis* larvae were collected from January - October, but 92% of the occurrences and 95% of the individuals were collected from May - August with a peak in July, where 55% of the occurrences and 60% of the individuals were collected. Larvae occurred from Santa Rosa Island, California to Santa Maria Bay, Baja California, with highest concentrations found in the inshore regions of Sebastian Viscaïno Bay and San Juanico Bay, Baja California. The size frequency distribution of the larvae collected was narrow, with a mean length of 3.4 mm and a range of 1.6 - 7.2 mm. Latitudinal trends in spawning season could not be determined with the limited length frequency data.

Guide to the identification of scorpionfish larvae (Family Scorpaenidae) in the eastern Pacific with comparative notes on species of *Sebastes* and *Helicolenus* from other oceans.

AUTHOR(S): Moser, H. G., E. H. Ahlstrom, and E. M. Sandknop.

YEAR: 1977.

SOURCE: NOAA Tech. Rep. NMFS. Circ. 402:71.

KEYWORDS: Early life history, life history, larvae, physiology, *Sebastes* spp.

ABSTRACT: Information and illustrations (including keys) for the identification of the larvae of eastern Pacific scorpaenids to genus are presented. Descriptions and illustrations of the larval stages of species for which larvae are known is presented. *Sebastes* larvae of Atlantic and Pacific species are compared. Other representatives covered include *Helicolenus*, *Sebastolobus*, *Scorpaenodes*, *Scorpaena*, *Pontinus*, and *Ectreposebastes*. A summary of characters with emphasis on those important in identifying genera is given. The most salient characteristic is the head spination. Meristic characters are essential and the most fundamental is the number of myomeres. Characters of the fins are indispensable in identifying scorpaenid larvae. Also important is the change in body shape, sizes at initiation of major developmental events, and locality of collection. Two keys are constructed for genera identification, one for prenotochord flexion larvae and one for those which have completed notochord flexion. In the guide 19 life history series are presented. For each genus a summary of literature and a description of distinguishing features is included. Species descriptions include a literature summary, distinguishing features, and a description on distribution.

Enhancement of the marine environment for fisheries and aquaculture in Japan.

AUTHOR(S): Mottet, M. G.

YEAR: 1981.

SOURCE: Washington Dept. Fisheries, Tech. Rep. 69.

KEYWORDS: Artificial reef, fishery, habitat, nursery, economics.

ABSTRACT: A review of the techniques used in Japan to enhance the

marine environment is described. Providing a suitable substrate or controlling water movement are solutions to common fishery or mariculture production problems. The marine environment can also be enhanced by improving water quality through pollution abatement projects and by increasing water circulation. With these enhancement factors in mind, this report covers the general topics of: productivity enhancement (substrate and soft-sediment structures, and mariculture), fish attracting systems (fish behavior, fish attractors, and building fishing grounds), and water quality changes.

Inland fishes of California.

AUTHOR(S): Moyle, P. B.

YEAR: 1976.

SOURCE: Univ. Calif. Press, Berkeley, CA. 405 p.

KEYWORDS: Chinook salmon, *Oncorhynchus tshawytscha*, Coho salmon, *Oncorhynchus*

*kisutch*, distribution, life history, early life history, spawning, reproduction, migration, habitat, physiology, feeding, age, growth, fishery.

ABSTRACT: This text provides information on the natural history identification

and management of California's inland fishes. An overview of the distribution, zoogeography, ecology and status of the inland fish fauna is presented as an introduction to individual characterizations which include detailed descriptions and illustrations to aid identification.

Fishes: An introduction to ichthyology.

AUTHOR(S): Moyle, P. B., and J. J. Cech, Jr.

YEAR: 1982.

SOURCE: Prentice-Hall, Inc., Englewood Cliffs, NJ. 593 p.

KEYWORDS: All species, physiology, feeding, growth, reproduction, behavior,

distribution, mortality, habitat, albacore, *Thunnus alalunga*.

ABSTRACT: This book was designed to be used as a text in classes in fish biology, in conjunction with a laboratory manual of fish anatomy, key to fishes, and various other readings. The purpose of the text is to provide a basic background in the ecology, physiology, evolution and behavior of fishes as well as summarize the recent developments in ichthyology.

Collins guide to the sea fishes of Britain and North-western Europe.

AUTHOR(S): Muus, B. J., and P. Dahlstrom.

YEAR: 1974.

SOURCE: Collins, London, 244 p.

KEYWORDS: All species, life history, early life history, feeding, reproduction, behavior, migration, distribution, economics, fishing gear, fishery, albacore, *Thunnus alalunga*, swordfish, *Xiphias gladius*.

ABSTRACT: The purpose of this text is to provide the reader with an easy to

use means for identifying approximately 173 species of fishes and invertebrates found off the coast of north-west Europe. The identification key lists two to four characteristics for each species in the text. The main section concisely describes and illustrates in color each species noting special characteristics, size, way of

life and distribution. An illustrated survey of the history of sea fishing from ancient times to present day is described as well as a general overview of the fishing industry.

Identification and description of assemblages of some commercially important rockfishes (*Sebastes* spp.) off British Columbia.

AUTHOR(S): Nagtegaal, D. A.

YEAR: 1983.

SOURCE: Can. Tech. Rep. Fish. Aquat. Sci. 1183.

KEYWORDS: *Sebastes entomelas*, widow rockfish, *S. paucispinis*, bocaccio seasonality, distribution, habitat.

ABSTRACT: Rockfish species assemblages abundances of species, and the temporal dynamics of patterns of abundance are described.

Identification of assemblages was accomplished by graphical examination of commercial catch statistics collected during 1977-1978 from British Columbia. Analysis of covariance was used to determine the persistence of assemblages over time. It is stressed that assemblages determined from relative abundance data derived from commercial catches may or may not infer actual biological associations. *Sebastes entomelas* was one of four rockfishes that constitute a "shelf community". *S. entomelas* was included in catches ranging from 72 to 327 m and was most abundant in the 109-144 m range. Catch statistics are also given for *S. paucispinis*. *S. paucispinis* was taken from depths ranging from 36 to 291 m and was most abundant in the 145-181 m range. Monthly trends in catch-per-unit-effort of *S. entomelas* illustrate highly seasonal catches with peak catch during May and September. Catches of *S. entomelas* co-occurred with catches of *S. flavidus*, the yellowtail rockfish.

FAO species catalogue. Vol. 5. Billfishes of the worldAUTHOR(S): Nakamura, I.

YEAR: 1985.

SOURCE: FAO Fish, Synopsis 125, Food Agr. Org., U. N., Rome, IT. 65 p.

KEYWORDS: Swordfish, *Xiphias gladius*, fishery, distribution, habitat, spawning, feeding, migration, reproduction, behavior, length/weight.

ABSTRACT: This volume, the fifth in the FAO series of major groups of organisms that enter the marine fisheries, is a worldwide annotated and illustrated catalogue of the 2 families and all 12 species of billfishes known thus far. Characterizations of each species include drawings, scientific and common names, information on habitats, biology, fisheries and distribution maps. A table indicating the distribution of each species by major fishing area and a glossary of technical terms and measurements are provided.

Fisheries of the United States 1984, current fishery statistics No. 8360.

AUTHOR(S): National Fishery Statistics Program.

YEAR: 1985.

SOURCE: Natl. Mar. Fish. Ser., NOAA, Washington, D. C. 121 pp.

KEYWORDS: All species, fishery, economics, fishing gear, distribution.

ABSTRACT: A summary of information on the fisheries of the United States and foreign catches in the U. S. Fishery Conservation Zone (FCZ) for 1984. The information for this report came from many sources such as various National Marine Fisheries Service Field offices,

U. S. Bureau of the census, and Food and Agriculture Organization (FAO) of the United Nations. Topics covered in this book include statistics on U. S. commercial fishery landings, U. S. marine recreational fisheries, world fisheries, U. S. production of processed fishery products, U.S. imports and exports, prices, and U. S. per capita use of commercial fish and shellfish.

Marine recreational fishery statistics survey, Pacific Coast, 1981-1982, current fishery statistics No. 8323.

AUTHOR(S): National Fishery Statistics Program.

YEAR: 1984.

SOURCE: Natl. Mar. Fish. Ser., NOAA, Washington, DC. 203 p.

KEYWORDS: Fishery, all species, distribution, length.

ABSTRACT: The Recreational Fishery Statistics survey is a report listing the

compiled data used for estimating the impact of marine recreational fishing on marine resources. A survey method was employed to acquire trip and catch data for 1981-1982. Survey methodology and procedures are described as well as sampling variances and the precision of the estimates. A brief summary of the survey findings is also included.

Marine recreational fishery statistics survey, Pacific Coast, 1983-1984, current fishery statistics No. 8325.

AUTHOR(S): National Fishery Statistics Program.

YEAR: 1985.

SOURCE: Natl. Mar. Fish. Ser., NOAA, Washington, DC. 189 p.

KEYWORDS: Fishery, all species, distribution, length.

ABSTRACT: The Recreational Fishery Statistics Survey is a report listing the

compiled data used for estimating the impact of marine recreational fishing on marine resources. A survey method was employed to acquire trip and catch data for 1983-1984. Survey methodology and procedures are described as well as sampling variances and the precision of the estimates. A brief summary of the survey findings is also included.

Disposal of offshore platforms.

AUTHOR(S): National Research Council (NRC).

YEAR: 1985.

SOURCE: National Academy Press, Washington, D. C. 86 p.

KEYWORDS: Platform.

ABSTRACT: The purpose of this report was to present information on the evaluation of alternative dispositions for offshore oil and gas platforms after petroleum production has ceased. The Department of Interior requested this information from the National Research Council which subsequently appointed the Committee on Disposition of Offshore Platforms. The Committee was to document and assess alternatives for removing, disposing, or reusing fixed platforms, and make recommendations concerning government policy on their disposition. This report contains a comprehensive synthesis of the Committee's findings regarding cost of removal, legal, environmental and safety issues as well as their conclusions and recommendations.

Diel foraging patterns of the sea urchin, *Centrostephanus coronatus*, as a predator avoidance strategy.

AUTHOR(S): Nelson, B. V., and R. R. Vance.

YEAR: 1979.

SOURCE: Mar. Biol. 51:251-258.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., feeding, behavior.  
ABSTRACT: Individual urchins, *Centrostephanus coronatus*, were monitored at three sites off Santa Catalina Island, southern California to determine their feeding behavior and site specificity. The urchins were found to leave their crevices after sunset and return in the morning. They fed on attached organisms within 1 m of the crevice. The sheephead, *Pimelometopon pulchrum*, was active during the day and fed on exposed urchins. Urchins in their crevices were not taken. The nocturnal foraging (which often began within 15 minutes of sheephead inactivity) pattern of the urchins may have evolved in response to predation pressure. In addition, site fidelity might be necessary to ensure refuge from predation in areas of limited habitat.

Fishes of the world.

AUTHOR(S): Nelson, J. S.

YEAR: 1984.

SOURCE: 2nd edition.

KEYWORDS: John Wiley & Sons, New York, NY. 523 p.

ABSTRACT: The purpose of this text is to provide a modern introductory systematic treatment of all major fish groups that can be used as a guide and reference to fish classification. Families, genera, enlarged family descriptions, biological and systematic information and fish figures are all included for use in courses in ichthyology or fish biology. Detailed descriptions and illustrations of fish morphology are also provided.

Distribution and biology of Pacific hake: A synopsis.

AUTHOR(S): Nelson, M. D., and H. A. Larkins.

YEAR: 1970.

SOURCE: U. S. Fish Wildl. Serv. Cir. 332:23-34.

KEYWORDS: Pacific Hake, *Merluccius productus*, distribution, migration, larvae.

ABSTRACT: The Pacific Hake, *Merluccius productus* is a resident of the upper continental slope and shelf and ranges from Alaska to Baja California. Adult hake migrate south in the late fall to spawn in the offshore waters of southern California from December to April. They return north to feed off the coast of Oregon, Washington and British Columbia during the late spring to fall. The hake undergo extensive diel vertical migrations. They feed on several fish and vertebrate species with emphasis on this preferred food. Hake grow rapidly to age 6 and are reproductively mature at 4 years; however, mortality reaches 43% at 5 years. The larvae occur around the thermocline and little is known about the abundance and distribution of juvenile (1-3 year old) hake.

The distribution of the larvae of swordfish, *Xiphias gladius*, in the Indian and Pacific oceans.

AUTHOR(S): Nishikawa, Y., and S. Ueyanagi.

YEAR: 1974.

SOURCE: Nishikawa, Y. and S. Ueyanagi 1974. The distribution of the larvae

of swordfish, *Xiphias gladius*, in the Indian and Pacific Oceans. Pages 261-264 in R. S. Shomura and R. Williams (eds.), Proceedings of the Int. Billfish Symp., Kailua-Kona, HA. 9-12 Aug. 1972. Part 2. Review and contributed papers. NOAA Tech. Rep. NMFS SSRF-675.

KEYWORDS: Distribution, larvae, reproduction, spawning, *Xiphias gladius*,

swordfish.

ABSTRACT: This paper studied the distribution of the larvae of swordfish, *Xiphias gladius*, in the Indian and Pacific ocean on the basis of 325 specimens collected by Japanese research vessels, and drew some conclusions on their reproduction. The larvae measured from 3 to 160 mm in length. Most of the larvae taken were at the surface, where the greater concentration was found both during the day and at night. The distribution appears to be continuous across the tropical and subtropical waters of the Indian and Pacific oceans. In the western Pacific the larvae are more broadly distributed north to south than in the eastern Pacific. The distribution of the larvae seem to be temperature dependent, with the lower limit being the 24 deg C surface isotherm. Newly hatched larvae (< 10 mm) were taken throughout the year in both tropical and subtropical waters indicating that spawning takes place year round.

Coho salmon (*Oncorhynchus kisutch*) and herring gulls (*Larus argentatus*) as indicators of organochlorine contamination in Lake Ontario.

AUTHOR(S): Norstrom, R. J., D. J. Hallett, and R. A. Sonstegard.

YEAR: 1978.

SOURCE: Jour. Fish., Res., Bd., Canada 35:1401-1409.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, contaminant levels, feeding.

ABSTRACT: Coho salmon and herring gulls were tested as indicator species to assess contamination by organochlorines in Lake Ontario. The objective of this study was to determine the bioaccumulation of organochlorines from alewives and smelts to herring gull eggs and coho salmon. Herring gulls and coho salmon commonly prey on alewives and smelts. Since all of these species range widely in the lake, they provide an integrated measure of levels of organochlorine contaminants in the lakes. This relatively simple food web is ideally suited for a description of lake-wide contamination. Accumulation of PCB's, DDE, mirex, and photomirex in coho salmon and herring gull eggs were  $1.5 \times 10^6$  and  $2.5 \times 10^7$ , assuming an apparent bioconcentration factor of  $5 \times 10^5$  for the corresponding values.

Feeding and general nutrition of sea urchins.

AUTHOR(S): North, W. J.

YEAR: 1964.

SOURCE: Unpubl. ms 22 pp.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., feeding.

ABSTRACT: The feeding mechanisms, diet and nutritive requirements of sea urchins, Echinoidea, were reviewed. Urchins have been found to subsist on plant and animal material. The common southern California species *Strongylocentrotus purpuratus*, *S. franciscanus* and *Lytechinus anamesus* were primarily herbivores, however they often resorted to scavenging and even cannibalism. Algae were caught by tube feet and carried to the Aristotle's lantern (masticating apparatus). Algal films were often grazed by the lantern at maximum extension. Season and temperature has been found to affect feeding rates (maximum rates were observed from May to October at 60 deg F). Food preference was noted in a number of species and usually corresponded to species within the urchin's distribution. Digestion and absorption occurred within the



esophagus and foregut and food may take up to seven days to pass through the gut.

Utilization of kelp-bed resources in southern California.

AUTHOR(S): North, W. J., and C. L. Hubbs.

YEAR: 1968.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 139, 264 pp.

KEYWORDS: All species, feeding, fishery, length/weight, distribution, habitat, reproduction, behavior.

ABSTRACT: The main emphasis of this bulletin is to assess the effects that kelp harvesting may have on kelp plants and the fishes in the kelp beds, as well as an evaluation of the potential and present methods used for improving and expanding our kelp resources. The various chapters of the book address the following topics related to kelp beds: life history of *Macrocystis*, large-scale cultivation of *Macrocystis*, physical aspects as related to kelp bed fishes, fish fauna of the rocky inshore, population estimates and standing crop of fishes, food and biology of the kelp bass, food of kelp-bed fish, the relation between kelp harvesting and sport fishing in kelp-beds, harvesting yields of kelp beds, harvesting effects on canopy invertebrates and kelp plants, and the effects of canopy cutting on kelp growth.

Swimming energies of the larval anchovy.

AUTHOR(S): Nymen, W. J. II.

YEAR: 1974.

SOURCE: Fish. Bull. 72(4):885-899.

KEYWORDS: Northern anchovy, *Engraulis mordax*, physiology, larvae.

ABSTRACT: The energy expenditure of swimming larval anchovy, *Engraulis mordax* was determined by modified theoretical models of sperm propulsions. 16 mm motion picture photographs were reviewed and the sinusoidal body movements were enumerated by 2-dimensional 16 point quadratures. Larvae, of an average 1.4 cm size, utilized 144.8 ergs/swimming excursion ( $4.91 \times 10^{-3}$  cal/w). These results were similar to calculated oxygen consumption measurements ( $2-19 \times 10^{-2}$  cal/w). The results of this study suggested high efficiency of large amplitude intermittent swimming behavior in the larval anchovy.

Histological criteria for diagnosing starving condition in early post yolk-sac larvae of northern anchovy, *Engraulis mordax* Girard.

AUTHOR(S): O'Connell, C. P.

YEAR: 1976.

SOURCE: Jour. Exp. Mar. Biol. Ecol. 25(3):285-312.

KEYWORDS: Northern anchovy, *Engraulis mordax*, feeding, physiology.

ABSTRACT: Starvation in post yolk sac larval anchovy, *Engraulis mordax*, was determined by grading 11 histological features. The characteristics considered included the notochord, cartilage, muscle, gastrointestinal system, liver and pancreas. These were graded according to texture, shape, fullness of nuclei, cytoplasm, intra and extracellular products and storage materials. Larvae were reared with and without food to 9 days old (post the yolk absorption point). The degree of emaciation was directly related to the amount of food deprivation and was reflected in survival rates and total length. The best

histological indicators included pancreas conditions, liver cytoplasm, trunk muscle fiber separation and intermuscular tissue condition.

Percentage of starving northern anchovy, *Engraulis mordax*, larvae in the sea as estimated by histological methods.

AUTHOR(S): O'Connell, C. P.

YEAR: 1980.

SOURCE: Fish. Bull. 78(2):475-489.

KEYWORDS: Northern anchovy, *Engraulis mordax*, feeding, early life history.

ABSTRACT: An estimation of the proportion of starving northern anchovy, *Engraulis mordax*, larvae is presented based on histological methods, in order to evaluate its use as an ultimate yearclass strength indicator. Anomalies were shown in trunk musculature, notochord, pancreas, and the foregut and midgut in specimens ranging from 2.5 to 10 mm; a condition arising from starvation. Emaciated larvae were all less than 10 mm SL. Collections indicated "patches" of starving larvae, were mostly from nearshore tows, especially off Newport Beach. Within tows with a high incidence of emaciation, 60% were in this condition, while the mean for the entire study was 8% emaciation. Plankton volume was lower in tows which showed starvation, although they were not always the lowest. In areas of high emaciation, plankton abundance was low; a condition which may be caused by water mass movement or instability. In areas of good conditions, some instances of starvation will occur by accident, detrimental combinations of genetic constitution, or chance failure of food capture. Net daily mortality of anchovy larvae due to starvation (8%) accounts for 40% of the total average daily larval mortality. A stereomicroscope scan of larval catches should suffice to identify and enumerate patches of starving larvae, using histology for verification.

The interrelation of biting and filtering in the feeding activity of the northern anchovy (*Engraulis mordax*).

AUTHOR(S): O'Connell, C. P.

YEAR: 1972.

SOURCE: Jour. Fish. Res. Bd. Canada 29(3):285-293.

KEYWORDS: Northern anchovy, *Engraulis mordax*, feeding, behavior.

ABSTRACT: Laboratory studies were done to determine the effect of *Artemia* adult and nauplii densities on the proportion of biting to filtering activity, and the contributions of biting and filtering to ingestion rate. Plankton pump samples from the sea surface were also taken to determine the interrelation between biting and filtering in the sea. The results showed that the biting to filtering ratio varies with the relative concentration of *Artemia* adults and nauplii in the water. It is also estimated that when feeding activity is half biting and half filtering, *Artemia* adults and nauplii would contribute equal dry weights to ingestion. In the sea, biting activity could often exceed 50% of total feeding activity as indicated by relatively high ratios of large-to-small crustaceans near the surface at night.

The life history of the cabezon, *Scorpaenichthys marmoratus* (Ayres).

AUTHOR(S): O'Connell, C. P.

YEAR: 1953.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 93.

KEYWORDS: Abalone, *Haliotis* spp., mortality, habitat.

ABSTRACT: An overview of the current information on the life history of the cabezon. Topics covered include food and feeding, range and habitat, and reproduction. An analysis of the important prey in the juvenile, preadult and adult stages indicate that crustaceans were the most important prey in all three stages. The other important groups of prey were found to be fish in the cabezon's juvenile stage and mollusca in the preadult and adult stages. It appears that the younger fish have not yet attained the strength necessary to dislodge even the smallest of the tenacious gastropods. The molluscan food identified consisted almost entirely of abalone, limpets, and chitons.

Histochemical indications of liver glycogen in samples of emaciated and robust larvae of the northern anchovy, *Engraulis mordax*.

AUTHOR(S): O'Connell, C. P., and P. A. Paloma.

YEAR: 1981.

SOURCE: Fish. Bull. 79(4):806-812.

KEYWORDS: *Engraulis mordax*, northern anchovy, larvae, feeding.

ABSTRACT: This study assessed whether a histochemical test for glycogen in the liver would indicate the occurrence of starvation among northern anchovy larvae, *Engraulis mordax*. Laboratory results indicated a high PAS glycogen rating for the "fed" category and low glycogen ratings for the "starved" category. The data was consistent over the entire larval length range involved, 3 to 15 mm SL. The glycogen concentration was lower for larvae from samples classified as emaciated than for larvae from samples classified as robust. However, the difference was not as strong as it was for larvae that were fed or starved in the laboratory. Starvation therefore seems to be directly related to glycogen level in the liver and is consistent with low glycogen levels found in emaciated larvae from the sea, where food availability was low. Glycogen levels increased significantly in larvae when food availability was high.

Respiratory metabolism and swimming performance of the squid, *Loligo opalescens*.

AUTHOR(S): O'Dor, R. K.

YEAR: 1982.

SOURCE: Jour. Fish. Aquat. Sci. Canada 39:580-587.

KEYWORDS: Market squid, *Loligo opalescens*, behavior, physiology.

ABSTRACT: Swimming energetics of squid, *Loligo opalescens*, were observed in a Brett tunnel respirometer and compared to similar size sockeye salmon, *Oncorhynchus nerka*. Variability in the critical speeds and burst speeds were affected by squid size and temperature of the water. An individual tested at 9.5, 12.5, and 17.5 deg C showed a progressive increase in critical speed with temperature of 1.29, 1.47, and 1.78 L/sec, respectively. The standard and active metabolic rates of the squid (254 and 862 ml O<sub>2</sub>/kg/hr) were higher than the salmon (50 and 627 ml O<sub>2</sub>/kg/hr). However, the sustainable speeds of squid were half those observed in salmon (.36 m/sec). The high cost of transport (12.5 J/kg/m), nearly five times that of salmon, confirms the low efficiency of jet-propelled swimming.

Swordfish and mercury - a case history.

AUTHOR(S): Officer, C. B., and J. H. Ryther.

YEAR: 1981.

SOURCE: *Oceanus* 24(1):34-41.

KEYWORDS: Swordfish, *Xiphias gladius*, contaminant levels.

ABSTRACT: Concerns are stated that scientists are not always consulted in matters in which the Federal regulatory bureaucracy makes decisions. A case in question is tolerable levels of mercury contamination in fish. A review of popular incidents of aquatic mercury pollution is undertaken, and their subsequent effect on humans in Japan, Sweden, Canada, the U.S. and England. Starting in December 1970, swordfish contamination by mercury became an issue in the U.S. with quantities being quarantined. Levels that were problematic in other countries (especially Japan), posed little or no threat to Americans since they consumed less fish, and our contamination levels were lower. Studies in Sweden set 1.0 ppm as a safe limit for Swedes. The American limit of 0.5 ppm was arrived at through a miscalculation. Instead of doubling the Swedish level, since Americans eat half the amount of fish, the government halved the level to 0.5 ppm. In conclusion, the mercury scare of the early 1970s was ill-founded and unnecessary.

Pacific Bonito Food Habits.

AUTHOR(S): Oliphant, M. S.

YEAR: 1971.

SOURCE: Calif. Dept. Fish Game, *Fish Bull.* 152:64-82.

KEYWORDS: Feeding, Pacific bonito, *Sarda chiliensis*, northern anchovy, *Engraulis mordax*, market squid, *Loligo opalescens*.

ABSTRACT: Stomach contents of Pacific bonito (*Sarda chiliensis*) were examined and analyzed by volume, number, frequency of occurrence, and by Index of Relative Importance in order to determine their feeding habits. Twelve fish species in nine families were the principal contributors to the bonito diet. They provided 91.1% by numbers, 81.8% in volume and occurred in 86.4% of the stomachs containing food. Northern anchovy (*Engraulis mordax*) alone represented 75.5% by numbers, 75.9% in volume, 56.3% frequency of occurrence, and had an overall Index of Relative Importance value of 8,524. Fish other than *E. mordax* were 15.6% by numbers, 5.9% by volume, 30.1% frequency of occurrence, and had an Index of Relative Importance of 647. Common squid (*Loligo opalescens*) contributed 8.1% by numbers, 18.0% by volume, 25.1% frequency of occurrence, and had an Index of Relative Importance value of 655. Data examined on a calendar quarter basis revealed some seasonal variations in bonito diet with squid occurring mostly in the first and second quarters of both years. Northern anchovy was the major food item in the diet of Pacific bonito. Common squid ranks as the species next in importance, mainly from January through June.

Parasites as indicators of English sole (*Parophrys vetulus*) nursery grounds.

AUTHOR(S): Olson, R. E., and I. Pratt.

YEAR: 1973.

SOURCE: *Trans. Amer. Fish. Soc.* 102(2):405-411.

KEYWORDS: English sole, *Parophrys vetulus*, nursery, migration.

ABSTRACT: Parasites of juvenile English sole, (*Parophrys vetulus*), were

examined and used as biological tags to obtain an estimate of the proportion of juveniles that use the estuary as a nursery and to determine whether non-estuarine nursery grounds exist in the vicinity of Yaquina Bay, Oregon. Juvenile English sole were most abundant from May through September in the lower estuary. Emigration from the bay was heavy in October and essentially complete by November. Fifteen species of parasites were associated with 0-group English sole in Yaquina Bay and an additional seven species parasitized those offshore. Of these, 3 parasites appear to have life cycles that operate only within the estuary. These were the acanthocephalan, *Echinorhynchus lageniformis*, the nematode *Philometra americana*, and a microsporidan protozoan, *Glugea* sp. The incidence of infection by *E. lageniformis* in bay fish before emigration (29.9%) was similar to the incidence in 0-group English sole collected offshore after emigration (28.5%). This result suggests that there was little or no influx of young from other than estuarine nursery grounds to the offshore study area. *P. americana* and *Glugea* sp. infected English sole only in the upper estuary. The presence of these parasites in the offshore English sole sample (8.6%) indicates a former upper estuary residence. The adult trematode *Zoogonus dextrocirrus* and metacercaria of *Otodistomum veliporum* are common parasites of offshore English sole. None of the bay fish were infected with *O. veliporum* and only 2 had one *Z. dextrocirrus* each. This indicates a negligible amount of back and forth movement between the estuary and the offshore areas. Other parasites found did not show characteristics of infection or life cycle that allowed their use as natural tags. Both trawl and parasite information give strong evidence that estuaries may be the exclusive nursery grounds for English sole on the Oregon coast.

A simple, rapid method for marking individual sea urchins.

AUTHOR(S): Olsson, M., and G. Newton.

YEAR: 1979.

SOURCE: Calif. Fish Game 65:58-62.

KEYWORDS: *Strongylocentrotus* spp., sea urchins.

ABSTRACT: A long-term urchin, *Strongylocentrotus* spp., tag was evaluated. The tag consisted of a 3 inch long nylon streamer, common in the textile industry, with round (1#) identification discs attached to the end. One hundred and fifty urchins were tagged in the field and 40 were recovered at subsequent samplings. Many urchins showed signs of test decalcification in the vicinity of the tag, however when the tags were removed the urchins showed signs of recovery. Fish predation of tagged urchins may be enhanced as evidenced by chewed discs.

Trap-caught sablefish in Monterey Bay, California.

AUTHOR(S): Osada, E. K., and G. M. Cailliet.

YEAR: 1975.

SOURCE: Cal-Neva Wildl. Trans. 1975:56-73.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, groundfish, fishing methods, life history.

ABSTRACT: This study was conducted to test the effectiveness of fishing for sablefish, *Anoplopoma fimbria*, using traps in Monterey Bay, California. Analysis of catch rates indicated that sablefish were most abundant at 300 - 750 fathoms. Sablefish showed a regular increase of size with depth, with a higher percentage of large

fish below 500 fathoms. Seasonal variation in catch rates and fish size was demonstrated at 100 fathoms; however, deeper fish showed little seasonality. Squid bait proved more effective than anchovy, and relative efficiencies and preparation of bait was discussed. Female sablefish predominated in the traps, while males were among the smaller fish. Spawning of sablefish in Monterey Bay occurs between November and February at depths greater than 300 fathoms. Among fish of a given size ripeness of the gonads increased with depth.

A new test for measuring seawater toxicity.

AUTHOR(S): Oshida, P. S., and T. K. Goochey.

YEAR: 1980.

SOURCE: Pages 149-159 in: W. Bascom (ed.). Coastal water research project biennial report for the years 1979-1980. Southern California Coastal Water Research Project, Long Beach, CA. 363 pp.

KEYWORDS: Strongylocentrotus spp., sea urchin, contaminant levels, contaminant susceptibility, larvae.

ABSTRACT: Gametes, embryos, and larvae of sea urchins (*Strongylocentrotus purpuratus*) were used as experimental organisms to determine the toxicities of municipal wastewater effluents, and of nearshore and Los Angeles Harbor waters. The results of the test show that the test was sensitive enough to reveal that municipal wastewaters significantly reduced fertilization of the sea urchin eggs at concentrations of only 1 to 7 percent effluent and higher. These results make it possible to demonstrate how the toxic effects of wastewater might be distributed in the ocean by relating the effluent concentrations that caused toxic reactions in sea urchins to the measured and theoretical concentrations of wastewater around sewage outfalls.

Direct evidence for oophagy in thresher shark, *Alopias pelagicus*.

AUTHOR(S): Otake, T., and K. Mizue.

YEAR: 1981.

SOURCE: Japanese Jour. Ichthy. 28(2):171-172.

KEYWORDS: Thresher shark, *Alopias vulpinus*, reproduction.

ABSTRACT: Eleven thresher sharks, *Alopias pelagicus*, were collected on tuna longlines in the Indian Ocean in 1979. The individuals (4 males 7 females) ranged from 235-285 cm TL and weighed 33-62 kg. Two pregnant females each contained two embryos (1 per uterus). These ranged from 42.1-52.1 cm TL and weighed 175-250 gms. A whole egg capsule, ovoid in shape (55 mm long, 12 mm maximum diameter weighing 4 gms), was recovered from the stomach of 1 embryo. The capsule contained 20-30 ova approximately 5-10 mm in diameter. The stomachs of the other embryos also contained yolk material and shell fragments. This evidence as well as the lack of yolk-sac attachment, pseudo-placenta and placenta on the maternal intrauterine wall suggest the embryos are nourished by ova from the maternal shark.

Ocean fishermen are urged to report all tagged halibut.

AUTHOR(S): Outdoor California

YEAR: 1962.

SOURCE: Outdoor California 23(3):15.

KEYWORDS: Life history, growth, migration, California halibut,

*Paralichthys californicus*.

ABSTRACT: All ocean fishermen were asked to report any tagged halibut (*Paralichthys californicus*), to the California Department Fish and Game. The halibut tagging program was started in 1956 to study the life history and effect of fishing on halibut. Tag returns indicate that small halibut grow from 1 1/2 to 3 1/2 inches per year. The larger or "legal size" halibut show a similar growth rate. The recovery of tagged halibut is important for growth and migration information.

Hybridization in the eastern Pacific abalone (*Haliotis*).

AUTHOR(S): Owen, B., J. H. McLean, and R. J. Meyer.

YEAR: 1971.

SOURCE: Bull. Los Angeles Co. Mus. Nat. Hist. Sci. 9:37 pp.

KEYWORDS: *Haliotis* spp., abalone, population trends.

ABSTRACT: The evidence to support hybridization of eastern Pacific abalones was presented. Several hundred thousand abalones, *Haliotis referens*, *H. corrugata*, *H. kamtschatkana assimilis*, *H. Sorensii*, *H. walallensis*, and *H. fulgens*, were examined from commercial catches. With the exception of *H. cracherodii*, all were found to have hybridized with at least two other species. Abalone hybridization was determined based on shell morphology and size and immunological studies. The evidence was supported by laboratory crosses of the species in question. Hybrids accounted for 0.02 to 0.37% of the commercial catches. The rarity of hybrids in natural populations was attributed to species segregation, non-affinity of gametes; differences in the breeding season and/or spawning stimuli, and reduced viability of the hybrid larvae.

Culture of the California red abalone *Haliotis rufescens*  
Swainson.

AUTHOR(S): Owen, B., L. H. DeSalvo, E. E. Ebert, and E. Fonck.

YEAR: 1984.

SOURCE: Veliger 27(2):101-105.

KEYWORDS: Abalone, *Haliotis* sp., reproduction, early life history.

ABSTRACT: Red abalone, *Haliotis rufescens*, culture in Chilean hatcheries was considered. Breeder and juvenile abalone were maintained very well on native brown algae. Growth rates averaged 10.5 mm in a 7-month period. Feeding rates and food conversion efficiency averaged 7.5% and 9.3%, respectively, for the same time period. The abalones are probably found throughout the year. Larval development and settlement rates were comparable to similar tests in California. These results suggest the introduction and culture of red abalone, to Chile, is feasible.

First amendment and implementing regulations to the Pacific Coast groundfish management plan incorporating the environmental assessment, the regulatory impact review/regulatory flexibility analysis, and other requirements of other applicable law.

AUTHOR(S): Pacific Fishery Management Council (PFMC)

YEAR: 1984.

SOURCE: Pac. Fish. Mgmt. Coun., Portland, OR. 97201.

KEYWORDS: Regulations, fishery, fishing gear, groundfish, lingcod, Ophiodon

*elongatus*, Pacific hake, *Merluccius productus*, sablefish, *Anoplopoma fimbria*, petrale sole, English sole, widow rockfish, *Sebastes*

entomela, Dover sole, *Microstomus pacificus*, *Eopsetta jordani*,  
*Parophrys vetulus*, jack mackerel, *Trachurus symmetricus*.

ABSTRACT: The first amendment to the Pacific Coast Groundfish Plan of 1983

revises various sections of the regulatory environment. Areas of amendment include: regulations on Pacific ocean perch, vessel identification, inclusion of additional species in the groundfish management unit, trip limits on sablefish, trawl rope requirements and management of northern jack mackerel.

Northern anchovy fishery management plan incorporating the final supplementary EIS/DRIR/IRFA.

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1983.

SOURCE: Pac. Fish. Mngt. Coun. Portland, Oregon.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, economics, regulations, life history, population trends.

ABSTRACT: An amendment of the original Anchovy Fishery Management Plan implemented in 1978 for the central subpopulation of northern anchovy. The need for an amendment was due to the use of a new more cost-effective and accurate technique used to estimate anchovy spawning biomass. This new technique utilizes anchovy egg production as a better measure of spawn production, and relates spawn production directly to spawner abundance by measurement of anchovy reproduction. Information collected with this new technique indicates that reproductive output of anchovy is greater than previously assumed. The revised Fishery Management Plan reviews the biological, ecological, social, and economic aspects of the anchovy and establishes a revised optimum yield (OY) formula. U. S. OY is calculated each year based on an annual estimate of stock abundance.

Draft Fishery Management Plan for Pacific Coast Billfish and Oceanic Shark Fisheries.

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1981.

SOURCE: Pacific Fishery Management Council Publ. 117 pp.

KEYWORDS: Thresher shark, *Alopias vulpinus*, fishery, regulations, fishing gear, economics, life history.

ABSTRACT: Background information and management plan for two species of billfish (swordfish and striped marlin), and three species of oceanic shark (common thresher, shortfin mako, and blue shark) are described. The information covered in the plan includes a description of the resource, description of the fisheries, social and economic characteristics of the fisheries, existing fishery management, optimum yield, domestic capacity, total allowable level of foreign fishing, alternative management measures and implementation requirements.

Pacific coast groundfish plan. Fishery management plan and environmental impact statement for the California, Oregon and Washington groundfish fishery (implemented September 30, 1982).

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1983.

SOURCE: NOAA/NMFS Coop. Agree. 80-ABH-00003.

KEYWORDS: Life history, economics, fishery, fishing gear, regulations,



groundfish, lingcod, *Ophiodon elongatus*, Pacific hake, *Merluccius productus*, sablefish, *Anoplopoma fimbria*, petrale sole, English sole, widow rockfish, *Sebastes entomela*, Dover sole, *Microstomus pacificus*, *Eopsetta jordani*, *Parophrys vetulus*.

ABSTRACT: This project document encompasses a wide range of topics concerning a number of fisheries for many commercial and sport groundfish and wetfish. Topics include: management and regulation measures, past, present and future (including possible alternatives); past, present and future of the fisheries, including the foreign and joint venture aspects; description and status of the stocks, including Acceptable Biological Catch (ABC), Optimum Yield (OY), Maximum Sustainable Yield (MSY), and life history features; fishery harvesting, processing, economics, and fishing gear considerations; and research history. Major species included in this document are Lingcod (*Ophiodon elongatus*), Pacific cod (*Gadus macrocephalus*), Pacific whiting (*Merluccius productus*), Sablefish (*Anoplopoma fimbria*), Pacific ocean perch (*Sebastes alutus*), shortbelly rockfish (*Sebastes jordani*), widow rockfish (*Sebastes entomelas*), dover sole (*Microstomus pacificus*), English sole (*Parophrys vetulus*) and petrale sole (*Eopsetta jordani*).

Status of the Pacific coast groundfish fishery through 1985 and recommended acceptable biological catches for 1986.

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1985.

SOURCE: Pac. Fish. Mgmt. Coun. Publ. 36 pp. plus appendices.

KEYWORDS: Dover sole, *Microstomus pacificus*, petrale sole, *Eopsetta jordani*, jack mackerel, *Trachurus symmetricus*, widow rockfish, *Sebastes entomelas*, bocaccio, *Sebastes paucispinis*, chilipepper, *Sebastes goodei*, English sole, *Parophrys vetulus*, groundfish, fishery, economics, Pacific hake, *Merluccius productus*, sablefish, *Anoplopoma fimbria*.

ABSTRACT: The purpose of this report is to summarize the development of the Pacific Coast Groundfish Fishery Management Plan and to describe the history of the fishery and its management since enactment of the Magnuson Fishery Conservation and Management Act. Included in this report is a description of landings, fishing patterns, estimates of the status of stocks, acceptable biological catches for 1983-85 (and those proposed for 1986), and economic status of the commercial groundfish fishery in 1984.

Final framework amendment for managing the ocean salmon fisheries off the coasts of Washington, Oregon, and California commencing in 1985.

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1984.

SOURCE: Pac. Fish. Mgmt. Council, Portland, OR 97201. 149 pp.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, Chinook salmon, *Oncorhynchus tshawytscha*, fishery, regulations, distribution, economics.

ABSTRACT: A framework amendment is proposed for the management of the salmon and steelhead fishery off the coasts of Washington, Oregon, and California. Species included are the coho salmon (*Oncorhynchus kisutch*), the Chinook salmon (*Oncorhynchus tshawytscha*), the pink salmon, and the steelhead trout. This amendment includes measures that are fixed, such as; the

management objectives and goals, the procedures for evaluating optimal yield and total allowable level of foreign fishing, and the process for modifying the plan during pre-season and in-season times. There are also several measures which are flexible and are determined annually. These include calculation and allocation of allowable harvest, and controls on the harvest, such as subarea boundaries, minimum harvest lengths, recreational daily bag limits, fishing gear restrictions, and seasons or quotas. Discussion is made on the possible range of environmental impacts of this plan, as well as social and economic impacts. Relationship of this framework amendment to existing regulations and laws is also discussed.

Environmental impact statement and fishery management plan for jack mackerel.

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1979.

SOURCE: Pac. Fish. Mgmt. Council/NMFS Publ. 100 pp.

KEYWORDS: Jack mackerel, *Trachurus symmetricus*, regulations, fishery, economics, life history, habitat, migration, feeding.

ABSTRACT: A draft Fishery Management Plan for the jack mackerel fishery describes the possible impact of implementing regulations for the management of the jack mackerel fishery resource within the U. S. Fishery Conservation Zone. The fishery management plan provides the basis for the determination of optimum yields predicated on scientific information and involving the needs of the states, the fishing industry, recreational groups, consumers, environmental organizations, and other interested parties. The topics covered in this plan include: description of the fishery, existing management laws, policies and jurisdictions, socio-economic characteristics, biological and environmental characteristics; catch and capacity, optimum yield, and management regime.

Draft fishery management plan for the Dungeness crab fishery off Washington, Oregon and California.

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1979.

SOURCE: Pac. Fish. Mgmt. Council, Draft ms 93 pp.

KEYWORDS: Market crab, *Cancer magister*, fishery, economics, life history, distribution, feeding, mortality, reproduction, growth.

ABSTRACT: A management plan for the dungeness crab fishery of the west coast was proposed. The goals of the plan included ways to minimize physical and economic losses (due to wasteful fishing practices), reduce social and economic impacts of management, and develop practices applicable to all state jurisdictions. The biology of Dungeness crabs, *Cancer magister*, was also considered. Factors such as distribution, movement, stocks, prey, predators, growth, molting, sexual maturity, reproduction, larval distributions and nursery areas were reported. The physical habitat utilized by the crabs were also considered. Salinities of 11-32 ppt, temperatures between 3.3 deg. C-18.3 deg C and sandy-mud bottoms were suitable conditions for the crab populations. A description of the fishery, including vessels, gear, and user groups was presented. Landings of crab, over the coastal range, varied from 7.8 million pounds (1974) to 53.5 million pounds (1977). Landings reflect cyclic patterns with lows

every 9 to 10 years and highs every 13 to 17 years. Maximum sustainable yields of approximately 7.4 to 8.6 million pounds have been proposed for each state. The management plan proposed to meet these criteria included limits on commercial and sport catches, seasons, presensor gear regulations, sex limits, escape ports in pots and pot destruct devices.

Draft fishery management plan and environmental impact statement for the pink shrimp.

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1980.

SOURCE: Pac. Fish. Mgmt. Council, Portland, Oregon 191 pp.

KEYWORDS: Ocean shrimp, *Pandalus jordani*, fishery, economic, habitat, life history, fishing gear, regulations.

ABSTRACT: A fishery management plan (FMP) for pink shrimp along the Pacific coast. The primary goal of the plan is to encourage harvest of the optimum yield (OY), defined as all the pink shrimp that can be taken during open seasons in permissible areas with legal shrimp trawls. The management plan covers the history of management, history of research, socio-economic characteristics of the fishery, biological and environmental characteristics, catch and capacity characteristics, optimum yield, total allowable level of foreign fishing, proposed management regime, operational needs and costs, research needs, and consistency of the pink shrimp FMP with Federal laws and policies and other FMPs.

Supplement to the final environmental impact statement/fishery management plan for commercial and recreational salmon fisheries off the coasts of Washington, Oregon and California commencing in 1978.

AUTHOR(S): Pacific Fishery Management Council.

YEAR: 1979.

SOURCE: Pac. Fish. Mgmt. Council, Portland, OR 97201. 115 pp.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, Chinook salmon, *Oncorhynchus tshawytscha*, fishery, population trends, regulations, economics.

ABSTRACT: Assessment is made of the 1978 management plan, along with its effects on ocean troll, recreational catches, spawning escapements, and stock recruitment of salmon for 1979. It is concluded that for 1979, natural stocks of coho salmon (*Oncorhynchus kisutch*) will be depressed in the Oregon Coastal, Columbia River, Washington Coastal, and Puget Sound regions. Favorable returns are expected for hatchery returns of coho salmon in Willapa Bay and Puget Sound. It is also predicted that wild stock of Chinook salmon (*Oncorhynchus tshawytscha*) will be depressed for the Columbia River region in 1979, whereas they will be favorable for the Oregon coastal region. The California stocks of wild chinook remain in doubt due to the 1975-1977 drought. The management plan for 1979 continues the basic plan approved by the council for 1978 with a few amendments. First, a reduction in the open fishing season for both commercial troll, and recreational fisheries, along with a reduction in the bag limit for recreational fisheries. Second, deferral is made on the proposal for a federal moratorium on entry into the fishery, and permission is given for coastal states to institute license moratoria for the 1980 fishing season. Finally, the total

allowable level of foreign fishing is set at zero, and no extension is made of a previous U.S.-Canada reciprocal fishing agreement.

Food web complexity and species diversity.

AUTHOR(S): Paine, R. T.

YEAR: 1966.

SOURCE: Am. Nat. 100:65-75.

KEYWORDS: Habitat, feeding, community, distribution.

ABSTRACT: The differences in food web complexity between a temperate (Mukkau Bay), subtropical (Baja California), and tropical (Costa Rica) ecosystem were discussed. Only Costa Rica exhibited spatial monopolization. In the other areas top level predators continually cleared the rocky intertidal for recruitment. When the predators were removed, the system moved towards simplicity resulting in less diversity. No correlation between latitude (10 deg to 49 deg N) and diversity was observed; however, on the geographic scale increased stability maybe related to the capacity of the system to support more predators. These data suggest tropical ecosystems (which are more diverse) will be characterized by more carnivores.

Synopsis of the biology of the swordfish, *Xiphias gladius*.

AUTHOR(S): Palko, S., J. Beardsley, and N. J. Richards.

YEAR: 1981.

SOURCE: NOAA Tech. Rep. NMFS Circ. 441, RAO Fish. Synopsis 127.

KEYWORDS: Swordfish, *Xiphias gladius*, age, behavior, distribution, early life history, feeding, fishery.

ABSTRACT: This synopsis is the compilation of all (or most) information available in the literature by November 1981 about the swordfish, *Xiphias gladius*. The following is a list of some of the topics covered in the paper: age, behavior, community, distribution, early life history, economics, feeding, fishery, fishing gear, growth, habitat, larvae ichthyoplankton, length/weight relationships, life history, migration, nursery, physiology, population trends, recruitment, regulations, reproduction, seasonality, spawning.

A direct method for estimating northern anchovy, *Engraulis mordax*, spawning biomass.

AUTHOR(S): Parker, K.

YEAR: 1980.

SOURCE: Fish. Bull. 78(2):541-544.

KEYWORDS: *Engraulis mordax*, northern anchovy, spawning.

ABSTRACT: Estimates of biomass for the northern anchovy, *Engraulis mordax*, are calculated using the direct method of dividing an estimate of egg production by the product of batch fecundity and female proportion in the mature stock. Spawning products, present all year, are most abundant in late winter and early spring. Production in eggs, batch fecundity (eggs/unit weight), fraction spawning (weight of spawning females/weight of all mature females), weight of females per weight of spawning stock, and the adjustment factor are  $2.321 \times 10^3$ ,  $3.96 \times 10^8$ , 0.159, 0.550, and 1.080, respectively. This yields a spawning biomass of 0.72 million, with a coefficient of variation (CV) of 0.614. Egg production adds 8 times more to the CV than all other parameters.

Size selective predation among juvenile salmonid fishes in a  
British Columbia inlet.

AUTHOR(S): Parker, R. R.

YEAR: 1971.

SOURCE: Jour. Fish. Res. Bd. Canada 28:1503-1510.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, feeding, predation,  
behavior.

ABSTRACT: Observations in the field suggest that juvenile coho salmon are the main source of mortality for pink and chum salmon fry. Laboratory experiments in this study confirm the observation that smaller prey suffered a higher mortality rate in the predator-prey situation. These experiments also showed that under ad libitum conditions, the juvenile coho grew at an average of about 0.7% in length per day. Other researchers have shown that pink fry grow at about 1.8%/day. This information indicates that members of the prey population outgrow the predators and hence become unavailable. It appears that the chums, in this situation, appear to have evolved a strategy to enhance their survival in a dangerous situation. The chums are larger (as unfed fry) than pinks, and enter the estuary during the earlier part of the pink migration. By the time the predator reaches the estuary, chums are among the larger members of the prey population. The chums are then protected against predation by the smaller and later arriving pinks.

Changes in relative abundance and size composition of  
sablefish in coastal waters of Washington and Oregon, 1979-81,  
and California, 1980-81.

AUTHOR(S): Parks, N. B.

YEAR: 1982.

SOURCE: Natl. Mar. Fish. Serv., Tech. Memo: NMFS F/NWC-26.

KEYWORDS: Length/weight, sablefish, *Anoplopoma fimbria*, fishery,  
distribution.

ABSTRACT: Annual changes in relative abundance of sablefish were determined from standardized trap catches off the Oregon, Washington and California coasts from 1979-81. The results suggest that sablefish abundance has been decreasing since 1979. Off Washington the results indicate that sablefish stocks have declined only slightly since 1979, but at one site there was a large reduction in numbers of medium and large marketable-size fish. Off San Diego, California 1980 and 1981, survey results indicated moderate declines in sablefish in all categories.

Results of comparative trawl and trap fishing off Oregon for  
sablefish, *Anoplopoma fimbria*.

AUTHOR(S): Parks, N. B.

YEAR: 1973.

SOURCE: Mar. Fish. Rev. 35(9):27-30.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, groundfish, fishery, fishing  
gear.

ABSTRACT: Comparison was made of the catch from set traps and trawling in the same location off the Oregon coast. The results showed that traps were more selective than trawls, especially for sablefish, *Anoplopoma fimbria*. Traps set below 200 fathoms caught only sablefish compared to trawls which brought up 11 spp. at 250 fathoms, and 14 spp. at 200 fathoms. On the average, trap caught

sablefish were 3.4 lbs. heavier, and 5.2 inches longer than trawl caught sablefish. This may be partly related to the fact that female sablefish are larger than male sablefish. The trap catches were 78% female, compared to 39% for the trawl catches. The authors conclude that this is due to some behavioral difference (i.e. trawl avoidance) by female sablefish. The trap catches were 93.3% of marketable size, compared to 57.2% for trawl catches.

Exploitation and recruitment of Pacific mackerel, *Scomber japonicus*, in the northeast Pacific.

AUTHOR(S): Parrish, R. H.

YEAR: 1974.

SOURCE: CalCOFI Rep. 17:136-140.

KEYWORDS: Pacific mackerel, *Scomber japonicus*, recruitment, population trends.

ABSTRACT: Computer estimates of population trends based on an expanded virtual population estimate were developed for *Scomber japonicus*. This used an assumed natural mortality rate and produced a calculated fishing mortality rate for each age group. The spawner-recruit curve derived indicates little resiliency in the population. Examining recruitment time series indicated that spawning success is aperiodic and varies in series of 2 to 10 years. Recruitment is heavily influenced by factors other than spawning biomass. Sardines may be influenced by the same or related factors. Exploitation of Pacific mackerel has been a factor of market demand and fishing gear, not the size of fish of the population. Currently, spawning biomass is too low to provide a strong year class and thus economically adequate stock for the fishing industry. They recommend that the moratorium regulations be continued until the population has recovered sufficiently to spawn a large year class.

The California sablefish fishery for the period 1953-1969.

AUTHOR(S): Parrish, R. H.

YEAR: 1973.

SOURCE: Calif. Fish Game 59(3):168-177.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, groundfish, fishery, economics.

ABSTRACT: This paper updates a 1954 report on the fishery for sablefish, *Anoplopoma fimbria*, in California from 1941-1952. The longline catch declined from 1945 to a low of 147,107 lbs. in 1963. Since then it has showed a strong increase, peaking at 2,401,057 lbs. in 1967; almost 2,000 lbs./boat/year. The increase was primarily due to greater demand for sablefish in the market. The otter trawl catches remained quite stable from 1953 - 1969. The annual catch varied between 962,557 and 2,157,047 lbs. with no obvious trends. The stability was primarily due to very little change in fleet size, and the fact that sablefish are primarily incidental catch in the otter trawl fisheries. The authors note that as of 1969, the fishery is still quite small, but they recommend careful monitoring of the fishery as it grows.

Climatic variation and exploitation in the Pacific mackerel fishery.

AUTHOR(S): Parrish, R. H., and A. D. MacCall.

YEAR: 1978.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 167.

KEYWORDS: Chub mackerel, *scomber japonicus*, fishery, economics, spawning, population trends, recruitment, mortality, seasonality.

ABSTRACT: The purpose of this report was to assess the role of environmental

variation in the decline of the California stock of Pacific mackerel (*Scomber japonicus*) and to evaluate the merits of using environmental data in management policies for this species. This study utilized the CalCOFI data base to determine associations between the recruitment of Pacific mackerel and environmental variables. The range of *Scomber japonicus* extends from the Gulf of Alaska to the Gulf of California. The majority of the Pacific mackerel fishery is located in southern California and Baja California. Due to the migratory nature of *S. japonicus*, most of the fish from central California are available to the southern California fishery, while the converse is not true. This report includes a brief history and management of the species. Until the mid-1950s, the fishing season was generally between June and December. Catch data and age composition is included for the years 1926-27 to 1969-70. The percentage of mature 1, 2 and 3 females is estimated at 26%, 77% and 88%, respectively. Males apparently mature at a slightly younger age than females. The eggs and larvae of Pacific mackerel are pelagic. The eggs hatch approximately three days after fertilization, depending on temperature. The distribution of Pacific mackerel larvae is considerably wider than that of the eggs. Principal concentrations are often well offshore and undoubtedly are heavily controlled by transport and convergence. ABSTRACT: Factors affecting recruitment are discussed. Fluctuation of recruitment suggests that recovery of the Pacific mackerel stock is more likely related to environmental conditions.

Transport mechanisms and reproductive success of fishes in the California current.

AUTHOR(S): Parrish, R. H., C. S. Nelson, and A. Bakun.

YEAR: 1981.

SOURCE: Biol. Oceanogr. 1:175-203.

KEYWORDS: Larvae, spawning, distribution, all species.

ABSTRACT: The California current and various oceanic conditions were considered in respect to transport mechanisms of larval fish. Coastal fish species were found to spawn typically during winter when surface drift was onshore. Few fish with planktonic larvae spawned during the upwelling period when surface water movement was directed offshore. The fish biomass of this region is dominated by migrating species. The local resident stocks make up a small proportion of the individuals. The closed gyre circulations in the southern California Bight have fostered favorable conditions for spawning and led to distinct subpopulations of pelagic fish. The observations suggested that anomalies in surface drift patterns could be a major cause of observed variations in spawning success of major fishery species.

The escape response of abalone (Mollusca, Prosobranchia, Haliotidae) to predatory gastropods.

AUTHOR(S): Parsons, D. W., and D. L. MacMillan.

YEAR: 1979.

SOURCE: Mar. Behav. Physiol. 6(1):65-82.

KEYWORDS: Abalone, *Haliotis* spp., behavior.

ABSTRACT: The escape response of three species of Australian abalones, *Haliotis laevigata*, *H. ruber*, and *H. sealaris* was examined. Following contact with predatory gastropods, *Haliotis laevigata*

exhibited a stereotypical series of responses. The subunits of the escape response include predator contact (stimulus) of the resting animal; withdrawal of the local tentacles and epipodium, tentacular sweep, mushrooming (elongation of muscle column off substrate), thrusting of the shell down at local contact point, twisting of the shell, and running. Similar responses were observed in *H. ruber* and *H. scaloris*.

Notable migrations of sablefish tagged in Puget Sound.

AUTHOR(S): Pasquale, N.

YEAR: 1964.

SOURCE: Washington Department of Fisheries, Fisheries Research Papers 2(3):68.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, groundfish, migrations.

ABSTRACT: In 1962, three sablefish, *Anoplopoma fimbria* were captured by Japanese fishermen in the Bering Sea, from a tagging study in Holmes Harbor, Whidbey Island, Washington during the years 1955-56. All of the fish had been at liberty for more than 6 years and had traveled a great circle course of 2100 nautical miles or roughly 2700 miles with a course following the coastline. Future recoveries might indicate if this migration could be considered normal for the species, or just chance wandering.

Short-term thermal resistance of hexagrammid eggs and planktonic larvae from Puget Sound.

AUTHOR(S): Patten, B. G.

YEAR: 1980.

SOURCE: Trans. Amer. Fish. Soc. 109:427-432.

KEYWORDS: Lingcod, *Ophiodon elongatus*, larvae, mortality.

ABSTRACT: Eggs of three hexagrammid species (kelp greenling, painted greenling, and white spotted greenling) and larvae of these species and of lingcod were exposed to different elevated water temperatures in an attempt to simulate the heat stress to which planktonic larvae are subjected as they pass through heat exchangers of a steam electric station. Temperature resistance by eggs of the three species was similar, but hatching success was curtailed for all species above 22 deg C. At the end of 10 and 20 minute tests, all larvae held at 22 deg C or greater were torpid. When larvae were returned to ambient temperature, most of those that had shown some sign of activity became hyperactive or torpid. By 30 minutes after exposure, the least resistant species, lingcod and the white spotted greenling, were still torpid from exposures to 24 deg C or greater. Lingcod larvae were least resistant to elevated temperatures, and painted greenling most resistant of the four species tested.

Body size and learned avoidance as factors affecting predation on coho salmon, *Oncorhynchus kisutch*, fry by torrent sculpin, *Cottus rhotheus*.

AUTHOR(S): Patten, B. G.

YEAR: 1977.

SOURCE: Fish. Bull. 75(2):457-459.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, early life history, behavior, mortality.

ABSTRACT: A study was initiated in order to determine the length at which torrent sculpin would cease predation on fry of the coho



salmon. The results indicated that sculpins while feeding on larger fry in the lab than they normally do in the field seemed to have an upper limit of 90 mm. A test was also made of percent survival of naive coho (those which had never experienced predation) versus coho conditioned to predation, and versus a group of half naive, half conditioned coho. The naive coho suffered significantly greater mortality than either group, however, the mixed group did not have mortality significantly different from the conditioned group indicating that the naive coho were picking up the behavioral responses from the conditioned individuals.

What do natural reefs tell us about designing artificial reefs in southern California?

AUTHOR(S): Patton, M. L., R. S. Grove, and R. F. Harman.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):279-298.

KEYWORDS: Artificial reef, community, colonization.

ABSTRACT: The relationships between bottom relief, algal turf density, kelp density, and rock surface area are examined along with the abundances of supra-benthic and cryptic demersal fish, in an attempt to learn whether shelter was limiting on natural high-relief areas or if populations were at all resource-limited. When rock height was less than 0.75 m, fish abundance was proportional to height; however, when height was greater than 0.75 m, fish abundance was constant at the maximum. Species number and total abundance seemed to be a saturating function of rock height, percent vertical substrate, and total reef height. Total fish abundance and species number was higher on high-relief sites, regardless of turf density. Species number and fish abundance were not related and number and abundance were saturating functions on rock area. The three variables; Pt. Conception distance, depth, and percent unstable substrate and sewage, were all important predictors of between-site variations in fish fauna. Total relief was a better predictor than total reef height. Fish abundance may be a saturating function of artificial and natural reef height. The essential resources provided by high bottom relief is unclear. Species number is also a saturating function of rock areas, and fish abundance a saturating function of shelter availability. An artificial reef could be "over-engineered". A smaller, simpler, cheaper reef may produce as many fish as a larger more complex reef.

Vertical migration of the ocean shrimp, *Pandalus jordani*: A feeding and disposal mechanism.

AUTHOR(S): Pearcy, W. G.

YEAR: 1970

SOURCE: Calif. Fish Game 56(2):125-129.

KEYWORDS: Ocean shrimp, *Pandalus jordani*, feeding, migration, fishing gear.

ABSTRACT: Ocean shrimp, *Pandalus jordani*, were taken in night midwater trawl collections off Oregon over a seven-year period. The catches consisted of mainly immature males and varied widely over various seasons. No shrimp were caught during May and June. Stomach contents suggested the shrimp caught in midwater trawls were feeding on euphausiids and copepods. Shrimps collected in bottom trawls fed only on benthos. The results indicated shrimp

vertically migrate to forage on midwater prey. However, the use of midwater currents may have been an important dispersal mechanism.

Feeding habits of Dover sole (*Microstomus pacificus*), rex sole (*Glyptocephalus zachirus*), slender sole (*Lyopsetta exilis*), and Pacific sanddab (*Citharichthys sordidus*), in a region of diverse sediments and bathymetry off Oregon.

AUTHOR(S): Pearcy, W. G., and D. Hancock.

YEAR: 1978.

SOURCE: Fish. Bull. 76(3):641-651.

KEYWORDS: Dover sole, *Microstomus pacificus*, feeding.

ABSTRACT: The food and feeding habits are described and related to depth and sediment, size of fish, and season, along with a comparison to biomass and composition of fish food for the Dover sole, *Microstomus pacificus*, off Oregon. At the deepest stations annelids constituted over 90% of the preferred food type eaten, while at the shallow areas mollusks and crustaceans were consumed most. At two stations coelenterates and echinoderms composed over one-half the diet, but were minor in all other areas. Based on frequency of occurrence of individual polychaete taxa, the range in overlap of diets was lower than that based on weight percentage of major taxa. Annelids dominated diets of all size groups in all seasons, while crustaceans decreased in importance with increasing size during winter and peaked in summer. Mollusks and echinoderms were most frequently found in intermediate-size and larger fish, respectively. Coelenterates showed the largest seasonal difference being uncommon in summer and sometimes a major food type (>30% by weight) in winter. Regardless of fish size, intensity of feeding showed seasonal differences, with a higher number of empty stomachs in winter. Dover sole feed mainly on benthic invertebrates. These food habits are related to mouth structure and digestive morphology. Depth related factors are more important to feeding than sediment type. Dover sole are versatile or opportunistic feeders, yet they select habitats where their principal preferred food is most abundant. Feeding habits of rex sole (*Glyptocephalus zachirus*), slender sole (*Lyopsetta exilis*), and Pacific sanddab (*Citharichthys sordidus*) were also reported. Dover sole seem very similar to rex sole; however, it was observed that food overlap and presumably competition are rare. Fish seemed to be less selective during the summer.

Catches of albacore at different times of the day.

AUTHOR(S): Pearcy, W. G., D. A. Panshin, and D. F. Keene.

YEAR: 1975.

SOURCE: Fish. Bull. 73(3):691-693.

KEYWORDS: Fishery, feeding, *Thunnus alalunga*, albacore.

ABSTRACT: Catch records from boats engaged in the albacore troll fishery off Oregon were used to examine the hypothesis that diel variations occur in the catches of albacore (*Thunnus alalunga*). Average catches per boat were calculated for each hour fished, for three months in 1969 and two weeks in 1970. The number of albacore caught versus the hour of the day showed no consistent trend for diel periodicity. Catch rates varied throughout the day. Only during 1970 was there an obvious trend for peak catch rates to occur early in the morning and in the evening. These peaks coincided with the local mean times of sunrise and sunset

(about 0600 and 2100 PDT). The separate months of 1969 showed a variable pattern with peaks occurring at different times during different months. It was concluded that albacore are involved in feeding activity throughout the day. Catch rates averaged over several weeks do not always indicate morning and evening periods of intense feeding.

Distribution and duration of pelagic life of larvae of Dover sole (*Microstomus pacificus*), rex sole (*Glyptocephalus zachirus*), and petrale sole (*Eopsetta jordani*), in waters off Oregon.

AUTHOR(S): Pearcy, W. G., M. J. Hosie, and S. L. Richardson.

YEAR: 1977.

SOURCE: Fish. Bull. 75(1):173-183.

KEYWORDS: Dover sole, *microstomus pacificus*, petrale sole, *Eopsetta jordani*, larvae, distribution.

ABSTRACT: The distribution of larvae of the Dover sole, *Microstomus pacificus*, and the petrale sole, *Eopsetta jordani*, are discussed for the Oregon population, along with the duration of pelagic life. Larvae were assigned to developmental states relative to the position of the left eye. Most Dover sole collected were stage I in bongo nets and metamorphosing stage IIIa in midwater trawls. Few larvae 3-4 mm SL were captured, and the largest individual was 65 mm and partially metamorphosed. Petrale occupied a small length range, with most being stage III. No larvae less than 10 mm were taken. Dover sole were widely distributed offshore and most abundant, representing 84.8% of all larvae taken. Largest catches occurred in waters more than 46 km offshore. Petrale sole were found from 2 to 120 km offshore. Dover sole larvae were shown to occupy a broad depth range, being most abundance (196 larvae/10 5 m<sup>3</sup>) in the upper 50 m of the water column. Dover sole larvae were rare, probably due to their reproductive strategy of few large eggs. Petrale larvae were also rare for an unknown reason. It seems that Dover and Petrale sole larvae remain pelagic for at least one year and 6 months, respectively. Dover sole settle at 30-50 mm SL. Larvae may delay metamorphosis and settlement until favorable conditions exist. Larvae of Dover sole greater than 11 mm were most common in waters beyond the continental shelf. The domination of smaller larvae over the shelf was due to spawning the previous winter. Larger larvae were found over the shelf during winter where they will settle. Distribution is related to currents and spawning location. Distribution and duration of pelagic life were also discussed for larvae of rex sole, *Glyptocephalus zachirus*.

Synchronization of gameto-genesis in the sea urchins, *Strongylocentrotus purpuratus* and *S. franciscanus*. Pages

AUTHOR(S): Pearse, J. S.

YEAR: 1980.

SOURCE: 53-68, in W. S. Clark, Jr. and T. S. Adams (eds). Advances in invertebrate reproduction. Elsevier, N. Holland.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., reproduction, seasonality.

ABSTRACT: The reproductive cycles of red, *Strongylocentrotus franciscanus*, and purple *S. purpuratus*, urchins were examined in laboratory and field experiments. Both species were found to exhibit well defined temporal sequence of events from oogonium

and oocyte proliferation to spawning. Seasonality and changes in sea temperature had little or no effect on synchronizing the process. Increases in food could augment gonad size and gamete production. In addition, gametogenesis could be prolonged by feeding. Cyclic food abundance had little effect; therefore, it was unlikely to influence synchronization of reproduction. The results left many questions unanswered regarding synchronization of reproduction in red and purple urchins.

Expansion of a central California kelp forest following the mass mortality of sea urchins.

AUTHOR(S): Pearse, J. S., and A. H. Hines.

YEAR: 1979.

SOURCE: Mar. Biol. 51:83-91.

KEYWORDS: Sea urchins, *Strongylocentrotus* spp., mortality, growth.

ABSTRACT: The numbers of red urchins, *Strongylocentrotus franciscanus*, within four experimental plots on the seaward border of a kelp forest were monitored for 1974-1977. Following the mass mortality and subsequent cropping of the population by otters a dramatic increase was noted in the expansion of four brown algae. *Macrocystis pyrifera*, *Pteryogophora californica*, *Laminaria dentigera* and *Nereocystis leutkeana* all became established in the barren area. *Cystocercia osmurdeacea*, which previously inhabited the region failed to become re-established in the area. Within one year, *Macrocystis* had outcarpeted all other species forming a dense monospecific stand of up to 50 plants/10m<sup>2</sup>. Experimental removal of *Macrocystis* suggested light limited growth of brown and red understory species.

Localized mass mortality of red sea urchins,

*Strongylocentrotus franciscanus*, near Santa Cruz, California.

AUTHOR(S): Pearse, J. S., P. P. Costa, M. B. Yellin, and C. R. Agegian.

YEAR: 1977.

SOURCE: Fish. Bull. 75(3):645-647.

KEYWORDS: Sea urchins, *Strongylocentrotus* spp., mortality, fishery, feeding.

ABSTRACT: Mass mortalities of red sea urchins, *Strongylocentrotus franciscanus*, off Point Loma (1970), Ano Nuevo Island (1976) and Point Santa Cruz (1976) were reviewed. The deceased urchins were characterized by tests denuded of spines and epidermis. Lesions were also apparent. The density of urchins off Point Santa Cruz, dropped from 55-65/10m<sup>2</sup>, at the edge of the kelp forest, to 20-30/10m<sup>2</sup> and from 20/10m<sup>2</sup>, approximately 50 m from the edge of the kelp forest, to 1-2/10m<sup>2</sup>. Approximately 9000 urchins were lost inshore and 5000 lost offshore. Within 6 months, small healthy populations were present. The results of the survey suggest localized mortalities could be important as a means to minimize grazing; however, these mortalities might also be a threat to developing urchin fisheries.

Olla.

Effects of oiled sediment on predation on the littleneck clam,

*Protothaca staminea*, by the Dungeness crab, *Cancer magister*.

AUTHOR(S): Pearson, W. H., D. L. Woodruff, P. C. Sugarman, and B. L.

YEAR: 1981.

SOURCE: Estuar. Coast. & Shelf Sci. 13(4):445-454.

KEYWORDS: Cancer magister, market crab, feeding.

ABSTRACT: Predation by Dungeness crabs, Cancer magister, on littleneck clams, Protothaca staminea, living in oiled sediments was examined in laboratory and field experiments. The field experiments, lasting 13 and 29 days, showed crabs consume more clams from oiled than clean sediment. The crabs unearth more than they ate and opened large (greater than 45 mm) clams differently than small (less than 45 mm) ones. Clams were found shallower in the oiled sand. Subsequent laboratory tests suggested clams burrowed slower in oiled substrate and this explained the increased predation (due to the accessibility to crabs) in shallow substrate.

and B. J. Higgins.

Effects of sediment contamination on predation of littleneck clams, Protothaca staminea by Dungeness crabs, Cancer magister.

AUTHOR(S): Pearson, W. H., D. L. Woodruff, S. E. Miller, P. C. Sugarman, YEAR: 1981.

SOURCE: Estuaries 4(3):248.

KEYWORDS: Market crab, Cancer magister, feeding, contaminant susceptibility.

ABSTRACT: Field experiments examined how sediment contaminated with crude oil and chemically-dispersed oil influenced predation on littleneck clams, Protothaca staminea, by Dungeness crabs, Cancer magister. In field enclosures crabs consumed twice the numbers and weights of clams from contaminated than clean sand. Clams were found at shallower depths in contaminated than clean sand irrespective of the presence of crabs. A laboratory experiment examining predation rates on clams buried different depths in sand indicated that shallow burial accounted for most of the higher consumption of clams from oiled sand. Also, clams burrowed slower into oiled than clean sand. Oil-induced changes in clam behavior increased the accessibility of clams to crabs and thereby led to the increased predation observed.

Thresholds for detection and feeding-behavior in the Dungeness crab, Cancer magister (Dana).

AUTHOR(S): Pearson, W. H., P. C. Sugarman, and D. L. Woodruff. YEAR: 1979.

SOURCE: Jour. Experimental Mar. Biol. Ecol. 39(1):65-78.

KEYWORDS: Market crab, Cancer magister, feeding, behavior.

ABSTRACT: The feeding behavior of Dungeness crabs, Cancer magister, was observed in the laboratory and in the field. Antennular flicking rate and substratum probing with the chelate were recognized as feeding behaviors. Chemosensory ability was also measured by presenting various concentrations of an extract of littleneck clam, Protothaca staminea, to the water and observing changes in behavior of the crabs. At the highest levels tested, nearly 100% of the crabs detected the extract. A threshold concentration (where 50% of the crabs detected the extract) of  $4.8 \times 10^{-10}$  g/l was calculated. However, feeding responses were not noted below  $10^{-6}$  g/l of extract, with a feeding threshold of  $10^{-1}$  g/l. The results were compared with studies involving other crustaceans and were quite similar to thresholds ( $10^{-1}$  to  $10^{-3}$  g/l) observed in blue crabs, Callinectes sapidus.

Detection of petroleum hydrocarbons by the Dungeness crab,  
Cancer magister.

AUTHOR(S): Pearson, W. H., P. C. Sugarman, and J. W. Blaylock.

YEAR: 1980.

SOURCE: Fish. Bull. 78(3):821-826.

KEYWORDS: Market crab, Cancer magister, physiology, contaminant  
susceptibility, behavior.

ABSTRACT: The ability of the Dungeness crab to sense the presence of petroleum products was tested in the laboratory. Water soluble fractions (WSF) of Prudhoe Bay crude oil and the petroleum hydrocarbon naphthalene were used as test substances. Exposed to solutions of different concentrations of these substances, crabs demonstrated different degrees of response. Using changes in orientation or flicking rate of the antennae as sensory behavioral responses, the crab showed a significant response to increasing concentrations of WSF, but variable and nonsignificant response to naphthalene. The authors speculate that this may be due to the small percentage of naphthalene in the WSF and they may be detecting other hydrocarbons, or a melange of them. It is also speculated that naphthalene may have a sensory blocking function at higher concentrations, resulting in the unusual variability in detection. The 50% detection threshold for WSF was 0.0004 mg/l.

Olla.

Impairment of chemosensory food detection in the Dungeness  
crab, Cancer magister, by petroleum hydrocarbons.

AUTHOR(S): Pearson, W. H., P. C. Sugarman, D. L. Woodruff, and B. L.

YEAR: 1980.

SOURCE: Amer. Zool. 20(4):923.

KEYWORDS: Market crab, Cancer magister, physiology, contaminant  
susceptibility, behavior.

ABSTRACT: This reference is not an actual paper, but a symposial abstract from the annual meeting of the American Society of Zoologists, and other societies. Behavior of Dungeness crab (Cancer magister) when exposed to clam extract was altered after a 24-hr exposure to petroleum concentrations typical of an oil spill. Typical antennular behavior indicating detection of food was significantly reduced, however, within one hour after return to clean water, the antennular response recovered. This rapid recovery suggests that the petroleum caused either light anesthesia of the chemosensory apparatus, or that it masked the odor of the food. Petroleum does impair Dungeness crab chemosensory ability and could cause crabs some difficulty in finding food.

Distribution of intertidal and subtidal fishes of northern  
British Columbia and southeastern Alaska.

AUTHOR(S): Peden, A. E., and D. E. Wilson.

YEAR: 1976.

SOURCE: Syesis 9:221-248.

KEYWORDS: Sebastes miniatus, vermillion rockfish, community,  
distribution.

ABSTRACT: Species encountered during surveys of shallow nearshore habitats throughout northern British Columbia and southeastern

Alaska were described. Includes many northern and southern range extensions were included. The northern range limit of *Sebastes miniatus* was extended to Gillen Harbour, British Columbia (52°58'48''N, 129°34'54''W).

Movements and growth of petrale sole (*Eopsetta jordani*) tagged off Washington and southwest Vancouver Island.

AUTHOR(S): Pederson, M. G.

YEAR: 1975.

SOURCE: Jour. Fish. Res. Bd. Canada 32(11):2169-2177.

KEYWORDS: *Eopsetta jordani*, petrale sole, growth, distribution, migration.

ABSTRACT: The Petrale sole (*Eopsetta jordani*) are commercially fished from Santa Barbara, California to Hecate Strait, British Columbia. The fish spawn in the same deepwater area each winter and migrate to the north and inshore during the summer. Tag return data showed that all summer recoveries occurred in depths less than 183 m with 80% occurring between 55 and 110 m. The majority of winter recaptures were from depths between 55 and 110 m. Fish tagged during the spawning season were larger than fish tagged during summer, and the recovery rate for males was significantly higher than for females. Growth estimates produced an average maximum size (L) of 48.9 cm and a growth coefficient (K) of .14. Ninety-seven percent of the offshore winter recoveries on deepwater spawning grounds occurred in the area of release. Tag data suggests the sole "homes" to the same area each year. Spawners from Cape Flattery Spit Deep and Willapa Deep make up 95% of the summer inshore fishery for Petrale sole in Washington and south Vancouver Island.

Economic aspects of the 1967 offshore Pacific hake fishery.

AUTHOR(S): Pereyra, W. T., and J. A. Richards.

YEAR: 1970.

SOURCE: U. S. Fish Wildl. Serv. Cir. 332:103-120.

KEYWORDS: Pacific hake, *Merluccius productus*, economics, fishery, fishing gear.

ABSTRACT: The purpose of this study was to provide economic information for vessel owners, fishermen, and fish processors which they would need to develop a feasible fishery for Pacific hake (*Merluccius productus*). Included in this study is information on cost and revenue aspects of the 1967 Pacific hake fishery. Also of interest was the relative economic success of different sized vessels and their fishing gear. The study was conducted by chartering 10 vessels to participate in an experimental fish meal processing venture. If the government assistance is neglected, four vessels showed a loss in the operation, one would have broken even, and four would have made return, though the ships were able to all make large hauls. The larger ships on the average did better economically than did the smaller ships.

The rock shrimp genus *Sicyonia* (Crustacea: Decapoda: Penaeoidea) in the eastern Pacific.

AUTHOR(S): Perez Farfante, I.

YEAR: 1985.

SOURCE: Fish. Bull. 83(1):1-80.

KEYWORDS: Ridgeback prawn, *Sicyonia ingentis*, life history, distribution, fishery.

ABSTRACT: A key to the 12 species of rock shrimp, *Sicyonia* spp., found between California and Peru was redefined and presented. Illustrations of all species, morphometrics, ranges, and life histories were discussed. Range extensions were noted for six of the species. Commercial importance varied, depending on the geographic locale, from incidental catches to target species. In addition to a complete synonymy, the distinguishing characteristics segregating members of the genus *Sicyonia* were thoroughly summarized.

Experimental management of Oregon coho salmon (*Oncorhynchus kisutch*) - Designing for yield of information.

AUTHOR(S): Peterman, R. M., and R. D. Routledge.

YEAR: 1983.

SOURCE: Jour. Fish. Aquat. Sci. Canada 40(8):1212-1223.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, fishery.

ABSTRACT: To determine the validity of a smolt-to-adult linear relationship hypothesis, a Monte Carlo simulation was used. Variability in survival of the Oregon coho salmon, *Oncorhynchus kisutch*, was controlled by differing smolt abundances and duration of the experiments. A minimum of 88 million smolts, released over 3 years, was found to produce a powerful test of the linearity hypothesis. To further reduce sources of human variability, rearing and release procedures were proposed for standardization. Increased environmental data collection, including prey, predators, competitors and oceanic conditions would increase interpretive understanding of stock returns.

Population characteristics of juvenile coho salmon (*Oncorhynchus kisutch*) overwintering in riverine ponds.

AUTHOR(S): Peterson, N. P.

YEAR: 1982.

SOURCE: Jour. Fish. Aquat. Sci. Canada 39:1303-1307.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, habitat, growth, feeding.

ABSTRACT: This study suggests that pond morphometry can have a great influence on juvenile coho salmon growth and mortality. From deep ponds which were examined overall survival was 78%, but average fish weight increase was only 49%. From shallow ponds the survival was only 28% but the weight increase was 94%. The deeper ponds provide greater protection from predation but offer less food for growth, and the shallow ponds offer more food but less protection. Diets of resident coho were examined and the variation between ponds compared. The authors suggest that manipulation of pond morphometrics can enhance maximal survival and growth.

Upwelling indices and annual catches of Dungeness crab, *Cancer magister*, along the west coast of the United States.

AUTHOR(S): Peterson, W. T.

YEAR: 1973.

SOURCE: Fish. Bull. 71(3): 902-910.

KEYWORDS: Market crab, *Cancer magister*, fishery, population trends, seasonality, distribution.

ABSTRACT: The relationship between upwelling and crab catches off the coast of northern California, Oregon and Washington was described. Scatter diagrams of upwelling vs. crab catch were prepared for lag times of 1/2 to 4 1/2 years for Washington and



Oregon, and 1/2 to 3 1/2 years for northern California. The results of statistical tests indicate that crab catch and upwelling are related. It appears that summers of strong upwelling generally produce a good crab catch 1 1/2 years later along the coasts of northern California and Oregon. Summers of strong upwelling along the coast of Washington always produce a good crab catch the following year. Conversely, weak upwelling results in poor crab catches.

Life history studies on ten species of rockfish (Genus *Sebastes*).

AUTHOR(S): Phillips, J. B.

YEAR: 1964.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 126.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *S. goodei*, chilipepper rockfish, *S. miniatus*, vermillion rockfish, *S. entomelas*, widow rockfish, age, growth, length-weight, feeding, reproduction, life, history, fishery, regulations, distribution.

ABSTRACT: Assessment of the major life history parameters (age, weight/length relationships, age of maturation, fecundity, spawning periodicity, feeding habits and distribution) of the ten most commercially important rockfishes of California is included. A short description of the importance of each species to the commercial catch and the current fishery regulations is given. Species specific accounts of the major life history parameters are given for *Sebastes entomelas*, *S. goodei*, *S. miniatus*, and *S. paucispinis* among others. Weight/length relationships were based on combined sexes and did not correct for state of maturity or stomach fullness. Scales and otoliths were used to determine fish age. Age/length curves were fitted to the exponential equation and were tested for agreement with 1 year old individuals collected from the field. Lengths of 1 year olds collected from the field corresponded closely with back-calculated lengths from the age/length equations for *S. paucispinis* and *S. goodei*. Growth rates indicate that males grow slightly slower than females. Age/length data were fitted to the von Bertalanffy growth equation. Spawning of larvae occurs during the winter (mid-November to mid-March) for most species. In general, the largest individuals of a species ripen and spawn earlier than smaller conspecifics. Adult *S. entomelas*, *S. goodei*, *S. miniatus* and *S. paucispinis* feed on macroplankton and small fishes.

A review of the lingcod, *Ophiodon elongatus*.

AUTHOR(S): Phillips, J. B.

YEAR: 1959.

SOURCE: Calif. Fish Game 45(1):19-27.

KEYWORDS: Lingcod, *Ophiodon elongatus*, life history, fishery, fishing gear, regulations, distribution, age, growth, length/weight, feeding, reproduction, groundfish.

ABSTRACT: The commercial fishery catch of lingcod, (*Ophiodon elongatus*), is reported from 1916-1935 for California, and from 1936-1957 for the entire Pacific coast. Also detailed is the California party boat angler catch from 1947-1957 compared with the total numbers of other fish caught. The gear used to catch lingcod is briefly discussed, as are the product potentials of the fish. Lingcod are benthic fishes, generally found around rocky areas, kelp beds,

and reefs. They are most abundant at 60 fathoms, though they have been reported as deep as 200 fathoms off British Columbia. Tagging studies indicate that lingcod is residential as an adult, and any movements it makes are more or less random (i.e. no migrations). Adult lingcod are omnivorous, though they are primarily piscivorous; young feed upon small crustaceans such as shrimp. Male and female lingcod are usually mature at 23 inches. Spawning occurs from December to mid-March, eggs are fertilized externally, and being adhesive form large masses in protective crevices; males guard the nests. Fecundity of larger females can be as high as one-half million eggs in a season. Analysis of vertebral rings demonstrates a growth curve ranging up to 14 years of age for males, and up to 16 years of age for females. As of 1957, there were no commercial regulations on the lingcod fishery, though sport fishermen are restricted to 10 lingcod per day.

A review of the rockfishes of California (Family Scorpaenidae).

AUTHOR(S): Phillips, J. B.

YEAR: 1957.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 104:158.

KEYWORDS: Population trends, fishery, groundfish, *Sebastes* spp.

ABSTRACT: The rockfish and scorpion fish of California (Family Scorpaenidae) were discussed. A taxonomic key to the 49 species of Sebastodes, 2 species of Sebastolobus and 1 species of Scorpaena was presented. The commercial importance of the species were considered. Rockfish landings have increased from 1-2 million pounds in 1900 to over 13 million pounds annually. A peak catch of 60 million pounds was recorded in 1945. Party boat records indicated an increase in fish caught from 9% in 1947 to 55% by 1955. Variations in fin ray counts, color and body proportion were noted between juveniles and adults of the same species. The range, depth, body color and meristics as well as common names of each species were presented. A typical specimen included fish with color abnormalities, meristic abnormalities and at least 3 hybrid species.

The market crab of California and its close relatives.

AUTHOR(S): Phillips, J. B.

YEAR: 1939.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 25(1):18-29.

KEYWORDS: Cancer magister, market crab, length/weight, distribution.

ABSTRACT: A general description of the market crab, *Cancer magister*, and four related species: *C. gracilis*, *C. antennarius*, *C. productus*, *C. anthonyi* is included. Each species is described in terms of distinguishing characteristics, color, size, and distribution. There is also a brief discussion of molting of crabs and distinction between male and female crabs.

The sablefish fishery of California, Part II: Catch analysis.

AUTHOR(S): Phillips, J. B., and S. Imamura.

YEAR: 1954.

SOURCE: Pac. Mar. Fish. Comm., Portland, Oregon, Bull. 3:23-37.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, fishery, distribution, fishing gear.

ABSTRACT: The sablefish fishery catch off California is analyzed for the

period 1941 to 1952. Ninety-five percent of the fishery is located north of and including Monterey. The landings from the Eureka, Fort Bragg and Monterey areas were broken down several different ways: annual pounds caught by longline versus otter trawl for each region; the percent of the total annual landings that occurred each month during 1941-1952; and annual number of boats, number of deliveries, and average pounds per delivery for both the longline and otter trawl fleets. During the post-war years (1946-1952), there was an inverse correlation between the (high) total United States cold storage holdings and the (low) California catch. Annual fluctuations in the catch appear to be associated with demand and not because of a depleted condition of the stocks.

Descriptions of postlarval and juvenile bonito from the eastern Pacific Ocean.

AUTHOR(S): Pinkas, L.

YEAR: 1961.

SOURCE: Calif. Fish Game 47(2):175-188.

KEYWORDS: Pacific bonito, *Sarda chiliensis*, larvae, physiology, length/weight.

ABSTRACT: Postlarvae and juvenile Pacific bonito, *Sarda chiliensis*, were collected off Baja California. The individuals ranged from 16.7 to 100.9 mm. Postlarvae were identified based on several morphometric characteristics including vertebrae number, teeth and gill rakers. The presence of all black pelvic and dorsal fins distinguished the bonito from other larval scombrids. In addition, 4 or 5 spines above the eye of postlarval bonito also characterized *Sarda chiliensis*. Illustrations of the larvae were included.

Food habits study.

AUTHOR(S): Pinkas, L.

YEAR: 1971.

SOURCE: Pages 5 to 10 in L. Pinkas, M. S. Oliphant and I. L. K. Iverson (eds.), Food habits of albacore, the bluefin tuna, and bonito in California waters. Calif. Dep. Fish. Game, Fish Bull. 152.

KEYWORDS: Feeding, mortality, northern anchovy, *Engraulis mordax*, albacore,

*Thunnus alalunga*, bonito, *Sarda chiliensis*.

ABSTRACT: This introduction to the food habits of albacore, the bluefin tuna, and bonito in California waters details the purpose of the study, the methods used, and explains the index of relative importance (IRI) which can be defined as  $(N + V)F = IRI$ ; where N = numerical percentage, V = volumetric percentage and F = frequency of occurrence percentage. Results of this food habit study detail the relative importance of organisms used for food by the study species during 1968 and 1969.

Food habits of albacore, bluefin tuna, and bonito in California waters.

AUTHOR(S): Pinkas, L., M. S. Oliphant, and I. L. K. Iverson.

YEAR: 1971.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 152 105 pp.

KEYWORDS: Albacore, Pacific bonito, *Thunnus alalunga*, *sarda chiliensis*, feeding, fishery, distribution.

ABSTRACT: Stomach contents from three pelagic species (albacore, bluefin tuna, and bonito) occurring along the southern California coast were analyzed for the relative importance of their food items. An Index of Relative Importance (IRI) value based on the relationship between number, volume and frequency of occurrence was determined for the prey species identified. The results show that, although there is some variation in diet between the three predator species, the northern anchovy is the dominate prey species in all their diets.

The spawning biomass of the northern anchovy.

AUTHOR(S): Piquelle, S. J., and R. P. Hewitt.

YEAR: 1984.

SOURCE: CalCOFI Rep. 25:16-27.

KEYWORDS: Northern anchovy, *Engraulis mordax*, reproduction, spawning, population trends.

ABSTRACT: A larval and egg census of northern anchovy, *Engraulis mordax* was used to estimate spawning biomass. The larval census estimate is the basis for calculating the California anchovy fishery optimum yield for 1983-84. Anchovy eggs and larvae, from 850 stations, were collected using a 25 cm diameter net of 150 micron mesh and a 15m<sup>2</sup> midwater trawl with a 2 mm mesh liner. The spawning biomass estimated from the larval census of the northern anchovy central subpopulation is 1,405,000 MT. A spawning biomass of 652,000 MT was estimated using the egg production technique, with a standard error of 137,000 MT. The central subpopulation of northern anchovy was distributed more northward and offshore than in previous years. The egg production and larval abundance method produced spawning biomass estimates that differed greatly. The egg production method incorporates variability in the proportionality constant between larval abundance and spawning biomass. The egg production method, therefore, seems to be a more accurate and efficient estimate of anchovy biomass than the larval census method.

The northern anchovy spawning biomass for the 1982-83 California fishing season.

AUTHOR(S): Piquelle, S. J., and R. P. Hewitt.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:16-28.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, larvae, mortality.

ABSTRACT: An egg production method of calculating biomass of the northern anchovy, *Engraulis mordax*, is used for the first time. An equivalent larval census estimate is compared by measuring larval mortality and projecting the number of larvae resulting from the measured egg production. Catches of adult fish were between Monterey and San Francisco, along the northern Baja California coast, and in the Southern California Bight, with the heaviest concentrations in the last area. Egg production estimate uses the equation  $B = \frac{PoA(kw)}{(RFS)}$ , where B=spawning biomass (mt), Po=daily egg production, W=average weight of mature females, R=sex ration (fraction of females), F=batch fecundity, S=fraction of mature females spawning per day, A=total area of survey, and k=conversion factor for grams to metric tons. Estimates of Po, W, F, S, and R are 3.023 eggs per day per 0.05 m<sup>2</sup>, 18,83 grams, 10845, 0.120, and 0.472, respectively. The

resulting estimate of spawning biomass is 378,000 mt, with 95% confidence intervals of +/-194,000 mt. In 1982 the equivalent larval census estimate of spawning biomass was  $1.866 \times 10^6$  mt, nearly five times the egg production estimate. Variation in egg survival and inaccuracy in estimating the average proportionality between the larval census and the spawning biomass are the most likely causes of the discrepancy between estimates. The egg production method is considered more precise than the larval census method.

The great abalone plant - Cooperation between divers - Amateur and professional.

AUTHOR(S): Pleschner, D. B.

YEAR: 1984.

SOURCE: Oceans 17(5):27-31.

KEYWORDS: Abalone, *Haliotis* sp., growth, spawning, life history.

ABSTRACT: The red abalone, *Haliotis rufescens*, was the subject of a cooperative seeding effort by commercial fishermen and sport divers. 9,000 yearling (20 mm) were seeded on reefs off San Miguel and the Channel Islands, southern California. The history of hatcheries, in America and Japan, was discussed. In addition, research and larval settlement, metamorphosis, growth rates and spawning were addressed. The potential for mariculture of abalone and the need for reseedling was also considered. Finally, the conflict between shell fisheries and other support groups was detailed.

The feeding habits and distribution of juvenile-small adult California halibut (*Paralichthys californicus*) in coastal waters off northern San Diego County.

AUTHOR(S): Plummer, K. M., E. E. DeMartini and D. A. Roberts.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:194-201.

KEYWORDS: California halibut, *Paralichthys californicus*, distribution, feeding.

ABSTRACT: A comprehensive food habits analysis in terms of body size, depth of capture, seasonal variation, and their interrelationships is presented for the California halibut (*Paralichthys californicus*), a species of major economic importance in California. Feeding was related to the abundance of major prey items. Northern anchovy and mysids were ranked as the top two prey types, comprising 82% of all prey by weight. Halibut body size and depth of capture are related to the frequency of occurrence (FO) of these two prey items. Large juvenile and small adults (>300 mm SL), small juvenile (<245 mm SL), and intermediate fish fed primarily on northern anchovy, mysids and larval fish, and both anchovy and mysids, respectively. The relative frequency of the prey types is primarily dependent on the size of halibut, regardless of depth. The % FO of anchovies and mysids in the stomachs of juvenile-small adult halibut is independent of depth, while the diets of small juveniles and larger adults is depth dependent. Juvenile-small adults switch to a more piscivorous diet at lengths corresponding to male maturation. Differences in the diets of juvenile and small adults may be due to prey selection. Small juveniles inhabit shallow coastal waters where their preferred prey, mysids, are more abundant. Fish less than 10 cm SL reside primarily in embayments.

This nursery ground may be essential during the early juvenile stage.

A description of laboratory-reared zoeae of *Cancer magister* Dana, and megalopae taken under natural conditions (Decapoda Brachyura).

AUTHOR(S): Poole, R. L.

YEAR: 1966.

SOURCE: *Crustaceana* 11(2):83-97

KEYWORDS: *Cancer magister*, market crab, larvae, reproduction, growth, early life history.

ABSTRACT: The Dungeness crab, *Cancer magister*, is the most economically important crab species, annually producing 35 million lbs. on the Pacific coast with a value of \$5.5 million to fishermen. This paper presents a detailed description of all larval stages of the crab. Larvae emerge from eggs as first-stage zoeae, with a total of five zoeal stages and one megalope to complete larval development. Zoea stages are described in terms of morphology, including cephalothorax spines, eyes, abdomen segments, telson, antenna, mandible, spinal arrangement on the endopodite and maxillae, maxillipeds, and chromatophore patterns. Two individual megalops are also described. Development occurred in salinities from 26 to 30 ‰ at a temperature of 51 deg F. The first, second, third, fourth, and fifth zoeal stages lasted 18.2, 11.2, 13.6, 14.6, and 22.4 days, respectively. The total time of development from egg to first crab instar was 111 days, which is slightly less than that found under natural conditions (128 to 158 days in central California). The highest mortality was found during the first zoeal stage.

Regulations and the market crab fishery.

AUTHOR(S): Poole, R., and D. Gotshall.

YEAR: 1965.

SOURCE: *Calif. Fish Game, Outdoor California* 26(9):6-7.

KEYWORDS: Market crab, *Cancer magister*, fishery, regulations, growth, migration, spawning.

ABSTRACT: The purpose of this article is to report on the regulations of the market crab (*Cancer magister*). Statewide crab landings fluctuate seasonally and reached an all time high of 19 million lbs in the 1956-57 season, followed by a record low of 2 million lbs in 1963-64. Due to recent low landings from 1960-65, the present regulations need to be examined critically. The minimum size of market crabs has gone from 6 inches in 1903 to 7 inches in 1911. A change in the methods used to measure crabs makes the former 7-inch measurement equivalent to a 6.25 inch crab. Based on current knowledge of the maturity, growth, mating activity and age of the market crab, the 6.25 inch size limit appears to be adequate protection for the resource. Only male crabs are harvested. Male crabs mature when 4 inches wide and 1.5 years old. Based on growth rate information, it appears that most male crabs go through at least one mating season prior to being harvested. The male spawning stock consists of all the sublegals and any legal males that escape harvesting. Only a few males are needed to fertilize a large number of females because of their polygamous behavior and a long mating season (March to July). Since few females attain widths exceeding 6.25 inches and 98% of the mature female crabs examined had been fertilized, it appears

that the current size regulation is adequate protection for the resource even though nearly all legal-sized males are taken. Preliminary tagging results indicate that crabs may migrate out of Humboldt Bay into ocean waters as they attain legal size. It also appears that they may migrate north or south of the Bay, and this migration is influenced by the direction of the inshore current.

Larval anchovy (*Engraulis mordax*) drift in the California current: Results of a simulation model.

AUTHOR(S): Power, J. H.

YEAR: 1983.

SOURCE: Southwest Fisheries Center, NMFS, NOAA, Admin. Rep. LJ-83-23.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, distribution.

ABSTRACT: To evaluate the extent of drift of northern anchovy, *Engraulis mordax*, larvae, a simulation model was developed. A graphical representation of results is presented for the California Current. A manuscript with a related discussion is available from the La Jolla Laboratory of the Southwest Fisheries Center. The model was based upon a finite-difference approximation to the two-dimensional form of the advection-diffusion equation, with no mortality or input of eggs and larvae after the initiation of drift. Simulations had a time step of one day and were ended at 30 days. Larvae were permitted to be advected out of the modeled region and into the Santa Barbara channel south of Point Conception, while transport across islands was not permitted. Geostrophic currents, Ekman currents, and final currents were computed. The effects of enhanced upwelling was evaluated. The overall 30-day larval distributions were summarized.

Tag retention of spot prawn, *Pandalus platyceros*, injected with coded wire tags.

AUTHOR(S): Prentice, E. F., and J. E. Rensel.

YEAR: 1977.

SOURCE: Jour. Fish. Res. Canada 34:2199-2203.

KEYWORDS: Growth, mortality, *Pandalus platyceros*, spot prawn, growth, mortality.

ABSTRACT: The growth and survival of juvenile spot prawn, *Pandalus platyceros* (15-22.5 mm carapace), subjected to tagging was observed. Three treatments evaluated included tagged prawns, wounded prawns and controls. Tagging was accomplished by injecting Besgman-Jefferts coded wire tags in the thoracic sinet. Wounded prawns were subjected to tag insertion needles without tags. No significant difference was noted in survival between the three treatments. Mortality was attributed to cannibalism and poor water quality. Growth rates for the three treatments were also similar. The average number of molts over 180 days was 2.71, 2.76 and 2.63 for the control, wounded and tagged treatments, respectively. The behavior of the larvae was normal and unvarying between the treatments. Tag retention during the experiment averaged 95% and was improved with modifications to the insertion needle.

Laboratory rearing of spot shrimp larvae (*Pandalus platyceros*) and descriptions of stages.

AUTHOR(S): Price, V. A., and K. K. Chew.

YEAR: 1972.

SOURCE: Jour. Fish Res. Board Canada 29(4):413-422.

KEYWORDS: Spot prawn, *Pandalus platyceros*.

ABSTRACT: The purpose of this paper is to report the results of a study undertaken to observe and identify the morphological stages of spot shrimp, *Pandalus platyceros*, larvae. Detached eggs and eggs from ovigerous females caught in Dabob Bay of Hood Canal, Washington were cultured in the laboratory for observation. Nine stages are identified and described in detail. Illustrations of these various larvae morphological stages are also presented.

Food of the copper rockfish, *Sebastes caurinus* Richardson, associated with an artificial reef in south Humboldt Bay, California.

AUTHOR(S): Prince, E. D., and D. W. Gotshall.

YEAR: 1976.

SOURCE: Calif. Fish Game 62(4):274-285.

KEYWORDS: Market crab, *Cancer magister*, northern anchovy, *Engraulis mordax*, artificial reef, feeding, *Sebastes* spp., age.

ABSTRACT: Feeding of the copper rockfish (*Sebastes caurinus*) from an artificial reef are reported in relation to fish age, season, and time of day. Six different phyla were represented in the diet with crustaceans making up the largest portion. Dungeness crab (*Cancer magister*) was most important followed by gammarid amphipods and the spotted bay shrimp (*Crangon nigromaculata*). Fishes were the second most important food group with the northern anchovy (*Engraulis mordax*) comprising the largest portion. Young-of-the-year rockfish preferred small size food organisms, while fishes played an increasing role in the diet of older fish. Feeding was more on non-reef oriented food organisms. The highest percentage of empty stomachs was found in the winter and early spring. The proportion of empty stomachs was similar during both day and night caught fish. The food habits of the copper rockfish can be categorized as opportunistic carnivore, with crustaceans being the most important food group. Larger fish eat larger sized and greater varieties of food organisms than smaller fish. Feeding was at least at the same level at night as during the daylight hours.

Cost of sustained and burst swimming to juvenile coho salmon (*Oncorhynchus kisutch*).

AUTHOR(S): Puckett, K. J., and L. M. Dill.

YEAR: 1984.

SOURCE: Jour. Fish. Aquat. Sci. Canada 41(11):1546-1551.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, behavior.

ABSTRACT: Juvenile coho salmon, *Oncorhynchus kisutch*, were observed in a respirometer (at 15 deg. C) to determine oxygen consumption at sustained and burst swimming speeds. One body length per second was approximately equal to 4.5 cm per second. The oxygen consumption, at sustained swimming speeds, was fit to an equation:  $\log \text{ oxygen consumption} = 2.2 + 0.13 (\text{body lengths per second})$ . At burst swimming speeds of 9 body lengths per second a metabolic rate of 38,000 mg O<sub>2</sub>/kg/hr was recorded. This value was over 40 times greater than the sustained swimming speed metabolic rate. The data were very similar to results obtained from sockeye salmon.

Observations on the food and biology of the kelp bass,



*Paralabrax clathratus*, with notes on its sport fishery at San Diego, California.

AUTHOR(S): Quast, J. C.

YEAR: 1968.

SOURCE: Pages 81-108 in: W. J. North, C. L. Hubbs (eds.). Utilization of kelp-bed resources in southern California. Calif. Dept. Fish Game, Fish Bull. 139.

KEYWORDS: *Paralabrax clathratus*, kelp bass, distribution, habitat, fishery, feeding, behavior, weight/length, spawning, maturity.

ABSTRACT: A description of the sport fishery, behavior, and diet of *P. clathratus* is given based on underwater observations and samples from the sport fishery. Diets are based on 1700 samples collected between August 1958 and July 1959. The majority (>75%) of samples are from party boats. Two-thirds of the sport fishing boat samples were from kelp beds at Point Loma, San Diego. Nearly all samples collected by spearing were taken from kelp beds at La Jolla, San Diego. Food items from the digestive tracts were analyzed for frequency of occurrence by monthly samples. Diet data are presented separately for 100-199 mm, 200-299 mm, 300-399 mm, and >400 mm individuals. The giant kelp fish, *Heterosticus rostratus*, was the most important fish consumed by all size classes. Fecundity estimates were based on volumetric displacement of the gonads. State of maturity was determined for the four size classes described above. A weight/length relationship is also given. *P. clathratus* ranges in depth from the surface to approximately 130 feet or more. Juveniles are abundant in the surf zone but rare in the intertidal. *P. clathratus* rely on structure of the giant kelp (*Macrocystis pyrifera*) for cover. No size-segregation with depth was obvious in kelp beds since adults and juveniles occur throughout the water column. Aggressive behavior between individuals was not observed in the field.

Estimates of the populations and the standing crop of fishes.

AUTHOR(S): Quast, J. C.

YEAR: 1968.

SOURCE: Pages 57-79 in: W. J. North, C. L. Hubbs (eds.). Utilization of kelp-bed resources in southern California. Calif. Dept. Fish Game, Fish Bull. 139.

KEYWORDS: *Paralabrax clathratus*, kelp bass, habitat, distribution, length/weight, *Engraulis mordax*, northern anchovy, *Trachurus symmetricus*, jack mackerel.

ABSTRACT: The standing crop of fishes associated with kelp forests off San Diego, California and northern Baja California, Mexico was estimated with two methods: 1) visual censuses of underwater belt transects and 2) treatment with rotenone of a 0.55 acre area enclosed by a 0.75 inch mesh wall net. Estimated densities of *P. clathratus* from a La Jolla kelp forest averaged around 1.2 fish per 100 m transect which was calculated to be 20.0 per acre. *P. clathratus* density estimates were examined with respect to kelp abundance and local fishing pressure. Presence or absence of giant kelp, *Macrocystis pyrifera*, had little effect on *P. clathratus* densities when fishing pressure was light or absent. Kelp abundance was positively related to *P. clathratus* densities in areas of moderate fishing pressure. *M. pyrifera* is not necessary for the maintenance of dense *P. clathratus* populations composed of large fish. However, indirect evidence suggests that

*P. clathratus* prefer stands of *M. pyrifera* to sites where *M. pyrifera* is absent.

Observations on the food of the kelp-bed fishes.

AUTHOR(S): Quast, J. C.

YEAR: 1968.

SOURCE: Pages 109-142 in: W. J. North, C. L. Hubbs (eds.). Utilization of kelp-bed resources in southern California. Calif. Dept. Fish Game, Fish Bull. 139.

KEYWORDS: California halibut, *Paralichthys californicus*, kelp bass, *Paralabrax clathratus*, white seabass, *Atractoscion nobilis*, vermillion rockfish, *Sebastes miniatus*, lingcod, *Ophiodon elongatus*, food habits, habitat, age.

ABSTRACT: Food habits of 45 species of kelp-bed fishes were evaluated. The information was based on previously published data and information from the Kelp Program research. A summary of the diets of some of the species follows. California halibut were almost completely piscivorous, eating, for example, engraulids, atherinids, and small flatfish. Young kelp bass fed on demersal crustaceans, but with growth they shifted to fishes and cephalopods. Information on the food habits of white seabass is limited but previous studies found squid, small fish (e.g. anchovies) and Pacific mackerel in their stomachs. Specimens of vermillion rockfish collected approximately 100 feet away from kelp beds contained squid as the most important species. Young lingcod appear to feed on shrimp and other crustaceans, while adults appear to mainly eat fish and squid.

Fish fauna of the rocky inshore zone.

AUTHOR(S): Quast, J. C.

YEAR: 1968.

SOURCE: Pages 35-55 in: W. J. North, C. L. Hubbs (eds.). Utilization of kelp-bed resources in southern California. Calif. Dept. Fish Game, Fish Bull. 139.

KEYWORDS: *Paralabrax clathratus*, kelp bass, yellowtail, lingcod, jack mackerel, vermillion rockfish, northern anchovy, *Seriola lalandei*, *Ophiodon elongatus*, *Trachurus symmetricus*, *Sebastes miniatus*, *Engraulis mordax*, community, habitat, distribution.

ABSTRACT: Describes the species composition of fishes associated with *Macrocystis pyrifera*, kelp beds and the geographic and bathymetric ranges of these species. *P. clathratus* was the most commonly encountered fish species observed during surveys of kelp forests in the San Diego area.

Status of California Dover sole stocks.

AUTHOR(S): Quirillo, L. F.

YEAR: 1985.

SOURCE: Appendix F from Pacific Fishery Management Council - Status of the Pacific Groundfish Fishery through 1985 and Recommended Acceptable Biological catches for 1986.

KEYWORDS: Dover sole, *Microstomus productus*, fishery, regulations.

ABSTRACT: Estimates of Dover sole landed in the Eureka, Monterey, and Pt. Conception areas of California are stated for 1972 - 1985. Most Dover sole production comes from the Eureka and Monterey areas, but the Pt. Conception area is increasing the most rapidly (3-fold increase in landings in 1984). The 1985 Dover sole harvest in California is projected to exceed 10,000 metric tons,

possibly resulting in the highest catch on record.

A management model for the central stock of the northern anchovy, *Engraulis mordax*.

AUTHOR(S): Radovich, J., and A. D. MacCall.

YEAR: 1979.

SOURCE: CalCOFI Rep. 20:83-88.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, population trends.

ABSTRACT: Maximum potential yield of the northern anchovy, *Engraulis mordax*, was estimated at 60% of the mean fishable biomass, with potential yields in 1951-1972 ranging from 1.5 to 2.4 million tons. If low population abundances in 1951 were due to poor year-classes from environmental variability, then high levels could be temporary and fishing not sustainable. The logistic growth curve was used as a more reliable estimate of sustainable yield based on observed dynamics. Estimate of carrying capacity, intrinsic rate of increase, and the time of inflection of the growth curve were 4.0 million tons, 0.36, and 1959.6, respectively. Peak growth rate at a spawning biomass of 2.0 million tons was estimated as 360,000 tons per year with an equilibrium yield at 450,000 tons per year. Due to violated assumptions this model must be viewed as an empirical description of population growth. Several years of observations may be needed to get a true population response to fishing pressure. Advantages of this curve over others include; it is based on observed rather than assumed growth, it does not rely on fishery catch and effort data, and it yields a more cautious estimate of maximum sustainable yield. In this way, management is aimed at maintaining optimum spawning biomass, resulting in a more variable fishery, but a much lessened risk of fishery collapse.

Age estimation and growth of broadbill swordfish, *Xiphias gladius*, from the northwest Atlantic based on external features of otoliths.

AUTHOR(S): Radtke, R. L., and P. C. F. Hurley.

YEAR: 1983.

SOURCE: Pages 145-150 in E. D. Prince and L. M. Pulos (eds.), Proc. Int. workshop on age determination of oceanic pelagic fishes: Tunas, billfishes, and sharks.

KEYWORDS: Swordfish, *Xiphias gladius*, wetfish, age, growth.

ABSTRACT: In this study, age and growth rates were estimated for swordfish, *Xiphias gladius*, collected from the northwest Atlantic, by counting the external ridges on sagittae. The ridges were measured under a SEM, and length at age estimates for males and females were applied independently to von Bertalanffy growth curves. Due to curvature and variability in sagittal shape, ridge radii were unmeasurable, and back calculation was impossible. Of the 303 swordfish sampled, only 7.5% possessed sagittae unsuitable for sampling. The age estimates suggest a maximum lifespan of 14 yrs for males and 32 yrs for females. The growth curves show different parameters from other studies which used different structures to estimate age. A differential maximum length between males and females existed (males 277.2 cm, females 266.7 cm, lower jaw-fork length). The authors indicate that their method of age determination has yet to be validated, but despite small difficulties (such as inability to back calculate), they

consider it a useful technique.

Background of market squid research program, basic life history, and the California fishery.

AUTHOR(S): Recksiek, C. W. and H. W. Frey.

YEAR: 1978.

SOURCE: Pages 7-10 in C. W. Recksiek and H. W. Frey (eds.,). Biological, oceanographic, and acoustic aspects of the market squid, *Loligo opalescens* Berry. Calif. Dep. Fish Game, Fish Bull. 169.

KEYWORDS: Market squid, *Loligo opalescens*, life history, fishery.

ABSTRACT: This section briefly introduces the research project composition and span of the study conducted on the market squid. The basic biology, life history, and a brief description of the market squid fishery are also discussed.

Biological, oceanographic, and acoustic aspects of the market squid, *Loligo opalescens* Berry.

AUTHOR(S): Recksiek, C. W., and H. W. Frey.

YEAR: 1978.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 169:185 pp.

KEYWORDS: Market Squid, *Loligo opalescens*, life history, spawning, age, growth, mortality, feeding.

ABSTRACT: The market squid, *Loligo opalescens*, was the subject of a three year study of its life history. Histological work on spermatogenesis and oogenesis showed the market squid spawns only once in its life between 1 and 2 years of age. Several animals were aged, utilizing statolith rings. The results showed a period of fast growth during the first year and slower growth the second year. The major prey item of the squid (determined by gut content analysis) were euphausiids. Other crustaceans, cephalopods and fish were a minor constituent of the squid's diet. Predators included 19 species of fish, many birds, and at least 9 species of marine mammals suggesting the squid represents an important trophic link between zooplankton and larger marine organisms. Several aspects of the squids diet behavior patterns were recognized by acoustic tracings. Correlations between hydrographic and catch data showed a tendency for good catches to follow warm water trends, while poor catches were associated with cool water trends. Several methods were utilized to determine if subpopulations existed and the results suggest at least two (northern and southern) stocks of *Loligo opalescens* are present.

Distribution of larval squid, *Loligo opalescens*, in various nearshore locations.

AUTHOR(S): Recksiek, C. W., and J. Kashiwada.

YEAR: 1979.

SOURCE: CalCOFI Rep. 20:31-34.

KEYWORDS: Market squid, *Loligo opalescens*, larvae, distribution.

ABSTRACT: Larval squid, *Loligo opalescens*, were collected with three types of nets in the nearshore waters of California. Quantitative analysis of samples was impossible due to difference in mesh size, and the lack of water volume estimates. However, the relatively high catches of larvae near the bottom was probably significant. An increase in catch by the midwater trawls in the day and concurrent decrease in catch by the bottom trawl was probably due to positive phototaxis of the larvae. An average of

2 squid/tow, were collected in Monterey Bay. However, 88% of the total catch was from 2 tows, suggesting the larvae are patchy in distribution.

Edible crabs of the United States.

AUTHOR(S): Rees, G. H.

YEAR: 1963.

SOURCE: Fish Wildl. Serv. Bur. Comm. Fish, Fish. Leaf. 550. 18 pp.

KEYWORDS: Market crab, Cancer magister, life history, economics.

ABSTRACT: The biology and natural history of crabs (Arthropoda, Crustacea, Decapoda, Brachyura and Anomura) as well as growth and molting, reproduction, development, and regeneration of lost limbs were discussed. The commercially important species from the Atlantic Coast, Pacific Coast and Hawaii were described. On the east coast blue crabs (*Callinectes sapidus*), stone crabs (*Menippe merceneria*), rock crab (*Cancer irroratus*), Joah crab (*Cancer borealis*), green crab (*Carcinus melenus*), deep sea red crab (*Geryon quiquedens*) and somoan crab (*Saylla serrata*) were fished. On the west coast, the three species were taken include Dungeness crab (*Cancer magister*), king crab (*Paralithodes contschatica*) and Tanner crab (*Chionectes tanneri*). In Hawaii, the principle important species was Kona crab (*Panina ranina*). In 1961, the Atlantic fishery produced 155,458,000 of crab valued at \$8,427,000; blue crab accounted for 98% of the landings. The Pacific Coast fishery produced 32,699,000 pounds of Dungeness crab (\$4,977,000), 43 million pounds of king crab (\$3.9 million) and only 7,000 pounds of Tanner crab (\$1,000).

As estimate of survival, mortality, and the number of lingcod (*Ophiodon elongatus*) off the southwest coast of Vancouver Island, British Columbia.

AUTHOR(S): Reeves, J. E.

YEAR: 1966.

SOURCE: Washington Department of Fisheries, Fishery Research Paper 2(4):55-66.

KEYWORDS: Lingcod, *Ophiodon elongatus*, groundfish, fishery, life history.

ABSTRACT: A tag-return study was conducted for the population of lingcod, *Ophiodon elongatus*, on Forty-Mile Bank; as of October 1963, 284 tags (65%) were recovered. The data from this experiment yielded a population estimate of 560,389 fish; however, after correction for the effect of recruitment, a more reasonable figure of 334,969 fish was reached. Survival was calculated as 0.084 for the year of the experiment with corresponding instantaneous rates of fishing and natural mortality of 1.450 and 0.724, respectively. Catch and effort data indicate that the Forty-Mile Bank lingcod population is being overfished. The authors recommend that conventional regulatory methods would not work well for this fishery.

Maps and charts of the distribution of physical/chemical parameters in the Pacific Ocean.

AUTHOR(S): Reid, J. L.

YEAR: 1977.

SOURCE: Unpubl. ms. Scripps Inst. Oceanog., Univ. Calif., San Diego, La Jolla, CA. 22 p.

KEYWORDS: All species, habitat.

ABSTRACT: A series of maps and charts encompassing the Pacific Ocean is presented in this pamphlet. Temperatures, oxygen content, salinity, inorganic phosphate-phosphorus and other anomalies are indicated on the maps or in chart form.

Lobster and crab.

AUTHOR(S): Reilly, P.

YEAR: 1982.

SOURCE: Pages 3D-1 to 3D-19 in MBC and CDFG, Marine environmental studies,

Little Cojo Bay, CA., proposed liquefied natural gas terminal, 1981 year end technical report, preconstruction study. MBC Applied Environ. Sci., Costa Mesa, CA., and Calif. Dep. Fish Game, Sacramento, CA.

KEYWORDS: Yellow crab, *Cancer anthonyi*, spiny lobster, *Panulirus interruptus*, population, distribution, physiology.

ABSTRACT: The objective of this environmental study was to develop a quantitative data baseline for lobster and crab populations and to assess the impacts of a proposed liquefied natural gas terminal on those populations in the Little Cojo Bay, California area. Preconstruction data will be compared with sampling efforts during construction. Resulting information will then be used to assess impacts during operation. The biology, ecology and behavior of *Cancer* spp. as well as the ecology and population dynamics of adult lobster are also discussed.

Ocean and estuarine conditions during Dungeness crab critical stage larval studies.

AUTHOR(S): Reilly, P. N.

YEAR: 1983.

SOURCE: Pages 43-56 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: *Cancer magister*, market crab, larvae, early life history.

ABSTRACT: This paper describes the physical environment during the Dungeness crab larval season in California (December to June) from 1975-1980. During the cruises where *Cancer magister* was sampled, water temperature and salinity were also measured; at the surface, 5 m, 15 m and 25 m. Refer to paper for further details of physical environment throughout each larval season.

Predation on Dungeness crabs, *Cancer magister*, in central California.

AUTHOR(S): Reilly, P. N.

YEAR: 1983.

SOURCE: Pages 155-164 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, *Cancer magister*, fishery, growth, distribution, mortality.

ABSTRACT: The purpose of this study was to determine whether predation on Dungeness crab, *Cancer magister*, could be related to the decline of the commercial crab fishery in central California. Biological samplers, such as pelagic king and silver salmon, as

well as various demersal fishes, were used to obtain data on growth, distribution, relative year class strength and mortality of Dungeness crabs in central California. This information was compared with conventional sampling methods. It was found that biological samplers were often more efficient than conventional sampling methods, especially in larval and early post-larval stages that are often missed by conventional trawls. Of 70 species of fishes sampled for stomach contents, 28 had preyed upon Dungeness crabs. Refer to paper for the relative importance of various predators on Cancer magister. It was determined that both pelagic and migratory coastal predators had the potential to significantly affect the mortality rate of Dungeness crabs. Predation continued to be a factor of natural mortality during periods of molting throughout the life of the crab. The occurrence of megalopae and young-of-the-year post-larval instars in stomachs of demersal fishes indicates that settling by megalopae and molting to the juvenile stage occurs primarily in the nearshore area; most samples were found in water of 25 m or less and within 10 km of shore. Early post-larval instars appeared more clumped in their distributions in the ocean. The average number of crabs per stomach was also higher in ocean waters than in the Bay, indicating an increased vulnerability to predation. There is indirect evidence that an increase in salmon production may in part be responsible for a decline of recruitment of larval crabs in the San Francisco area fishery. Dungeness crab are known to be important prey items in various demersal fishes and invertebrates. However, since there has been no significant increase in commercial demersal fish populations, it seems unlikely that inherent natural mortality from these predators would have caused a significant decline in the commercial crab fishery.

Effects of commercial trawling on Dungeness crab survival.

AUTHOR(S): Reilly, P. N.

YEAR: 1983.

SOURCE: Pages 165-170 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies on the Dungeness crab, Cancer magister, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Cancer magister, mortality, fishery, market crab.

ABSTRACT: The purpose of this study was to estimate mortality of Dungeness crabs caused by commercial trawlers in crabbing areas in the Gulf of the Farallons and to determine whether there is a significant impact on the crab fishery in the San Francisco area. Total mortality of 3,296 crabs taken in 25 tows was 64 crabs, or 1.9% of the total catch. Of the dead males, 75% were of sublegal size (<159 mm). Nineteen (45%) of the dead males and 14 (58%) of the dead females had soft shells and were crushed by the weight of the catch. An additional 9 (22%) of males and 3 (8%) females had filling shells which were fractured or crushed. The remaining hard-shelled casualties either suffered puncture wounds from pens used by the crew to discard fish or sustained broken chelate or legs and/or had fractured carapaces. Percentages of total catch of hard, filling, and soft-shelled males killed from trawling operations during the study were 0.9, 1.8, and 20.2%, respectively. Total mortality was 0.53 crabs per trawling hour for all male crabs and 0.12 crabs per trawling hour for legal-size males. The author believes that this study reflects

conservative mortality rates for Dungeness crabs as they may occur in actual trawling operations in the Gulf. These relatively low estimates should not be used to dismiss the potential impact of a combination of large fish catches and careless handling of recently-molted Cancer magister in trawl catches. The majority of the mortality observed occurred in females and sublegal males. Any significant mortality should be avoided due to the depressed Dungeness crab fishery in central California.

Dynamics of Dungeness crab, Cancer magister, larvae off central and northern California.

AUTHOR(S): Reilly, P. N.

YEAR: 1983.

SOURCE: Pages 57-84 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, Cancer magister, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, Cancer magister, larvae, distribution, early life history, life history.

ABSTRACT: The purpose of this study was to identify any life history stages that may be critical to the recruitment and survival of the adult populations of Dungeness crabs, in the Gulf of the Farallons and San Francisco Bay. Cancer magister larvae were found from mid-December (Zoea I) until early March (megalopa). Spawning appears to be concentrated in October and early November with most of the larvae hatching by late January. Stage I larvae of C. magister were found to occur occasionally with Stage I larvae of C. productus and C. oregonensis, although in much greater numbers. Stage I zoeae also evidenced diel vertical migration, being more abundant at the surface by night. Horizontal dispersal was noted during early zoel stages. As the stages progressed, they were found farther out from the Gulf of Farallons. The relative abundance of megalopae was directly related to the subsequent year class of juvenile crabs. The critical stage in the life history of Cancer magister to subsequent year class strength of juvenile crabs was found to be during zoel stages and early megalopal development. However, it was not possible to determine more precisely which early life stages are the most critical.

Studies on the Mytilus edulis community in Alamitos Bay, California: Development and destruction of the community.

AUTHOR(S): Reish, D. J.

YEAR: 1964.

SOURCE: Veliger 6(3):124-131.

KEYWORDS: Artificial reef, community, growth, seasonality, colonization.

ABSTRACT: In one part of this study boat docks were scraped and all macroscopic organisms collected over a 3-year period. Each successive collection had been exposed one month longer than the preceding one. The results show the organisms and order of settlement to be: bacterial-algal scum, Bugula neritina (ectoproct), Hydroides norvegica (tube-building polychaete), Ulva eobata (green algae), then the climax species Mytilus edulis. The number of mussels gradually declined over the next 2 years until the entire population was killed by a red tide. In another part of the study one float was scraped clean each season of the year to determine whether the M. edulis



community was established through seasonal progression or true succession. A comparison of the results from this part of the study with data from the floats cleared over the 3-year study indicate that seasonal progression versus true succession occurred in Alamitos Bay Marina. It is the time of the year when the float is first submerged which determines which organisms will attach.

First record of a second mating and spawning of the spot prawn, *Pandalus platyceros*, in captivity.

AUTHOR(S): Rensel, J. E., and E. F. Prentice.

YEAR: 1977.

SOURCE: Fish. Bull. 75(3):648-649.

KEYWORDS: *Pandalus platyceros*, spot prawn, spawning, reproduction.

ABSTRACT: Spot prawns, *Pandalus platyceros*, are protandric hermaphrodites which mature as a male at 1.5 years and breed one or more times for about a year. After the transitional phase (3.5 years), the prawn becomes a female and probably breeds once before dying. Ovigerous females were held in the lab until eggs were hatched. Spawners were held in pens with cultured males and fed clam and salmon meal. Females held in a benthic pen exhibited the highest rates of survival. Eight-five percent of the surviving females spawned, although fecundity was low with 10-1000 viable larvae. The average carapace length of the female spawners was 39.2 mm. This data could be important to fishery biologist in estimating year class recruitment.

Growth of juvenile spot prawn, *Pandalus platyceros*, in the laboratory and in net pens using different diets.

AUTHOR(S): Rensel, J. E., and E. F. Prentice.

YEAR: 1979.

SOURCE: Fish. Bull. 76(4):886-890.

KEYWORDS: *Pandalus platyceros*, spot prawn, growth, feeding.

ABSTRACT: Spot prawns (*Pandalus platyceros*) were examined as a potential polyculture species to be used with net pen-reared salmon, using several diets of under-utilized marine species or fishery byproducts. Juvenile prawns fed mussels had the highest survival and growth rate in the laboratory, followed by salmon which were significantly lower; however, both were equal to or greater than natural populations. Prawns fed oyster wastes and those not fed at all had similar growth, both less than when fed mussels or oyster wastes. Animals fed in the net pens grew significantly faster than those in the lab, and there was no difference between mussels and salmon. The presence of net fouling organisms added to the diets of those grown in pens. Prawns grown with salmon after 6.5 months had growth which exceeded those in monoculture and showed no adverse salmon/prawn interactions, with 93% prawn survival. Foods available in polyculture include dead fish, uneaten fish food pellets, fish feces, and net fouling organisms.

Factors controlling growth and survival of cultured spot prawn, *Pandalus platyceros*, in Puget Sound, Washington.

AUTHOR(S): Rensel, J. E., and E. F. Prentice.

YEAR: 1980.

SOURCE: Fish. Bull. 78(3):781-788.

KEYWORDS: *Pandalus platyceros*, spot prawn, growth, fishery, feeding, mortality, early life history.

ABSTRACT: The effect of environmental factors on growth and survival of spot prawns, *Pandalus platyceros*, held in net pens was examined. Environmental data for the study area was obtained and reported. Juvenile and yearling prawns avoided brightly illuminated areas. Temperature was a major factor, affecting growth only after September. At the end of October, growth of cultured prawns was similar to wild populations, while from the end of October to January cultured prawns outgrew wild prawns. Mortality increased with intense plankton blooms. Those lowered to deeper colder water out of the bloom had an increased survival. At one site a significant difference in survival of prawns fed clams (78.6%) and not fed at all (66.7%) occurred, while the former did maintain themselves on net fouling and pelagic organisms, and dead prawns. Five major molting peaks were evident, in summer about 50 days apart, in winter 75 days apart, and in the spring back to 50 days. Molting peaks occurred in a pattern of 1.6 - 2.5 month intervals, depending on season. Water temperature and decreased food availability account for decreased growth and survival of spot prawns, with plankton blooms adding to mortality. Surface waters in some areas may be unsuitable for prawn culture.

Effects of copper on early life history stages of northern anchovy, *Engraulis mordax*.

AUTHOR(S): Rice, D. W., F. L. Harrison, and A. Jearld.

YEAR: 1980.

SOURCE: Fish. Bull. 78(3):675-683.

KEYWORDS: *Engraulis mordax*, northern anchovy, early life history, contaminant susceptibility, larvae, mortality.

ABSTRACT: The sensitivity of embryonic and larval stages of the northern anchovy, *Engraulis mordax*, from San Francisco Bay, was examined from 1976-78. A flow-through bioassay system was developed and the median lethal concentrations (LC50) of the life stages to cupric chloride were recorded. The embryos were observed from 8-10 hrs after fertilization until hatching and larvae were observed from 12 hrs after hatching until yolk-sac absorption. The embryos exhibited a high degree of mortality with hatching success decreased under increased copper exposure. The incipient LC50 for embryos was 190 ugCu/L. The larvae were less sensitive and an incipient LC50 of 370 ugCu/L was recorded.

Coastal and oceanic fish larvae in an area of upwelling off Yaquina Bay, Oregon.

AUTHOR(S): Richardson, S. F., and W. G. Pearcy.

YEAR: 1977.

SOURCE: Fish. Bull., U. S. 75(1):125-145.

KEYWORDS: Thresher shark, *Alopias vulpinus*, larvae, distribution, Parophrys

*vetulus*, English sole, *Ophiodon elongatus*, lingcod.

ABSTRACT: This paper presents the results of a 1 1/2 year study of planktonic

fish larvae collected from 2 to 111 km off the mid-Oregon coast during 1971-72. A total of 289 samples were taken which yielded 23,578 individuals. Separate coastal and offshore larvae assemblages were identified as well as the dominate species and peak abundance times for each group. In conclusion, the data generated by this study is compared with larvae in Yaquina Bay, Northeast Pacific

larvae and also with other planktonic components.

Abundance and distribution of larval fishes off Oregon,  
May-October 1969, with special emphasis on the northern  
anchovy, *Engraulis mordax*.

AUTHOR(S): Richardson, S. L.

YEAR: 1973.

SOURCE: Fish. Bull. 71(3):697-711.

KEYWORDS: Northern anchovy, *Engraulis mordax*, distribution, larvae,  
community.

ABSTRACT: Three types of gear, bongos, meter net, and Issacs-Kidd  
midwater trawl, are compared for their effectiveness in catching  
fish larvae. The collected samples were analyzed in terms of  
species composition, frequency of occurrence, abundance, and  
dominance of fish larvae. Species in the most important families  
are described in terms of distribution pattern. The results  
showed that the dominate species in all three gear types were the  
same: *Engraulis mordax*, *stenobranchius leucopsarus*, *Tarletonbeania*  
*crenularis*, and *Sebastes* spp. A comparison of shallow versus deep  
tows showed small anchovy larvae were concentrated near the  
surface while larvae of myctophids and scorpaenids were more  
common in deeper waters. The discussion of the distribution of  
the important species focused on inshore-offshore aspects as no  
north-south differences were evident except with *E. mordax*.

Spawning biomass and early life of northern anchovy, *Engraulis*  
*mordax*, in the northern subpopulation off Oregon and  
Washington.

AUTHOR(S): Richardson, S. L.

YEAR: 1980.

SOURCE: Fish. Bull. 78(4):855-876.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, reproduction,  
population trends.

ABSTRACT: Spawning centers are defined and spawning biomass estimated  
for the northern subpopulation of the northern anchovy, *Engraulis*  
*mordax*, along with an examination of ecological data on their  
early life. Hydrography and plankton volume are also discussed.  
The study centers around the Columbia River plume. The center of  
egg abundance was north of the Columbia River plume in 1975 and  
83 km off the Oregon coast in 1976. Overall mean egg abundances  
were 642 and 291 under 10 m<sup>2</sup> surface, respectively, with egg  
distribution bounded to the south and offshore. The farthest  
offshore that eggs were taken was 194 km. At positive stations,  
mean temperatures (3 m depth) ranged from 15.18 deg C to  
16.09 deg C while salinities were 30.69 to 30.07 o/oo. The  
regions of greatest egg concentrations were in areas of low  
plankton volumes. Larvae were more widely dispersed, with overall  
mean abundances of 115 and 278 under 10 m<sup>2</sup> surface in 1975 and  
1976. Evidence suggests a southern drift from the spawning  
center, with the spawning aggregation more widely distributed  
in a north-south distance. Spawning biomass estimates  
ranged from 262,506 to 769,511 t in 1975 and 144,654 to  
1,005,263 t in 1976 using Sette and Ahlstrom, Simplson, and  
Saville egg methods, and the Smith larva method. It can be  
concluded that the true biomass lies between 100,000 and  
1,000,000 t, and includes only mature spawning adult fish.  
Fish less than 2 years old may represent a sizeable amount of

biomass. Estimates indicate a smaller spawning biomass than the central subpopulation and a comparable one to the southern. Off Oregon relatively little nearshore spawning occurs and is probably related to water temperature. A spawning center within the northern subpopulation is closely associated with the Columbia River plume, which provides an optimal environment in terms of stability and productivity. Whether this is the only or primary spawning center is not known. Evidence indicates the Strait of Georgia may be an additional site, with the Fraser River creating an environment similar to that of the Columbia River.

Between Pacific tides.

AUTHOR(S): Ricketts, E. F., J. Calvin, and J. W. Hedgpeth.

YEAR: 1968.

SOURCE: Stanford University Press, Stanford, California. 614 pp.

KEYWORDS: Platform, habitat, distribution.

ABSTRACT: Various habitats in the intertidal zone of the coast are described. Some of the habitats include those in the protected outer coast (e.g. upper, middle, and low intertidal), open coast (e.g. rocky shores and sandy beaches), and bay and estuary (e.g. rocky shores, sand flats, eelgrass flats, mud flats, and wharf pilings). Intertidal zonation and the open sea are also discussed. The authors base their description of the distribution of shore invertebrates on 1) the degree of wave shock, 2) the type of bottom, and 3) the tidal exposure.

A preliminary evaluation of prey selection by juvenile-small adult California halibut (*Paralichthys californicus*) in nearshore coastal waters off southern California.

AUTHOR(S): Roberts, D., E. DeMartini, C. Engel, and K. Plummer.

YEAR: 1982.

SOURCE: Pages 214-223 in G. M. Cailliet and C. A. Simenstad (eds.). Gutshop 81: Fish Food Habits Studies, Proc. 3rd Pac. Workshop, 6-9 December 1981, Asilomar Conf. Center, Pacific Grove, CA. 312 pp.

KEYWORDS: California halibut, *Paralichthys californicus*, feeding.

ABSTRACT: An evaluation of prey selectivity by 193 halibut, *Paralichthys californicus*, was based on a comparison of its diet with prior approximations of prey abundances. Sixty percent (115) of the fish had food in their stomachs. The most important food item was adult *Engraulis mordax*, which accounted for 84% of the ingested biomass. Of the fish examined, *E. mordax* was observed in 46% of the stomachs. Mysids were also an important prey item and were the numerically dominant species in gut contents. Smaller halibut were found in shallower depths where abundance of mysids was higher (114/m<sup>2</sup> at 6 m vs. 23/m<sup>2</sup> at 32 m). Smaller halibut fed more extensively on mysids, while larger, deeper dwellings, halibut fed primarily on anchovies. Some seasonal variations indicated halibut collected during March to May fed on mysids while those collected during June to September fed on anchovies; this pattern was independent of depth. The data suggests that juvenile and adult halibut feed on the largest prey available. Anchovies are preferred over mysids and, among the mysids size selectively, is also important.

Effect of swimming speed on the excess temperature and

activities of heart and red and white muscles in the mackerel, *Scomber japonicus*.

AUTHOR(S): Roberts, J. L., and J. B. Graham.

YEAR: 1979.

SOURCE: Fish. Bull. 76(4):861-867.

KEYWORDS: Pacific mackerel, *Scomber japonicus*, physiology.

ABSTRACT: The effects of swimming speed on the magnitude of the small temperature excesses in a "cool" scombrid, *Scomber japonicus*, not equipped with the retia exchangers was examined. Also, it was determined how heart rate and red and white muscle activity of *S. japonicus* are affected by swimming speed. *Scomber japonicus* does not develop large temperature excesses in its tissues while swimming at basal speeds which are 1.3-1.9 TL/s (total lengths per second), nor at sustainable speeds (3-5 TL/S). Excess temperatures reached a maximum of about 0.3 deg. C in the red and white muscles, but doubled with 3 min swimming at enforced higher speeds (3.2-4.5 TL/s). Excess temperatures recorded in the heart averaged about one-half of the excess developed in muscles at all swimming velocities. Electromyographs (EMGs) demonstrated that both red and white muscle fibers contract synchronously while the mackerel swims at 2 TL/s and was correlated with tail beats. Amplitudes of EMGs in both muscle types seemed to reach a maximum for steady swimming at 3-4 TL/s, demonstrating that white fibers are active within the range of sustainable cruising velocities for this species and that red muscle remains active at high speeds. A wide range was found in heart rates of mackerel cruising at 1-1.5 TL/s (mean 106, range 80-140 beats/min). With acceleration to 4-5 TL/s, the mean heart rate increased by 54% (mean 130, range 112-150), but rapidly returned to the resting rate within a few minutes of deceleration.

Surface distribution of albacore tuna, *Thunnus alalunga* bonnaterre, in relation to the subtropical convergence zone east of New Zealand.

AUTHOR(S): Roberts, P. E.

YEAR: 1980.

SOURCE: New Zealand Jour. Mar. & Freshw. Res. 14(4):373-380.

KEYWORDS: Albacore, *Thunnus alalunga*, distribution, fishery, fishing gear, length/weight.

ABSTRACT: Trolling studies of albacore tuna were conducted off the west and northeast coasts of New Zealand. The results confirm that tuna are not generally present in subantarctic waters, and that they avoid waters where surface temperatures are below 15 deg C and salinities below 34.6 ‰. Length frequency distributions from trolling vessels are presented. The hydrology of the Subtropical Convergence Zone near Chatham Rise is also discussed.

A field guide to Atlantic Coast fishes.

AUTHOR(S): Robins, C. R., G. C. Ray, and J. Douglass.

YEAR: 1986.

SOURCE: Houghton-Mifflin Co., Boston, MA. 354 p.

KEYWORDS: All species, distribution, size, physiology, habitat, albacore, *Thunnus alalunga*.

ABSTRACT: This field guide was designed to assist in the identification of the

more than 1,000 fish species that occur in the marine environment of the eastern coast of North America from Arctic Canada to Mexico. The

text gives an overview of each family, followed by species characterizations wherein identification range, habitat, life stages and size are presented. To make identification of a species as simple as possible, a section containing 64 black and white and color plates is featured, along with a guide for its use.

Lachner, R. N. Lea, and W. B. Scott.

A list of common and scientific names of fishes from the United States and Canada.

AUTHOR(S): Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A.  
YEAR: 1980.

SOURCE: Am. Fish. Soc., spec. publ. No. 12. 4th edition, 174 p.

KEYWORDS: All species.

ABSTRACT: The fourth edition of common and scientific names is a revision and

enlargement over earlier published lists and includes 2,268 species of fishes that are found in the area of coverage. This includes all species of fishes purportedly known in areas that encompass the fresh waters of the continental United States and Canada, and those marine species inhabiting the contiguous shore waters on or above the continental shelf to a depth of 200 meters. The purpose of the list is to recommend common names for North American fishes. Scientific names are also included as well as family names with a brief synopsis.

The venom apparatus of California rockfishes (family Scorpaenidae).

AUTHOR(S): Roche, E. T., and B. W. Halstead.

YEAR: 1972.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 156.

KEYWORDS: *Sebastes goodei*, widow rockfish, *Sebastes miniatus*, vermillion rockfish, *Sebastes paucispinis*, bocaccio, physiology.

ABSTRACT: The venom apparatus of 14 species of rockfish (genus *Sebastes*) including *S. goodei*, *S. miniatus* and *S. paucispinis* is described.

The venom apparatus of *Sebastes* consists of 13 dorsal spines, 3 anal spines, 2 pelvic spines and their associated musculature, venom glands, and integumentary sheaths.

A racial study of the Pacific mackerel, *Pneumatophorus diego*.

AUTHOR(S): Roedel, P. M.

YEAR: 1952.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 84.

KEYWORDS: Chub mackerel, *Scomber japonicus*, fishery, population trends.

ABSTRACT: The purpose of this study was to determine whether or not Pacific mackerel taken from different regions along the coast formed physically distinguishable groups. The Pacific mackerel (*Pneumatophorus diego*) ranges from southern Alaska to Baja California. Knowledge of the movements of the fish within their broad range is important for management purposes. Most (95%) of the state-wide catch is made between Pt. Conception and the Mexican border. The commercial catch has been dependent largely on fish 1-3 years old and the fish do not mature until their second or third year. The future of the fishery is, consequently, not bright, and the magnitude of the catch is and probably will remain a function of spawning success from year to year.

Collections for this study were made in various months from October 1939 to April 1942, mostly off Santa Catalina Island. Other samples were obtained from Mexican, southern California and British Columbian waters. The samples are separated on a geographic basis into six groups: British Columbia, California, Soledad, Viscaïno, Cape San Lucas and Gulf of California regions. Meristic counts were centered on the number of the vertebrae. The position of the first haemal spine did not show sufficient variation within and between geographic regions to warrant detailed analysis. The results for the Viscaïno group suggest that differences in environmental factors between spawning grounds in any given year may produce variations in meristic characteristics as pronounced as those between size or age class. The first pair of haemal braces was found most often on the 16th vertebra, frequently on the 15th, and rarely on the 17th. Overall, based on certain meristic characteristics, the mackerel populations along the Pacific Coast are very heterogeneous. Intraregional variation did not appear to exist. However, evidence from tagging experiments does not support the theory of distinct stock populations of mackerel. Fish tagged in Soledad and Viscaïno were recovered in central and southern California. Thus, to some degree, the southern California mackerel fishery draws from the population in the north, although fish taken from various areas differ physically. The population from Cape San Lucas region was found to differ significantly in all respects from the northern regimes and is considered a distinct population.

The jack mackerel, *Trachurus symmetricus*: A review of the California fishery and of current biological knowledge.

AUTHOR(S): Roedel, P. M.

YEAR: 1953.

SOURCE: Calif. Fish Game 39(1):45-68.

KEYWORDS: Jack mackerel, *Trachurus symmetricus*, fishery, fishing gear, distribution, age, weight, larvae, spawning, economics.

ABSTRACT: A history of the jack mackerel fishery catch statistics is presented

from 1888 to 1952. The status of the fishery, the fishing grounds, gear and methods, price, and catch trends are examined in detail for the following fishery regions: San Francisco, Monterey, Santa Barbara and Los Angeles. A brief discussion of the biological knowledge of the jack mackerel is included.

California based fisheries off the west coast of Mexico for temperate tunas, market fish, and sport fish.

AUTHOR(S): Roedel, P. M., and H. W. Frey.

YEAR: 1968.

SOURCE: Fish. Bull. 138:49-76.

KEYWORDS: Fishery, habitat, California halibut, *Paralichthys californicus*, kelp bass, *Paralabrax clathratus*, Pacific bonito, *Sarda chiliensis*, chub mackerel, *Scomber japonicus*, white seabass, *Atractoscion nobilis*, yellowtail, *Seriola lalandei*.

ABSTRACT: The impending implementation of a 12 mile wide exclusive fishery zone in Mexican waters resulted in a study to determine the loss to commercial and sport anglers. The albacore landings off Mexico for 1951 to 1963 averaged 13 million lbs. per year.

Only 200,000 lbs. were taken within the 12 mile zone. Bluefin landings were quite variable but often contributed significantly to the total catch. Several market fish species were considered; these included barracuda, grouper, seabass, rockfish, yellowtail and bonito. Up to 2 million lbs. were landed annually at a value of \$350,000. The economic value of the sport fishery was extremely difficult to determine, however, up to 17,500 anglers in 1965 paid \$250,000 to partyboat operators. The catches of bluefin tuna and various market species accounted for a total of \$1.75 million to California fishermen.

Descriptions of the prezoeae of *Cancer magister* Dana and *Cancer productus* Randall and the larval stages of *Cancer antennarius* Stimpson (Decapoda, Brachyura).

AUTHOR(S): Roesijadi, G.

YEAR: 1976.

SOURCE: *Crustaceana* 31(3):275-295.

KEYWORDS: *Cancer magister*, market crab, *Cancer productus*, rock crab, early life history, larvae.

ABSTRACT: Six ovigerous *Cancer magister* and three ovigerous females of *C. productus* and *C. antennarius* were collected and maintained in laboratory cultures. The lengths for free swimming prezoea were 2.25, 2.0 and 1.65 mm for *C. magister*, *C. productus* and *C. antennarius*, respectively. Color and chromatophore location also differed among the species. Several morphological features varied in the five instar stages and became more pronounced in the later stages. *Cancer magister* was longest at the megalop stage (11.0 mm) with *C. productus* and *C. antennarius* at 6.0 mm at 4.8 mm, respectively. The duration of development time for *C. antennarius* (36 days) appeared to be half that of *C. magister* or *C. productus* at similar temperatures (13 deg C).

Cephalopods of the world.

AUTHOR(S): Roper, C. F. E., M. J. Sweeney, and C. E. Nauen.

YEAR: 1984.

SOURCE: *FAO Fish. Synopsis* 125(3):277.

KEYWORDS: Market squid, *Loligo opalescens*, habitat, life history, fishery, distribution, feeding, reproduction.

ABSTRACT: This volume, the third in the FAO series of major groups of organisms that enter the marine fisheries, is an annotated and illustrated worldwide catalogue of the 173 cephalopod species of actual or potential fishery interest. Characterizations of each species include drawings, scientific and common names, information on habitats, biology, and fisheries. Distribution maps as well as a glossary of technical terms and measurements are also included.

Growth during metamorphosis of English sole, *Parophrys vetulus*.

AUTHOR(S): Rosenberg, A. A., and J. L. Laroche.

YEAR: 1982.

SOURCE: *Fish. Bull.* 80(1):150-153.

KEYWORDS: Early life history, growth, age, larvae, ichthyoplankton, English sole, *Parophrys vetulus*.

ABSTRACT: The period of metamorphosis in the early life history of fishes is usually accompanied by changes in growth rates. Now that age and growth determinations are possible (eg. daily



otolith growth rings, etc.) this change in growth rate physiology can be documented. This study was conducted using 127 pelagic larvae and transforming English sole (*Parophrys vetulus*) ichthyoplankton. Standard length of individuals plotted against age shows a distinct plateau of decreased growth at metamorphosis between 18 and 22 mm SL. Other plots, Body Depth/SL vs. SL; Snout-Anus Length/SL vs. SL; Jaw Length vs. SL; and Left Eye Migration vs. SL, all show varying degrees of inflection between 18 and 22 mm SL. The exact duration of the metamorphosis could not be determined from the data. It was postulated that the physical environment could have an influence on the duration. It was noted, however, that the migration of the left eye in 11 individuals could be seen at 49 days and resumption in growth of body length was noted by 120 days.

Survey of nearshore bottomfish in the outside waters of southeastern Alaska.

AUTHOR(S): Rosenthal, R. J., L. J. Field, and D. Myer.

YEAR: 1981.

SOURCE: Alaska Coastal Research. 84 pp.

KEYWORDS: *Sebastes entomelas*, widow rockfish, distribution.

ABSTRACT: Species composition of fishes inhabiting the nearshore shallow waters off southeastern Alaska is described. Species abundances were assessed by hook and line fishing and underwater visual observations. Spatial distributions (depth and position in the water column) and habitats of species collected and observed at various localities along the southeastern Alaskan Coast is described. Estimates of the relative and absolute abundances of various species and age and growth estimates of selected species are given. *Sebastes entomelas* was collected by hook and line but constituted very little of the total catch (1.4%).

LaRiviere, J. Underwood, and M. Murphy.

Inshore and shallow offshore bottom fish resources in the southeastern Gulf of Alaska. (1981-1982).

AUTHOR(S): Rosenthal, R., L. Haldorson, L. Field, V. Moran-O'Connell, M.

YEAR: 1983.

SOURCE: Alaska Fish Game. 166 pp.

KEYWORDS: *Sebastes entomelas*, widow rockfish, feeding, distribution, habitat, fishery, fishing gear, community.

ABSTRACT: An assessment of inshore and shallow offshore bottomfish stocks in southeast Alaskan waters was conducted during summer (1981) and winter (1982) by test fishing and scuba diving. Estimates of bottomfish abundance, density, and vertical distribution were made by scuba divers in the shallow sublittoral. Direct comparisons were made of two fishing methods (jigging vs. longlining). Commercial catches were monitored. The history of the current Sitka fishery is described as well as the local oceanographic conditions. *S. entomelas* comprised 7.4% of the deepest (41-60 fm) depth zone sampled with jigging gear. It was also common in nearshore and shallow offshore waters in mixed schools with black, yellowtail, and dusky rockfish. *S. entomelas* consumed sand lance, larval pollock and gelatinous zooplankton (salps and jellyfish). Unidentifiable fish remains and invertebrates such as hyperid amphipods, mysids, euphausiids and small octopus were common in the stomach samples of 27 specimens

analyzed. *S. entomelas* is currently fished by trawling at night in mid-water and marketed as either red or Pacific snapper. There was a consistent depth-related structuring of population size, as rockfish species increased in size and percent maturity with depth. Most of the fish observed in the inshore zone were juveniles or sub-adults. Species composition also changed with depth. Density and biomass peaked in summer, followed by strong declines in oceanic waters. Schooling species dominated the vertical jig catch, whereas bottom-dwelling species dominated the longline catch.

Combined effects of temperature and salinity on the survival and growth of the larvae of *Pandalus jordani* (Decapoda Dandalidae).

AUTHOR(S): Rothlisberg, P. C.

YEAR: 1979.

SOURCE: Mar. Biol. 54:125-134.

KEYWORDS: *Pandalus jordani*, ocean shrimp, growth, mortality, larvae, early life history.

ABSTRACT: Ovigerous female *Pandalus jordani* were held in the laboratory at 10 deg C until larvae hatched. Larvae were subjected to various temperature (5, 8, 11, 14 and 17 deg C) and salinity (26, 28, 30, 32, and 34 0/100) regimes. Survival and growth rates were compared to a control at 32 0/100. Larvae reared at extreme temperatures (5 and 17 deg C) exhibited significantly slower growth rates. In addition, mortalities were high at 17 deg C. At 11 deg C the larvae were slightly larger than those grown at 8 and 14 deg C. The highest survival rates were noted at temperatures of 8 to 11 deg C. The larvae exhibited a high degree of tolerance to salinity. The results of this study suggested that fluctuations in adult populations could be attributed to larval survival and growth rates which were significantly affected by variations in water temperatures.

A complete larval description of *Pandalus jordani* Rathbun (Decapoda, Pandalidae) and its relation to other members of the genus *Pandalus*.

AUTHOR(S): Rothlisberg, P. C.

YEAR: 1980.

SOURCE: *Crustaceana* 38(1):19-48.

KEYWORDS: *Pandalus jordani*, ocean shrimp, larvae, early life history.

ABSTRACT: The developmental stages of *Pandalus jordani* were noted by observation of lab cultured larvae. Thirteen distinct, often subtly different, stages were seen. Newly hatched larvae were positively phototactic. At the thirteenth (and last) stage the larvae began to vertically migrate. After the molt to the first juvenile instar, the larvae recruited to the bottom. Differences in morphological characteristics between the 12-13 species of north Pacific Pandalids were reported. The variability between counts reported in the literature and obtained by the authors was probably due to the geographic and sampling differences.

Factors affecting the distribution, abundance and survival of *Pandalus jordani* (Decapoda, Pandalidae) larvae off the Oregon coast.

AUTHOR(S): Rothlisberg, P. C., and C. B. Miller.

YEAR: 1983.

SOURCE: Fish. Bull. 81(3):455-472.

KEYWORDS: *Pandalus jordani*, ocean shrimp, distribution, mortality, larvae, early life history.

ABSTRACT: The importance of larval survival to year class strength of the pink shrimp, *Pandalus jordani*, is evaluated and the effects of ocean dynamics reported. In 1971, Zoea I was spread over the 60 nautical miles transect but concentrated inshore. The trend continued to Zoea V, but increasing numbers of stages II - V were evident further offshore. Most Zoea VI were outside 15 nautical miles and this trend persisted through Zoea XIII. In 1972, early stages were generally less dispersed seaward. Overall larval abundance was generally less dispersed seaward. Overall larval abundance varied between transects, averaging 250/1000 m<sup>3</sup> but was as high as 1093/1000 m<sup>3</sup>. Offshore displacement and dispersion of larvae occurred by late April. March showed no consistent gradient of larval age, while by April transects were more uniform. The median rate of growth increased 2.4 stages from March to April. The rate of change of developmental stage frequency differed between the two years. Faster development corresponded to higher water temperatures. In 1971, only 26.9% survived to Zoea II, while in 1972 over 64% survived through stage III. The percent surviving to juveniles in 1972 was an order of magnitude higher than in 1971. Mean estimated instantaneous daily mortality rate was 0.0788 for larvae. Larval survival was poor in 1971 and slightly above average in 1972. An upwelling index accounted for 56.2% of variability in larval survival. There was no evidence of an inshore migration of females prior to hatching of eggs. Widespread distribution of early larval stages is due to mixed winds. There was a positive correlation of larval survival and upwelling, explained by optimal survival at temperatures of 11 deg to 12 deg C, which are maintained by cold upwelling waters. The pink shrimp appears to have a reproductive strategy relying on a complex advection of late winter and spring. Larva have planktonic stages extending through the transition from northward - onshore to southward - offshore currents, encountering onshore retention in early stages and offshore displacement later, reaching suitable habitat for settling in deeper water.

An epibenthic sampler used to study the ontogeny of vertical migration of *Pandalus jordani* (Decapoda, Caridea).

AUTHOR(S): Rothlisberg, P. C., and W. G. Pearcy.

YEAR: 1976.

SOURCE: Fish. Bull. 74(4):944-997.

KEYWORDS: *Pandalus jordani*, ocean shrimp, migration, distribution, early life history, larvae.

ABSTRACT: An epibenthic sampler was designed to sample larval and juvenile shrimp (*Pandalus jordani*) just off the bottom. Vertical migration of this species is also described. Larvae were distributed throughout the water column during the day being most abundant from 0-10 meters. Early juveniles were present in low numbers from 51 to 150 meters and found in high concentrations on the bottom during midday. At night larvae were still distributed throughout the water column, however, no larvae concentrations were found at the 0-10 meter range. During the day a trend of increasing age with depth was found, while at night it was not evident. Vertical migration of early stages was shown to occur

nightly; a behavior starting late in the larval phase, before the juvenile molt and transition to bottom dwelling.

Observations on the spearfishes of the central Pacific.

AUTHOR(S): Royce, W. F.

YEAR: 1957.

SOURCE: Fish Bull. 57(124):437-553.

KEYWORDS: Swordfish, *Xiphias gladius*, distribution, size, feeding, spawning.

ABSTRACT: Six species of spearfishes from the central Pacific were considered in respect to taxonomy, distribution, size, food and spawning habits. The swordfish (*Xiphias gladius*), shortnose spearfish (*Tetrapturus angustirostris*) sailfish (*Istiophorus orientalis*), black marlin (*Istiompas martina*), striped marlin (*Makaira audox*), and blue marlin (*Makaira ampla*) are all highly migratory but with different centers of abundance. The black marlin was found in coastal areas off Asia, America and Australia. The blue marlin preferred equatorial waters while the swordfish and striped marlin were centered in temperate waters. The shortfin spearfish was not abundant in any water mass. The sailfin was often found in coastal waters throughout the tropical Pacific. A morphometric study of diagnostic characteristics and allometric growth suggested marked variation among the species. In addition, some degree of variability within species from different areas was noted. This suggests substocks of the species may exist. All species feed on fish and cephalopods.

Models of oceanic migrations of Pacific salmon and comments on guidance mechanisms.

AUTHOR(S): Royce, W. F., L. S. Smith, and A. C. Hartt.

YEAR: 1968.

SOURCE: Fish. Bull. 66(3):441-462.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, Chinook salmon, *Oncorhynchus tshawytscha*, migration, wetfish, habitat.

ABSTRACT: In this study, the authors examine the oceanic migration patterns of pink salmon and sockeye salmon stocks, and using this data, model the migration patterns, as well as make several observations about salmon migrations in general. The authors find that salmon in the ocean usually occur in the upper 10 m of the water column, though silver salmon (*Oncorhynchus kisutch*) occur at 10-20 m, and king salmon (*O. tshawytscha*) occur at 20-30 m. The authors indicate that salmon migrations are not random, but generally follow a circular migration pattern that corresponds closely with the oceanic gyre systems. The authors conclude that the salmon use oceanic currents as a migrational cue, discuss possible sensory mechanisms used, and speculate on secondary electroreceptor senses that detect the minute electrical field caused by the current.

Dispersion and food differences between two populations of the sea urchin, *Strongylocentrotus franciscanus*.

AUTHOR(S): Russo, A. R.

YEAR: 1979.

SOURCE: Jour. Biogeogr. 6:407-414.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., distribution, feeding.

ABSTRACT: Two allopatric species of red sea urchin, *Strongylocentrotus franciscanus*, exhibited differences in spatial patterns. These

differences were correlated to the amount of macroscopic algal food available. When food was limiting the urchins were randomly dispersed. However, dense, highly aggregated populations of urchins were found in food abundant areas. These results were also noted in laboratory aquaria. The random dispersal in food limited areas was due to the random movement of urchins searching for food.

Natural history of the quinnat salmon. A report of investigations in the Sacramento River, 1896-1901.

AUTHOR(S): Rutter, C.

YEAR: 1904.

SOURCE: Bull. of the U. S. Fish Comm. 22:65-141.

KEYWORDS: Chinook salmon, *Oncorhynchus tshawytscha*, life history, early life history, distribution, mortality, migration, feeding.

ABSTRACT: Observations of salmon in various stages of their life history were made in both the laboratory and field. The purpose of this study was to gather information on the habits and enemies of quinnat salmon in their natural environment and apply that information to artificial propagation. Most of the work was done in the Sacramento River in the Sacramento basin. The different life history stages observed were: eggs and milt, alevin, fry, and adults. Experiments were performed on the ova and on the vitality of spermatozoa. Alevin were observed both under artificially reared and natural conditions. Observations were made on migration of fry, fry as summer residents and food of young salmon. Adult salmon were evaluated in terms of migration, physical changes after entering fresh water, comparison of the sexes, natural propagation, injuries and diseases, and death.

Growth of laboratory-reared northern anchovy, *Engraulis mordax*, from southern California.

AUTHOR(S): Sakagawa, G. T., and M. Kimura.

YEAR: 1976.

SOURCE: Fish. Bull. 74(2):271-279.

KEYWORDS: Northern anchovy, *Engraulis mordax*, growth, larvae.

ABSTRACT: Growth rate of northern anchovy, *Engraulis mordax*, larvae is reported from hatching to about 20 months old. The Gompertz model was used to describe growth on a monthly time scale. The model was used with  $L_0$  fixed at 2.5 mm and again without this constraint. A two-phase curve best described growth from hatching to juvenile stage with the separation occurring at about six days of age, the onset of feeding. Growth during juvenile to adult stage was characterized by steplike stages of rapid growth followed by a leveling off. The first and second stages were between 4-12 and 12-20 months of age, respectively. The Gompertz model did not adequately fit the data. The model did not describe growth from hatching to adult stage well, also. The sizes of fish 4-12 months old was overestimated while fish older than 13 months were underestimated. A two-phase Gompertz model was fitted to the data. Growth from hatching to 11 months and 11-20 months of age had equations  $L_t = 2.745 \exp(3.563(1 - \exp(-0.848t)))$  and  $L(t-11) = 96.782 \exp(0.213(1 - \exp(-0.258(t-11))))$ , respectively. A 12 month cycle is evident in the results. Most of the first year's growth (95%) is completed by the 8th month and most of the second (91%) by the 20th month of life. Anchovies in the wild at 1 year and 2 years old are 95-115 mm and 115-125 mm long,

respectively, while growth estimates of those in the laboratory are 102 mm and 119 mm, respectively. Growth of northern anchovies in the wild is similar to that estimated in the laboratory. It is unknown whether wild fish show a cyclic pattern as those in the laboratory.

Interrelationships of the family Pleuronectidae (Pisces: Pleuronectiformes).

AUTHOR(S): Sakamoto, K.

YEAR: 1984.

SOURCE: Mem. Fac. Fish., Hokkaido Univ. 31:95-215.

KEYWORDS: English sole, *Pleuronectes vetulus*, (*Parophrys vetulus*), Dover sole,

*Microstomus pacificus*, petrale sole, *Eopsetta jordani*, physiology.

ABSTRACT: This report presents the results of a detailed morphological study of

the fishes of the family Pleuronectidae. Specimens of 77 species of the 114 known species collected from nearly all the waters of the world were used for the comparative analysis. Systematic methodology was applied using cluster analysis for forming phenetic groups which then enabled taxonomic ranking. The species were ranked to supra-specific taxa, genus and subfamily by selecting a level of phenetic similarity. Four subfamilies and their characterizations were identified and discussed in this study.

Distribution and food habits of king salmon, *Oncorhynchus tshawytscha*, and steelhead rainbow trout, *Salmo gairdnerii*, in the Sacramento - San Joaquin Delta.

AUTHOR(S): Sasaki, S.

YEAR: 1966.

SOURCE: J. L. Turner and D. W. Kelley (eds) Ecological Studies of the Sacramento - San Joaquin Delta. Part 2: Fishes of the Delta. Calif. Fish & Game, Fish Bull. 136. pp 108-114.

KEYWORDS: Chinook salmon, *Oncorhynchus tshawytscha*, distribution, feeding.

ABSTRACT: Fifty adult and approximately 1,272 young salmon were collected in the Sacramento - San Joaquin River system. Most of the adults were collected during the fall run when they are migrating up the river to spawn. Adult salmon do not feed while they are in the Delta as indicated by empty stomachs for 46 of the 47 fish examined. Young salmon were collected during the journey downstream after hatching. Most of the young were caught with a midwater trawl, which indicates that young king salmon migrate downstream near the surface. Insects appeared to be the primary food of young salmon as evidenced by the presence of insects in 74% of the stomachs containing food.

Scientific rationales for fishing reef design.

AUTHOR(S): Sato, O.

YEAR: 1985.

SOURCE: Bull. Mar. Sci., 37(1):329-335.

KEYWORDS: Habitat, artificial reef, recruitment, economics.

ABSTRACT: State-of-the-art design and the extent of scientific rationales for

the construction and use of artificial reefs in Japan is the subject of this paper. Other topics of discussion include: fishing reef practices, cause of fish aggregations, fish tracking, reef density

and the life cycle and deployment of an artificial reef.

Effects of streamflow and upwelling on yield of wild coho salmon (*Oncorhynchus kisutch*) in Oregon.

AUTHOR(S): Scarnecchia, D. L.

YEAR: 1981.

SOURCE: Jour. Fish. Aquat. Sci. Canada 38(4):471-475.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, fishery, habitat, early life history, population trends.

ABSTRACT: The objective of this study was to determine if there was a correlation between coho salmon catch and streamflow and/or oceanic upwelling conditions of the Oregon coast. The results indicate a significant relationship between total November (x-3) through May (x-1) streamflows and commercial catch of coho for the year x from 1949 to 1962. There was also a significant correlation between total annual flow and commercial catch two years later. Finally, a significant relationship existed between the combined April (x-1) through June (x-1) upwelling and catch from 1947 to 1962. For the Oregon coast there is no significant relationship between summer stream flows and the annual flows, or the commercial catch of coho. From 1962 to 1973 with the introduction of hatchery reared coho, the total streamflow correlated poorly with commercial catches. A difference is noted between Washington and Oregon stream/coho interactions, and speculation is put forward as to the reasons behind the correlations.

The sea urchin fishery.

AUTHOR(S): Scattergood, L. W.

YEAR: 1961.

SOURCE: Bur. Commer. Fish., U. S. Fish Wildl. Serv., Washington, DC. Fish.

Leaflet 511. 5 p.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., physiology, fishery, economics,

feeding, reproduction, distribution.

ABSTRACT: A brief description of sea urchin distribution, physiology, reproduction and feeding habits is presented as an introduction to a discussion on the fishery. General catch information and their associated value as well as fishing methods, fishing regions and the ultimate food value of the urchin are the subjects discussed in the remainder of this paper.

Vertical stratification of 3 nearshore southern California larval

fishes (*Engraulis mordax*, *Genyonemus lineatus*, and *seriphus politus*).

AUTHOR(S): Schlotterbeck R. E., and D. W. Connally.

YEAR: 1982.

SOURCE: Fish. Bull. 80(4):895-902.

KEYWORDS: *Engraulis mordax*, northern anchovy, spawning, distribution, larvae, feeding, early life history, age.

ABSTRACT: Vertical stratification of larval northern anchovy, *Engraulis mordax*, was determined using length-frequency distributions. The anchovy is important as a forage fish as well as commercially in southern California. Length-frequency distributions indicated a major spawning period from December through May. Neuston samples

indicate high concentrations of small larvae (0-15 mm) during the heaviest spawning periods, while 2 to 3 months after, larger larvae appeared. During late summer, low spawning activity was shown by reduced numbers of larvae. Midsize larvae outnumbered 2.5 to 6 mm larvae in midwater collections except in months of heavy spawning. Only at the end of the main spawning period did significant numbers of larvae greater than 21 mm occur. Epibenthic samples showed a consistent dominance of 6 to 18 mm larvae throughout the year. There was a significantly greater number of larvae at all water column levels at night. Larvae apparently migrate from the neuston soon after hatching and return at lengths of about 20 mm. Vertical length-frequency distributions are related to mode of feeding, development during life history, and food availability. A range of size classes is encountered at all depths indicating adequate food throughout the water column, and vertical movement of adults may be related to natural behavior. This same analysis was also reported for the white croaker (*Genyonemus lineatus*) and queenfish (*Seriphus politus*).

Cooperative foraging by yellowtail, *Seriola lalandei*  
(Carangidae) on two species of fish.

AUTHOR(S): Schmitt, R. J., and S. W. Strand.

YEAR: 1982.

SOURCE: *Copeia* 1982(3):714-717.

KEYWORDS: Yellowtail, *Seriola lalandei*, feeding, behavior.

ABSTRACT: Foraging episodes of yellowtail were observed once off Santa Catalina Island, California and four times off Danzante Island, Gulf of Mexico. Actual feeding episodes were described and evaluated. The observations were presented as supporting two conclusions: 1) yellowtail use a high degree of cooperative foraging behavior during feeding maneuvers, and 2) the type of foraging tactic employed depends on the nature of prey defense. Cooperative foraging is defined as having two distinguishing characteristics: 1) there is a division of labor between individual predators during foraging ventures, and 2) individuals exercise temporary restraint in feeding until prey are more vulnerable.

Early stages of the spiny lobster taken by the boat  
"Albacore".

AUTHOR(S): Schmitt, W. L.

YEAR: 1919.

SOURCE: *Calif. Fish Game* 5(1):243.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, larvae.

ABSTRACT: A previously unknown larval stage of the California spiny lobster, *Panulirus interruptus*, is reported. On August 29, 1918, four phyllosome larvae of large size were taken by otter trawl in 75 fathoms of water. The larvae were an average of 1.0 inch in length. Later, 14 lots of large and intermediate sized phyllosomes and puerulus stages were also collected.

The marine decapod crustacea of California.

AUTHOR(S): Schmitt, W. L.

YEAR: 1921.

SOURCE: *Univ. Calif. Publ. Zool.* 23. 470 p.

KEYWORDS: Distribution, habitat, physiology, *Pandalus jordani*, ocean shrimp,



*Panulirus interruptus*, spiny lobster, cancer spp.

ABSTRACT: This paper reports the results of a field study undertaken in San Francisco Bay, CA. from January 1912 to April 1913 in relation to the decapod Crustacea collected during that survey. The 47 species taken during this biological survey are fully discussed from the point of view of their distribution and habitat. A systematic discussion of the California representatives of the Order Decapoda is presented as well as a diagrammatical explanation of terms and measurements.

Otter trawl cod-end escapement experiments for California halibut.

AUTHOR(S): Schott, J. W.

YEAR: 1975.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 61(2):82-94.

KEYWORDS: California halibut, *Paralichthys californicus*, fishing gear.

ABSTRACT: Experiments were performed to determine a cod-end mesh size that

would provide optimum escapement for sublegal California halibut, *Paralichthys californicus*, (22 inches TL), while still retaining the larger sized fish. The dominate species captured in the experiments were California halibut, hornyhead turbot (*Pleuronichthys verticalis*), fantail sole (*Xystreureys liolepis*), English sole (*Parophrys vetulus*), and sand sole (*Psettichthys melanostictus*). Comparison of the 5 1/2 - and 7 1/2 inch mesh cod ends showed that almost all sublegal fish escaped through the larger mesh while many were retained by the smaller mesh. Percentages of sublegal and legal fish in the 5 1/2 inch net were 58 and 42%, respectively, while in the 7 1/2 inch net, they were 6 to 94%, respectively. Legal size halibut in the larger mesh net also tended to be larger than those in the smaller mesh net. Generally, the 7 1/2 inch mesh cod end provided almost complete escapement for halibut less than 560 mm. while the 5 1/2 inch mesh cod end retained many undersized unmarketable fish. The 7 1/2 inch mesh trawl cod end is a suitable management tool.

Hermaphroditic California halibut, *Paralichthys californicus*.

AUTHOR(S): Schott, J. W.

YEAR: 1978.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 64(3)221-222.

KEYWORDS: California halibut, *Paralichthys californicus*, reproduction.

ABSTRACT: A California halibut (*Paralichthys californicus*) with its reproductive system in the hermaphroditic condition was reported from Morro Bay. The fish, 24 inches long and weighing 10 to 12 lbs. was unusually deep bodied (4-4.5 inches), its weight being more than 2.5 times normal for that length. Testes were ripe with running milt and ovaries contained maturing eggs.

Digest of California commercial fish laws.

AUTHOR(S): Schultze D. L. (ed.).

YEAR: 1986.

SOURCE: Calif. Dept. Fish Game, Sacramento, CA., 40 pp.

KEYWORDS: Fishing gear, fishery regulations.

ABSTRACT: Digest of laws concerning commercial fisheries. Includes information on commercial licensing, restrictions on the take of fish and invertebrates, and commercial fishing gear (e.g. nets, lines and traps).

Revised Draft. Environmental Impact Statement/Report.

Technical Appendix 8, Marine Biology for Santa Ynez Unit/Las Flores Canyon Development and Production Plan. Proposed by Exxon Co., U. S. A.

AUTHOR(S): Science Applications, Inc.

YEAR: 1984.

SOURCE: Document prepared for U. S. Minerals Management Service, California State Lands Commission, and County of Santa Barbara.

KEYWORDS: Platform, all species, contaminant susceptibility, habitat.

ABSTRACT: A description of the marine biology of the Southern California Bight and Santa Ynez/Las Flores Canyon coastal area. The general topics covered include a description of the affected environment, environmental consequences, cumulative impacts, mitigation, and project alternatives. The local setting and environmental consequences of the proposed oil development area are described in terms of the intertidal communities; benthic communities; plankton; fishes; marine mammals and seabirds; rare, endangered, and threatened species; and areas of special biological sensitivity.

Logging impacts and some mechanisms that determine the size of spring and summer populations of coho salmon fry, (*Oncorhynchus kisutch*) in Carnation Creek, British Columbia.

AUTHOR(S): Scrivener, J. C., and B. C. Andersen.

YEAR: 1984.

SOURCE: Jour. Fish. Aquat. Sci. Canada 41(7):1097-1105.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, early life history, larvae, growth.

ABSTRACT: Densities and growth of coho salmon, *Oncorhynchus kisutch*, fry were observed from March to September and contrasts in numbers before and after logging were noted. Fry emerged 6 weeks earlier in years after logging. These differences were attributed to warmer waters. Deposition of fine logging debris led to an increase in fry densities with a corresponding decrease in areas where fine debris was removed. Growth rates of the fry were inversely proportional to the densities within each area. Larger fry remained in the stream in September after logging. The increased size can be attributed to a longer growing season afforded by an earlier emergence season. The results suggest a number of complex interactions affect numbers and size of fry during the autumn and increased smolt production the following spring.

Various species of phytoplankton as food for larval northern anchovy, *Engraulis mordax*, and relative nutritional value of dinoflagellates *gymnodinium splendens* and *gonyaulax polyedra*.

AUTHOR(S): Scura, E. D., and C. W. Jerde.

YEAR: 1977.

SOURCE: Fish. Bull. 75(3):577-585.

KEYWORDS: *Engraulis mordax*, northern anchovy, larvae, feeding.

ABSTRACT: Feeding experiments on first feeding larval anchovies were conducted to assess the effects of changing prey type and abundance of prey in the chlorophyll maximum layer. First feeding larvae were placed in experimental containers with a prey

organism for 8 hrs. The larval gut was then analyzed for content. The larvae ate the five species of dinoflagellates, *Gymnodinium splendens*, *Gonyaulax polyedra*, *Prorocentrum micans* and *Peridinium trochoideum* but did not feed on diatoms or small flagellates. Anchovy larvae reared for 10 days on different prey indicated the survival rate was higher for larvae reared on *Gymnodinium splendens* than on *Gonyaulax polyedra* diet. Larval survival was better on *G. polyedra* and microzooplankton than on microzooplankton diet alone. Larvae grew faster but survival did not increase when microzooplankton was added to the *G. splendens* diet. During time periods when *G. polyedra*, diatoms and/or small flagellates predominate, feeding conditions for post yolk-sac anchovy larvae would be less suitable than when *G. splendens* are more abundant.

Ecological studies of puerulus larval stage of California spiny lobster, *Panulirus interruptus*.

AUTHOR(S): Serfling, S. A., and R. F. Ford.

YEAR: 1975.

SOURCE: Fish. Bull. 73(2):360-377.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, larvae, early life history, nursery.

ABSTRACT: The mode of life, benthic or pelagic, of the puerulus larval stage in the life history of the California spiny lobster, *Panulirus interruptus*, was determined. The development of a suitable field sampler was discussed and used to study recruitment dynamics, general abundance, and the possibility of collecting this stage for use in aquaculture. Pueruli were collected at an average rate of 4 per hour, with the highest rate reaching 12 within 90 minutes. This stage first appeared in late May with a maximum in August and was not seen after September. Seasonal influxes may be due to seasonal upwelling, as seen by pueruli maximums corresponding to periods of high temperatures. Cold canyon water masses may push larvae out of shallow water areas. Individuals were only seen swimming in the top few centimeters of water, indicating it is a surface dwelling stage. Mean swimming speed was 8 cm/s and seemed to be maintained continuously. Larvae would spread their antennae and legs and sink 50-20 cm in response to disturbance. The puerulus stage lasts approximately 2.5 months and the degree of pigmentation was a reliable method for determining the date of settlement within 1-2 days, with the pelagic stage being clear. After settlement, pueruli were never again seen swimming. The presence of a suitable habitat is needed to induce transformation. During the new moon phase, settlement was highest and did not occur at all during full moons. Nocturnal illumination from land and the prevailing overcast may have masked any lunar effect, which may serve as a stimulus for settlement. A comparison of habitat trap types was performed, with larvae having a strong preference for those containing *Phyllospadix torreyi*. Results indicate that the puerulus stage is a member of the surface-dwelling neuston, well developed for directional swimming. This may allow them to actively swim back to their shallow water nursery grounds, indicating that this stage may have evolved for the purpose of recruitment. Increasing fishing pressure may require the need to protect their natural habitats, develop artificial habitats, and supplement natural stocks by

culturing the puerulus stage.

Lead in albacore: Guide to lead pollution in Americans.

AUTHOR(S): Settle, D. M., and C. C. Patterson.

YEAR: 1980.

SOURCE: Science 207(4436):1167-1176.

KEYWORDS: Contaminant levels, Thunnus alalunga, albacore.

ABSTRACT: The effects of lead contaminant levels of albacore, Thunnus alalunga, from food processing operations was determined and the importance of lead in tuna muscle as a pollution monitor is discussed. Albacore muscle fresh from the sea contains the smallest concentration of lead measured in any biological tissue - about 0.3 nanogram (ng) per gram of fresh tissue. Albacore muscle when packed in unsoldered cans contains 7 ng of lead per gram, contaminated by industrial lead in refrigerant and thawing brines, and by lead-containing dust, lubricants, and alloys on machinery at the canning plants. When albacore was packed in lead-soldered cans it contained 1,400 ng/g. Therefore, lead contamination in canned tuna is about 10,000-fold above natural levels. The concentration of barium in fresh albacore muscle was 6 ng/g and increased to 13 ng/g in albacore muscle from lead-soldered cans. This was only a two-fold increase and not considered an important difference. Lead concentrations have been incorrectly analyzed by many researchers in the past because of lead contamination during sample collection and analysis. This has masked the true magnitude of lead contamination of food by lead-soldered cans. It was recommended that lead-soldered cans be eliminated immediately because they constitute a major source of lead pollution in foods. The global extent of lead pollution, the exposure of humans to lead and biochemical dysfunctions caused by lead are also discussed.

Surface slicks associated with tidally forced internal waves may transport pelagic larvae of benthic invertebrates and fishes shoreward.

AUTHOR(S): Shanks, A. L.

YEAR: 1983.

SOURCE: Mar. Ecol. Prog. Ser. 13:311-315.

KEYWORDS: Larvae, all species, early life history, recruitment, distribution.

ABSTRACT: Fluctuations in the abundance of crab megalope larvae collected several hundred meters offshore were found to correlate with the tide range. The data suggest that the megalope are carried to shore in surface slicks by tidal currents. These surface slicks were found to transport drogues 1 to 2 km shoreward in 2 to 3 hours. Neuston net tows made along the slicks, as well as in the ripples between slicks, were found to have a higher concentration of pelagic larvae in the surface slicks than between them. The combination of the results from the drogues and net tows suggest that concentration and transport in slicks associated with tidally driven internal waves may be an important means for the onshore transport of pelagic life history stages of marine organisms.

The homing instinct in trout and salmon.

AUTHOR(S): Shapovalov, L.

YEAR: 1941.

SOURCE: Proc. 6th Pacific Science Congress 3:317-322.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, Chinook salmon, *Oncorhynchus*

*tshawytscha*, wetfish, migration, behavior.

ABSTRACT: The purpose of this paper was to review the known facts about homing instincts in trout and salmon in the face of a controversy as to whether or not such instincts actually exist. The author concludes that, based on the literature, the phenomenon is actual. Referring to several previous studies, he notes that "straying" to other streams occurs 1.2 to 2.1% of the time between streams with proximal mouths, and as much as 20.8% in different tributaries of the same stream. It is undetermined how far a fish can travel at sea without becoming "lost". The author also notes that the mechanism by which salmon and trout home is unknown, although chemical and hydrographic conditions are theorized to be at least clues to homing behavior. Finally, the author concludes that according to accepted biological definitions that the terms instinct, homing, and parent stream are appropriate to the behavior in question, in answer to statements to the contrary.

An electrophoretic study of hemoglobins of some scombroid fishes and related forms.

AUTHOR(S): Sharp, G. D.

YEAR: 1973.

SOURCE: Comp. Biochem. Physiol. 44:381-388.

KEYWORDS: *Sebastes miniatus*, vermillion rockfish, physiology.

ABSTRACT: Electrophoretic characteristics of the hemoglobin of various scombroid fishes was described. *Sebastes miniatus* has six separate hemoglobins.

Energy for migration in albacore, *Thunnus alalunga*.

AUTHOR(S): Sharp, G. D., and R. C. Dotson.

YEAR: 1977.

SOURCE: Fish. Bull. 75(2):447-450.

KEYWORDS: Albacore, *Thunnus alalunga*, migration, length/weight, physiology.

ABSTRACT: A length/weight regression was constructed for albacore that were caught in June. September caught albacore fit the predicted curve; however, albacore caught in July averaged below the predicted weight. Body density analysis indicated that the difference was due to fat loss, probably related to migration. The authors conclude that it may be possible to determine individuals just entering a local population from a body density analysis. Data from swimming energetics studies were used to calculate the energy requirements for albacore migrations.

Fate of post-larval bottom fishes in a highly urbanized coastal zone.

AUTHOR(S): Sherwood, J. J., and A. J. Mearns.

YEAR: 1981.

SOURCE: Rapp. P-v. Reun. Cons. Int. Explor. Mer. 178:104-111

KEYWORDS: Dover sole, *Microstomus pacificus*, contaminant susceptibility.

ABSTRACT: The bottom fish assemblages on the Palos Verdes shelf were sampled at 12 stations and depths of 23, 61 and 137 m using small otter trawls. Of the 60,000 fish (comprising 90 species) in 169 samples approximately 15% were juveniles smaller than 60 mm SL.

The percentages of Dover sole exhibiting fin erosion and skin tumors increased from 0.93 to 72% and 0 to 7.7%, respectively, from April to December 1977. The degree of liver enlargement and levels of chlorinated hydrocarbons were also considered. Liver enlargement occurred within one month (May) and the average increase at contaminated areas was three times higher than at control stations. The results of this study suggested that fin erosion, and necrosis of the liver cells were affected by exposure to wastewater contaminants. Skin tumors were probably not related to wastewater discharge exposure.

Recruitment of nearshore demersal fishes.

AUTHOR(S): Sherwood, M.

YEAR: 1980.

SOURCE: Pages 319-333 in W. Bascom (ed.), Coastal water research project biennial report for years 1979-80. Southern California Coastal Water Research Project, Long Beach, California.

KEYWORDS: Dover sole, *Microstomus pacificus*, chilipepper, *Sebastes goodei*, groundfish, distribution, growth.

ABSTRACT: This study set out to identify demersal species of fish with abundant juvenile populations in nearshore waters off southern California. Approximately 15% of each trawl contained specimens less than 60 mm standard length (the chosen range for juvenile fishes). In each area sampled, less than 10 species represented over 95% of the trawl caught juveniles. These included the Dover sole, *Microstomus pacificus*, which was sampled below 30 m at the three coastal sampling areas, and the chilipepper, *Sebastes goodei*, which was the least abundant fish sampled off Catalina Island, and was found only at stations between 23-26 m deep. The striptail rockfish, Pacific sanddab, and speckled sanddab were among the most abundant species in each area sampled. Recruitment occurred during all seasons, with winter and spring the primary seasons. The calico rockfish and the California lizardfish showed strong aperiodic recruitment. Dover sole recruit primarily during spring. Reduced growth was exhibited during the winter months by several species collected in San Pedro Bay, including Dover sole.

The fin erosion syndrome.

AUTHOR(S): Sherwood, M. J.

YEAR: 1978.

SOURCE: Pages 203-221 in: W. Bascom (ed.) Southern California Coastal Water Research Project Annual Report 1978.

KEYWORDS: Dover sole, *Microstomus pacificus*, contaminant levels, contaminant susceptibility, English sole, *Parophrys vetulus*, northern anchovy, *Engraulis mordax*, Petrale sole, *Eopsetta jordani*, vermillion rockfish, *Sebastes miniatus*, sablefish, *Anoplopoma fimbria*.

ABSTRACT: Demersal fishes between Santa Monica Bay and Dana Point were collected and analyzed for prevalence of fin erosion. Most species affected with fin erosion had highest frequencies of the disease in the vicinity of the waste water discharge on the Palos Verdes Shelf. In general, Dover sole was the species most frequently affected (30% of the 27,991 specimens examined). Infected individuals were histologically examined and it was found that individuals from the Palos Verdes Shelf also had enlarged livers containing increased amounts of fat and exhibiting structural disorganization. Fin erosion in recently

settled Dover sole, temporal trends in fin erosion, and hypotheses on possible causes of fin erosion are also discussed. Fin erosion appears to result from the exposure of susceptible species to sediments contaminated with chemical wastes. The precise causes of the disease remain unknown; however, elevated levels of PCB's may be a factor in the development of the disease.

Occurrence of tumor-bearing Dover sole (*Microstomus pacificus*) off Pt. Arguello, California and Baja California, Mexico.

AUTHOR(S): Sherwood, M. J. and A. J. Mearns.

YEAR: 1976.

SOURCE: Trans. Am. Fish. Soc. 105(4):561-563.

KEYWORDS: Dover sole, *microstomus pacificus*, distribution.

ABSTRACT: Museum collections of the Dover sole, *Microstomus pacificus*, were examined to determine the effect of waste discharge on tumor acquisition in southern California. The known southern range of tumor-bearing Dover sole was extended south along the Pacific Coast of North America to waters off Baja California in Mexico. Tumor size was related to fish size with the smallest tumors on the smallest fish. It was evident that Dover sole bearing tumors were found far from sources of waste discharge and urban development.

S. Guy.

A note on spawning of the Pacific market squid, *Loligo opalescens* (Berry, 1911), in the Barkeley Sound region, Vancouver Island, Canada.

AUTHOR(S): Shimek, R. L., D. Fyfe, L. Ramsey, A. Bergey, J. Elliott, and  
YEAR: 1984.

SOURCE: Fish. Bull. 82(2):445-446.

KEYWORDS: Market squid, *Loligo opalescens*, spawning.

ABSTRACT: Spawning of the market squid, *Loligo opalescens*, was observed in the Barkeley Sound region. The size of egg masses varied from individual masses of 1.3m<sup>2</sup> to large aggregations of 69.3m<sup>2</sup>. Approximately 1,937 capsules per isolated mass were found and totaled about 288,000 eggs (150 eggs/capsule). The large aggregation would have been the result of 24,000 females spawning (with each female laying about 20 capsules). The northern population of squid form large spawning schools and lay large egg mass clusters as seen in the California population.

Summary report of the billfish stock assessment workshop Pacific resources.

AUTHOR(S): Shomura, R. S., ed.

YEAR: 1980.

SOURCE: NOAA-TM-NMFS-SWFC-5. 58 pp.

KEYWORDS: Swordfish, *Xiphias gladius*, wetfish, fishery, fishing gear, population trends.

ABSTRACT: This paper is the summary of a stock assessment workshop on Pacific billfish. Catch data, stock appraisals, and population parameters are given for marlin, shortbill spearfish, sailfish, and the swordfish, *Xiphias gladius*. Most of the catch of swordfish is from the northwestern Pacific Ocean, and is landed by the Japanese longline fleet. The total Pacific catch peaked at 24,300 mt in 1961, and declined abruptly to 14,600 mt in 1962;

between 1963 and 1977 it has averaged at 13,800 mt. The stock structure is not well understood. There is either one Pacific-wide population, or three separate stocks. For the one stock scenario a maximum sustainable yield of 20,000 mt has been estimated, which would indicate that the fishery is in good condition. There are no estimates of some of the basic population parameters for the swordfish, primarily due to a lack of a reliable aging technique. Longlining for swordfish is more effective at night. The drop in swordfish catch in the early 60s was primarily due to a shift to daytime fishing for tuna. Return to night fishing could result in overexploitation of the fishery. Recommendations are made for the collection of size and sex data from all fisheries, and that research attention be given to find a reliable aging technique.

The ecology of estuarine channels of the Pacific Northwest Coast: A community profile.

AUTHOR(S): Simenstad, C. A.

YEAR: 1983.

SOURCE: U. S. Fish. Wildl. Serv. FWS/OBS-83-05 181 pp.

KEYWORDS: Community, ichthyoplankton, life history, migration, spawning, reproduction, northern anchovy, *Engraulis mordax*, coho salmon, *Oncorhynchus kisutch*, chinook salmon, *Oncorhynchus tshawytscha*, rockfish, *Sebastes* spp., lingcod, *Ophiodon elongatus*, English sole, *Parophrys vetulus*.

ABSTRACT: A review of the estuarine channels of the Pacific Northwest in terms of the physical characteristics, primary productivity, detritus, mammals, trophic and community ecology, and assemblages of invertebrates, fish and birds. The survey of fish assemblages included both demersal and pelagic fishes (resident and anadromous pelagic fishes, and ichthyoplankton). Information on migrating spawning and life history are also included.

L. J. Bledsoe.

Food web relationships of northern Puget Sound and the Strait of Juan de Fuca.

AUTHOR(S): Simenstad, C. A., B. S. Miller, C. F. Nyblade, K. Thornburgh, and

YEAR: 1979.

SOURCE: U. S. Interagency (NOAA/EPA) Energy/Environ. Res. Dev. Prog. Rep.,

EPA-600/7-70-259. Washington, DC. 335 p.

KEYWORDS: English sole, *Parophrys vetulus*, contaminant susceptibility, habitat, feeding, community.

ABSTRACT: The purpose of this study was to identify biological means by which

petroleum constituents may be transferred through the trophic levels in biological communities. The northern Puget Sound and the Strait of Juan de Fuca were the areas of study, selected because of their anticipated increase in petroleum transfer and refining activities. Information from literature, both published and unpublished, and from the ongoing MESA studies was synthesized to identify the potential transfer process of petroleum hydrocarbons through the marine ecosystem. Previous fish stomach analysis and quarterly sampling for the purpose of collecting stomach samples was also undertaken to identify prey/predator species and food web structures.



The biology of two offshore oil platforms.

AUTHOR(S): Simpson, R. A.

YEAR: 1977.

SOURCE: IMR Ref. 7613. 14 pp.

KEYWORDS: Platforms, artificial reef, community, colonization.

ABSTRACT: Two oil platforms located approximately two miles offshore in 100 ft of water, in the Santa Barbara Channel were the site of an ongoing survey of biological succession and community assemblages. The project was initiated to estimate plant and animal abundances on and near the platforms, observe changes over time, determine the impact of the changed water chemistry, and assess the overall productivity of the region. Dive teams conducted underwater surveys of the midwater, platform structure, and bottom communities. The platform was covered with a variety of fouling organisms including mussels, barnacles and anemones. Several species of vertebrates were associated with the "cuttings" pile. These included mussels, crabs, anemones and echinoderms. Forty-five species of fish were associated with the platforms; 17 were abundant and were localized in the midwater between 30 and 70 ft. The bird and mammal assemblages were represented by 16 and 4 species, respectively. Species diversity was greater near the platform than on nearby rocky reefs or sandy bottoms. The abundance was estimated at 20 to 50 times higher. The diver surveys also accumulated evidence for reproductive activities at the platforms. Chemical analyses of tissues and sediment suggest the animals are not being contaminated. The results of this study suggest oil platforms may enhance productivity of offshore fish assemblages.

El-Nino events and variability in a Pacific mackerel.

AUTHOR(S): Sinclair, M., M. J. Tremblay, and P. Bernal.

YEAR: 1985.

SOURCE: Jour. Fish. Aquat. Sci. Canada 42(3):602-608.

KEYWORDS: Scomber japonicus, chub mackerel, recruitment, seasonality.

ABSTRACT: It has been shown that zooplankton abundance in the California Current is primarily influenced by large-scale variations such as those caused by El Nino events. However, the effect on recruitment to fish populations in this current system was not addressed. This newly available data on plankton in combination with the greater understanding of the importance of El Nino events on the oceanography of the California Current system was used to reevaluate recruitment mechanisms of the Pacific mackerel, *Scomber japonicus*. Variations in sea levels were used as an index of changes in transport of the California Current. These changes correlate with El Nino events. An essentially one-to-one relationship existed between the interannual variability in survival of the fish to age 1 and the sea level index. Good survival is correlated with the El Nino associated events, but is negatively correlated with all the zooplankton estimates. Thus, although a food or advection hypothesis cannot be ruled out, (the results are consistent with Hjort's (1914) second hypothesis proposed to explain recruitment variability), they stress the importance in a direct sense of the physical oceanographic processes.

An assessment of the South Pacific albacore, *Thunnus alalunga*,

fishery, 1953-72.

AUTHOR(S): Skillman, R. A.

YEAR: 1975.

SOURCE: Mar. Fish. Rev. 37(3):9-17.

KEYWORDS: Fishery, age, fishing gear, *Thunnus alalunga*, albacore.

ABSTRACT: A production model was used to assess the effects of the fishery on the albacore, *Thunnus alalunga*, population and the biological potential for expansion of the fishery in the South Pacific. The albacore fishery was established in the South Pacific in 1954 when Japanese tuna vessels began using longline fishing gear in the vicinity of American Samoa. This fishery has expanded over the years and albacore catches reached a peak in 1967 and have since declined. The production models for effort in both days and hooks fished indicated a maximum sustainable "average" yield (MSAY) of 33,000 - 35,000 metric tons. Therefore, it was concluded that the South Pacific albacore fishery has reached or nearly reached the level of MSAY, given the current constitution of the fishery. Any further increase in fishing effort, deployed in the same manner as the present fishing effort, will result in a further decline in catch per unit effort, without any significant increase, and most likely a decrease, in yield. However, if the fleet were to change its fishing strategy for example, by harvesting different age groups, the estimated MSAY for the stock might change. If a 25% increase in fishing effort over the 1971 level is hypothesized, the estimates of sustainable "average" yield (SAY) would decrease to 27,900 mt from a 1971 SAY level of 30,000 for the model using effort in days fished, or would increase to 34,300 mt from a 1971 SAY of about 34,000 mt for the model using effort in hooks fished.

Length-weight relationships for six species of billfishes in the central Pacific Ocean.

AUTHOR(S): Skillman, R. A., and M. Y. Y. Yong.

YEAR: 1972.

SOURCE: Pages 126-137 in Part 2, Review and contributed papers.

Proc.Intl. Billfish Symp., Mailwa-Kona, Hawaii, August 1972.

NOAA Tech. Rep. NMFS SSRF-675.

KEYWORDS: Swordfish, *Xiphias gladius*, length/weight.

ABSTRACT: Length-weight relationships for six species of billfish; black marlin (*Makaira indica*), blue marlin (*Makaira nigricans*), sailfish (*Istiophorus platypterus*), shortbill spearfish (*Tetrapturus angustirostris*), striped marlin (*Tetrapturus audox*) and swordfish (*Xiphias gladius*), were determined. A 20-year sampling database from central Pacific fishing records was used to test log linear and nonlinear models. Derivations from 3.0 as a coefficient of allometry were considered. Blue marlin ranging from 50 to 135cm FL and male blue marlin larger than 135 cm had a coefficient of allometry less than 3.0 whereas the females larger than 135 cm had coefficients of allometry equal to 3.0. Coefficients of allometry for the sailfish and black marlin were less than 3.0 and equal to 3.0, respectively. The shortbill spearfish, striped marlin and swordfish all had coefficients of allometry greater than 3.0. The authors cautioned that small data sets with little variation were somewhat questionable.

A management-oriented model of an abalone fishery whose substocks are subject to pulse fishing.

AUTHOR(S): Sluczanowski, P. R.

YEAR: 1984.

SOURCE: Jour. Fish. Aquat. Sci. Canada 41(7):1008-1014.

KEYWORDS: Abalone, *Haliotis* spp., fishery.

ABSTRACT: A fishery management model which takes into account periods between fishing was proposed. The model is more useful and more easily measured than a mortality (Z) model. The benefits include long-term biomass yield estimates and egg production estimates due to the control of minimum legal lengths (Lr) or fishery closure periods (P). This model was utilized in the case of the greenlip abalone, *Haliotis laevis* from southern Australia. By increasing either control variable (Lr or P) significant increases in egg production (up to 100%) can be expected with little effect on the yield (less than 7% difference). However, without implementation of the model, a serious overexploitation situation could threaten survival of the resource.

Gonad structure and the reproductive cycle of the kelp bass, *Paralabrax clathratus* (Girard), with comments on the relationships of the serranid genus, *Paralabrax*.

AUTHOR(S): Smith, C. L., and P. H. Young.

YEAR: 1966.

SOURCE: Calif. Fish Game 52(4):283-292.

KEYWORDS: Spawning, reproduction, *Paralabrax clathratus*, kelp bass.

ABSTRACT: Reproduction in kelp bass, *Paralabrax clathratus*, was investigated and the reproductive mechanism was compared to other serranids. Both the ovary and testes of mature kelp bass are described in histological detail and ovarian and testicular classes were designated. Spawning occurs during June, July, August, and September. The ova begin to develop in late April or early May and reach maturity in June. Development continues until the following September, and by November all individuals are sexually inactive. The male cycle is comparable. In April and May all males showed active spermatogenesis and by June some individuals had abundant sperm. Spermatogenesis starts to cease in September, although many sperm remained in the testes. Females ranged from 224 to 485 mm TL and males ranged from 241 to 431 mm TL. There was no increase in the proportion of males with increasing size and, in fact, the largest specimens were females. The presence of a testicular lumen indicates that the kelp bass is derived from a protogynously hermaphroditic ancestor and that functional change has preceded structural change. Hypothetical steps leading to secondary gonochorism are postulated. It is suggested that *Paralabrax* is more closely related to *Centropristes* than any other extent serranid based on the reproductive system and skeletal characters.

Maturity and fecundity.

AUTHOR(S): Smith, E. J., Jr., and C. V. Paul.

YEAR: 1960.

SOURCE: Pages 46-52 in J. L. Baxter (ed.), A study of the yellowtail, *Seriola dorsalis* (Gill). Calif. Dep. Fish Game, Fish Bull. 110.

KEYWORDS: Age, growth, spawning, yellowtail, *Seriola lalandi* (=dorsalis).

ABSTRACT: This section of A Study of the Yellowtail discusses maturity and

fecundity and is based on ova diameter measurements collected from 140 samples over a five-year period. Spawning, frequency of spawning

and age and size at first maturity are also included in this report.

Age and rate of growth.

AUTHOR(S): Smith, E. J., Jr., and H. M. Mekjian.

YEAR: 1960.

SOURCE: Pages 22-32 in J. L. Baxter (ed.), A Study of the yellowtail, *Seriola dorsalis* (Gill). Calif. Dep. Fish Game, Fish Bull. 110.

KEYWORDS: Yellowtail, *Seriola lalandi* (=dorsalis), age, growth.

ABSTRACT: A systematic study was undertaken to determine a reliable way to age

yellowtail. This paper reports the results of that study, identifying the various methods tried and discarded, and the successful method employed to obtain the sought-after results. Illustrations of scale enlargements are provided with the annual growth rings identified.

Age and growth studies of English sole, *Parophrys vetulus*, in Monterey Bay, California.

AUTHOR(S): Smith, J. G., and R. J. Nitsos.

YEAR: 1969.

SOURCE: Pac. Mar. Fish. Comm. Bull. 7:73-79.

KEYWORDS: Age, growth, length/weight, *Parophrys vetulus*, English sole.

ABSTRACT: The interoperculum bone was used to estimate age and growth of English sole, *Parophrys vetulus*, in Monterey Bay.

Length-frequency data for English sole show modes at 4, 14, and 19 cm. Fish in age classes I and II (determined from interopercular) averaged 14 and 20 cm. respectively. Therefore, the 4 cm mode represents the 0-age class. The relationship of interopercular length to total length was similar for males and females and could be expressed by the equation:  $Y = 0.403X + 1.77$ ; where  $Y$  = total length in cm, and  $X$  = magnified interopercular length ( $3.4X$ ) in mm. Calculated mean, maximum and minimum lengths at age Class I were determined from English sole representing 10 year classes. These data indicate a mean length (TL) of 13.5 cm with a range of 12.9 to 15.0 cm at age 1. Calculated age-length data were fitted to a von Bertalanffy equation. The growth curves constructed from these data conform closely to the observed values except at the extreme ages of 9 and 10 years. Females were larger than males for all ages. The length/weight relationship of female English sole was determined to be  $W = 0.00024524 L^3.082384$  and for male English sole  $W = 0.00034156 L^2.96793$ ; where  $W$  = weight in ounces and  $L$  = total

The effects of internal waves on fish school mapping with sonar in the California current area.

AUTHOR(S): Smith, P. E.

YEAR: 1977.

SOURCE: Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 170:223-231.

KEYWORDS: Distribution, habitat, behavior, seasonality.

ABSTRACT: Sonar mapping provides estimates of the horizontal dimensions of fish schools, as well as an estimate of the number of fish schools and their cross-sectional area. This technique is useful in surface waters where echo-sounders are ineffective. Data collected in this study were examined to determine the effects of transmission loss variation on target detection. The most important results from the study show that the effect of internal waves on fish school mapping with sonar is the variation of

detection range. It appears that internal waves of shorter period are important sources of variation. Two directions of research are recommended from this study: explore the optimum sonar transducer placement depth with respect to internal waves and sound velocity profile, or explore the further allocation of sound velocity profiling effort according to the incidence of fish schools by region and by month.

Primary production and the anchovy population in the Southern California Bight: Comparison of time series.

AUTHOR(S): Smith, P. E., and R. W. Eppley.

YEAR: 1982.

SOURCE: *Limnol. Oceanogr.* 27(1):1-17.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, ichthyoplankton, spawning.

ABSTRACT: Time series are used to examine the functional relationships between primary production, zooplankton abundance, and northern anchovy, *Engraulis mordax*, populations in the Southern California Bight region. A detailed description is given for estimated primary production, zooplankton standing stock, and microplankton standing crop for the area. Anchovy larvae have a seasonal maximum in January-March. Mean abundances in winter, spring, and autumn are 74.2, 66.0, and 7.7 m<sup>-2</sup>, respectively, with a mean of annual seasonal averages of 43.9 m<sup>-2</sup>. Although annual values show no dependence of larvae on plankton, quarterly values show production, zooplankton standing stocks, and anchovy larvae are all positively intercorrelated. The relationship explains 46% of the abundance of larvae. Adult and juvenile anchovy biomass in g.m<sup>-2</sup> increased 12-fold, decreased 5-fold, and increased 12-fold in the years 1952-1957, 1957-1961, and 1961-1966, respectively. The total range of values was 28-fold. In 1957 the reproduction investment in eggs was about 0.9% of the annual primary production while in 1966 egg production was 1.8% of the local phytoplankton production. Fish-scale deposition rates showed no significant correlations with primary production and anchovy biomass from 1785-1970 in five-year intervals. The intensity of spawning activity in part depends on zooplankton abundance three quarters earlier and in part on the productivity of the area in the same season. Anchovy schooling may be important in providing nutrients for phytoplankton as it imposes both spatial and temporal variability in nutrient distribution. Results suggest that there was a higher zooplankton biomass per unit primary production when anchovies were abundant than when they were less abundant.

Fish colonization and the effect of fishing activities on two artificial reefs in Monterey Bay, California.

AUTHOR(S): Solonsky, A. C.

YEAR: 1985.

SOURCE: *Bull. Mar. Sci.* 37(1):336-347.

KEYWORDS: Artificial reef, recruitment, colonization.

ABSTRACT: Juvenile recruitment is compared with adult colonization in an attempt to determine whether artificial reefs actually enhance, redistribute or concentrate fish stocks. The possible advantages from constructing unmarked reefs next to marked reefs is investigated. Studies are conducted through underwater fish surveys, tagging, fishing success, and fishing pressure. Of 20 recreationally important fish species observed on the reef, the

most common were the blue rockfish (*Sebastes mystinus*), olive rockfish (*S. serranoides*), white surfperch (*Phanerodon furcatus*), black surfperch (*Embiotoca jacksoni*), and the rainfow surfperch (*Hypsurius caryi*). Recruitment of small (>20 cm) rockfish was observed at varying seasons after their initial recruitment in the summer of 1982. Results of tagging studies demonstrate that fish movement was directed from the unmarked to the marked reef. Fishing success was greater on the unmarked reefs in all months except January and February (1982) when it was similar on both. On the marked reef catch-per-unit-effort (CPUE) averaged 0.9 fish per angler hour while on the unmarked reef average CPUE was 2.3. No recreational fishermen were observed on the unmarked reef. On the marked reef, fishing varied with season with a peak in May of an average of 132 hours fishing pressure per month. Due to fishing pressure, fish movement and colonization was from an unexploited reef to a reef with substantial fishing pressure. Fishing pressure was sufficiently strong enough to reduce CPUE in a one-year period. The movement of fishes was not fast enough to replace the losses from fishing. Reefs were rapidly colonized by fishes, with 3/4 of the species observed recorded within 6-months of construction. The increase in available habitat is a benefit, this habitat may increase a movement in that direction. Artificial reefs will probably not contribute to production until they become natural communities. A potential problem in artificial reef construction may be the concentration of fishes where high fishing pressure can be applied. Locating unmarked reefs nearby can mitigate this problem by providing a refuge from fishing pressure, allowing movement and reproduction by mature adults.

Stock identification studies on the Dungeness crab, *Cancer magister*.

AUTHOR(S): Soule, M., and R. N. Tasto.

YEAR: 1983.

SOURCE: Pages 39-42 in P. W. Wild and R. N. Tasto (eds.), *Life history, environment, and mariculture studies on the Dungeness crab, Cancer magister, with emphasis on the central California fishery resource*. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: *Cancer magister*, population trends, market crab.

ABSTRACT: The purpose of this study was to determine if genetic and geographic variation exist in Dungeness crab stocks in commercial fishing areas. Electrophoretic techniques were used on various internal tissues. The study was divided into two phases. In Phase I, crabs were studied in nine localities ranging from northern California to Alaska. The low level of electrophoretic variation indicate that gene flow in *Cancer magister* is sufficient to prevent local differentiation of populations. In Phase II, the study concentrated on juvenile crabs from San Francisco and Humbolt Bays. It was found that each crab had two loci (instead of one, as concluded in Phase I) but neither was polymorphic. It was concluded that due to an extensive larval phase continuously exposed to strong currents, discrete populations of Dungeness crabs are unlikely to develop.

Abundance of pelagic fish during the 19th and 20th centuries as recorded in anaerobic sediment off the Californias.

AUTHOR(S): Soutar, A., and Isaacs, J. D.

YEAR: 1974.

SOURCE: Fish. Bull. 72(2):257-273.

KEYWORDS: Distribution, population trends, recruitment, *Engraulis mordax*, northern anchovy, Pacific hake, *Merluccius productus*, chub mackerel, *Scomber japonicus*.

ABSTRACT: This paper analyzes anaerobic sediments from the Santa Barbara Basin, Alta California, and the Soledad Basin, Baja California. Within these sediments are scales from the Pacific sardine (*Sardinops sagax caeruleus*), the northern anchovy (*Engraulis mordax*), the Pacific hake (*Merluccius productus*), the Pacific saury (*Coloias saira*), and the Pacific mackerel (*Scomber japonicus*). Using the relative abundance of the scales of these species in the deposits, the authors draw conclusions on the population trends, abundance and distribution over the past hundred years or so. The years from 1855 to 1865 show strong recruitment for the Pacific sardine, with the years from 1865 to 1880 showing poor year-class success. The decline of the Pacific sardine is considered to have begun by at least 1890, thirty years before the inception of the fishery. Northern anchovy populations appear to have made moderate increases in the population densities over the past one to two hundred years. Pacific hake appears to have increased in density since a low in 1920, with higher concentrations appearing before. The combined mean biomass for these three species over the past thirty years is about 2 million MT. While over the past 150 years the mean biomass was about 8 million MT. The Pacific saury and Pacific mackerel appear only to have invaded, in significant numbers, the coastal waters of California since the 1940s.

Summary of data taken for oil platform studies.

AUTHOR(S): Southern California Coastal Water Research Project.

YEAR: 1975.

SOURCE: Manuscript prepared for Institute of Marine Resources, University of California 5L-21174-0.

KEYWORDS: All species, platform, habitat, contaminant levels, distribution.

ABSTRACT: Information was obtained on the environment surrounding platforms Hazel, a softbottom control site, and Hilda, a hardbottom control site. Sampling techniques and instruments included T.V. video, 35 mm slides, benthic samples, cores, B.T. (temperature with depth) and D. O. (dissolved oxygen) meters, sediment collectors, current meters, hydrographic mapping, fish and invertebrate collections (trapping, hook and line, and divers), and plankton tow. Data on the protozoans, plants, and animals observed around the platforms, and trace metal concentrations in fish and invertebrates are summarized. The initial conclusion from this study indicates that the platform structure itself appears to enhance the typical mud bottom by providing shelter and a food web.

1980 annual report, San Onofre Nuclear Generating Station, Vol. III: Marine environmental analysis and interpretation.

AUTHOR(S): Southern California Edison Company.

YEAR: 1981.

SOURCE: Southern California Edison Co. Research & Development ser 81-RD-9.

KEYWORDS: California halibut, northern anchovy, *Paralichthys*

californicus, Engraulis mordax, habitat, community, seasonality.

ABSTRACT: Annual report of oceanographic and marine biological studies performed in the vicinity of the San Onofre Nuclear Generating Station. The main purpose of the study was to collect preoperational baseline data prior to the operation of units 1 and 2, and to continue assessment of Unit 1 operational effects. The topics covered include Oceanography (temperature, turbidity, water quality, and sedimentology), plankton, intertidal (sand, and cobble), subtidal (sediment infaunal, and cobble), fish (field study, and in-plant study), and kelp.

1980 annual report, San Onofre Nuclear Generating Station,  
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Effects of diets containing dogfish (*Squalus acanthias*) meal on the mercury content and growth of pen-reared coho salmon (*Oncorhynchus kisutch*).

AUTHOR(S): Spinelli, J., and C. Mahnken.

YEAR: 1976.

SOURCE: Jour. Fish. Res. Bd. Canada 33:1771-1778.

KEYWORDS: Contaminant susceptibility, coho salmon, *Oncorhynchus kisutch*, feeding, growth.

ABSTRACT: In two separate experiments captive coho salmon were fed on fish-meal diets containing dogfish versus the usual herring. The results of the dog fish meal diet were analyzed for the amount of mercury deposited in the muscle and liver, whether chelating agents in polygalacturonic acid or orange peel have the ability to reduce the deposition of mercury in the muscle and liver, and the effects of the nutritive value on growth. The results indicated that dogfish meal may be used as a partial (<50%) replacement for the fish meal portion of the diet without encountering mercury values (in the muscle) that exceed 0.5 ppm mercury. The chelating agents appeared to have no effect on mercury deposition in muscle and liver. Decreased growth occurred when the salmon were fed diets where 50% or more herring meal was replaced with dogfish meal.

Age and growth of the market squid, *Loligo opalescens* Berry, from statoliths.

AUTHOR(S): Spratt, J. D.



YEAR: 1979.

SOURCE: CalCOFI Rep. 20:58-64.

KEYWORDS: Market squid, *Loligo opalescens*, growth, spawning.

ABSTRACT: Growth increments in the statoliths of market squid, *Loligo opalescens*, were of two varieties. Up to 150 "daily" growth marks are initially laid down followed by a series of "monthly" growth marks in individuals over 6 months old. The validity of growth increments were tested using lunar periodicity marks and squid of known age. The results indicate that squid are mature enough to spawn within the first year. All squid spawn after 14-22 months (100-145 mm dorsal mantle length).

Anomalous otoliths from northern anchovy, *Engraulis mordax*.

AUTHOR(S): Spratt, J. D.

YEAR: 1975.

SOURCE: Calif. Fish Game 61(4):235-236.

KEYWORDS: Northern anchovy, *Engraulis mordax*, physiology, age, growth.

ABSTRACT: Northern anchovy (*Engraulis mordax*) otoliths were collected from the California reduction fishery for age and growth studies. Three types of anomalous otoliths have been described. Opaque and translucent otoliths are the most common, making up an estimated 5% of all otoliths taken. The second type is narrow on the dorso-ventral axis, only three-fourths the width of a normal otolith, and very rare. The final type was oval and to date only one has been reported. The different shaped otoliths probably are due to a genetic trait while the completely calcified or transparent ones are most likely due to some environmental factor.

Growth rate of northern anchovy, *Engraulis mordax*, in southern California waters, calculated from otoliths.

AUTHOR(S): Spratt, J. D.

YEAR: 1975.

SOURCE: Calif. Fish Game 61(3):116-126.

KEYWORDS: *Engraulis mordax*, northern anchovy, growth, length/weight, age.

ABSTRACT: Using annuli formed in otoliths, the growth rate of the northern anchovy, *Engraulis mordax*, from southern California was examined. Individual year classes were followed using back calculations, relating the measurement of only the most recently formed annuli and the standard length of the fish. Back calculated mean lengths at age (1-6) were 92, 112, 124, 135, 145, and 155 mm, which closely compared to von Bertalanffy growth equation ( $L_{\infty} = 165.52$ ,  $K = 0.298682$ ,  $t_0 = -1.7144$ ) estimates of 92, 111, 125, 135, 143, and 149 mm. In southern California the mean length of *E. mordax* is smaller along with a slower growth rate, compared to the more northern populations. This may be due to the density dependent nature of the species along with a population size increase in southern California.

Age and growth of the market squid, *Loligo opalescens* Berry, in Monterey Bay.

AUTHOR(S): Spratt, J. D.

YEAR: 1978.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 169:35-44.

KEYWORDS: Market squid, *Loligo opalescens*, growth, age.

ABSTRACT: Market squid, *Loligo opalescens*, were collected from Monterey

Bay over four years (1972-1976) and the statoliths were extracted. Growth rings were counted and plotted against dorsal mantle lengths (5 mm - 190 mm) to obtain a growth curve. The growth rate suggested maximum age of the squid was 2 years old. Statoliths exhibited daily and monthly growth increments. Squid were found to spawn after 1 year with all others spawning before 2 years. The results suggested serious management implications and good recruitment necessary to maintain a spawning population.

Anglers guide to United States Pacific Coast.

AUTHOR(S): Squire, J. L., and S. E. Smith.

YEAR: 1977.

SOURCE: U. S. Dept. of Commerce, NOAA, NMFS Publication. 139 pp.

KEYWORDS: Fishery, distribution, habitat, all species.

ABSTRACT: Guide to sport fishing areas along the coasts of California, Oregon, Washington, Alaska, Hawaii, American Samoa, and Guam. Information on sport fishing facilities, coastline fishing charts, and common game fishes and their availability to the angler. The fishing sites within a given geographic area are described in terms of sport fish species in different habitats (e.g. offshore vs. onshore habitats) at different times of the year.

Angler catch rates of billfishes in the Pacific Ocean.

AUTHOR(S): Squire, J. L., Jr.

YEAR: 1974.

SOURCE: Pages 290-295 in Part 2, Review and contributed papers.

Proc. Intl. Billfish Symp., Kailua-Kona, Hawaii, August 1972.

NOAA Tech. Rep. NMFS SSRF-675.

KEYWORDS: Swordfish, *Xiphias gladius*, distribution, population trends.

ABSTRACT: A billfish angler survey from 1969-1971 resulted in 17,876 angling days reported with a catch of 10,234 billfishes. The data was analyzed by geographic localities in the eastern Pacific and Australia. The catch off southern California was 0.10 fish/angler day accounting for 10.3 days of fishing per fish. The data for Baja California showed 0.82 fish/angler day which equaled 1.22 days of fishing per fish. The greatest catch rates were recorded off Mazatlan and Acapulco with 1.21 fish/day and 0.95 fish/day, respectively. The records for Australia showed 0.55 fish/day equalling 1.83 days per fish. The average catch rate over the 3-year period was 0.57 fish/day or 1.75 days of fishing per fish. The catch rates showed little fluctuation over the 3-years with the exception of the Australian black marlin fishery which dropped from 0.53 fish/day in 1969 to 0.26 fish/day in 1970 and rose to 1.48 fish/day in 1971.

Outer Continental Shelf Oil and Gas Information Program -  
Pacific Summary Report.

AUTHOR(S): Stadnychenko, A., and C. McCord.

YEAR: 1982.

SOURCE: Minerals Management Service Publ.

KEYWORDS: Platform, habitat, distribution.

ABSTRACT: A presentation of information concerning the exploration, development, and production of offshore oil and gas on the Pacific Coast. The topics covered include the geology of the Pacific offshore region, the magnitude and timing of offshore oil and gas development, offshore transportation of oil and gas, and

an overview of the nature and location of onshore support facilities.

Estimate of the spawning biomass of the northern central anchovy subpopulation for the 1979-80 fishing season.

AUTHOR(S): Stauffer, G. D.

YEAR: 1980.

SOURCE: CalCOFI Rep. 21:17-23.

KEYWORDS: Northern anchovy, *Engraulis mordax*, reproduction, spawning.

ABSTRACT: The 1979 estimate of northern anchovy, *Engraulis mordax*, spawning biomass is reported for the central subpopulation in order to establish the optimum yield for the 1979-80 season. The estimate is based on the 1979 California Cooperative Oceanic Fisheries Investigations egg and larva survey. Spawning north of Point Conception off central California was found only during January, while to the south larvae were consistently taken. In 1979 the percent of larvae south of the U.S.-Mexico border was 53.5%, while the long-term average is 30%. Off southern California and Baja California spawning persisted from January through May. The winter-plus-spring larva abundance was  $15.670 \times 10^{E12}$  larvae. The 1979 estimate of annual larva abundance was  $17.580 \times 10^{E12}$  larvae. Spawning biomass was estimated at 1,723,000 short tons, a 28% increase over the 1978 estimate. Optimum yield for the 1979-80 season was 241,000 short tons. Optimum yield in the U.S. zone, U.S. nonreduction reserve, and the U.S. reduction quotas were 168,700, 12,600, and 156,100 short tons, respectively.

Calibration of northern anchovy spawning biomass estimates derived by egg production and larval census methods.

AUTHOR(S): Stauffer, G. D.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:11-15.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, larvae, ichthyoplankton.

ABSTRACT: Traditionally northern anchovy, *Engraulis mordax*, spawning biomass has been estimated through larval census. A new egg production method was to be used by 1982 and concurrent surveys by the two methods used in 1981. The procedure for converting egg production estimates to equivalent larval census estimates is presented. The basis for the calibration between the two estimators uses cases of proportionality. In this way the larval census estimate can be calculated from just an ichthyoplankton survey of eggs and an assumption of larval mortality. If an estimate of biomass is desired, then only a survey of adult fish is needed. Larval census estimates for 1980 and 1981 are 1,611,000 and 2,544,000 metric tons (mt), respectively, while egg production estimates of biomass are 782,000 mt for 1980, 585,000 mt for the first 1981 estimate and 343,000 mt for the second. One method of calculation yielded large variations in the constant of proportionality; changes for the two 1981 surveys in respect to 1980 amount to a 111% and a 260% increase. A second method yields relatively constant values of the proportionality constant, larval production estimates from larval data being 38% of the value derived from egg data. Anchovy spawning biomass can be estimated in years which only an egg production survey is conducted, using calibration equations.

The northern anchovy spawning biomass for the 1981-82  
California fish season.

AUTHOR(S): Stauffer, G. D., and R. L. Charter.

YEAR: 1982.

SOURCE: CalCOFI Rep. 23:15-29.

KEYWORDS: Northern anchovy, *Engraulis mordax*, spawning, reproduction,  
larvae.

ABSTRACT: The 1981 spawning biomass is estimated for the northern anchovy, *Engraulis mordax*, for the 1981-82 fishing season. Estimates use an optimum yield formula from the Fishery Management Plan implemented in 1978 and are based on larval census. Of all stations surveyed, 56% had larvae with their geographic distribution expanded farther offshore than the previous three years. High abundances were found in the north during winter and off Baja California in March and April. The highest abundance was found in the Southern California Bight. Winter and spring totals from the central subpopulation were 11,127.4x10E9 and 14,164.3x10E9 larvae, respectively. The 1981 biomass estimate was 2,803,000 short tons, a 58% increase over the previous year. Optimum yield for the 1981-82 fishing season is 601,000 tons with that from the U.S. Fishery Conservation Zone being 420,700 short tons. The U.S. capacity to process is only 371,885 tons. The National Marine Fisheries Service set the U.S. quota at 359,285 tons for 1981-82.

Factors affecting fish diversity on a temperate reef: the fish  
assemblage of Palos Verdes Point, 1974-1981.

AUTHOR(S): Stephens, J. S. Jr., P. A. Morris, K. Zerba, and M. Love.

YEAR: 1984.

SOURCE: Env. Biol. Fish. 11(4):259-275.

KEYWORDS: *Paralabrax clathratus*, kelp bass, distribution, population  
trends, habitat, nursery, community.

ABSTRACT: Visual transects, benthic quinaldine samples, and ichthyoplankton collections were used to census the fish assemblages over reefs at Palos Verdes Point, California during 1974-1981. Temporal changes in giant kelp, *Macrocystis pyrifera*, abundance and sea surface temperature were monitored in order to assess the influence of these factors on the observed temporal changes of species composition and abundance of the fish assemblages. Over the course of the study, the rank order of species off Palos Verdes has been stable, even during a period of temperature and habitat (i.e. kelp abundance) change. Since the establishment of the Palos Verdes Point kelp bed, data from the benthic transects indicate that only *Paralabrax clathratus* exhibited a significant increase in benthic abundance ( $P < 0.05$ , mean of years 1974-1977 vs. 1978-1981) and *P. clathratus* also increased in nearby kelp-free King Harbor. *Paralabrax clathratus* is more common in benthic (56%) than in midwater (44%) transects but regularly occurs in both habitats. Utilization of the water column was not important prior to the development of the kelp bed; the increased numbers there subsequent to the development of the bed indicates that *P. clathratus* density has increased due to the development of the kelp bed. No increase in juvenile fishes (including *P. clathratus*) was correlated with the development of the kelp bed. Juvenile *P. clathratus* did not use the kelp canopy as a nursery area at Palos Verdes. Density of *P. clathratus*

increased with depth (3-14m;  $r^2 = 0.93$ ,  $p$  equal to or less than 0.05).

Resource partitioning among age-classes of the Dungeness crab, *Cancer magister*, in Grays Harbor, Washington.

AUTHOR(S): Stevens, B. G.

YEAR: 1983.

SOURCE: *Estuaries* 6(3):273.

KEYWORDS: Market crab, *Cancer magister*, age, growth, feeding, migration, habitat, life history.

ABSTRACT: Crabs were collected by trawl on a monthly or bimonthly basis at 10

stations in Grays Harbor, representing intertidal, eelgrass beds, shallow and deep subtidal, and inner and outer estuarine habitats. Age classes were separated by probit analysis, and densities analyzed by age class. Food habits were studied on a diel and seasonal basis and results compared among age groups. Female crabs do not spawn in the estuary. Zoeal larvae develop offshore, but megalops larvae enter the harbor en masse in April and May and metamorphose. The first 3 instars are most abundant in or near mud flats and eelgrass, *Zostera* spp., and numbered 15-20 million in 1980. Year-old animals have a wider distribution including most of the habitats present, and are found in salinities as low as 10‰. Second year animals are restricted to the outer harbor, and third year animals to channels near the harbor mouth. First year animals preyed almost exclusively on small clams, and small crustaceans, including their conspecifics. Second year animals included a large amount of shrimp and fish in their diet but fewer clams. Third year animals preyed mostly on fish, less on shrimp and clams. The data indicate that *C. magister* shows ontogenetic changes in preference for certain habitat types, and that salinity and food requirements probably play a significant role in this selection process. Spatial separation of age classes allows reduced competition for local food sources.

Distribution, abundance, and growth of juvenile Dungeness crabs, *Cancer magister*, in Grays Harbor Estuary, Washington.

AUTHOR(S): Stevens, B. G., and D. A. Armstrong.

YEAR: 1984.

SOURCE: *Fish. Bull.* 82(3):469-483.

KEYWORDS: *Cancer magister*, market crab, age, distribution, growth, recruitment, fishery, nursery.

ABSTRACT: The age of juvenile Dungeness crabs, *Cancer magister*, were estimated from width-frequency analyses, and the population density and growth rates were monitored for each age class in Grays Harbor Estuary over a 14-month period. Mean density of crabs were greatest at the mouth of the estuary (2,190 crabs per hectare) and decreased with increasing distance from the estuary mouth and decreasing bottom salinity. Crab densities at all sampling sites were greatest from May to August. Lowest densities occurred in October and November. The distribution of crabs within the estuary varied with age group. Crabs in the 0+ age group averaged 46 crabs per hectare and represented 16.6% of all crabs caught. Catches of 0+ crabs were abundant near eelgrass beds. First instar crabs were abundantly distributed on the mudflats at low tide, buried just beneath the sediment surface. The 1+ age group were the most abundant, averaging 268 crabs per hectare and 54.7% of all crabs caught, and were found mainly in

subtidal channels. The 2+ age group, consisting of sexually mature crabs, averaged 121 crabs per hectare, or 21.3% of all crabs caught. They were abundant only at the outer estuary areas. The 3+ age group was the least abundant with an average density of 17 crabs per hectare, representing 3% of all crabs caught. Monthly weight and size growth rates were greater in spring - summer than in fall - winter for all age groups and decreased with size. The seasonal total crab population was estimated at 39.0 million crabs (summer); 3.3 million (fall-winter); and 7.8 million (spring). This estuary serves as an important nursery ground and provides a substantial portion of recruitment to the offshore commercial fishery.

Mass mortality of female Dungeness crab, *Cancer magister*, on the southern Washington Coast.

AUTHOR(S): Stevens, B. G., and D. A. Armstrong.

YEAR: 1981.

SOURCE: Fish. Bull. 79(2):349-352.

KEYWORDS: Market crab, *Cancer magister*, population trends, fishery, mortality.

ABSTRACT: On 18 April 1979, an estimated 6,461 dead Dungeness crabs (*Cancer magister*) washed up on the beach at Grayland, Washington. All of the individuals examined, which could still be sexed after decay and destruction by scavengers, were female. Previous to this there had been reports of dead crabs in the pots of commercial fishermen in February 1979. The lack of previous reports of mass mortalities is probably due to confusion with large strandings of crab molts. Other sitings since then include an estimated 955-1910 dead female Dungeness crabs on the beach from Ocean Park to Long Beach, Washington on 29 November 1979, and approximately 947 dead crabs, 95% of which were females, from the Umpqua River mouth, north to Tahkenitch Creek, Oregon on 30 January 1980. Deaths of crabs in the pots have many possible explanations, a cold spell affecting crabs trapped in shallow crab pots, or sanding in of a pot during bad weather, however it is more difficult to explain the mass mortalities. The authors conclude that disease is the most likely explanation for the mortality, but whatever the cause, such an event, especially if it is seasonal in nature and not an acute problem, represents an enormous loss to the fishery.

Distribution and abundance of juvenile Dungeness crab (*Cancer magister*) in Grays Harbor, Washington, in relation to salinity tolerance and food preferences.

AUTHOR(S): Stevens, B. G., and D. A. Armstrong.

YEAR: 1980.

SOURCE: Amer. Zool. 20(4):889.

KEYWORDS: *Cancer magister*, market crab, distribution, feeding, early life history.

ABSTRACT: This reference is not an actual paper, but an abstract of the annual meeting of the American Society of Zoologists, and other societies. This is a proposed study as to the value of Grays Harbor as a nursery ground for juvenile Dungeness crab (*Cancer magister*) which appear to be able to tolerate a wider range of salinities than adults. This allows juveniles to utilize areas of marginal importance to adults, and partition resources to reduce competition between adults and

juveniles. Trawl capture and stomach analysis is proposed in Grays Harbor to test this theory.

Diel activity of an estuarine population of Dungeness crabs, *Cancer magister*, in relation to feeding and environmental factors.

AUTHOR(S): Stevens, B. G., D. A. Armstrong, and J. C. Hoeman.

YEAR: 1984.

SOURCE: Jour. Crustacean Biol. 4(3):390-403.

KEYWORDS: Feeding, behavior, age, market crab, *Cancer magister*.

ABSTRACT: The diel movements of Dungeness crabs, *Cancer magister*, in a large coastal estuary, Grays Harbor, Washington, was examined with respect to day/night, tide, depth, season, and feeding behavior. The mean densities of crabs in each combination of environmental conditions did not show a similar pattern of density change in each season. Crabs were significantly more abundant in the channel (subtidal site) than intertidal flats. Daytime crab densities in the channel were significantly greater than nighttime densities in January. On the flats, crab densities were generally greater at night than during daytime. June density values for both subtidal and intertidal sites were greater than all other seasons for each site, due to the abundance of 0+ age group crabs which had recently entered the harbor. Crangonid shrimp densities during high tides increased greatly from day to night in September and January. Crab and shrimp densities on the flats were positively correlated in September and January. Analysis of population age structure of *C. magister* collected in June found 41% recruits (0+ age class), 39% in the 1+ age class, 18% in the 2+ age class, and 2% in the 3+ age class. Catches during all other seasons were predominated by 1+ age class crabs. Proportions of age groups were virtually identical at both sites. Most crabs usually remained in subtidal environments, but some ventured into intertidal areas at high tide. Increased nighttime densities of crabs on the flats were probably the result of feeding movements, and were most pronounced in September and January, coinciding with the increased crangonid shrimp density. Crab densities on the flats decreased at times of heavy rainfall and subsequent low salinity.

Feeding habits of the Dungeness crab, *Cancer magister*, as determined by the Index of Relative Importance.

AUTHOR(S): Stevens, B. G., D. A. Armstrong, and R. Cusimano.

YEAR: 1982.

SOURCE: Mar. Biol. 72(2):135-145.

KEYWORDS: Market crab, *Cancer magister*, feeding, life history.

ABSTRACT: The gut contents of freshly caught crabs from different sites in an estuary in Washington State were examined. Analysis was made using the Index of Relative Importance, a method which takes into account the frequency of occurrence, percent of total numbers, and percent of total biomass of each prey taxon. In contradiction to previous studies, the most important major taxon was fish, although the most important actual genus was crangonid shrimp. Important prey taxa changed with growth; first year crabs fed primarily on small bivalves or crustaceans, second year crabs concentrated on *Crangon* spp. and some fish, third year crabs fed mostly on fish. No consistent diel or seasonal pattern of feeding was detected, and the authors concluded crabs are primarily

opportunistic feeders with selection only occurring in areas of high food availability. Cannibalism is noted as a common phenomenon, especially among young crabs, decreasing with intermediate ages, and increasing again among older crabs.

Food and feeding ecology of the swordfish, *Xiphias gladius*, in the western North Atlantic Ocean with estimates of daily ration.

AUTHOR(S): Stillwell, C. E., and N. E. Kohler.

YEAR: 1985.

SOURCE: Mar. Ecol. Prog. Ser. 22(3):239-247.

KEYWORDS: Swordfish, *Xiphias gladius*, feeding, behavior.

ABSTRACT: The purpose of this paper was to make observations on the feeding ecology of the swordfish (*Xiphias gladius*) in the western North Atlantic with respect to diet, behavior, and consumption. Stomach analyses were run on 168 swordfish. Cephalopods, 9 families of squid and 1 family of octopod, made up the most important food source, with the highest percentages by number (82%), volume (67%), and frequency of occurrence (82%). Teleosts occurred in 35% of the stomachs analyzed. At least 20 species or family groups were identifiable from these. Silver hake was the most prominent fish prey by number, volume and frequency of occurrence, while Atlantic mackerel ranked second in importance. The rest of the fish species were postulated to be incidental prey items, consumption dependent on abundance or density in a given location being high. The data showed that squid was the most important prey item south of Hudson Canyon, while they were equal in importance with teleosts north of the canyon. There was no evidence of food preference with respect to sex or size of the swordfish throughout the sampling area. The volume of food in the stomach of the swordfish averaged 604 ml, or 1% of the average body weight (the range was from 0% to 8.3% body weight). The average degree of fullness was 23.5% (with 100% being a stuffed stomach). Many prey items appeared to be ingested whole, while others showed signs of maiming. Small prey items were more often swallowed whole, while large prey showed more signs of being maimed. This supports the theory that swordfish use their sword to stun, kill or reduce the size of their prey. It was calculated that an average swordfish has a daily ration range of 0.94% to 1.60% of its body weight.

Chlorinated hydrocarbon levels in fishes and shellfishes of the Northeastern Pacific Ocean, including the Hawaiian Islands.

AUTHOR(S): Stout, V. F., and F. L. Beezhold.

YEAR: 1981.

SOURCE: Mar. Fish. Rev. 43(1):1-12.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Sebastes miniatus*, vermillion rockfish, contaminant levels.

ABSTRACT: Thirty-nine species of marine fishes and 8 species of marine invertebrates collected off California, Oregon, Washington, British Columbia, Alaska and Hawaii were analyzed for DDT, DDE, PCB and other chlorinated hydrocarbon concentrations. Samples consisted of the edible portions of the animal. Chlorinated hydrocarbon levels varied widely between individual fish in a single catch (30 times as much for *S. paucispinis* collected at 34 N). Coefficients of variation are given for concentrations of



chlorinated hydrocarbons in *S. paucispinis*. Significant correlations were found between fish length/weight and PCB concentration, lipid concentration and PCB concentration, and other contaminants and PCB concentration for bocaccio from 34 deg. N. Chlorinated hydrocarbon concentrations are given for *S. paucispinis* collected from four sites and *S. miniatus* collected from Santa Monica Bay. Chlorinated hydrocarbon levels were generally quite low (below FDA guidelines of 5 ppm). Concentrations increased along a southward gradient from Alaska to southern California. Distinctly elevated levels were observed at point sources of contamination associated with rivers and sewer outfalls.

Distribution, abundance, and habits of pelagic sharks in the central Pacific Ocean.

AUTHOR(S): Strasburg, D. W.

YEAR: 1958.

SOURCE: Fish. Bull. 138(58):335-361.

KEYWORDS: Thresher shark, *Alopias vulpinus*, distribution, feeding, reproduction.

ABSTRACT: Over 6,000 sharks (from 12 species) were caught by longline methods from 1952-1955 during an investigation into the distribution and abundance of Pacific pelagic sharks. The most common species caught were great blue, *Prionace glauca* (2,512), silky shark, *Eulamia floridana* (2,760) and whitetip, *Ptesolamiops longimanus* (1,187). Other species (243) including the bonito, thresher, mackerel, blacktip, soupfin, and hammerhead were rarely caught. The abundance of the three common species was affected by temperature. Blue and bonito sharks were wide ranging, while whitetip and silky were confined to warmer waters. Blues were seen to make northern migrations apparently reproductive in nature. Vertical distributions suggested the species prefers temperatures between 45 and 69 deg F. In equatorial waters blue and whitetips were common during warm years while silkys were common during colder years. Silky and thresher sharks were abundant near land whereas whitetips and blues were strictly oceanic. The diets of all sharks examined were typically small fish and squid. The blue, whitetip and silky sharks all exhibited some degree of sexual segregation. Gravid females of blue and silky sharks were found year around with non-gravid females of the same size (208-247 and 213-236 cm, respectively). The length-weight relationships for the silky, whitetip and bonito sharks were nearly identical, however the blue was a lighter more slender fish.

Size and organic content of eggs of echinoderms and other invertebrates as related to developmental strategies and egg eating.

AUTHOR(S): Stratham, R. R., and K. Vedder.

YEAR: 1977.

SOURCE: Mar. Biol. 39:305-309.

KEYWORDS: Mortality, larvae, feeding.

ABSTRACT: The organic content of eggs from three different phyla, Echinoderms (7 species), Polychaetes (2 species) and mollusca (1 species), were compared to egg volumes. Small eggs were found to have more concentrated organic matter than large eggs. A difference between the taxa, in the minimum size of eggs produced

was also noted. This was probably due to relationships between mortality and larval feeding mechanisms. Larger larvae presumably fed more efficiently; however, might make better prey. The size at metamorphosis was also important in determining maximum egg size. Eggs were found to have five times the organic matter of similar size diatoms thereby providing more energy to suspension feeders.

Caribbean spiny lobster fisheries surveyed.

AUTHOR(S): Streeter, D. H., and D. M. Weidner.

YEAR: 1976.

SOURCE: Mar. Fish. Rev. 38(7):31-33.

KEYWORDS: Spiny lobster, *Panulirus* spp., fishery, feeding, migration, regulations.

ABSTRACT: The Caribbean spiny lobster, *Panulirus argus*, fishery is reviewed. The lobster is found only in the western central Atlantic, the Caribbean and, in the Gulf of Mexico from North Carolina to northeastern Brazil. Spiny lobsters feed on marine worms, mollusks, smaller crustaceans, and fish. They migrate between shallow and deep water during different times of the year. The total catch has increased significantly since 1965 to a record high in 1973 of 30,300 metric tons. Increased catches are primarily due to increased catches in Brazil and the United States. According to the FAO, many areas can safely harvest more, while fishing grounds already fully exploited include Cuba and Florida. Major producers mainly use traps to harvest lobsters. Most countries have seasonal closures sometime between February and August, but size regulations vary widely from country to country. Additional regulations include gear type restrictions, seasonal limits, and the prohibition of capturing, purchasing, possessing, processing, storing, transporting, or sale of egg-bearing lobsters. Of all countries with both Atlantic and Pacific coasts, only Mexico harvests significant quantities of spiny lobsters other than *P. argus*. These include *P. interruptus*, *P. inflatus*, and *P. gracilis*.

Effects of benzene (a water-soluble component of crude oil) on eggs and larvae of Pacific herring and northern anchovy.

AUTHOR(S): Struhsaker, J. W., M. B. Eldridge, and T. Echeverria.

YEAR: 1974.

SOURCE: Pages 253-284 in *Pollution and Physiology of Marine Organisms*, Academic Press, NY.

KEYWORDS: Northern anchovy, *Engraulis mordax*, contaminant susceptibility.

ABSTRACT: Effects of lethal and sublethal concentrations of benzene on eggs and larvae of the northern anchovy, *Engraulis mordax*, are examined. Percent mortality, percent abnormal larvae, types of abnormalities, larval length and growth, yolk utilization, feeding, and respiration were all measured. Similar results on contaminant susceptibility were presented for the Pacific herring, *Clupea pallasii*. Development of anchovy larvae was accelerated and survival decreased at a benzene concentration of 4.7 ppm, while at 10.5 and 24.0 ppm the opposite trend was observed. At higher concentrations death was probably delayed due to narcotization. At 24.0 ppm there was an increase in grossly abnormal larvae. Larvae at 53.5 ppm had significantly lower survival than controls and other treatments. Among those

surviving (34%), about 30% were still abnormal in some way, and development of these was greatly delayed. The lowest mean initial concentration range at which 50% mortality occurs is approximately 20 to 25 ppm. The most obvious abnormality was the bending of the notochord and somatic musculature. Benzene affected the developmental rates of exposed eggs and larvae, with accelerated utilization of yolk at lower concentrations and delayed utilization at higher. This pattern was also reflected in the mean standard length of larvae. Benzene induces considerable physiological stress on anchovy eggs and larvae. Yolk absorption, growth, and respiration changes due to benzene show that it influences metabolic rate and energy utilization of embryos and larvae. A greater exposure is required to affect mortality in eggs than in larvae, however, the exposure of eggs induces abnormalities in embryos. The effect is permanent, larvae eventually dying. In regards to oil spills, recommendations on allowable contaminant levels must involve knowledge of specific effects at sublethal and lethal concentrations.

Detection thresholds and behavioral-responses to salinity changes by the Dungeness crab, *Cancer magister*.

AUTHOR(S): Sugarman, P. C., W. H. Pearson, and D. L. Woodruff.

YEAR: 1980.

SOURCE: Amer. Zool. 20(4):922.

KEYWORDS: *Cancer magister*, market crab, behavior.

ABSTRACT: Dungeness crabs, *Cancer magister*, responded to increased or decreased salinity concentrations by flicking their antennae. Threshold concentrations (50% of the crabs detected a change) were at 97‰ above ambient salinity. The patterns of behavioral responses were correlated with the magnitude of salinity changes and with the crab's physiological capabilities to osmoregulate.

Bioenergetics of the sablefish, *Anoplopoma fimbria* occurring off southern California: A hypothesis for energetics of low-frequency feeding in deep-living benthopelagic fishes.

AUTHOR(S): Sullivan, K. M.

YEAR: 1982.

SOURCE: Ph.D. dissertation Univ. Calif. San Diego.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, physiology, feeding, growth.

ABSTRACT: Sablefish, a benthopelagic species, was studied in the laboratory to determine the physiological and biochemical energetics of feeding on large, infrequent meals. Sablefish fed on large rations every 7 to 10 days showed growth rates 2 to 3 times higher than known growth rates of field fish. Activities of muscle glycolytic enzymes increased significantly with increased body size. Experiments also showed that during long term food deprivation, the fish were able to suppress respiration rates, and switch between protein and lipid energy stores throughout the course of starvation.

Size-related and diet-related variations in enzymic activity and tissue composition in the sablefish, *Anoplopoma fimbria*.

AUTHOR(S): Sullivan, K. M., and G. N. Somero.

YEAR: 1983.

SOURCE: Biol. Bull. 164(2):315-326.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, seasonality, feeding, distribution.

ABSTRACT: Biochemical properties of the sablefish, *Anoplopoma fimbria*, muscle and liver were studied to determine the effects of seasonality, stock location, size and diet on the organism. During starvation periods, large decreases in glycolytic enzymes and lipids were noted. This suggested that these reserves were utilized or an energy source in preference to proteins. The diet quantity and quality also affected muscle enzyme activity. Lactate dehydrogenase and pyruvate kinase levels increased with increased body size. The muscle content of lactate dehydrogenase was directly proportional to the food ingestion rate. Latitudinal population shifts between Alaska and southern California may have been due to seasonal variations in diet availability and quality.

Energetics of sablefish, *Anoplopoma fimbria*, under laboratory conditions.

AUTHOR(S): Sullivan, K. M., and K. L. Smith.

YEAR: 1982.

SOURCE: Jour. Fish. Aquat. Sci. Canada 39(7):1012-1020.

KEYWORDS: Sablefish, *Anoplopoma fimbria*, physiology, feeding, growth.

ABSTRACT: The respiration, ingestion, excretion, and growth rates of a group of sablefish, were measured in the laboratory. The water, protein, and lipid content of white skeletal muscles was also measured. The results showed that sablefish have an estimated 162 days of energy stored in body lipids, based on respiration and excretion rates in laboratory conditions. Sablefish starved for up to 6 months showed no signs of deprivation. Conversion efficiency was shown to be extremely low (10-15% ration wet wt). Growth rate varied with size and composition of the ration ranging from growth rates calculated from wild sablefish to four times that. At a constant temperature weight specific oxygen consumption rates decreased with increasing body weight (from routine metabolic rates of 195.8 mg oxygen/kg/hr for a 0.25 kg fish to 60.8 mg oxygen/kg/hr for a 2.78 kg fish). The relatively slow growth rates, low conversion efficiency, and low metabolism suggest a deep living fish with large infrequent meals, and this is supported by its resistance to starvation. This correlates well with what is known of the life history of the sablefish and other deep living fishes.

Biology of marine life.

AUTHOR(S): Sumich, J. L.

YEAR: 1976.

SOURCE: Wm. C. Brown Co. Publ. Dubuque, IA. 348 p.

KEYWORDS: All species, physiology, habitat, distribution, reproduction, feeding, mortality.

ABSTRACT: This book was written as an introductory college level text dealing

with the biology of marine plants and animals and begins with a general overview of the marine environment, its inhabitants, and how both have evolved to the present. The text also includes a cursory survey of marine animal groups, the roles that marine plants and animals assume in their respective environments, detailed descriptions of the structural and physiological adaptations necessary to fill these roles, and a concluding chapter on understanding man's interventions into the marine ecosystem.

Food and feeding of bocaccio (*Sebastes paucispinis*) and

comparison with pacific hake (*Merluccius productus*) larvae in the California current.

AUTHOR(S): Sumida, B. Y., and H. G. Moser

YEAR: 1984.

SOURCE: CalCOFI Rep. 25:112-118.

KEYWORDS: *Sebastes paucispinis*, bocaccio, feeding, ichthyoplankton, larvae, early life history. behavior, *Merluccius productus*, Pacific hake.

ABSTRACT: Stomach content data, mouth size, and feeding incidence (percentage of larvae containing food) of bocaccio (*Sebastes paucispinis*) larvae collected during CalCOFI cruises (1975) were summarized. Feeding habits of larval *S. paucispinis* and larval hake (*Merluccius productus*) are compared. Copepod nauplii were the dominant food items (75-81%) consumed by bocaccio less than 7mm long, with calanoid nauplii far out numbering those of other groups. Copepod nauplii remained the dominant food item until larvae reached 9mm. Adult copepods and copepodites became increasingly more important with larger larvae (greater than 10mm). Mouth width quadrupled from birth to 9mm long larvae. Feeding incidence data suggest that bocaccio larvae fed diurnally with onset at early morning. Feeding is maintained through the daylight hours and declines rapidly thereafter.

Food and feeding of Pacific hake larvae, *Merluccius productus*, off southern California and northern Baja California.

AUTHOR(S): Sumida, B. Y., and H. G. Moser.

YEAR: 1980.

SOURCE: CalCOFI Rep. 21:161-166.

KEYWORDS: Feeding, ichthyoplankton, larvae, Pacific hake, *Merluccius productus*.

ABSTRACT: This study analyzes data obtained on gut contents, mouth size, and feeding incidence of Pacific hake (*Merluccius productus*) larvae. The analysis was done on 298 larvae captured from an ichthyoplankton cruise in 1975, roughly between Punta Baja, Baja California, to San Pedro, California. Copepod eggs, calanoid adults, copepodites, and nauplii were the principal prey of the hake larvae. Copepod adults made up 74% of the larvae's prey volume. This rather low diversity implies a feeding selectivity by the larvae. No significant difference existed in the stomach analysis of the larvae prey when analyzed as night versus day, or inshore versus offshore. However, evidence of diurnal feeding variation exists, with the freshest stomach contents occurring around 1000 hours PST, stomach content reaching its fullest state sometime after sunset, and complete stomach evacuation occurring between 0600 and 0800 hours PST. One case of cannibalism was observed. Some of the yolk containing larvae had begun feeding before yolk depletion. First feeding larvae had a prey size range of between 50 to 400 micrometers width.

Description of larvae of California yellowtail, *Seriola lalandei*, and three other carangids from the Eastern Tropical Pacific: *Chloroscombrus orqueta*, *Caranx caballus*, and *Cranax sexfasciatus*.

AUTHOR(S): Sumida, B. Y., H. G. Moser, and E. H. Ahlstrom.

YEAR: 1985.

SOURCE: CalCOFI Rep. 26:139-159.

KEYWORDS: *Seriola lalandei*, yellowtail, larvae, length/weight, growth,

early life history.

ABSTRACT: Larvae from 4 carangid species were collected mainly in the eastern tropical Pacific and described in terms of their morphological, pigmentation, and meristic characteristics. Yellowtail larvae were found to be slender-bodied, heavily pigmented, lacking a supraoccipital crest, and develop the largest number of dorsal fin rays (31-39) among eastern Pacific carangids.

The anchovy reduction fishery for the 1976-77 season.

AUTHOR(S): Sunada, J. S.

YEAR: 1979.

SOURCE: Calif. Fish & Game, Mar. Res. Tech. Rep. 42. 23 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, recruitment.

ABSTRACT: Results of a monitoring program for the northern anchovy, *Engraulis mordax*, are reported for southern California and Monterey Bay. The seasons landings, number of boats, and processing capacities for the southern areas were 92,515 mt, 43 vessels, and 1,678 mt, respectively. Fish prices ranged from \$39.75 to \$58.75 per ton. In the central area, total landings totaled 4,571 mt, 6 boats operated, and prices were similar to those south. In southern California age groups 0 and III each represented 28% by number of the catch, while age groups II and I combined for 28%. In Monterey Bay age groups III through VI represented 77% of the catch, and age groups 0, I, and II totaled only 23%. Average standard lengths of fishes in southern and central California were 121 mm and 139 mm, respectively. Females were larger than males in both areas. In southern California the female to male ratio was 1.1:1, the highest incidence of mature fish was in April, and males mature earlier than females, while in Monterey Bay the ratio was 2:1 and mature fish appeared in November and December. There was early recruitment of the 1976 year class in southern California, while the 1975 and 1974 cohorts were present in below normal numbers. The 1973 and 1972 year classes were in above average numbers. Central California was characterized by older age groups.

Spot prawn (*Pandalus platyceros*) and ridgeback prawn (*Sicyonia ingentis*) fisheries in the Santa Barbara channel.

AUTHOR(S): Sunada, J. S.

YEAR: 1984.

SOURCE: CalCOFI Rep. 25:100-104.

KEYWORDS: Spot prawn, *Pandalus platyceros*, ridgeback prawn, *Sicyonia ingentis*, fishery, age, recruitment.

ABSTRACT: The spot prawn, *Pandalus platyceros*, and ridgeback prawn, *Sicyonia ingentis*, developed into major fisheries in the Santa Barbara channel during the late 1970s. Catches increased from 4,533 kg (1970) to 116,954 kg (1981) and 1,813 kg (1974) to 161,378 kg (1979) for spot prawns and ridgeback prawns, respectively. The catch per unit effort decreased significantly for both species during that time. Spot prawns recruited at ages 3 and 4, whereas ridgeback prawns recruited at ages 2 and 3. The results suggested that winter closures for spot prawns and summer closures for ridgeback prawns were necessary for effective management of the fishery.

Age and length composition of northern anchovies, *Engraulis*

mordax, in the 1972-73 season California anchovy reduction fishery.

AUTHOR(S): Sunada, J. S.

YEAR: 1975.

SOURCE: Calif. Fish Game 61(3):133-143.

KEYWORDS: Northern anchovy, *Engraulis mordax*, age, growth, recruitment.

ABSTRACT: Catch, age, length, and sex composition are reported for the northern anchovy, *Engraulis mordax*, fishery in the 1972-73 season from central and southern California. Total catch for the season was 68,510 metric tons (MT) with San Pedro, Port Hueneme, and Moss Landing yielding 88, 11.5 and 0.0%, respectively. Fleet capacity was about 3,175 MT per day while processing capacity was only 1,451 MT. Cannery prices paid from \$24.00 to \$47.50 per ton. In the southern zone mean length was 116 mm SL. Fish 105-124 mm SL comprised 70% of the catch and those larger than 125 mm SL comprised 17%. Data indicated a 3-8 mm decrease in size of Ages I, II, III and IV compared to the same age groups from the previous season. In central California 85% of fish were 135-168 mm SL, and a 6-11 mm increase in length was observed in age Groups I, II and III. Southern California's catch was dominated by 2-year olds (48% by number). Southern and central zones had age Groups I, II, III and II, III and IV comprise 88 and 81% of the total catch, respectively. Female to male sex ratio was 1.98:1 in southern and 2.05:1 in central California, while both were constant throughout most of the season. Data indicates a strong 1970 year class and good recruitment of 1971 and 1972 year classes. This suggests a relatively healthy southern California population and no adverse effects from the anchovy reduction fishery.

Age and length composition of northern anchovies, *Engraulis mordax*, in California anchovy reduction fishery, 1973-74 season.

AUTHOR(S): Sunada, J. S.

YEAR: 1976.

SOURCE: Calif. Fish Game 62(3):213-224.

KEYWORDS: *Engraulis mordax*, northern anchovy, age, length/weight, economics, age.

ABSTRACT: Northern anchovy (*Engraulis mordax*) catches are analyzed in terms of catch, weight, sex, and age composition for the years 1973-1974 for southern and central California stocks. At the beginning of the season a record price of \$57.50 per short ton was paid. During these years a 12-mile mainland shore restriction was imposed and the season closed on April 30. In southern California, catch length ranged from 66 to 162 mm standard length (SL) with a mean of 119 mm. Females were slightly larger than males, with a sex and weight ratio of 2.01:1 and 2.18:1, respectively. Catch composition consisted of 86%, by number and weight, age groups I, II, and III. In central California lengths ranged from 91 to 179 mm SL, with 55% over 135 mm. As in southern California, females were larger than males. Female to male ratios by number and weight were 1.12:1 and 1.28:1, respectively. Age groups I through III comprised 73% by number and 68% by weight. Compared to past years, catch records show no evidence of overexploitation.

The fishery for northern anchovy *Engraulis mordax* off California and Baja California in 1976 and 1977.

AUTHOR(S): Sunada, J. S., and S. Silva.

YEAR: 1980.

SOURCE: CalCOFI 21:132-138.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, population trends.

ABSTRACT: This report is from a cooperative study between the United States and Mexico, and deals with the catch data for the northern anchovy, *Engraulis mordax*, for 1976 and 1977. Anchovy landings for 1976 totaled 189,066 metric tons of which 60% were caught by American fishermen, while landings for 1977 totaled 243,124 mt and Mexico accounted for 58.6% of the catch. In 1976 and 1977, a total of 106 and 86 vessels, respectively, fished for anchovies. The average capacity of the Mexican boat was greater than that of the American boat. From 1976 to 1977, the catch capacity of the Mexican fleet increased considerably, while the American fleet only increased slightly. Monthly landings for the U.S. fishery were greatest during the fall and winter, while in Mexico landings were greatest in summer and fall. Major fishing grounds for both countries are reported. In 1976 the price for anchovies paid to U.S. and Mexican fishermen ranged from \$31-44.50 per ton and \$17-30 per ton, respectively. Prices in 1977 ranged from \$34.50-58.75 per ton in the U.S. and \$24-32 per ton in Mexico. Southern California and Baja California samples in 1976 had large numbers of the 1973 year class, and Mexican catches were dominated by the 1976 year class. In 1977, both areas were characterized by large percentages of young fish. California anchovies averaged lengths of 125 mm SL and 120 mm SL in 1976 and 1977, respectively. Those from the Mexican fleet averaged 106 mm SL in 1976 and 113 mm SL in 1977. The biological data from both countries indicate the fisheries to be harvesting primarily the central stock.

The brown pelican as a sampling instrument of age group structure in the northern anchovy population.

AUTHOR(S): Sunada, J. S., P. R. Kelly, I. S. Yamashita, and F. Gress.

YEAR: 1981.

SOURCE: CalCOFI Rep. 22:65-68.

KEYWORDS: Northern anchovy, *Engraulis mordax*, mortality, age, length/weight.

ABSTRACT: A preliminary report on the use of the brown pelican (*Pelecanus occidentalis californicus*), as a sampling device for northern anchovy (*Engraulis mordax*) is presented. The pelican which feeds almost exclusively on the anchovy is reproductively dependent on the fishes availability and/or abundance. Age and length compositions from birds and commercial catches are compared. In 1979 collections, the 1978 and 1977 year classes represented 97% and 2%, respectively, of pelican samples and 90% and 8% of commercial catches. Two areas were looked at in 1980. Pelican samples consisted of 41% 1979 year class and 55% 1978 year class, while those from commercial catches were 35% 1979 year class and 55% 1978 year class, in the first area. The second area had pelican and commercial samples of 79% and 70%, respectively (1979 cohort), plus 19% and 26%, respectively (1978 cohort). Length frequencies from the two types of sampling were not significantly different. The results from each sampling



method may be affected by numerous variables. Samples taken from both sources were significantly correlated. There is a potential for interaction between pelican and the anchovy fishery. When there is no fishery or conventional sampling means are unavailable, this technique may provide an opportunity to examine the northern anchovy population.

The California sardine-anchovy fisheries.

AUTHOR(S): Talbot, G. B.

YEAR: 1973.

SOURCE: Trans. Amer. Fish. Soc. 102(1):178-187.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, distribution, life history.

ABSTRACT: This paper presents a review of the Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*) fisheries off California and discusses controversies concerning their harvest. A brief description of each species life history, distribution, and fishery is given. Early researchers expressed concern about sardine overfishing. There were no restrictions on catches until 1967. At that time a two-year moratorium was placed on sardine fishing. Maximum incidental catch regulation levels probably still overfished the population. Population estimates for anchovies were based on sardine data. With the disappearance of sardines, industry increased pressure to allow harvest of anchovies for reduction. Industry met opposition by sport fishing organizations and anchovy bait fishermen. In 1965 an experimental fishery was adopted in hope that this would help the sardines recover. First and second year catches were 17,000 and 38,000 tons, respectively. In 1969-70 the quota was raised but catches were still poor. In 1970 a committee of commercial and sport fishermen was formed (Commercial and Sportsmen Committee on Ocean Resources). Several problems were discussed, yet curtailment of the sardine fishery was not implemented. Regulations administered by a single non-partisan body dedicated to wise use of natural resources is needed. This group must be quickly responsive to the needs of the resource.

Spiny lobster culture: An alternative to natural stock assessment.

AUTHOR(S): Tamm, R. G.

YEAR: 1980.

SOURCE: Fisheries 5(4):59-62.

KEYWORDS: Spiny lobster, *Panulirus* sp., larvae, reproduction.

ABSTRACT: Previous culture attempts of the spiny lobster (*Panulirus* sp., *Jasus* sp.) are reviewed, along with major constraints in raising them, optimal conditions for cultivation, and growth and mortality in captivity. Viable larvae are obtainable from egg-bearing lobsters in captivity. Many difficulties are encountered when culturing spiny lobster larvae, while raising post larvae and older animals is straightforward. Larvae are subject to a series of highly vulnerable periods. Inadequate diet is considered the major problem in rearing spiny lobsters. Other obstacles include water quality, attaining adequate numbers of individuals to stock a system, and the lobsters slow growth rate (at least 3-4 years until legal size). Growth can be improved by optimizing the environmental regime of the culture system. It is suggested that culture focus on raising *P. cygnus*, *P. ornatus*, *J.*

verreaux, and *J. edwardsii*. Any serious attempt at raising spiny lobsters should begin with juveniles. Extensive culture systems and polyculture systems appear to be an attractive approach. As far as the fishery is concerned, aquaculture is not yet a viable alternative to natural stocks. However, a coordinated project between the two may significantly increase the harvestable yields.

Juvenile Dungeness crab, *Cancer magister*, studies in the San Francisco Bay area.

AUTHOR(S): Tasto, R. N.

YEAR: 1983.

SOURCE: Pages 135-154 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, *Cancer magister*, early life history, fishery, distribution.

ABSTRACT: The purpose of this study was to assess the extent to which the San Francisco Bay-San Pablo Bay complex contributes to the fishery of the Dungeness crab, *Cancer magister*, based on its life history and distribution. It appears that Dungeness crabs enter the Bay via bottom currents as early post-larval instars, not as megalopae. Crabs-of-the-year reached maximum distribution in September through December. A mixing of outgoing and incoming year classes was generally seen in May and June. By September, replacement of the old year class by the new was essentially complete. Major reductions in crab abundance and shifts in location of crab concentrations occurred concurrently with reduced salinities. No crabs were caught where salinities were measured at less than 10.2 ppt. Abundance estimates were compared for Bay vs. ocean populations. Male crabs were significantly larger than female crabs in the ocean population throughout this study. Throughout the course of this study, 1977 year class crabs had the greater carapace widths, followed by the 1979 year class; 1978 year class crabs were the smallest. Size differences also appeared between sampling locations. There was a differential sex ratio seen throughout different seasons. Of 8,027 Dungeness crabs collected during the Bay shore-based ringnet survey, 52.5% were male and 47.4% female. Ringnetting and trawling inside the Bay complex also showed a dominant sex ratio of males to females. A comparison of food habits between Gulf and Bay-reared crabs was also undertaken. It is not clear as to why Bay-reared crabs have a faster growth rate than ocean-reared crabs. Temperature is probably an important factor, since Bay temperature averaged about 5 deg C higher than ocean temperatures. Settling rates may also play an important role. Overall, the San Francisco Bay complex appears to be an important nursery ground for Dungeness crabs. The contribution the Bay makes to local recruitment appears to be directly proportional to megalopal year-class strength.

Spiny lobsters and sea urchins: Analysis of a predator-prey interaction.

AUTHOR(S): Tegner, M. J., and L. A. Levin.

YEAR: 1983.

SOURCE: Jour. Exp. Mar. Biol. Ecol. 73:125-150.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., mortality, growth, length/weight.

ABSTRACT: Laboratory experiments and field observations related to spiny lobster predation on two species of sea urchins, *Strongylocentrotus franciscanus* and *S. purpuratus*. Lobster preferred *S. purpuratus* over *S. franciscanus*. Larger sized *S. franciscanus* appeared to be protected from lobster predation by their long spines, while smaller individuals gained protection by hiding under the larger individual's spine canopy. The mid-sized *S. franciscanus* are subject to intense predation which appears to explain the bi-modal size-frequency distribution typical of that species in areas where lobsters are common.

Do sea urchins and abalones compete in California kelp forest communities?

AUTHOR(S): Tegner, M. J., and L. A. Levin.

YEAR: 1982.

SOURCE: Pages 265-271 in J. M. Lawrence (ed.), Intl. Echinoderms Conf., Tampa Bay, FL.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., abalone, *Haliotis* spp.

ABSTRACT: The red sea urchin, *Strongylocentrotus franciscanus*, and red abalone, *Haliotis rufescens* have similar life styles and co-occur in kelp forest communities. Growth was measured in laboratory experiments which utilized single and mixed species groups at three food concentrations. The red urchins were better adapted to survival in low food situations. Growth rates of red urchins were depressed in the presence of abalone even under excess food conditions. The urchins were about 1.5 times more efficient at converting *Macrocystis* to body weight. The results suggested that weak competitive interactions occurred, however they probably have little effect in controlling populations today.

Population structure, recruitment and mortality of two sea urchins (*Strongylocentrotus franciscanus* and *Strongylocentrotus purpuratus*) in a kelp forest.

AUTHOR(S): Tegner, M. J., and P. K. Dayton.

YEAR: 1981.

SOURCE: Mar. Ecol., Prog. Ser. 5:255-268.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., recruitment, mortality.

ABSTRACT: The red sea urchin, *Strongylocentrotus franciscanus*, and purple sea urchin, *Strongylocentrotus purpuratus*, populations of a kelp bed in southern California were studied. Recruitment patterns were found to be minimal in occurrence and the rates were lower in shallow waters (12 m) than in deeper waters (15 and 18 m). Predation rates were difficult to quantify, however, urchin test numbers suggested that predation was a major factor in mortality rates. Several species consumed juvenile urchins. Only the California sheephead and spiny lobster consumed adult urchins. Size frequency distributions of red urchins appeared bimodal whereas the purple urchins exhibited a unimodal distribution. The purple urchin, with its shorter spines, was unable to provide a refuge from predators.

Sea urchin recruitment patterns and implications of commercial fishing.

AUTHOR(S): Tegner, M. J., and P. K. Dayton.

YEAR: 1977.

SOURCE: Science 196:324-326.

KEYWORDS: Sea urchin, *Strongylocentrotus* spp., recruitment, fishery.

ABSTRACT: The recruitment patterns of larval purple sea urchins, *Strongylocentrotus purpuratus*, and red urchins, *Strongylocentrotus franciscanus*, were tested. A variety of microhabitats were sampled and the results were found to be quite different. The juveniles utilized the spine canopy of adult urchins as refuge. Purple urchins showed a preference for rocks (35%) and approximately equal preferences for holdfasts, adult purple urchins, and adult red urchins (20.0 22.3 and 18.9%, respectively). Red urchins exhibited significant preference for red adults (81.2%) with little preference for adult purple urchins (10.7%) and holdfasts (6.9%). A simulated small-scale fishery experiment showed lower recruitment levels could be expected as adults were cropped from the population. The commercial harvest of red urchins could affect the reproductive potential of the exploited population as well as the nursery grounds.

Drift-tube study of the dispersal potential of green abalone (*Haliotis fulgens*) larvae in the Southern California Bight - Implications for recovery of depleted populations.

AUTHOR(S): Tegner, M. J., and R. A. Butler.

YEAR: 1985.

SOURCE: Mar. Ecol., Prog. Ser. 26(1-2):73-84.

KEYWORDS: Abalone, *Haliotis* spp., larvae.

ABSTRACT: The green abalone, *Haliotis fulgens*, larval dispersal from offshore islands and the southern California mainland was studied using drift tubes. A total of 2,400 tubes were released during June and October (the peak spawning periods) with a total recovery rate (inshore and offshore) of 30% and 13%, respectively. Only 4% of the tubes released at the Channel Islands were found on the mainland and only 0.4% were recovered within the larval span of green abalone. Most drift tubes were recovered in suitable habitat a few kms from the release site. These results suggest that the lack of suitable broodstock in an area (due to overexploitation) could lead to the loss of the fishery, since distant populations would not significantly affect recruitment rates.

The survival and mortality of seeded and native red abalones, *Haliotis rufescens*.

AUTHOR(S): Tegner, M. J., and R. A. Butler.

YEAR: 1985.

SOURCE: Calif. Fish Game, 71(3):150-163.

KEYWORDS: Abalone, *Haliotis rufescens*, mortality, behavior, growth.

ABSTRACT: This paper reports the results of a one year red abalone, *Haliotis*

*rufescens*, seeding experiment conducted off the Palos Verdes Peninsula in Los Angeles County. The habitat selected included reef structures with ledges and crevices and abundant drift kelp. Hatchery-reared juveniles were placed in this environment and their growth monitored and compared with naturally occurring individuals. Predators and scavengers were removed periodically to ease pressure on the seed. Results of this experiment indicate that predation appears to be the greatest limiting factor to recovery of red abalone populations in this area.

Food-chain dynamics of abalone in a polyculture system.

AUTHOR(S): Tenore, K. R.

YEAR: 1976.

SOURCE: Aquaculture 8(1):23-27.

KEYWORDS: Abalone, *Haliotis* spp., growth, feeding.

ABSTRACT: Growth and feeding rates of three commercially important species of abalone; the red (*Haliotis rufescens*), the green (*Haliotis fulgens*) and the Japanese (*Haliotis discus*) were studied for 112 days in a polyculture system. The abalones were fed sea lettuce (*Ulva laetuca*) which was grown on the nutrients regenerated by bivalves. All three species of abalone grew during the experiment, with growth efficiencies (net production/food ingested) of 10.2, 13 and 22.7% for reds, Japanese and greens, respectively. The average length increases were 0.96 cm for *H. discus*, 0.53 cm for *H. rufescens*, and 1.03 cm for *H. fulgens*. The differences in temperature regime (16 to 23 deg. C) during the experiment may have accounted for differences in growth rates. The results suggest the feasibility of using abalone, in a browsing role, in a polyculture system.

Effect of starvation on the histological and morphological characteristics of jack mackerel, *Trachurus symmetricus*, larvae.

AUTHOR(S): Theilacker, G. H.

YEAR: 1978.

SOURCE: Fish. Bull. 76(2):403-414.

KEYWORDS: Larvae, feeding, *Trachurus symmetricus*, jack mackerel.

ABSTRACT: Morphological and histological criteria for assessing the nutritional condition of jack mackerel, *Trachurus symmetricus*, larvae were developed. These criteria were evaluated by comparing success in identifying fed and starved larvae reared in the laboratory. Twelve histological criteria, which appeared to be indicators of starvation, were identified. The effects of starvation were noted in the brain, liver, pancreas, digestive tract, musculature, cartilage, kidney, and swim bladder. It was found that in grading only two histological characteristics, the arrangement of the cells in the pancreas and the sloughing of mucosal cells from the midgut gave the same conclusions as using all 12 features. Morphological examination determined that 1) all larvae (3.30 mm SL) that do not have a yolk sac probably are starving (feeding is initiated at 3.35 mm); and 2) larvae with a body depth (0.47 mm) are feeding. For individuals in the size class between 3.30 and 3.55 mm analysis of 5 morphometric variables (standard length, head length, eye diameter, body depth at the pectoral, and body depth at the anus), identified 83% of the fed and 86% of the starved larvae. When all size classes of larvae were included in the analysis, 87% of the fed and 94% of the starved were correctly classified. When compared, both histological and morphometric methods were equally effective in determining whether or not a larva was fed or 3-day starved. It is hoped that these criteria may be useful for estimating larval survival in the field by assessing the condition of sea-caught larvae.

Starvation-induced mortality of young sea-caught jack mackerel, *Trachurus symmetricus*, determined with histological

and morphological methods.  
AUTHOR(S): Theilacker, G. H.  
YEAR: 1986.  
SOURCE: Fish. Bull. 84(1):1-18.  
KEYWORDS: Jack mackerel, *Trachurus symmetricus*, larval mortality.  
ABSTRACT: Larval jack mackerel, *Trachurus symmetricus*, from offshore and inshore stations were examined by histological and morphological methods to determine their health and nutrition state. Their shrinkage in standard length, head length, eye diameter, and body depth were taken as indications of starvation. In addition, various tissues including brain, gut and musculature supported the morphometric analyses. Up to 70% of the larvae from offshore stations were found to be starving compared to 12% collected inshore and near islands. The starving condition dropped to near zero at both sampling sites for too weak and older larvae.

Changes in body measurements of larval northern anchovy, *Engraulis mordax*, and other fishes due to handling and preservation.

AUTHOR(S): Theilacker, G. H.  
YEAR: 1980.  
SOURCE: Fish. Bull. 78(3):685-692.  
KEYWORDS: *Engraulis mordax*, northern anchovy, larvae, length/weight.  
ABSTRACT: Models are generated to describe live body proportions for larval northern anchovies, *Engraulis mordax*, from those which shrank due to handling or preservation. Factors considered included size, type of fixative, treatment of larvae before fixation, and duration of net retention, while treatment categories were live, laboratory pipetted and preserved, net treated, and preserved after net treatment. In formalin preserved specimens the shrinkage (SL) ratio of preserved to live was 0.92 and did not decrease with age. Eye diameter increased in size. Alcohol preservation caused no change in standard length. Net-treated larval shrinkage varied with fish size and handling time, ranging from 1-2 to 19% reduction in size. Shrinkage is related to the degree of ossification. Fish preserved after net shrinkage shrank further in a constant proportion to length, with a 3% reduction in all body parts. Preservation in alcohol caused no further shrinking. Netting live larvae and formalin preservation caused small changes in eye diameter, 0.0443+/-0.0069 and 0.0177+/-0.0046 mm, respectively. Eye diameter should be a useful parameter for estimating the standard length of field collected larvae. Autolysis and osmoregulatory problems are major factors involved in shrinkage of field collected anchovy larvae. The amount of this size reduction depends on larval fish size and the extent of handling.

Rearing container size affects morphology and nutritional condition of larval jack mackerel, *Trachurus symmetricus*.

AUTHOR(S): Theilacker, G. H.  
YEAR: 1980.  
SOURCE: Fish. Bull. 78(3):789-791.  
KEYWORDS: *Trachurus symmetricus*, jack mackerel, larvae, feeding.  
ABSTRACT: Jack mackerel (*Trachurus symmetricus*) larvae were raised in 10L and 100L rearing containers. Half of these treatments were starved, the rest fed a standard diet. Daily samples were taken to determine relative sizes and nutritional condition. The

largest sizes and best survivorship of feeding age larvae were found in the fed, 100 mL containers. 10L fed fish were also larger than either of the starved treatments. However, the starved larvae in the smaller container were larger and survived 2 days longer than those in the 100L containers. No difference in nutritional condition was noticed between the two starved groups. All starved fish were dead by 10 days, but fed larvae in 10L containers died at 12-13 days. One fed, 100L container larvae survived 49 days, although there was a major mortality at 13 days. Container size and nutritional condition can make significant, early differences in larvae. Results from reared larvae should be related cautiously, if at all, to field studies. Also, container size must be considered as another variable along with light, temperature, etc., when examining data.

Management of the white seabass (*Cynoscion nobilis*) in California waters.

AUTHOR(S): Thomas, J. C.

YEAR: 1968.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 142, 34 pp.

KEYWORDS: White seabass, *Atractoscion nobilis*, fishery, growth, age, length/weight.

ABSTRACT: The white seabass, *Cynoscion nobilis*, fishery has been subjected to regulation since 1931 and this management has probably affected the yield. Seabass were mainly landed in the San Pedro area and landings peaked from April through September. The fishery peaked in 1959 at 72,000 lbs, however catch per unit effort data showed the population was not overharvested. Ages of 2,831 fish were determined using scales and 16 year classes were noted, although the older classes were somewhat questionable. The total lengths (in mm) for the age classes were: 1, 231; 2, 336; 3, 467; 4, 571; 5, 723; 6, 886; 7, 929; 8, 981; 9, 1033; 10, 1072; 11, 1144; 12, 1194; 13, 1217. The survival rate increased to 57% in 1960, up from 44% in 1959. The results indicated fishermen should target smaller fish by decreasing mesh size to 4 inches to achieve a better yield.

Status of the California coastal pelagic fisheries.

AUTHOR(S): Thomson, C., A. Grover, and W. L. Craig.

YEAR: 1985.

SOURCE: N.M.F.S. Ad. Rep SWR 85-1:1-27.

KEYWORDS: Wetfish, northern anchovy, *Engraulis mordax*, chub mackerel, *Scomber japonicus*, jack mackerel, *Trachurus symmetricus*, Pacific bonito, *Sarda chiliensis*, market squid, *Loligo opalescens*, regulations, fishing gear, economics.

ABSTRACT: This report on the status of California coastal pelagic fisheries

describes their 1984 economic value, management regulations, the commercial harvesting and processing sectors, and recreational fisheries. The major coastal pelagic species, also called wetfish, are northern anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), Pacific bonito (*Sarda chiliensis*), Pacific sardine (*Sardinops sagax*), and market squid (*Loligo opalescens*). The combined commercial landings of the coastal pelagic species in 1984 were 59,200 mt with an ex-vessel value of \$9.1 million. Landings and real value were down 2% and 10% from 1983's 60,000 mt and \$10.1 million, respectively. Most fishing

for coastal pelagic species is under regulations set by the State of California, except for northern anchovy which is regulated by the U.S. Department of Commerce, based on a plan developed by the Pacific Fishery Management Council. Management regulations are described for each species. Each harvesting sector is described by fishing area and includes type of fishing gear, target species, landings for each species and ex-vessel values. There have been no major changes in the types or forms of products derived from the California coastal pelagic species. They are canned for human consumption and pet food, reduced to oil and meal, and are sold as fresh and frozen products. Recreational anglers target on jack mackerel, Pacific mackerel and Pacific bonito, while anchovies and squid are used as live, frozen and salted bait. The 1984 commercial landings of anchovies were 2,905 mt, a decline from the 1979-83 average of 37,798 mt. Mackerel landings were 52,947 mt, up from the 1979-83 average of 3,941 mt, while squid landings were 564 mt, a drastic decline from the 1979-83 average of 13,604 mt.

California's northern anchovy fishery in 1983/84.

AUTHOR(S): Thomson, C., and R. Klingbeil.

YEAR: 1984.

SOURCE: Southwest Fisheries Center, NMFS Admin. Rep. LJ-84-23. 19 pp.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, feeding, regulations, population trends.

ABSTRACT: Fishing regulations, status of the fishery, and fishing fleet and processing plant capacities are reported for the California northern anchovy, *Engraulis mordax*, fishery. A summary of regulations for the coming 1984/85 season is also given. In 1983, the size limit on reduction fishery landings was eliminated and a quota reserve procedure established. A minimum mesh size requirement goes into effect in 1986 to protect the pre-spawning portion of the population. In 1984, an amendment to the Fishery Management Plan eliminated the reduction quota reserve, changed the harvest formulas, and altered the periods of reduction fishery closure. Optimum yield in 1983/84 was calculated as 104.8 thousand metric tons, based upon a spawning biomass estimate of 1.405 million metric tons. Landings were a record low of 1,680 metric tons with the southern permit area accounting for only 79 metric tons. In the northern permit area, the first landing was made in January and the last in early June. Price paid dropped from \$42 to \$38 per ton. The non-reduction fishery landed 3,737 metric tons, 2,998 of which were live bait and 739 for package bait. Bait was available for most of May coastwide, catches being dominated by 80-100 mm fish. The number of vessels in the commercial fleet indicated a net increase in potential harvesting capacity, however, 1983 revenues fell to 1974-76 levels after increasing to a maximum in 1980-82. There was a substantial loss of processing capacity in San Pedro with the closure of the larger Terminal Island facility, while Monterey and Port Hueneme report no change in processing capacity.

Additional evidence substantiating existence of northern subpopulation of northern anchovy, *Engraulis mordax*.

AUTHOR(S): Tillman, M. F.

YEAR: 1975.

SOURCE: Fish. Bull. 73(1):212-215.

KEYWORDS: *Engraulis mordax*, northern anchovy, spawning. larvae.



ABSTRACT: The northern anchovy, *Engraulis mordax*, has three distinct subpopulations ranging from Queen Charlotte Islands, B. C. to Cape San Lucas, Baja California. Length-frequency distributions are presented to refute the hypothesis that the northern subpopulation does not reproduce, and the observed larvae are from incidental spawning. Bar graphs show that 0-age anchovies, with lengths of 0-9 cm, are present from 1966 to 1970. Spawning occurred in the summer prior to each collecting period (1965-1969). This information, along with genetic and meristic evidence and larval surveys, indicates that the northern population is one of three independent subpopulations.

Development and example application of a simulation-model of the northern anchovy fishery.

AUTHOR(S): Tillman, M. F., and D. Stadelman.

YEAR: 1976.

SOURCE: Fish. Bull. 74(1):118-130.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, population trends.

ABSTRACT: A computer model of the northern anchovy, *Engraulis mordax*, fishery was designed to simulate the sectors utilizing the resource. Included within the routine were data on locations, stocks, harvesters, regulators, processors and market producers. The biological model took into account the stock structure of the population and the recruit behavior. These factors accounted for age, dependent exploitation and variable recruitment. The model was tested biologically and economically with results suggesting many inherent problems in regulating fisheries while lacking economic or biological knowledge. Since the model was not effectively validated the value lay in the ability to illustrate research needs.

Differential growth in juvenile black abalone, *Haliotis cracherodii*.

AUTHOR(S): Tissot, B. N.

YEAR: 1980.

SOURCE: Amer. Zool. 20(4):928.

KEYWORDS: Abalone, *Haliotis* spp., growth.

ABSTRACT: Juvenile black abalone, *Haliotis cracherodii* were raised for 90 days on diets of *Macrocystis*, *Iridaea*, and *Ulva* to demonstrate differential growth rates. The onset of reproductive maturity was correlated to a shift from shell growth to body growth. The three algae were found to promote one form of growth over the others. The differential growth rates, with respect to diet, were hypothesized to be caused by nutrient availability within the algal species.

Cephalopods in the diet of the swordfish, *xiphias gladius*, from the Florida straits.

AUTHOR(S): Toll R. B., and S. C. Hess.

YEAR: 1981.

SOURCE: Fish. Bull. 79(4):765-774.

KEYWORDS: *Xiphias gladius*, swordfish, feeding.

ABSTRACT: Stomach analyses conducted on 65 individuals of *Xiphias gladius* from the Straits of Florida indicated cephalopods (particularly squid) overwhelmingly constituted the main dietary factor in the swordfish studied, both in numbers and

volumetrically. Species of the squid genus (*Illex*) were the single most important component. No correlations to variations in stomach content and swordfish sex, size, capture method, hookup time, or season was found. Therefore, swordfish were suggested to be opportunistic feeders. Stomachs with decapitated and slash-marked squid support the theory that swordfish kill or stun their prey by slashing through schools of squid with their bills. Swordfish are also postulated to be epipelagic to upper mesopelagic feeders based on the bathymetric range of the cephalopods found. In comparing this data with data from studies of Istiophorids stomach analyses, reverse dietary preferences are observed. Istiophorids prefer fish, whereas swordfish prefer cephalopods.

Intertidal recruitment and feeding in relation to optimal utilization of nursery areas by juvenile English sole.

AUTHOR(S): Toole, C. L.

YEAR: 1980.

SOURCE: Environ. Biol. Fish. 5(4):383-390.

KEYWORDS: Parophrys vetulus, English sole, feeding, growth, early life history, habitat, nursery.

ABSTRACT: Juvenile English sole, *Parophrys vetulus*, of Humbolt Bay were examined for changes in feeding method and habitat selection accompanying growth. The fish ranged from 19-102 mm and prey ingested varied with size. Fish less than 50 mm fed mostly on harpacticoid copepods, 67% by biomass. During winter, pericarid crustaceans were of nearly equal importance. A feeding transition occurred between 51-65 mm, where fewer copepods and more polychaetes, cumaceans, amphipods and insects were consumed. Polychaetes as prey dominated in guts of fish 66-102 mm, averaging 82% of the biomass. Spionids and capitellids were present in equal proportion during summer, but capitellids dominated during winter. These seasonal variations were probably due to annual fluctuations in prey availability. Feeding niche width and size of prey increased with predator size. Data suggests that recently metamorphosed English sole recruit into the intertidal habitat and migrate from this nursery into subtidal channels after growth. Possible reasons for this size distribution include: refuge from subtidal predators, presence of suitably small prey items, and reduced inter- and intraspecific competition during the early life history of this ground fish.

How offshore platforms help fishing.

AUTHOR(S): Treybig, D. L.

YEAR: 1971.

SOURCE: Ocean Industry 6:64-65.

KEYWORDS: Platforms, artificial reefs, fishery, colonization, community.

ABSTRACT: The use of oil platforms to increase the commercial fish catch is discussed. Organisms vital to marine life including plankton, invertebrates, barnacles, corals, and algae attached themselves to platforms. These in turn feed small fish which again feed larger fish. Since drilling platforms first appeared in the Gulf of Mexico, the commercial fish catch has increased almost six-fold. Drilling platforms in the proximity of the Caribbean Current serve as "marine hotels", providing food, rest and security for the spectrum of organisms that are in the current. Creatures also find sanctuary near platforms in times of water

temperature and current pattern changes. The National Marine Fisheries Service is developing a platform to automatically fish surrounding waters. This platform may increase U. S. fishing yields 10-fold. Two basic needs sought by marine life are provided by oil platforms; a safe, dark place to hide, and abundant food. Automatic fishing platforms could maximize seafood production. Placing the platforms in appropriate locations is important to luring great numbers of fish.

Apartment for rent; please don't disturb tenants until housing survey is completed!

AUTHOR(S): Turner, C. H.

YEAR: 1961.

SOURCE: Outdoor California 22(1):10-12.

KEYWORDS: Artificial reef, colonization, community.

ABSTRACT: New homes for fishes as artificial reefs are constructed from old cars, streetcars, and concrete shelters. Biologists hope that these reefs will entice fish to remain in areas which were once only sand and mud, where fish normally wander aimlessly in search of food. The structures used formed a satisfactory break in the otherwise low relief of the spacious flat bottom. Tenants began to arrive before construction had hardly ceased and after two years the residents numbered in the thousands. Surfperches are the most common fishes while species of interest to fisherman include kelp bass, sand bass, sheephead, and numerous rockfish. Giant kelp attached to structures and biologists are observing growth. Results of this program could mean numerous new fishing reefs.

Seascapes from car 1538.

AUTHOR(S): Turner, C. H.

YEAR: 1962.

SOURCE: Outdoor California 23(7):11-13.

KEYWORDS: Artificial reefs, colonization, community.

ABSTRACT: Artificial reefs built from old car bodies near Paradise Cove in Santa Monica Bay, streetcars off Redondo Beach, and various structures in Santa Monica Bay are discussed briefly. First organisms to appear were moss animals and barnacles, then abalone jingles, sponges, tunicates, and finally kelp. Fishes included seaperches, kelp bass, and sand bass, followed by rockfish and sheephead. Within three years, 50 species and over 10,000 individuals were present on old cars. Populations were lower on streetcars with 47 species and 2,000 to 3,000 individuals. Scientists studied fish numbers, breeding behavior, and feeding habits. Fish were tagged to look at movements. Of the various structures used, the fish appeared to prefer concrete. At oil platforms numerous foods for fishes are found, and consequently populations are high.

California Department Fish & Game's study of offshore oil drilling and its effects on the marine environment.

AUTHOR(S): Turner, C. H.

YEAR: 1967.

SOURCE: Calif. Dept. Fish Game, MRO Ref. 67-29.

KEYWORDS: Platform, yellowtail, Pacific bonito, jack mackerel, chub mackerel, nursery, kelp bass, *Seriola lalandei*, *Sarda chiliensis*, *Trachurus symmetricus*, *Scomber japonicus*, *Paralabrax clathratus*, habitat.

ABSTRACT: Observations were made by biologist-divers around five oil platforms off the coast of southern California. The purpose of the work was to evaluate the effects of offshore drilling (e.g. depositing washed drill cuttings on the ocean floor) on the surrounding marine life. The platforms observed were platforms "Hazel" and "Hilda" at Summerland, Richfield oil island at Rincon, Monterey oil platform at Seal Beach, and Texaco oil platform at Gaviota. The results of the study showed that the events surrounding oil production had no negative effects on the marine environment and instead had a positive effect. Many fishes were observed to be attracted to the platforms, and encrusting organisms (such as kelp scallops, barnacles and mussels) grew on the structures which increased the available fish food.

Marine baits of California. 1st revision.

AUTHOR(S): Turner, C. H., and J. C. Sexsmith.

YEAR: 1967.

SOURCE: Calif. Dep. Fish Game, Sacramento, CA. 70 p.

KEYWORDS: Market squid, *Loligo opalescens*, fishery, fishing gear, distribution, life history, mortality, physiology.

ABSTRACT: This booklet discusses a wide range of species used as bait and describes the primary fish attracted to each bait species. Included in each bait species characterization is its distinguishing characteristics, range, life history notes and a description of its capture and use. The booklet is intended as an aid for California saltwater fishermen.

Man-made reef ecology.

AUTHOR(S): Turner, C. H., E. E. Ebert, and R. R. Given.

YEAR: 1969.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 146, 221 pp.

KEYWORDS: *Sebastes miniatus*, vermillion rockfish, *Paralabrax clathratus*, kelp bass, artificial reef, habitat, migration, feeding, life history, distribution, behavior, community.

ABSTRACT: Cost-effectiveness of three types of artificial reef materials (quarry rock, discarded automobiles, and concrete shelters) in enhancing local fish and invertebrate abundance were examined. Abundance estimates, trophic relationships, behavioral observations and movement estimates were conducted. Three sites comprised of each of the three reef materials were located offshore of Malibu, Santa Monica and Hermosa Beach, cities within Santa Monica Bay, California. All three sites were established during August of 1960. One *S. miniatus* was recovered 5 to 6 miles south of the tagging site 5 days after tagging. An 80 ft. depth break at which adults remain below and juveniles and sub-adults occur above is described. All individuals observed in the vicinity of the artificial reefs in Santa Monica Bay were 3-6 inch long juveniles. *P. clathratus* was observed to feed on juvenile *Cancer productus*. Among the three reefs sites, *P. clathratus* ranged from the second to the sixth most common fish species. *P. clathratus* was attracted to all three reef materials. Individuals were evenly distributed through the water column irrespective of thermocline. *P. clathratus* typically form loose aggregations except during breeding season, at which time they form tightly concentrated aggregations which "balloon" well above the substrate into the surface waters. As spawning time approaches, aggressiveness increases within the school and the schooling

clusters circulate more freely. At the height of the breeding period *P. clathratus* were absent from one or more of the reef sites. Larvae and juveniles (smaller than 3 inches) were not observed on any of the reefs. The observed kelp bass ranged from 3 to 24 inches in length. The authors conclude that habitats void of kelp are less desirable for this species. The authors conclude that the artificial reefs enhanced local fish abundance and that quarry rock was the most cost-effective of the materials used.

Man-made reef ecology.

AUTHOR(S): Turner, C. H., E. E. Ebert, and R. R. Given.

YEAR: 1969.

SOURCE: Fish. Bull. 146, 221 pp.

KEYWORDS: Artificial reef, community, colonization.

ABSTRACT: Four artificial reefs (3 multicomponent and 1 quarry rock) were constructed in approximately 60 feet of water off Santa Monica, southern California. The physical data collected for each site (over a 4-year period) included water clarity, sediments, and temperatures. The numbers of plants, invertebrates and fish were estimated by divers. A successional sequence was noted amongst the reef organisms progressing from barnacle-hydroids to mollusk polychaetes, ascidian-sponge and finally encrusting ectoprot phases. The climax community included aggregate anemones, gorgonians and stony corals. In all, more than 200 invertebrate species were recorded on the reefs; 90% of the fish population was dominated for the first 2 years by Enbiotocid perches and Serranids. Their numbers declined as resident populations of gobies, cottids, damselfish and rockfish increased. Seventy-eight species (35 families and 60 genera) were noted during the study. Few algae species were recorded on the reefs (4 browns and 4 reds) in negligible numbers. *Macrocystis* transplants proved unsuccessful, presumably due to turbidity at the sites. Of the various reef materials used quarry rock was preferred (based on cost and ease of handling). Streetcars and automobile bodies deteriorated quite rapidly. Concrete shelters attracted the greatest numbers of fish. Fishing success on the reefs was good; sometimes 2-3 times higher than surrounding natural reefs. The results of the study suggested that nonproductive nearshore areas can be turned into productive fishing areas with construction of artificial reefs; however, various physical, biological and economic factors must be considered before artificial reefs are constructed.

Reproductive biology of three species of abalones (*Haliotis*) in southern California.

AUTHOR(S): Tutschulte, T., and J. H. Connell.

YEAR: 1981.

SOURCE: Veliger 23(3):195-206.

KEYWORDS: Abalone, *Haliotis* spp., reproduction.

ABSTRACT: Collections of green, *Haliotis fulgens* (500 animals), pink, *H. corrugata* (1100 animals), and white, *H. sorenseni* (600 animals) abalone were made between 1969 and 1973 at Santa Catalina Island. The pooled sex ratio was 1:1; however, females predominated at an early age and males at a later age. These observations suggest lower growth rates or higher mortalities for mature females. The pink abalones were found to mature at the earliest age (3 yrs), spawned several times per year and released about 1 million eggs. The white abalones matured at 4 yrs and were more synchronized in

their spawnings (once per year during the winter). The average female produced 5 million eggs. The greens matured latest and produced about half as many eggs as the whites. Their spawning season was much longer, lasting from late fall to mid-spring.

Maturation and fecundity of swordfish, *Xiphias gladius*, from Hawaiian waters.

AUTHOR(S): Uchiyama, J. H., and R. S. Shomura.

YEAR: 1974.

SOURCE: Pages 142-148 in: R. S. Shomura and F. Williams (eds.). Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972, Part 2. Review and contributed papers. NOAA Tech. Rep. SSRF-675.

KEYWORDS: Swordfish, *Xiphias gladius*, reproduction, spawning, migration, weight, age.

ABSTRACT: Ovaries from 16 swordfish were examined. Ripe ova were taken from ovary subsamples and measured, then seven developmental stages of an ova were determined and described. An analysis of variance to test the distribution of the ripe ova throughout the ovaries showed they were not distributed homogeneously. Spawning time of swordfish appears to be from April to July as indicated by the highest gonad indices (gonad size relative to fish size). The appearance of large swordfish in the late stages of maturity in April through July suggests that the movement into coastal waters of the Hawaiian archipelago may be part of a spawning migration. Fecundity measurements from 8 swordfish indicated that fecundity ranges from 3.0 million ova for a 80 kg fish to 6.2 million ova for a 200 kg fish.

Regulation of maturation and spawning of an abalone, *Haliotis* (gastropoda) by external environmental factors.

AUTHOR(S): Uki, N., and S. Kikuchi.

YEAR: 1984.

SOURCE: Aquaculture 39(1-4):247-261.

KEYWORDS: Abalone, *Haliotis* sp., spawning, reproduction.

ABSTRACT: The rate of gonadal maturation of *Haliotis discus hannai* was found to be proportional to the effective accumulative temperature (which has units of degree-days). Nutritional levels must be at least 5% over normal feeding rates for the onset of gonad maturation. Gonads mature to three noticeable levels; immature (0-500 degree-days), mature (500-1500 degree-days), fully mature (after 1500 degree-days). Temperature was found to be the major external environmental factor regulating breeding cycles in abalone. Artificially produced spawning periods (after 1500 degree-days) correspond well with natural spawning season data.

Female size and nest depth in coho salmon (*Oncorhynchus kisutch*).

AUTHOR(S): van den Berghe, E. P., and M. R. Gross.

YEAR: 1984.

SOURCE: Jour. Fish. Aquat. Sci. Canada 41(1):204-206.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, reproduction, spawning, behavior.

ABSTRACT: Nest depth is an important factor in brood survival among salmon, as greater nest depth affords greater protection from destruction by floods and by superimposition of nest sites by

other female salmon. In this study, nest depth was shown to be strongly correlated with female size. This was due to greater body size allowing greater flexion and thus a stronger digging vortex.

Detection of market squid, *Loligo opalescens*, with echo sounders.

AUTHOR(S): Vaughan, D. L., and C. W. Recksiek.

YEAR: 1979.

SOURCE: CalCOFI Rep. 20:40-50.

KEYWORDS: Market squid, *Loligo opalescens*, behavior.

ABSTRACT: Low (38 kHz) and high (200 kHz) frequency echo sounders were used simultaneously to locate schools of market squid, *Loligo opalescens*, in Monterey Bay. The tracings were verified by visual observations, jigging and midwater trawls. Two distinct behaviors were recorded with the echo sounders. A continuous bottom trace was seen typically during the day. Plumes, and often "speckle", traces were observed at night. These probably represented small schools and individuals. The performance of both echo sounders, in relation to imagery, was considered.

Compositional analysis of jack mackerel and blue mackerel.

AUTHOR(S): Vlieg, P.

YEAR: 1982.

SOURCE: New Zealand Jour. Sci. 25(3):229-232.

KEYWORDS: *Trachurus symmetricus*, jack mackerel, physiology.

ABSTRACT: The protein composition and fatty acid analysis of the jack mackerel *Trachurus declivus* and *T. novaezelandiae* and of the blue mackerel *Scomber australasicus* from the north island of New Zealand in 1980 was determined for processing purposes. The mean protein levels of almost all samples was higher than 20%, and mean oil levels were less than 5%. There was significant correlation between body size or sex and oil content, although lower oil content seemed associated with a viceral nematode. Some differences in the blue mackerel seem to be due to hand-skinning techniques. These fish are appropriate for products requiring fish high in protein and low in oil. The variation in oil content in the blue mackerel may make it more difficult to obtain a homogeneous product.

A mathematical model of the relationship between larval anchovy (*Engraulis mordax*) growth, prey microdistribution and larval behavior.

AUTHOR(S): Vlymen, W. J.

YEAR: 1977.

SOURCE: Environ. Biol. Fishes 2(3):211-233.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, growth, distribution, behavior.

ABSTRACT: A model is constructed and analyzed to simulate dynamically the interrelationship between the northern anchovy (*Engraulis mordax*) larval physiology and behavior and its food microdistribution, especially as they affect the growth of larvae. The model simulates the growth of larvae at the beginning of exogenous nutrition from 0.4 cm to the onset of schooling at 2.0 cm for various levels of contagion of food organisms. Major components required to construct the complete system are a random walk model of larval anchovy feeding behavior, a model of attack

rate in various concentrations of food prey, prey size distribution and environmental geometrics, and additional physiological components including excursion length, maximum gut volume, caloric values of prey particles, digestive times, basal metabolic rate, excursion energies, processing energy requirement, digestive efficiency, and conversion of excess energy growth. The average growth rate is a nonsymmetric, nonlinear function of contagion  $K$ . A single peak maximum growth rate is obtained for all temperatures at the same degree of contagion of  $K=0.10$ . Except for very high degrees of contagion the lower temperatures exhibit strikingly higher average growth rates. The importance of microstructure to the survival of anchovy larvae in their environment may be of great importance.

White seabass, *Atractoscion nobilis*, in California-Mexican waters: Status of the fishery.

AUTHOR(S): Vojkovich, M., and R. J. Reed.

YEAR: 1983.

SOURCE: CalCOFI Rep. 24:79-83.

KEYWORDS: Fishery, regulations, fishing gear, distribution, white seabass, *Atractoscion nobilis*.

ABSTRACT: The white seabass, *Atractoscion nobilis*, fishery, catch data, and management regulations are reviewed to provide a background for future management considerations. The white seabass is an important sport and commercial fish in southern California. Their range has been recorded in the past from Magdalena Bay, Baja California to Juneau, Alaska. The present range is from Pt. Conception to Punta Abreojos, Baja California. Management regulations have been established since 1931, when declining catches were first noted. However, the white seabass resource continues to decline. Regulations in effect as of January 1, 1983, include a 71 cm TL size limit for both sport and commercial fisheries, with a three fish per day bag limit for the sport fishery. A permit and logbook reporting system is required for commercial fishermen using gill or trammel net fishing gear. A closed season exists from March 15 to June 15 south of Pt. Conception. Factors contributing to the decline of the white seabass fishery off California include environmental degradation, overfishing, and unfavorable oceanographic conditions. Also, changes in the availability of prey may be influencing the distribution. Catch records show the sport catch peaked in 1949, with 64,000 fish caught and hit a record low of 284 fish in 1978. The commercial landings were under 45 MT (100,000 lbs) in 1981, the lowest level on record. The percentage of white seabass landings taken in Mexican waters increased substantially over the years, until Mexico denied permits to U. S. commercial fishermen in 1982. This has cut the U.S. commercial catch by more than 80%. Additional information is needed on fecundity, movement and reproductive requirements in order to protect the white seabass resource.

Homing and fisheries contribution of marked coho salmon, *Oncorhynchus kisutch*, released at two Columbia River locations.

AUTHOR(S): Vreeland, R. R., and R. J. Wahle.

YEAR: 1983.

SOURCE: Fish. Bull. 81(1):143-148.



KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, behavior.

ABSTRACT: Approximately 200,000 1971-brood coho salmon, *Oncorhynchus kisutch*, were fin clipped and released from either the Willard National Fish Hatchery or Youngs Bay on the Columbia River. Both groups were transported equal distances to eliminate the mortality effects. The sport and commercial fisheries and Columbia River studies in 1973 and 1974 were sampled. Youngs Bay releases accounted for 23 fish/1000 released while Willard Hatchery fish only contributed 5.6 fish/1000 released. The differences may have been due to more abundant food in Youngs Bay or possible mortalities suffered by Willards Hatchery young due to dams and spillways. Homing specificity was almost exclusively to the area of release.

Dwarf hake off the coast of Baja California, Mexico.

AUTHOR(S): Vrooman, A. M., and P. A. Paloma.

YEAR: 1977.

SOURCE: CalCOFI Rep. 19:67-77.

KEYWORDS: Age, growth, distribution, Pacific hake, *Merluccius productus*.

ABSTRACT: This paper attempts to determine if the stock of hake off Baja California, known as "dwarf hake", and the stock of hake off the coast of California, known as *Merluccius productus*, are the same species, or if the dwarf hake are a species of hake referred to in the literature as *Merluccius angustimanus* from farther south than Baja California. The analysis was conducted through a series of protein electrophoresis, morphometrics, and meristics tests. The conclusions were that a distinct division existed between the stocks of *Merluccius productus* in the north and "dwarf hake" in the south around the 28 deg N latitude. Unfortunately, not enough information could be gleaned from the literature about *Merluccius angustimanus* to determine if "dwarf hake" was that species. It was also concluded that the growth of "dwarf hake" was much slower than that of *Merluccius productus*. Dwarf hake also appear to be sexually mature at age 2, while *Merluccius productus* is not mature until age 4.

Biomass of the subpopulations of northern anchovy *Engraulis mordax* Girard.

AUTHOR(S): Vrooman, A. M., and P. E. Smith.

YEAR: 1971.

SOURCE: CalCOFI Rep. 15:49-51.

KEYWORDS: Northern anchovy, *Engraulis mordax*, population trends.

ABSTRACT: The number of northern anchovy (*Engraulis mordax*) larvae and spawning biomass are reported for the three subpopulations off the west coast of North America from 1951-1966. Total numbers of larvae for all areas combined ranged from a low of 6,504x10E12 in 1951 to 79,292x10E12 in 1965. The greatest increase has taken place in the central subpopulation. Spawning biomass increased from 639,000 tons in 1951 to 6,260,000 tons in 1962, after which it fluctuated from 5 and 8 million tons. During 1960-66, the southern subpopulation biomass was on the average twice as great as during 1951-59, while the ratios in the central and northern subpopulations were three and a half and intermediate, respectively. The mean total biomass from 1962-66 was 6.1 million tons, with the central, southern and northern subpopulations contributing 77.3, 18.5 and 4.2% of the total, respectively.

Electrophoretic, morphometric, and meristic studies of subpopulations of northern anchovy, *Engraulis mordax*.

AUTHOR(S): Vrooman, A. M., P. A. Paloma, and J. R. Zweifel.

YEAR: 1981.

SOURCE: Calif. Fish Game 67(1):39-51.

KEYWORDS: *Engraulis mordax*, northern anchovy, population trends, distribution.

ABSTRACT: Using electrophoretic, morphometric, and meristic comparisons, northern anchovy (*Engraulis mordax*) subpopulations are distinguished. Transferring polymorphism was found to originate in a genetic system of four co-dominant autosomal alleles. Northern, central, and southern groups were evident with a fourth in San Francisco and Monterey Bays. This fourth was included in the central subpopulation. The northern and central subpopulations overlap by 70 nautical miles, with the northern's southern limit in Monterey Bay and the central's northern limit in San Francisco Bay. It is probable that the two subpopulations are not in the overlap area at the same time, but both move north in the spring and summer and south in the fall and winter. Transferring data indicate little or no interbreeding between subpopulations. Morphometric data also support the subpopulation differentiation with the southern anchovies having a longer head, larger eye and longer snout to post-orbit ratio. The northern subpopulation has a deeper body while the northern and southern have slightly deeper heads. These differences are consistent at all sizes. Meristics show some significant differences also. Vertebrae number was higher in the northern subpopulation, while southern and central showed no difference. This same pattern was found in anal fin rays. Dorsal fin rays showed no differences. Any conclusions on subpopulations based on meristics should keep in mind the high variability from year-to-year and from month-to-month.

Sequential mortality of the fish fauna impounded in construction of a marina at Dana Point, California.

AUTHOR(S): Waggoner, J. P., III, and C. R. Feldmeth.

YEAR: 1971

SOURCE: Calif. Fish Game 57(3):167-176.

KEYWORDS: Groundfish, mortality.

ABSTRACT: Physical factors, salinity, D.O., and temperature, were measured in an impoundment pool at Dana Point, California, over a three-month period in 1969. Fish mortalities were collected daily and identified. Oxygen levels below 30 ppm were assumed to be fatal to many fish species. Temperature fluctuations also stressed fish significantly. Mortalities were noted at 30 to 32 deg C (about 10 deg C above normal even at high D.O. concentrations). Salinity probably had little effect on fish since it was only 37 o/oo during intensive dieoffs. Embiotocids were extremely susceptible to environmental stresses while elasmobranchs and flatfish were most tolerant.

Feeding relationship within assemblages of nearshore and mid-continental shelf benthic fishes off Oregon.

AUTHOR(S): Wakefield, W. W.

YEAR: 1984.

SOURCE: Master's Thesis. Oregon State University 72 pp.

KEYWORDS: English sole, petrale sole, Dover sole, Cancer magister, *Parophrys vetulus*, *Eopsetta jordani*, *Microstomus pacificus*,

market crab, feeding, mortality, habitat.

ABSTRACT: Food habits of 22 benthic fish species occurring at nearshore and mid-shelf depths were determined from fishes collected during the spring. Food webs for both these habitats were constructed to summarize the trophic relationships within the two continental shelf areas. Both habitats contained fish which fell into one of two feeding types: fishes that prey on pelagic crustaceans and fishes, and fishes that feed on infaunal invertebrates, including polychaetes, nemertean, amphipods, cumaceans and molluscs. Prey types consumed by some of the fish observed were: *Parophrys vetulus* fed on epifauna and infauna; *Eopsetta jordani* fed on or above the substrate; *Microstomus pacificus* fed primarily on polychaetes and amphipods; and *Raja binoculata* preyed heavily on *Cancer magister*, the market crab.

The sharks and rays of California.

AUTHOR(S): Walford, L. A.

YEAR: 1935.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 45:1-66.

KEYWORDS: Thresher shark, *Aliopias vulpinus*, fishery.

ABSTRACT: The 23 species of shark and 15 species of rays recorded from the coast of California were discussed in relation to uses and methods utilized by the fishery. Sharks are poorly used in the U.S. with little interest in anything other than shark liver oils, soupfins and ornaments ("leather" and teeth). Typically the commercially caught species were taken by hook and line, longlines, and gill nets. However, most sharks were incidental catches of the gill net fishery where they are considered a destructive pest. A key, glossary and illustrative description of each species was also presented.

1983 fisheries statistical report.

AUTHOR(S): Washington State Department of Fisheries (WSDF).

YEAR: 1984.

SOURCE: Wash. State Dep. Fish., Olympia, WA. 99 p.

KEYWORDS: Salmon, *Oncorhynchus* spp., economics, fishery, fishing gear, squid,

*Loligo opalescens*, market crab, *Cancer magister*, rockfish, *Sebastes* spp., Pacific hake, *Merluccius productus*, all species.

ABSTRACT: This booklet represents a statistical compilation of data summarizing Washington state's commercial fisheries for the year 1983. Pounds landed and their corresponding dollar values are listed for salmon, marine fish and shellfish.

Scorpaeniformes: Development.

AUTHOR(S): Washington, B. B., H. G. Moser, W. A. Laroche, and W. J. Richards.

YEAR: 1984.

SOURCE: Pages 405-428 in G. Moser (chief ed.), *Ontogeny and systematics of*

*fishes*, Am. Soc. Ichthol. Herpetol., Spec. Publ. 1, Allen Press Inc., Lawrence, KS.

KEYWORDS: Widow rockfish, *Sebastes* spp., larvae, reproduction, physiology.

ABSTRACT: The purpose of this paper is to present a detailed discussion of the

larval taxonomy of the scorpaeniform family Cyclopteridae. A summary

of eggs and larval size characteristics, based on available literature, is provided in table format. Detailed illustrations of larvae of Scorpaenidae are included as well as written descriptions.

Responses of northern anchovy, *Engraulis mordax*, larvae to predation by a biting planktivore, *Amphiprion percula*.

AUTHOR(S): Webb, P. W.

YEAR: 1981.

SOURCE: Fish. Bull. 79(4):727-735.

KEYWORDS: *Engraulis mordax*, northern anchovy, larvae, mortality.

ABSTRACT: The purpose of this study was to examine responses of northern anchovy, *Engraulis mordax*, larvae to attacks by fish, and to determine how avoidance responses and larval susceptibility to predation change during early development. Escape attempts by larvae, escape success of larvae, mean speed during escape attempt, catch success of the predator, predator errors and the number of attacks were used to evaluate larval anchovy avoidance from a biting planktivore, *Amphiprion percula*. Larval response to attack increased from 9% for 0.29 cm larvae to 80% for 1.2 cm larvae. Of these larvae responding to attack, 26% were caught. This proportion was not related to larval size. Mean speeds and escape distances increased with size. Apparent looming threshold (ALT), the rapid magnification of an approaching object on the retina, decreased rapidly with increasing size, and hence development. The changes in ALT may be the basis for increased predator avoidance by larger larvae.

Burst swimming performance of northern anchovy, *Engraulis mordax*, larvae.

AUTHOR(S): Webb, P. W., and R. T. Corolla.

YEAR: 1981.

SOURCE: Fish. Bull. 79(1):143-150.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, behavior.

ABSTRACT: Burst swimming performance of the northern anchovy, *Engraulis mordax*, was determined to evaluate escape probability of anchovy larvae from predators and towed plankton nets. Electric shock was used to initiate burst swimming in anchovy larvae. Larvae responding to the stimulus increased from 9% 40 hrs after spawning to 95% after 125 hrs. The time to reach maximum burst speed was not affected by total length. Maximum burst speed increased linearly with total length. Mean speeds during burst swimming also increased linearly with length, but at a lower rate than maximum burst speeds. The difference between maximum and mean speeds increased with total length because variations in speed in a burst increased with total length. Larger larvae have a much greater escape probability than small larvae. Speed and endurance are the major determinants of increased avoidance ability.

Respiration and depth control as possible reasons for swimming of northern anchovy, *Engraulis mordax*, yolk-sac larvae.

AUTHOR(S): Weihs, D.

YEAR: 1980.

SOURCE: Fish. Bull. 78(1):109-117.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, behavior.

ABSTRACT: The hypothesis of respiration and depth control as a function of swimming behavior in northern anchovy, *Engraulis mordax*,

larvae is investigated using theoretical and experimental methods. A model is developed for oxygen transport to motionless and swimming yolk-sac larvae and to estimate possible oxygen uptake. Relatively slight motions causing local flow around the fishes body suffices for respiratory functions, and actual swimming is not required. Once larvae start swimming, the mass transfer of oxygen to its surface increases at least 10 times. No significant change in the time spent swimming was observed in larvae at 60, 80, and 100% oxygen saturation, while those in <60% of saturation showed large increases in the time spent swimming. Burst duration increased monotonically as oxygen decreased, while the number of bursts dropped significantly at 60 to 80%, increasing sharply after that. Swimming direction is random for day 0 larvae and at one day shows a positive bias. The model predicted that motionless larva could pick up oxygen at a decreasing rate at any given spot. An increase in the general activity of larvae is evident as they grow. Pure diffusion supplies all oxygen for day 0 larvae only when <math>42 \pm 4\%</math> of saturation is available, while at day 1 <math>63 \pm 4\%</math> saturation must be present. When the oxygen concentration is 60% or higher, diffusion alone can satisfy respiratory requirements, while at the 40 to 60% level the observed increase in swimming activity must be a respiratory reaction. The most plausible reason for swimming at high oxygen levels is to keep the larvae from sinking.

Energetic significance of changes in swimming modes during growth of larval anchovy, *Engraulis mordax*.

AUTHOR(S): Weihs, D.

YEAR: 1979.

SOURCE: Fish. Bull. 77(3):597-604.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, behavior.

ABSTRACT: The function of the changes in swimming behavior of northern anchovy, *Engraulis mordax*, larvae is discussed. A theoretical framework is set up to analyze the energetics of swimming during various stages of the fish's life history. During the first three to four days of growth swimming consists of continuous bouts of very energetic motion, changing to an intermittent or beat-and-glide mode of locomotion. At speeds and sizes at which viscous effects dominate, continuous swimming is more efficient. The sharp change in swimming mode coincides with the time the fish leaves the viscous regime, at 5 mm long. Larvae 3-4 mm long and swimming at over 1 cm/s have a smaller drag coefficient and some coasting is possible at the end of the bout, while those in a purely viscous regime cannot coast at all because inertial effects are negligible. For larger larvae and adult anchovy intermittent swimming is more efficient and the slower the average velocity the higher the possible gains. These stages usually swim with a single beat followed by a long glide. Computations indicate that there is a gradual transition between modes. Changes in swimming mode of anchovy larvae is correlated with the passage from a highly viscous regime to the boundary layer regime. This behavioral change is an adaptive energy sparing mechanism.

A comparative study of skin neoplasmas in four species of pleuronectid fishes.

AUTHOR(S): Wellings, S. R., R. G. Chuinard, and M. Bens.

YEAR: 1965.

SOURCE: Ann. N. Y. Acad. Sci. 126:479-501.

KEYWORDS: English sole, *Parophrys vetulus*, contaminant susceptibility, mortality.

ABSTRACT: A description and comparison of the occurrence and morphology of epidermal papillomas in four species of Pleuronectidae: sand sole, rex sole, English sole, and flathead sole. Skin tumors found in the four species were distinguished as three histopathic types. In flathead sole, English sole, and rex sole (one to two years old and greater), the skin tumors were typical epidermal papillomas. The second type of skin lesion, angioepithelial module, was observed only on flathead sole less than one year old. Angioepithelial polyp, the third type of lesion, was observed only on the two specimens of sand sole. None of the three types of tumors appears to be related to lymphocystic disease of fresh water and marine fish. The virus-like particles described in the paper have no morphologic resemblance to any known virus.

Mariculture of the crab, *Cancer magister* (Dana) utilizing fish and crustacean wastes as food.

AUTHOR(S): Welsh, J. P.

YEAR: 1974.

SOURCE: Humbolt State University - Sea Grant Publication No. 4. 76 pp.

KEYWORDS: *Cancer magister*, market crab, growth, feeding.

ABSTRACT: The purpose of this study was to determine if post-molt meat recovery rates could be increased, and if wild-captured adult crabs could be held for an extended period of time at a given mortality level. Crabs were held in mariculture pens and fed fish and crustacean waste from the fishery until they exceeded the minimum meat rate of 23% required for marketing. An increase in meat recovery rates would result in the crabs being put on the market earlier than wild crabs. In the second part of the study, crabs were held in mariculture pens for an extended period of time. The extra holding time would allow an increase in the amount of time they would be available on the market. The results of the study mainly address the feasibility of crab culture using fish and crustacean wastes as a food base. The primary goals of acceleration of post-molt recovery rates and long range holding of crabs with minimal mortality loss have tentatively been accomplished. The results of the study mainly address the feasibility of crab culture using fish and crustacean wastes as a food base. The primary goals of acceleration of post-molt recovery rates and long range holding of crabs with minimal mortality loss have tentatively been accomplished.

Movement of sablefish, *Anoplopoma fimbria*, in the northeastern Pacific Ocean as determined by tagging experiments (1971-80).

AUTHOR(S): Wespestad, V. G., K. Thorsen, and S. A. Mizroch.

YEAR: 1983.

SOURCE: Fish. Bull. 81(2):415-420.

KEYWORDS: *Anoplopoma fimbria*, sablefish, migration, seasonality.

ABSTRACT: A tagging study was initiated in order to determine the movements of the sablefish. Most tagged sablefish were recovered in the same area that they were tagged in, indicating only a limited amount of long range movement. No discernable pattern of seasonal migration was detected, nor was there any correspondence

between size at tagging and distance traveled. The authors concluded that sablefish are primarily nonmigratory and that the Northeastern Pacific sablefish population can be subdivided into "stocks" or management units.

Reproduction, maturation and identification of larvae of some *Sebastes* (Scorpaenidae) species in the Northeast Pacific Ocean.

AUTHOR(S): Westrheim, S. J.

YEAR: 1975.

SOURCE: Jour. Fish. Res. Bd. Canada 32:2399-2411.

KEYWORDS: *Sebastes entomelas*, *Sebastes paucispinis*, widow rockfish, bocaccio, reproduction, spawning, larvae, length/weight, age.

ABSTRACT: An analysis of 66,760 specimens from 21 *Sebastes* species collected throughout the northeast Pacific ocean from Oregon to the western Gulf of Alaska was conducted. The specimens were analyzed for insemination, parturition, maturation, size (age) at maturity, and description of pre-extrusion and post-extrusion larvae. Four of the most important results from this study were: 1) the bathymetric variation in development of *S. alutus* testes; 2) the presence of an intermediate maturing stage during the development of *Sebastes* gonads; 3) latitudinal variation in size (age) at maturity for *S. alutus*; 4) the interspecific similarities and intraspecific differences in *Sebastes* larvae.

Results from tagging a spawning stock of Dover sole, *Microstomus pacificus*.

AUTHOR(S): Westrheim, S. J., and A. R. Morgan.

YEAR: 1963.

SOURCE: Pac. Mar. Fish. Comm. Bull. 6:13-21.

KEYWORDS: Dover sole, *Microstomus pacificus*, migration, population trends.

ABSTRACT: The purpose of this study was to tag a spawning stock of Dover sole, *Microstomus pacificus*, in order to obtain information on seasonal migrations (if any). This study was conducted in Willapa Deep off Willapa Bay, Washington. Tagging was conducted on two discrete fishing grounds about 10 miles apart. In Area A, 1,559 Dover sole were tagged and 206 (13.2%) were recovered; whereas in Area B, 847 were tagged and 54 (6.4%) were recaptured. Tagging revealed that most fish did not migrate extensively away from the tagging area throughout a seven year period of recapture. Most fish (97.3%) were captured less than 30 miles from the tagging area. Maximum migrations were 110 miles north to southern Vancouver Island and 360 miles south to northern California. Tagged fish did exhibit a seasonal offshore-inshore migration. Fish were caught inshore at 30-60 fathoms during June-September and offshore at 180-300 fathoms during November-April. For Area A, the mean size at tagging was 420 and 422 mm at recovery. For Area B, the mean size at tagging was 427 mm and 434 mm for recovered fish. Offshore areas recovered a high percentage of males (76-86%); whereas inshore areas recovered only 44-49% males. The high ratio of males is probably due to the fact that tagging took place late in the spawning season, since they tend to linger on in the spawning area after the females have left.

Age-length relationships for 26 Scorpaenids in the northeast Pacific Ocean.

AUTHOR(S): Westrheim, S. J., and W. R. Harling.  
YEAR: 1975.  
SOURCE: Fish. Mar. Serv. Tech. Rep. 565:12.  
KEYWORDS: *S. entomelas*, widow rockfish, *S. paucispinis*, bocaccio, age, growth, length/weight.  
ABSTRACT: Age-length relationships for 25 *Sebastes* species and 1 *Sebastolobus* species based on otoliths are presented. Von Bertalanffy parameters were calculated from age-group mean lengths based on direct otolith readings. Usable data for von Bertalanffy growth analysis were available for 16 *Sebastes* species. Von Bertalanffy parameters had the following ranges: L<sub>∞</sub>: 29.9 cm (*S. variegatus*) to 13.07 cm (*S. paucispinis*); K: 0.05 (*S. babcocki*) to 0.16 (*S. flavidus*, *S. pinniger*, *S. variegatus*); and t<sub>0</sub>: 0.9 (*S. pinniger*) to -9.14 (*S. brevispinis*). All species except *S. aleutianus* showed a decline in calculated length of 10- and 20-year fish from south to north.

Preliminary report on maturity, spawning season and larval identification of rockfishes (*Sebastes*) collected off British Columbia in 1967.

AUTHOR(S): Westrheim, S. J., W. R. Harling, and D. Davenport.  
YEAR: 1968.

SOURCE: Jour. Fish. Res. Bd. Canada unpubl. ms. No. 951.

KEYWORDS: *Sebastes entomelas*, widow rockfish, *Sebastes miniatus*, vermillion rockfish, *Sebastes paucispinis*, bocaccio, spawning, reproduction, ichthyoplankton, larvae.

ABSTRACT: Seasonal reproductive patterns, size at maturity and larval identifications of rockfishes (genus *Sebastes*) collected off British Columbia during 1967 are described. Estimated principal spawning time for *S. entomelas* is April and for *S. paucispinis* is March. Gonad conditions for *S. entomelas* and *S. paucispinis* from February to June are summarized.

*Carcinonemertes errans* and the fouling and mortality of eggs of the Dungeness crab, *Cancer magister*

AUTHOR(S): Wickam, D. E.

YEAR: 1979.

SOURCE: Jour. Fish. Res. Bd. Canada 36(11):1319-1324.

KEYWORDS: Market crab, *Cancer magister*, mortality, reproduction.

ABSTRACT: The eggs of *Cancer magister* were placed in petri dishes and exposed to 0, 1, 2 and 3 worms, *Carcinonemertes errans*, in an investigation into egg mortality and epibiotic foulings. The results indicated that fouling and mortality were correlated to clutch invasion by *Carcinonemertes*. Worm feeding and defecation in the clutch caused the release of yolk material which led to fouling. Egg mortality was directly related to predation by the worm whereas fouling appeared to be incidentally correlated. A high degree of fouling and mortality was also observed in several field samples studied.

An evaluation of mid-water artificial structures for attracting coastal pelagic fishes.

AUTHOR(S): Wickham, D. A., and G. M. Russell.

YEAR: 1974.

SOURCE: Fish. Bull. 72(1):181-191.

KEYWORDS: Artificial reef, recruitment.



ABSTRACT: Three dimensional fish attraction devices (FADs) were positioned off Panama City, Florida in mid-water (9-18 m) depths to establish the feasibility of attracting large numbers of coastal pelagic fishes. Estimates of fish numbers were determined by diver counts and purse seine catches. The average catch of 398 kg at each FAD occurred when the local fisheries were depressed. Ninety-five percent of the catch were mixed schooling fish (round scad and Spanish sardine) with jacks making up approximately 5% of the catch. Sampling, by purse seine showed that fish left the FADs each night and reassembled each day. Higher productivity was obtained by fishing the FADs daily instead of every 3 days. The results of the study suggest that fish attraction devices have potential as a technique to increase harvests of fishes in the Gulf of Mexico.

Predation by the nemertean *Carcinonemertes errans* on eggs of the Dungeness crab *Cancer magister*.

AUTHOR(S): Wickham, D. E.

YEAR: 1979.

SOURCE: Mar. Biol. 55(1):45-53.

KEYWORDS: *Cancer magister*, market crab, life history, reproduction, mortality.

ABSTRACT: The nemertean *Carcinonemertes errans* has been determined to be an important predator on the eggs of the Dungeness crab (*Cancer magister*). It lives epibiotically on the crab until oviposition, then migrates to the egg mass concealed under the abdomen, feeding exclusively on these eggs during its only trophic phase. The conversion of crab eggs to worm tissue (including worm egg-strings) has an efficiency of 28.9%, based on micro-bomb calorimetry. Previous studies indicating a fungal infection as highly correlated with egg mortality are shown to be a side effect of nemertean feeding. The worms pierce the yolk sac which allows growth of the fungi, however, it is worm infection, and not fungal infection which is the cause of mortality. High numbers of this worm on the Dungeness crab population along central California have resulted in over 50% mortality of eggs, making *C. errans* the most significant predator on these crabs.

Distribution of some common decapod crustaceans and a pycnogonid from the continental shelf of northern California.

AUTHOR(S): Wicksten, M. K.

YEAR: 1984.

SOURCE: Calif. Dep. Fish Game 70(3):132-139.

KEYWORDS: Yellow crab, *Cancer anthonyi*, *Pandalus jordani*, ocean shrimp, distribution, habitat.

ABSTRACT: This paper presents the results of a sampling study off the coast of

California from Trinidad Head to Bodega Bay, undertaken to determine the distributions of common decapod crustaceans. Species distribution and frequency of occurrence is listed in table format at depth interval. A brief description of the substrate the animals inhabit is also included.

The lingcod, *Ophiodon elongatus* Girard.

AUTHOR(S): Wilby, G. V.

YEAR: 1937.

SOURCE: Fish. Res. Bd. Can. Bull. 54, 23 pp.

KEYWORDS: Lingcod, *Ophiodon elongatus*, distribution, habitat, feeding, life history, early life history, spawning, fishery, fishing gear.

ABSTRACT: A general overview of lingcod biology and fishery. Information on the biology includes a physical description of the species, distribution (Gulf of Alaska to Santa Barbara, California), habitat (rocky bottom with considerable current), and food (voracious feeder, preys on both fish and invertebrates). There is also a detailed section on the life history of the lingcod which includes information on the spawning migration, spawning process, egg counts, protection of eggs, incubation period and larval and juvenile stages, maturity and maximum size. Information on the fishery includes catch statistics from 1927 to 1934, fishing season, uses of captured individuals (flesh, liver oil, and insulin), and methods of capture (trolling in the sport fishery, and trawling and jigging in the commercial fishery).

The influence of seawater temperature on spawning, egg development, and hatching success of the Dungeness crab, *Cancer magister*.

AUTHOR(S): Wild, P. W.

YEAR: 1983.

SOURCE: Pages 197-214 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource. Calif. Dept. Fish Game, Fish Bull. 172 pp.

KEYWORDS: Market crab, *Cancer magister*, life history, spawning, population trends, reproduction.

ABSTRACT: The purpose of this study was to determine the effects of seawater temperature on spawning, egg development, and hatching success of female Dungeness crabs from central and northern California. This information was used in an analysis to determine relationship to fluctuating crab populations. Adult crabs were collected from both San Francisco and Eureka areas and held at three different seawater temperature regimes (17 deg C, 10 deg C and ambient 13-14 deg C). Spawning occurred between mid-September and early December, although most occurred before mid-November. There was no significant difference in dates of spawning by year within temperature regimes. Spawning dates were not significantly different between ambient and warm regions, but were significantly different between cold and ambient, and cold and warm regimes. Thus, there appeared to be a trend toward crabs spawning later in colder water. Furthermore, it appears that crabs from both Eureka and San Francisco areas spawn at the same time. The egg brooding period varied inversely with seawater temperature. This is consistent with prolonged occurrences of ovigerous crabs and cooler ocean temperatures progressively northward along the coast. Hatching occurred on the average at about 110 days. Egg diameters were found to increase in size as the eggs developed toward hatching. Egg diameter at hatching was found to be significantly larger in cold versus warm water regimes, and in warm versus ambient regimes. Refer to article for discussion of various organisms associated with egg masses. It was also found that hatching success decreased as temperature increased. The data suggests that 16-17 deg C may be an upper lethal limit for developing Dungeness crab eggs. These laboratory studies, therefore, indicate that seawater temperatures which have occurred in central

California could adversely affect egg survival and hatching success, and thus, could have been a factor in the decline of Dungeness crab fishery landings. Seawater temperature was also found to be a major factor affecting adult crab survival in the laboratory. Additional information on nemertean worms and crab eggs is included.

Comparisons of ovary development in Dungeness crabs, *Cancer magister*, in central and northern California.

AUTHOR(S): Wild, P. W.

YEAR: 1983.

SOURCE: Pages 189-196 in P. W. Wild and R. N. Tasto (eds.), Life history, environment, and mariculture studies of the Dungeness crab, *Cancer magister*, with emphasis on the central California fishery resource.

Calif. Dept. Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, *Cancer magister*, early life history.

ABSTRACT: The purpose of this study was to compare relative fecundity of Dungeness crabs (*Cancer magister*) in central and northern California. This was done by comparing maturity rates and weights of Dungeness crab ovaries. Carapace width from San Francisco crabs ranged from 93 to 172 mm, whereas carapace width from Eureka area crabs ranged from 109 to 163 mm. All crabs 110 mm and over had developing ovaries. The data indicates that ovaries from the two areas studied had similar developmental spawning rates. Overall ovary weights ranged from a few tenths of a gram in early stages of development to 81.5 g in well-developed ovaries. As the ovaries matured, ovary weights increased. Analyses show that Eureka crabs produced more ovarian tissue than San Francisco area crabs. Crab ovaries begin redeveloping soon after spawning while the crabs are still brooding their eggs.

Some relationships between seawater temperature and Dungeness crab, *Cancer magister*, spawning, egg development, hatching success, and population fluctuations.

AUTHOR(S): Wild, P. W.

YEAR: 1980.

SOURCE: CalCOFI Rep. 21:115-120.

KEYWORDS: Market crab, *Cancer magister*, life history, fishery, spawning, reproduction, population trends.

ABSTRACT: In the 1960s, Dungeness crab, *Cancer magister*, landings for central California declined drastically while landings in northern California fluctuated. The effects of seawater temperature on crab reproduction were tested in the laboratory and compared to crab landing data. Crabs mate (in the wild) from March through June and brooding crabs are found from October through January with hatching about three months later. Spawning, development and hatching success was found to be affected by temperature. Spawning occurred later in colder water (10 deg C) and hatching took twice as long (123 days) at 9.4 deg C than at 16.7 deg C (64 days). However, egg survival and hatching success were significantly higher at 10 deg C (685,000 larvae) than at 11.7 deg C (14,000 larvae). Comparisons of ocean temperatures to the crab landing showed a warming period in 1957 (16 deg C) followed by a decline in the fishery. The subsequent warm waters since 1957 might have depressed the crab landings.

Variations in ocean climate and the Dungeness crab fishery in

California.

AUTHOR(S): Wild, P. W., P. M. W. Law, and D. R. McLain.

YEAR: 1983.

SOURCE: Pages 175-188 in Calif. Dept Fish Game, Fish Bull. 172.

KEYWORDS: Market crab, Cancer magister, fishery, distribution.

ABSTRACT: The purpose of this study was to determine the part that environmental factors may have played in the long-term decline of the central California Dungeness crab (*Cancer magister*) fishery. Refer to paper for detailed discussion on historical yearly and seasonal fluctuations of the ocean climate off central California. Mean monthly values of a variety of environmental parameters were correlated. Although several variables were significantly correlated with each other, sea level was not consistently correlated with all the rest. These variables included sea surface temperature, atmosphere pressure, and upwelling index. Most of the correlations between crab landings and environmental variables were statistically insignificant, although a few were marginally significant. There is a statistically significant difference in pre-1957 versus post-1956 year analysis with certain environmental factors. Sea surface temperature and the fourth quarter season (Oct-Dec) stand out as the major contributors for this difference. Further analysis suggests that there is a relationship between ocean climate and the Dungeness crab fishery in central California. It must be cautioned that these correlations do not necessarily reflect a cause and effect relationship. Furthermore, the changes in ocean conditions examined in the study probably have less impact on adult crabs than earlier life stages. It is interesting to note however that the highest crab landings on record in California were correlated with the lowest temperatures recorded for that area. In conclusion, the evidence for the major cause of the decline in fishery landings in the San Francisco area points strongly to a major, long-term fluctuation in the ocean climate.

Size composition, age composition, and growth of chilipepper, *Sebastes goodei*, and bocaccio, *S. paucispinis* from the 1977 rockfish survey.

AUTHOR(S): Wilkins, M. E.

YEAR: 1980.

SOURCE: Mar. Fish. Rev. 42(3-4):48-53.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Sebastes goodei*, chilipepper rockfish, age, growth, distribution, population trends, recruitment.

ABSTRACT: Growth rates, size composition and age composition of *Sebastes paucispinis* and *Sebastes goodei* from samples collected during the 1977 trawl survey between latitudes 34 deg 09' and 46 deg 16'N and within the bottom depth interval of 50-200 fathoms were investigated. Von Bertalanffy growth curves for *S. goodei* were very similar among latitudes and depths for each sex. Males and females exhibited different growth curves. Similar trends were observed for *S. paucispinis*. The size composition for both species differed considerably above and below 100 fathoms with smaller size classes most abundant above 100 fathoms. A slight latitudinal trend of larger fish to the north was observed. Age and size frequency histograms are presented for both species. Divergence of growth curves between sexes for both species occurs at the size of onset of male maturity.

Development and evaluation of methodologies for assessing and monitoring the abundance of widow rockfish, *Sebastes entomelas*.

AUTHOR(S): Wilkins, M. E.

YEAR: 1986.

SOURCE: Fish. Bull. 84(2):287-310.

KEYWORDS: *Sebastes entomelas*, widow rockfish, fishery, distribution, behavior.

ABSTRACT: The purpose of this study was to document the work done to date on the development of widow rockfish assessment methodologies, to evaluate the utility of those methods for routine assessment, and to recommend a means of enhancing future assessment efforts. The project was conducted in three phases: 1) an examination of the biology and behavior of widow rockfish on commercial fishing grounds, 2) the development of a practical survey method for assessing distribution and abundance, and 3) an evaluation of the feasibility and effectiveness of applying such assessment methodology on a routine coastwide monitoring basis. The results show that the best time to survey widow rockfish is when the schools are large and their location predictable. The line transect survey method, using a sector scanning sonar and a quantitative echo sounder, was chosen over conventional echo integration and the line intercept method. Problems with the technique chosen are discussed and suggestions for improvements made.

Estimation of intertidal harvest of Dungeness crab, *Cancer magister*, on Puget Sound, Washington, beaches.

AUTHOR(S): Williams, J. G.

YEAR: 1979.

SOURCE: Fish. Bull. 77(1):287-292.

KEYWORDS: Market crab, *Cancer magister*.

ABSTRACT: Aerial surveys of Washington beaches were utilized to estimate the availability of crabs, *Cancer magister*, and the actual harvest by sport fishermen. Interviews with crabbers on a beach during low tide series provided information on success rates, size and sex of catch and the effort. Only 27% of the 762 crabbers interviewed used the beach from October to February. Whereas 96% crabbed from April to August. The data suggested that aerial estimates were overcounting by 15.5% total number of crabbers. The recalculated estimates for Puget Sound showed 19,987 crabbers from April to August 1974. The crab catch was highest in May with 5,792 crabs and totaled 15,310 over the five months.

Temperature-metabolism relations of two species of *Sebastes* from different thermal environments.

AUTHOR(S): Wilson, F. R., G. Somero, and C. L. Prosser.

YEAR: 1974.

SOURCE: Comp. Biochem. Physiol. 47B:485-491.

KEYWORDS: *S. miniatus*, vermillion rockfish, physiology.

ABSTRACT: The thermal tolerance of a shallow dwelling rockfish (*Sebastes auriculatus*) and a deeper dwelling rockfish (*Sebastes miniatus*) were compared in order to determine whether a species exposed to fluctuating temperatures (the shallow water habitat) exhibited a greater range in thermal tolerance than a species exposed to a

nonfluctuating thermal habitat (the deeper water habitat). The activity of cytochrome oxidase, an enzyme shown in other fishes to compensate in thermal acclimation, was measured on samples of epaxial muscles in order to determine the thermal tolerance of each species. The cytochrome oxidase activity of the deeper dwelling *S. miniatus* was 70% higher than that of the shallow dwelling *S. auriculatus* at 10, 15 and 20 deg C. The data indicate that there are metabolic differences between the two species which are correlated with differences in their depth distribution and appear to be genetically controlled. *S. miniatus* was unable to tolerate temperatures as high as *S. auriculatus*. *S. miniatus* did not acclimate to higher temperatures as well as *S. auriculatus* acclimated to higher or cooler temperatures as indicated by *S. inatus*'s increased cytochrome oxidase activity at those temperatures tested. Thus, the species from a fluctuating thermal environment exhibited greater ability to acclimate to temperature changes.

A review of the southern California spiny lobster fishery.

AUTHOR(S): Wilson, R. C.

YEAR: 1948.

SOURCE: Calif. Fish Game 34(2):71-80.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, distribution, feeding, regulations, fishery, fishing gear.

ABSTRACT: California spiny lobster, *Panulirus interruptus*, ranges from San Luis Obispo County, California, south to Magdalena Bay, lower California. In the very early fishery lobsters were extremely abundant. At the turn of the century supply fell short of demand. Thus, from that time on various restrictions were imposed on the fishery. At this time minimum and maximum length are 10.5 inches and 16 inches, respectively, and the season is closed from March 15 to October 1. In 1946, the fishery was ranked 11th by value for the state. The three major fishing regions are San Diego, Los Angeles, and Santa Barbara. Two basic types of traps and pots are in general use. Mexican importations are also reported. Lobsters hide in crevices during the day and move about on the bottom at night. Predators include the black seabass, sheephead, moray eel, octopus, and man, plus they are cannibalistic. Feeding behavior is omnivorous, but they prefer flesh of all kinds. Lobsters move into deeper water during fall and winter, and back to shallower water in spring and summer. Molting occurs year around with the highest frequencies in summer and early fall. Sizes of over 30 pounds have been reported but most are under 6, with males being larger than females. Males reach maturity at a smaller size than females. Sex ratios are extremely variable. Females spawn each year, with spawning from March to August. Eggs are carried by the females for about two months before they hatch into free-swimming larvae.

Trophic relationships and metabolic energy budget of the California spiny lobster, *Panulirus interruptus* (Randall).

AUTHOR(S): Winget, R. R.

YEAR: 1968.

SOURCE: M. S. Thesis, Calif. State Univ., San Diego, CA. 232 p.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, feeding, habitat, community.

ABSTRACT: The metabolic energy budget (ie. storage = ingestion - egestion

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metabolism) of the California spiny lobster (*Panulirus inerruptus*) taken off San Diego was investigated to aid in understanding the mariculture potential of this species and its trophic position in the nearshore community. The California spiny lobster is a nocturnal feeder that defecates after sunrise. Although a wide variety of food is eaten, molluscs and crustaceans provide most of its energy. Quantities and caloric content of ingested and egested food were determined along with ingestion and egestion rates. At 16 - 17 deg C, 4.0 - 13.4 cal/g/day of food was ingested, 0.3 - 0.9 cal/g/day was egested, and 3.7 - 12.5 cal/g/day was assimilated. The daily energy loss due to metabolism was about 6.5 cal/g/day. The efficiency of energy storage (storage/assimilation) was less than 50%. Predation on subadults and adults appears to be negligible, although predation on earlier stages may be appreciable.

Resistance of different stocks and transferrin genotypes of coho salmon, *Oncorhynchus kisutch*, and steelhead trout, *Salmo gairdneri*, to bacterial kidney disease and vibriosis.

AUTHOR(S): Winter, G. W., C. B. Schreck, and J. D. McIntyre.

YEAR: 1980.

SOURCE: Fish. Bull. 77(4):795-802.

KEYWORDS: Coho salmon, *Oncorhynchus kisutch*, mortality, population trends.

ABSTRACT: Juvenile coho salmon, *Oncorhynchus kisutch*, and steelhead trout, *Salmo gairdneri*, were infected with bacterial kidney disease or vibriosis to determine mortality within and between stocks. Transferrin genotypes were utilized to study intrastock relationships. Coho salmon stocks showed different degrees of resistance to bacterial kidney infection. The susceptibility to vibriosis between stocks was strongly influenced by environmental factors. The individual stocks of coho and steelhead often showed resistance to one disease and susceptibility to another. No difference in resistances to vibriosis was noted among the transferrin genotypes. However, resistance to bacterial kidney infection were stock-specific for the genotypes.

Stock separation of five rockfish species using naturally occurring biochemical genetic markersAUTHOR(S): Wishard, L. N., F. M. Utter, and D. R. Gunderson.

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YEAR: 1980.

SOURCE: Mar. Fish. Rev. 42(3-4):64-73.

KEYWORDS: *Sebastes paucispinis*, bocaccio, *Sebastes goodei*, chilipepper rockfish, physiology.

ABSTRACT: Genetic characteristics of samples from various locations are compared in order to assess the patterns of reproductive isolation (i.e. stock separation) of five commercially important rockfish species. Samples were collected during the 1977 Rockfish Survey from Pt. Hueneme, California to southern Oregon. Gene frequencies were assessed electrophoretically. *S. goodei* exhibited very low levels of genetic variation. *S. paucispinis* had two highly polymorphic loci. The data strongly suggest no genetic differentiation for either *S. goodei* or *S. paucispinis* between samples (ie. areas). Genetic relationships between the five species are discussed. The utility of electrophoresis to

marine fisheries is discussed.

The marine life of an offshore oil platform.

AUTHOR(S): Wolfson, A., G. Van Blaricon, N. Davis, and G. S. Lewbel.

YEAR: 1979.

SOURCE: Mar. Ecol. Prog. Ser. 1:81-89.

KEYWORDS: Platform, artificial reef, community, distribution, colonization.

ABSTRACT: The use of man-made structures as artificial reefs and their impact on the marine environment was evaluated at the Union Oil platform off Huntington Beach, California. Diver surveys were used to estimate densities, distributions and compositions of the fouling organisms, epibenthic populations and epifaunal and infaunal animals. Support structures were densely inhabited by *Mytilus* and to a lesser degree *Corynactis*. The substrate beneath the platforms was completely altered by "biological fallout" from the platforms. Dense asteroid populations (29/m<sup>2</sup>) were supported by mussel clumps falling from the support structure. A comparison of the sandy bottom communities both near and far from the platform showed the structure had a significant impact on the populations. A trophic model, based on populations associated with the platform, showed a high productivity and turnover rate (11-18 months).

A description of the northern anchovy live-bait fishery, and the age and length composition of the catch during the seasons 1957-58 through 1964-65.

AUTHOR(S): Wood, R., and A. R. Strachan.

YEAR: 1969.

SOURCE: Marine Resources Operation, California State Fisheries Lab, Terminal Island, CA. MRO Ref. 69-3.

KEYWORDS: Northern anchovy, *Engraulis mordax*, fishery, age, length.

ABSTRACT: The live-bait fishery for the northern anchovy, *Engraulis mordax*, is described and the age and length composition reported for the 1957-58 through 1964-65 fishing seasons. Fifty-four tables are presented to report the catches by port. The industry harvests, maintains, and sells live fish to be used as bait and/or chum to fishermen. The 1963-64 season consisted of more than 20 boats, the main fishing gear being lampara nets. The fishery is located primarily in southern California with smaller fisheries to the north. The northern anchovy represents 98% of the live-bait sold. The catch is measured by the "scoop" which equals 12.5 pounds. The catch varied little in poundage landed throughout the period. In most seasons the dominant age group was I with age group II a close second. These two groups generally comprised 75% or greater of the catch. The oldest fish captured were 5-year-olds. The 1959-60 season was an exception with 86.7% of the total catch represented by age group 0. This heavy year class was observed in all five years of life. It was determined that larger anchovies prefer colder waters while the smaller younger fish like warmer inshore waters.

Invertebrates of southern California coastal waters. Vol. 1. Select groups of annelids, arthropods, echinoderms, and molluscs.

AUTHOR(S): Word, J. Q. and D. K. Charwat.

YEAR: 1975.

SOURCE: South. Calif. Coast. Water Res. Proj., Long Beach, CA. 164 p.



KEYWORDS: Cancer anthonyi, yellow crab, physiology, distribution.  
ABSTRACT: Volume I is the first in an anticipated four part series initiated

in an attempt to standardize identification of southern California marine invertebrates obtained in trawls, benthic grabs and intertidal collections. This volume focuses on animals likely to be found in waters at depths of 200 m. An illustrated key, information on synonyms and the distribution of the individual species is also included.

Invertebrates off southern California coastal waters. II.

Natantia.

AUTHOR(S): Word, J. Q., and D. K. Charwat.

YEAR: 1976.

SOURCE: El Segundo: Southern California Coastal Water Research Project  
238 pp.

KEYWORDS: Pandalus platyceros, spot prawn, Pandalus jordani, ocean shrimp,

Sicyonia ingentis, ridgeback prawn.

ABSTRACT: Illustrated key to eight families of shrimp found in southern California coastal waters. Information on synonyms and distribution of the individual species is also included.

Blackwell.

A midwater fish attraction device study conducted for Hydrolab.

AUTHOR(S): Workman, I. A., A. M. Landry, Jr., J. W. Watson, Jr., and J. W.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):377-386.

KEYWORDS: Artificial reefs, recruitment, distribution, behavior.

ABSTRACT: This paper reports the results of the use of fish attraction devices

(FADs) deployed off the northern coast of St. Croix, U.S.V.I. in February 1983. The FADs were assessed to determine: 1) composition; abundance and behavior of attracted species; 2) recruitment time and variation in abundance; 3) effect of adjacent natural reefs on FADs attractability; and 4) differences in attraction between variously designed FADs. The findings of this study are discussed in detail, with suggestions for using these results as an aid in determining the best methods for harvesting fishes concentrated at the FADs.

Growth in the black abalone, Haliotis cracherodii.

AUTHOR(S): Wright, M. B.

YEAR: 1975.

SOURCE: Veliger 18(2):194-199.

KEYWORDS: Abalone, Haliotis sp., growth.

ABSTRACT: Seventy-four black abalone, Haliotis cracherodii, were marked and observed for a two-month period on Santa Cruz Island, southern California. In situ tagging occurred by three methods: 1) small numbered tags were glued to the shell, 2) monofilament nylon line with color coded beads were threaded through the respiratory aperture, 3) numbers were glued on acetate which were attached the shell. No method was entirely satisfactory. A cross on the shell was used as the reference point for growth rate. For animals 50 mm and less growth was 14.78 mm/year. This rate dropped to 14.64 mm/year for 51 to 80 mm animals. There was a

substantial decrease in growth rates of 90-150 mm animals to 0.78 mm/year. At this rate an animal would need about 51 years to grow from 90-130 mm. This value seemed unlikely.

Formulation of growth and mortality of larval northern anchovy in a turbulent feeding environment.

AUTHOR(S): Wroblewski, J. S.

YEAR: 1984.

SOURCE: Mar. Ecol. Prog. Ser. 20(1-2):13-22.

KEYWORDS: Northern anchovy, *Engraulis mordax*, growth, mortality, larvae, feeding.

ABSTRACT: A model is presented to depict the influence of the feeding environment on the survival of the northern anchovy, *Engraulis mordax*, during the critical larval stage. The model develops the biological and physical oceanographic processes which influence survival, looking at storm events and the link between the cause and the effect (higher mortality). Prey patches increasing in concentration will enhance larval survival, while if the patch erodes there is a decrease in growth rate accompanied by a higher mortality rate. This is expressed as a function of the larval feeding history. Wind will cause diffusivities and in well-mixed water columns suitable food concentrations are unlikely, unless the prey has swimming abilities which allow them to aggregate. Consequently, sufficient amounts of this type of food may be found in well-mixed water under moderate wind conditions, however if a violent storm occurs and the food patch dissipates, a higher mortality of larval northern anchovy may arise.

Inland fishes of Washington.

AUTHOR(S): Wydoski, R. S., and R. R. Whitney.

YEAR: 1979.

SOURCE: Univ. Wash. Press, Seattle, WA. 220 p.

KEYWORDS: Chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *O. kisutch*,

life history, length, physiology, economics, reproduction, age, feeding, habitat.

ABSTRACT: This text is designed as a handbook for individuals interested in

fish and provides information useful for identifying those fish found in the inland waters of Washington. The text includes information on life histories and habits, distribution, habitat, age and growth, reproduction and food. A taxonomic key with instructions for its use, drawings depicting special fish structures and color plates of the fish are provided to aid identification.

Politics and management of California abalone fishery.

AUTHOR(S): Wyner, A. J., J. E. Moore, and B. Cincinsain.

YEAR: 1977.

SOURCE: Mar. Policy 1(4):326-339.

KEYWORDS: Abalone, *Haliotis* spp., fishery, regulations.

ABSTRACT: The fishery management plans and the politics that lead to their implementation were examined for the California abalone, *Haliotis* spp., fishery. The limited entry program was politically sound since no additional funds or personnel were required. Seeding projects received much support, however, lacked the funding and organization necessary to implement the program. Several policies aimed at sport and commercial divers, sea otter

containment, area rotation and opening the north coast were discussed and appeared to be the subject of much debate. These policies will probably be made based on priority objectives and traditional political skills.

H. Hulet.

Laboratory rearing of *Loligo opalescens*, the market squid of California.

AUTHOR(S): Yang, W. T., R. T. Hanlon, M. E. Krejci, R. F. Hixon, and W. YEAR: 1983.

SOURCE: *Aquaculture* 31(1):77-88.

KEYWORDS: Market squid, *Loligo opalescens*, growth, feeding, length/weight.

ABSTRACT: The California market squid, *Loligo opalescens*, was successfully reared in closed, artificial seawater systems. Hatchlings were kept in 1,300 liter circular tanks until they reached 20-30 mm ML then were transferred to 10,000 liter raceways. Mantle length growth occurred exponentially at a rate of 1.69% per day. Maximum survival was 233 days with 50% of the squid surviving to 52 days. The largest lived squid reached a length of 77 mm ML in 8 months. Mortality was greater at 20 days and again between days 45 and 70. The cause of mortality seemed to be starvation of post-larvae (not able to make the transition from yolk to live food) and juveniles (during a spring low in food). Fin degradation was another cause of mortality.

Growth, food consumption, and conversion efficiency of juvenile English sole (*Parophrys vetulus*).

AUTHOR(S): Yoklavich, M.

YEAR: 1982.

SOURCE: Proc. 3rd Pacific Workshop, Fish Food Habits Studies, Dec. 1981 Asilomar Conf. Ctr., Pacific Grove, CA: 97-105.

KEYWORDS: Growth, age, distribution, spawning, feeding, English sole, *Parophrys vetulus*.

ABSTRACT: Growth, daily ration, and conversion efficiency were determined for two age classes of English sole (*Parophrys vetulus*), under laboratory conditions reflecting the temperature regime and type of prey available in their natural environment. Growth was positively related to daily ration at both temperatures (13.0 deg C and 17.5 deg C) and age classes (0-group fish and age class II). Mean daily ration was significantly higher at 13 deg than at 17.5 deg for 0-group fish. Ingestion rates averaged 6.55% body weight/day at 13 deg and 4.96%/day at 17.5 deg. No difference in daily ration was determined between age classes at 13 deg. Age class II ingestion rates averaged 6.8% at 13 deg. Growth rate for 0-group fish was significantly lower at 17.5 deg with a mean of 1.17% compared to 1.87% at 13 deg. Relative growth rates of the age class II fish at 13 deg (0.94%) were considerably lower than those of 0-group fish at the same temperature, although mean daily rations were similar. Individual gross conversion efficiencies generally increased with increasing ration for 0-group fish at 13 deg, ranging from 20.2 to 34.4% and averaging 26.8% (based on dry weight). Although ingestion and growth were lower at 17.5%, efficiencies were not significantly different than those at 13 deg (22.4 vs. 26.8%, respectively). While both age classes at 13

deg were ingesting the same relative amount of energy, the average relative growth of age class II was less than half that of the 0-group fish, resulting in a significantly lower conversion efficiency of 12.1%. Caloric content of fish in all experiments increased but age class II fish increased proportionally to a greater degree than did 0-group fish, possibly indicating the additional storage of high energy lipids in preparation for spawning.

Metals in seafood organisms near a large California municipal outfall.

AUTHOR(S): Young, D. R., M. D. Moore, T. K. Jan, and R. P. Eganhouse.  
YEAR: 1981.

SOURCE: Mar. Poll. Bull. 12(4):134-138.

KEYWORDS: Contaminant levels, contaminant susceptibility, *Haliotis* spp, *Panulirus interruptus*, *strongylocentrotus* spp., *Paralichthys californicus*, *Sebastes paucispinis*, abalone, spiny lobster, sea urchin, California halibut, bocaccio.

ABSTRACT: Five bottom feeding fish species and five benthic invertebrate species, all popular seafood organisms, were collected from near the Los Angeles County municipal waste water system outfall, and from island and coastal control sites. Concentrations of target metals were then compared between the outfall and control sites. The results show that, with the exception of copper and zinc, the level of metals in fish species from the outfall was similar to that found in the controls. In contrast, trace metal levels in the edible tissue of the invertebrates from outfall areas were higher than in control areas. Generally, the concentrations were about 2 to 3 times as great, but in the case of chromium levels in abalone and scallop the level was 10 times as great.

The California party boat fishery 1947-1967.

AUTHOR(S): Young, P. H.

YEAR: 1969.

SOURCE: Calif. Dep. Fish Game, Fish Bull. 145. 91 p.

KEYWORDS: Regulations, fishery, economics, rockfish, *Sebastes* spp., lingcod,

*Ophiodon elongatus*, kelp bass, *Paralabrax clathratus*, yellowtail, *Seriola lalandi*, Pacific bonito, *Sada chiliensis*, California halibut, *Paralichthys californicus*.

ABSTRACT: A history of the fishery off the California coast from the early

1900s to the present is discussed with particular emphasis on the party boat fishery. The regulatory environment as well as the economics of the party boat fleet are analyzed as they pertain to specific areas of the California marine waters. Statewide catch statistics and species accounts are given for the years 1947-1967.

The kelp bass (*Paralabrax clathratus*) and its fishery, 1947-1958.

AUTHOR(S): Young, P. H.

YEAR: 1963.

SOURCE: Calif. Dept. Fish Game, Fish Bull. 122:1-67.

KEYWORDS: Kelp bass, *Paralabrax clathratus*, fishery, life history, distribution, length/weight, age.

ABSTRACT: The life history and sport fishery for the kelp bass (*Paralabrax clathratus*) was examined. Kelp bass number among the

top five species taken in the California sportboat fishery. Their geographic range extends from Monterey Bay, California to Magdalena Bay, Baja California, but few are caught north of Point Conception or south of Abreojos. San Clemente Island was the outstanding bass fishing ground in southern California from 1947 through 1958. Kelp bass tagging studies were conducted from Point Loma north to Santa Cruz Island. Data from 458 tag recoveries showed 364 were recovered at the release locality, 62 moved as much as 5 miles, 14 moved 5 to 10 miles and 18 moved 10 or more miles. None of those transplanted were known to return to their place of origin. The equation of a straight line fitted to growth records from tag recoveries was  $Y = 2.94 + .857X$ . Age determinations were made using scales. The oldest fish encountered was 32 years. The growth equation of the line fitted to the age length data was  $Y = 2.47 + .913X$ . The length/weight relationship gave the equation  $W = .00376L^{3.27}$ . Kelp bass maturation occurs as early as April for bass 325 mm long and longer. In June, fish as small as 201 mm were mature. By September and October, spawning had been completed. Natural mortality for fish from age 7 to 13 years was estimated to be 25% annually. Regulations to the kelp bass fishery includes no commercial fishing and a sport size limit of 12 inches.

Artificial marine reefs off Catalina Island; recruitment, habitat specifically and population dynamics.

AUTHOR(S): Zahary, R. G., and M. J. Hartman.

YEAR: 1985.

SOURCE: Bull. Mar. Sci. 37(1):387-395.

KEYWORDS: Artificial reefs, recruitment, population dynamics.

ABSTRACT: Seven cubic meter artificial reefs were constructed of steel reinforced concrete providing vertical and horizontal substrate. In addition, the presence of tubes provided 144 crevices. The reefs were deployed in 10 m of water on sand flats off Catalina Island. Macroalgae was removed, on a monthly basis, from 3 of the reefs while the remaining 4 were left undisturbed. The density and species of reef inhabitants were monitored over time and comprised over 30,000 individuals. Only the undisturbed reef data was analyzed with results over time indicating no habitat preference by bluebanded gobies, *Lythrypnus dalli*, and blacksmiths, *Chromis punctipinnis*, the most common reef residents.

A proposed dual role of odor in foraging by the California spiny lobster, *Panulirus interruptus* (Randall).

AUTHOR(S): Zimmer-Faust, R. K., and J. F. Case.

YEAR: 1983.

SOURCE: Biol. Bull. 164(2):341-353.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, feeding, behavior.

ABSTRACT: The influence of odor on feeding behavior of the California spiny lobster, *Panulirus interruptus*, was investigated in the laboratory and the field. Food search behavior exhibited responses in a linear hierarchy, with threshold concentrations for antennule flicking, leg probing, and locomotion of  $10E-8$ ,  $10E-6$ , and  $10E-4$  grams abalone muscle effluence (AME) per liter, respectively. In the field a sigmoidal log-linear relationship existed between the capture efficiency and rate of effluence. Effluent releases or effluent concentrations in immediate trap

environments were critical in lobster attraction, with effluences of  $>/_0.32$  g/h producing maximum asymptotic capture rates. Locomotion and detection thresholds ( $10E-3$  and  $<10E-7$  g/l) were not significantly different using lyophilized tissues or AME, indicating minimal microbial influences. Chemical activation of distant foraging is unlikely in *P. interruptus*, which probably initiate only local food search behavior. Low concentrations of effluence appear to modulate rather than activate distinct locomotion patterns. The precise position of food is important in the attraction of lobsters. Locomotion activated by non-food stimuli is very important and their ability to acquire food may be dependent on contacts with limited chemically active spaces.

Odors influencing foraging behavior of the California spiny lobster, *Panulirus interruptus*, and other decapod Crustacea.

AUTHOR(S): Zimmer-Faust, R. K., and J. F. Case.

YEAR: 1982.

SOURCE: Mar. Behav. Physiol. 9:35-58.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, rock crab, *Cancer* sp., feeding, behavior.

ABSTRACT: Behavior tests were performed to study the interpretation of chemical stimuli by the spiny lobster, *Panulirus interruptus*. Types of prey cause attraction and aversion, effects of field exposure duration, and the molecular weight ranges of chemical attractants were described. Live intact and injured prey along with excised tissues were used to evaluate the in situ chemical attraction of lobsters to food. Mean carapace lengths of males and females were 75.2 and 77.0 cm, respectively. Female to male ratios were near 1:1 except during August when it was 5:1. Females with attached spermatophores were captured in greatest numbers from April to May. All tested live prey species failed to attract significant numbers of lobsters. Mussels and abalones became attractive once injured and chopped abalone was the more attractive. Sea urchin failed to influence lobster behavior while shrimp cephalothoraces actually appeared repellent. Rates of effluence for shrimp cephalothoraces and sea urchin were competitive with those for abalone, while that for mackerel was particularly large. Mackerel was as effective as abalone in attraction. Abalone appears to become increasingly attractive with age after injury, dependent on the mass and volume of tissues. Molecules  $<10,000$  daltons were effective when leached from abalone, with a 1000-10,000 dalton fraction contributing significantly to the attraction. Similar experiments were performed and reported for the crab, *Cancer antennarius*. Live intact prey do not emit natural stimulants capable of attracting lobsters distances  $>/_17$  cm from them. Initial recognition of intact prey requires visual and/or chemotactile stimuli in addition to olfaction. Chemical stimuli direct movements of lobsters to or away from potential foods, with markedly specific preference. This demonstrates keen discriminatory ability. Small molecules cause immediate food searching responses but not delayed responses. Exposed tissues become more attractive with aging, possibly due to attractant molecules produced by decomposition at increasing rates. Chemical preferences were very different between *Panulirus* and *Cancer*, potential competitors for food.

Chemical attraction causing aggregation in the spiny lobster,  
*Panulirus interruptus* (Randall), and its probable ecological  
significance.

AUTHOR(S): Zimmer-Faust, R. K., J. E. Tyre, and J. F. Case.

YEAR: 1985.

SOURCE: Biol. Bull. 169(1):1060118.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, migration.

ABSTRACT: Evidence is presented to show the use of chemical attraction for communal den occupancy and aggregation behavior in the spiny lobster, *Panulirus interruptus*. In the field a total of 16 multiple occupied dens were encountered, with as many as 30 or more lobsters per den. Eight of the 16 dens had multiple occupancies from day to day. A daily migration occurred to and from shelters, dens not being inhabited at night. Field trap experiments showed factors other than habitat and environmental variabilities were responsible for capture frequencies, a likely factor being conspecific attraction. Trap selection by an initial lobster seemed to be by thigmotaxis in the laboratory. Both male and female lobsters attract conspecifics through the release of chemicals. Abalone muscle was unable to affect trap residency while dead lobsters were found to significantly repel test animals. Living or dead crabs did not influence den residency. The spiny lobster is highly gregarious. Residency patterns arise from non-random habitat colonization and cohabitation by choice, and shelter selection influenced by chemical attraction may be the key to explaining these observations. These aggregations form overnight and are probably antipredatory in function.

Chemical induction of feeding in California spiny lobster,  
*Panulirus interruptus* (Randall) - Responses to  
molecular-weight fractions of abalone.

AUTHOR(S): Zimmerfaust, R. K., W. C. Michel, J. E. Tyre, and J. F. Case.

YEAR: 1984.

SOURCE: Jour. Chem. Ecol. 10(6):957-971.

KEYWORDS: Spiny lobster, *Panulirus interruptus*, feeding, behavior.

ABSTRACT: Molecular weight fractions (<1000, 1,000-10,000, >10,000 dalton) of abalone muscle extracts were utilized to stimulate feeding of spiny lobster, *Panulirus interruptus*. The two lower weight fractions were ineffective while the >10,000 fraction was highly effective at stimulating feeding and locomotive behavior. Continuations of the various fractions enhanced stimulation of feeding, suggesting that large molecular weight fractions were essential in initiating response feeding behavior. The active ingredients appeared to be peptides and polypeptides.

Estimates of abundance and mortality of larval anchovies  
(1951-75): Applications of a new method.

AUTHOR(S): Zweifel, J. R., and P. E. Smith.

YEAR: 1981.

SOURCE: Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 178:248-259.

KEYWORDS: Northern anchovy, *Engraulis mordax*, larvae, population trends, length/weight.

ABSTRACT: Description of a statistical model for the expected frequencies of the catches of eggs and larvae taken in large scale oceanographic surveys. The method of analysis is based upon the maximum likelihood solution for the parameters of a modified negative binomial frequency mode. Abundance and mortality

estimates of the northern anchovy were calculated with this model. The results of the analyses show that estimates of mean abundance and mortality generally coincided with year-class strength estimates from fishery data.