Bering Sea Aleutian Islands
Squid and Other Species Stock Assessment

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Executive Summary

Summary of Major Changes

<u>Changes in the input data:</u>

1) Total catch weight for squid and for the Other species complex are updated with 2003 data.
2) Survey biomass data are updated with 2004 EBS shelf, slope and AI bottom trawl survey results.
3) Considerable information on life history, distribution, current research, and biodiversity for each species group within this complex has been added.

<u>Changes in assessment methodology:</u>

4) This year, the assessment is formatted into separate sections for each species group within Other species for ease of reading and to support more effective management of each group within this category. A stand-alone shark SAFE was developed this year and is included as an appendix.

<u>Changes in assessment results:</u>

5) The recommended ABC for squid in the year 2005 is calculated as 0.75 times the average catch from 1978-1995, or **1,970 mt**; the recommended overfishing level for squid in the year 2004 is calculated as the average catch from 1978-1995, or **2,624 mt**. The rationale for a Tier 6-based ABC recommendation is that there is no reliable biomass estimate for squid.
6) We recommended group specific ABCs and OFLs (based on the 10 year average EBS shelf survey biomass by group plus the 10 year average EBS slope survey biomass by group plus the 10 year average AI survey by group, all times the natural mortality rates listed below times 0.75 for ABC and 1 for OFL), and **placing all groups on "bycatch-only" status until information improves**:

	Sharks	Skates	Sculpins	Octopi
Avg Biomass	17,711	477,993	206,148	6,321
M (see text)	0.09	0.10	0.19	0.50
BSAI ABC	**1,195**	**35,849**	**29,376**	**2,371**
BSAI OFL	**1,594**	**47,799**	**39,168**	**3,161**
recent avg catch	545	18,645	6,861	297

These ABCs and OFLs would permit the levels of bycatch historically observed (1997-2002 average) while increasing protection for the species groups.

Responses to SSC Comments

SSC comments specific to the BSAI Squid and Other species assessment:

From the December, 2003 SSC minutes: *The SSC agrees with the plan team recommendation to place these other species into bycatch-only status. In addition, the SSC recommends not permitting directed fisheries for other species without an industry proposed, Council-approved data collection program that minimally provides accurate data on location of catch, total fishery removals by species, and opportunities for biological sampling of the catch for age, length, weight, and sex. Finally, the SSC recommends initiation of a FMP-amendment process to allow setting of group-specific (one for each of the four groups) ABCs and OFLs rather than complex-wide specifications.*

Bycatch-only status (meaning retention of other species is only allowed as a percentage of target species on board) is recommended to prevent directed fishing on all species groups in this category until stock assessment information improves. The assessment authors wholeheartedly concur with SSC recommendations for data collection programs and setting of group-specific ABCs and OFLs. The entire assessment has been reformatted this year to better accomodate group-specific management. Within each section we suggest potential data collection programs, including increased retention for the purpose of collecting biological data at delivery points without additional burdens to at-sea obervers.

SSC comments on assessments in general:

From the February, 2004 SSC minutes: *While the SSC encourages continued development of multispecies and ecosystem models, we note that models are metaphors; abstractions intended to approximate certain aspects of the behavior of real systems. When models are used in simulations or for forecasting, there is valid concern as to whether the simulations (forecasts) reflect the behavior of the system or are merely an artifact of the model specification, a concern that cannot be resolved based on how closely the model tunes to data used in the estimation of model parameters or fitting of free variables.*

No metaphors are used in this assessment. However, we have been working under the assumption that it would be desirable to gather adequate information to develop models for some species within this category to simulate and forecast the effects of fishing on non-target species populations. Given that the above comment applies to single species population dynamics models, or models of any system, we seek clarification from the SSC on how to address concerns regarding assessment modeling and forecasting.

General Introduction

Other species are considered ecologically important and may have future economic potential; therefore an aggregate annual quota limits their catch. In the Bering Sea and Aleutian Islands FMP area (BSAI), squids are considered separately from the Other species management group, which includes sculpins, skates, sharks, and octopi. A list of species within the Other species category was compiled from AFSC survey and fishery observer catch records for the Bering Sea and Aleutian Islands (Table 16- 1). This list is considered more comprehensive for the region than the more general literature (Hart, 1973; Eschmeyer et al., 1983; Allen and Smith, 1988), but it should be considered provisional because species identification is difficult within this category, and taxonomy for certain groups is not fully resolved.

Information on distribution, stock structure, and life history characteristics is limited for squid and Other species in the Bering Sea and Aleutian Islands. Some life history information is available for the same or similar species in other geographic areas. Given the wide diversity of species represented in this management category, we feel it is important to attempt to describe general life history characteristics at least at the species group level in order to evaluate the potential effects of fishing on other species. Therefore, we summarize the available life history information by group below, with the caveat that this should not substitute for future investigations specific to Bering Sea and Aleutian Islands stocks.

From this point forward, all discussion centers on the Other species complex in aggregate; BSAI squid are discussed in their group section below. Please note that this differs from previous assessments.

General Fishery Information

Directed fisheries

There are currently no directed fisheries for species within the BSAI other species category. Directed fishing on one component of the Other species category, skates, began in 2003, and continues in the Gulf of Alaska. While there may be interest in targeting skates elsewhere, the catches within the Other species category in the BSAI region were apparently still primarily incidental in 2002-2003. There is currently interest in developing a target fishery for octopus species in the BSAI. Detailed information on catch is presented in each species group's section below.

Bycatch and discards of Other species in aggregate, 1977-2004

Other species are taken incidentally in target fisheries for groundfish, and aggregate catches of the other species complex (Table 16- 2) are tracked inseason by the Alaska Regional Office. Please note that the composition of the complex has changed over time, complicating the interpretation of aggregate catch trends. Reported catches of Other species increased during the 1960's and early 1970's and reached a peak of 133,000 mt in 1972, the year when total catches of all species of groundfish reached a maximum of 2.3 million mt. The Other species catch in 1972 represented 6% of the total groundfish catch. In 1973-76 catches declined to a range of 33,000-70,000 mt annually as total catches of groundfish also declined. Catches of Other species were relatively high from 1977-1981 (43,000-73,000 mt), but thereafter declined to a range of 5,000-13,000 mt in 1984-89 despite increased catches of total groundfish (Table 16- 2). Part of the reason may be incomplete reporting of domestic catches before 1990 which would cause those reported catches to be understimates of total catch. Since 1990, catches have ranged between 17,000 and 33,000 mt, and represented 2% or less of the total groundfish catches from the Bering Sea and Aleutian Islands. From 1992-1998, between 90% and 94% of the Other species catch was discarded (NMFS Regional Office, Juneau, AK).

Until 2004, the Other species TAC has never been exceeded in the BSAI or the GOA with the current composition of the category. In 2004, the BSAI open access TAC of 23,124 t was exceeded as of October 23 (AKRO Catch Accounting web page, http://www.fakr.noaa.gov/2004/car110_bsai.pdf), so all Other species were put on prohibited status (meaning no further retention is allowed, but catch and discard can continue up to the Other species OFL of 81,150 t). In addition, the Other species CDQ reserve of 2,040 t was also exceeded as of November 4 (http://www.fakr.noaa.gov/cdq/daily/cdqctd04.pdf). We note that the TAC of Other species was reduced from the ABC recommended by the SSC in December 2003, likely to keep the total catch of groundfish in compliance with the BSAI OY cap. However, if interest continues in developing fisheries within this category, the lower aggregate TAC may restrict retention and utilization of the more valuable components of the Other species category (skates and octopus).

Catch estimation methods for species groups, 1997-2002

Because annual Other species catches are reported in aggregate, catches by species group or individual species must be estimated using data reported by fishery observers. A new method (described below) has been used since 2000 to estimate species group catch within the other species complex in the BSAI. This method most closely matches the Regional Office blend catch estimation system, and is considered an improvement over past methods. However, the species group catch estimates presented here may not be identical to those presented in past assessments. Catches for all non-target species were estimated at the lowest practical taxonomic level for the recent domestic fishery, 1997 - 2002, by simulating the Regional Office's blend catch estimation system as follows. Target fisheries were assigned to each vessel / gear / management area / week combination based upon retained catch of allocated species, according to the same algorithm used by the Regional office. Observed catches of Other species (as well as forage and non-specified species) were then summed for each year by target fishery, gear type, and management area. The ratio of observed Other species group catch to observed target species catch was multiplied by the blend-estimated target species catch within that area, gear, and target fishery. Total annual catch by species group has been relatively stable between 1997-2000, although there were some changes in 2001-2002 (Table 16- 3). Estimated annual species group catches are reported by target, gear, and area within each of the species group sections below. Annual estimated total catches for identified shark species are reported in the appendix. Catch patterns for each species group are discussed within the individual sections below.

The accuracy of catch estimates for groups or species within the Other species complex depends on the level of observer coverage in a given fishery (no observers, no catch estimates). Observer coverage requirements are based upon vessel size. In general, larger vessels fish in the Bering Sea, such that observer coverage levels in some fisheries approach 100%. Our calculations for 1997-2002 suggest that the BSAI region has approximately 70-80% observer coverage overall. Therefore, in making these catch estimates, we are assuming that Other species catch aboard observed vessels is representative of other species catch aboard unobserved vessels throughout Alaska. Because observers are not randomly assigned to vessels in the 30% coverage class, there is a possibility that this assumption is incorrect.

As of 2003, the Alaska Regional Office converted from the Blend catch estimation system to a new Catch Accounting System (CAS). While this makes catch estimation using the above method impossible, we are working to incorporate a similar method of observer data based total catch estimation for non-target species within the new CAS. This will represent a substantial improvement in consistency and quality of nontarget species estimates over the previous method. During this interim period, detailed catches of nontarget species by target fishery, gear, and area will not be available for 2003.

General Survey Information

Data from AFSC surveys provide the only abundance estimates for the various groups and species comprising the "other species" category (Table 16- 4). Biomass estimates for the eastern Bering Sea are from a standard survey area of the continental shelf. The 1979, 1981, 1982, 1985, 1988 and 1991 data include estimates from continental slope waters (200-1,000 m in 1979, 1981, 1982, and 1985; 200-800 m in 1988 and 1991), but data from other years do not. Slope estimates were usually 5% or less of the shelf estimates. Stations as deep as 900 m were sampled in the 1980, 1983 and 1986 Aleutian Islands bottom trawl surveys, while surveys in 1991 and 1994 obtained samples only to a depth of 500 m. The actual catches made by research vessels are shown in Table 16- 5. In 2003, a special project was completed at the end of the EBS shelf bottom trawl survey which was designed to evaluate escapement of selected Other species under the survey footrope. The analysis is complete, but the document is currently undergoing review and so is not available for this assessment. We expect results of this project to be very useful to the Other species assessment, especially with respect to estimating ABC and OFL based on Tier 5 criteria.

General Projectons and Harvest Alternatives

At the moment, Other species are currently taken only as bycatch in directed target fisheries, so future catches of Other species are more dependent on the distribution and limitations placed on target fisheries than on any harvest level established for this category. For example, changes in the allocation of quota by gear type in a major target fishery (i.e., Pacific cod longline vs. trawl) will result in different proportions and species composition of catches within the Other species category. However, if target fisheries develop in the BSAI for components of the complex as they did in the GOA, this will no longer be true. With this in mind, we present options for Other species managment.

The status quo management has been setting Other species ABC and OFL at the complex level. **We do not recommend setting ABC and OFL at the other species complex level.** However, if it remains necessary to manage Other species as an aggregate biomass complex, there is only one way to establish ABC and OFL for this complex. Following the rules of the Tier system, we believe there is no reliable estimate of natural mortality, M, at the Other species complex level. Therefore Other species complex ABC is set using Tier 6 criteria as 75% of the average catch of the complex between 1978-1995, and OFL as average catch over the same period:

> The average catch of the Other species complex between 1978-1995 is 25,760 metric tons. Therefore, the Tier 6 ABC for the BSAI Other species complex in the year 2004 is calculated as 0.75 times the average catch from 1978-1995, or **19,320 mt**; the Tier 6 overfishing level for the Other species complex in the year 2004 is calculated as the average catch from 1978-1995, or **25,760 mt**.

We note that this OFL would potentially constrain target fisheries, as catch of Other species has exceeded this amount in all of the past four years, regardless of catch estimation method. This is an undesirable property if we are not sure that the OFL is providing protection to the complex. While this method results in the lowest possible ABC and OFL for the Other species complex as a whole, it should be noted that this option does nothing to prevent the entire catch within the ABC or OFL from comprising a single species group or even a single species within the Other species category. This may happen if a directed fishery were to develop. In such a situation it is possible that any OFL that might have been established for that single species (or species group) might be exceeded, especially for less productive stocks.

A second, and recommended alternative, is to attempt to estimate a separate ABC and OFL for each species group within the Other species category, based on the information available. Although this option will afford better protection to less productive groups within other species (e.g. sharks and skates), it requires that other species catch be monitored at the species group level instead of the current aggregate level. Although a catch history exists for the Other species group as a whole during this period, there are no reliable catch estimates by species group prior to 1990 at present. Tier 6 criteria for establishing ABC and OFL require a reliable catch history from 1978 to 1995. Therefore, we cannot estimate ABC or OFL based on Tier 6 criteria at the species group level unless the rules are amended by the Plan Team and or SSC.

Tier 5 criteria require reliable point estimates of biomass and natural mortality rate M. Relatively conservative estimates of M were developed for each species group based on life history analysis (Table 16-6). An analysis was undertaken to explore alternative methods to estimate natural mortality (M) for Other species found in the BSAI. Several methods were employed based on correlations of M with life history parameters including growth parameters (Alverson and Carney 1975, Pauly 1980, Charnov 1993), longevity (Hoenig 1983), and reproductive potential (Roff 1986, Rikhter and Efanov 1976). The species group specific results are discussed in each section below.

For certain groups within Other species (cephalopods), our current lack of reliable biomass estimates makes ABC and OFL determination difficult using this method, and potentially results in severe underestimates of allowable catch. Several ABC and OFL options are available using the current tier 5 criteria for each species group within the Other species category. Within tier 5, ABCs and OFLs are presented which are based on the average biomass from the past 10 years for each species group (see full description in Table 16- 11).

	Sharks	Skates	Sculpins	Octopi
Avg Biomass	17,711	477,993	206,148	6,321
M (see text)	0.09	0.10	0.19	0.50

BSAI ABC	**1,195**	**35,849**	**29,376**	**2,371**
BSAI OFL	**1,594**	**47,799**	**39,168**	**3,161**
recent avg catch	545	18,645	6,861	297

These alternative ABCs and OFLs reflect our current understanding of the basic biology for each species group while protecting the less productive components of the category. In addition, they would allow similar levels of bycatch in target fisheries to those observed since 1990 (1997-2002 average catch is shown for comparison), assuming fishing patterns remain stable. We recognize that these taxonomic categories still contain many ecologically unrelated species with different levels of productivity, so that even within these smaller ABCs there is a possibility of overfishing the least productive individual species. However, we think species group ABCs which result in quota management at the species group level are an improvement over an aggregate TAC for this diverse category.

Alternative management for components of the Other species complex (expanded in group sections) Because TAC setting may not be equally effective for all "other species", alternative management measures might be considered for some of these groups, depending upon the management objective. For instance, if the management objective is simply to reduce bycatch of a given "other species", management tools such as gear restrictions or area management might be more efficient than TAC management. An example of area management to reduce squid bycatch in the EBS pollock fishery was included as an appendix to last year's assessment. Bycatch of squid is reduced by limiting pelagic trawl fishing within relatively small areas of the shelf break; this has already been demonstrated through the indirect effects of closures related to Stellar sea lions. In 1999 and 2000, the pollock fishery was restricted or removed from one area of historically concentrated squid bycatch and squid catch was cut to less than half that observed in 1997-1998 (Table 16- 3). In 2001-2002, the pollock fishery moved back into the area and squid catch increased to levels approaching the ABC. Another option for bycatch reduction is the use of specialized gear. Excluder devices designed to reduce halibut bycatch have also been found to be effective in some configurations at releasing skates from trawl nets before they are captured (Craig Rose, NMFS AFSC, and John Gauvin, Groundfish Forum, personal communication). Other configurations may reduce shark bycatch in trawls. For sharks and skates caught on longlines, it is possible that changes in release methods (eg., not gaffing through the body or running them through the crucifier) would improve survival, as has also been shown for halibut.

For more sedentary species, there are also ways to combine catch information with survey information in applying area-specific TACs to achieve individual species management without individual species TACs. While there are several species within each sculpin genus in the EBS, there is reasonably good geographic separation of these species according to AFSC bottom trawl survey data. It is therefore possible to have only identification to genus in the catch, along with location, and determine which species were in the catch with a reasonable degree of certainty. A sculpin genus-level TAC (e.g. "Irish lords") applied within a given area where species do not overlap would then be species specific. This might result in fewer area-specific group TACs to manage as opposed to many area-wide species TACs to track. It may also be possible to apply this type of area-specific TAC at the assemblage level, and estimate which species are in the assemblage using survey data. These management measures may be incorporated into these plan amendments or developed in future amendments.

Ecosystem Condsiderations

Understanding other species population dynamics is fundamental to describing ecosystem structure and function in Alaska, because each group in other species plays an important ecological role. The species groups in this category occupy all marine habitats from pelagic to benthic, nearshore to open ocean, and shallow to slope waters. We discuss the ecosystem role of each in their respective sections below. This assessment is, in effect, an assessment of fishery impacts on the ecosystem via incedental catch of other species.

Summary

Catches of Other species have been very small compared to those of target species in Alaska, but they appear to be increasing. There are data limitations in terms of life history for all creatures in the other species complex; we lack information on age and growth, reproductive biology, habitat requirements, and in some cases, species descriptions. Considerable further investigation is necessary to be sure that all components of Other species are not adversely affected by groundfish fisheries. Furthermore, if target fisheries develop for any component of the other species group (as they have for skates in the Gulf of Alaska this year), effective management will be extremely difficult with the current limited information. Regardless of management decisions regarding TAC and the future structure for Other species, it is essential that we continue to improve species identification, survey sampling, and biological data collection for the species in this group if we hope to ensure their continued conservation.

We recommend that each species group within BSAI Other species be managed separately according to Tier 5 estimates reported in Table 16-7. We further recommend that all of these groups be placed on bycatch-only status to prevent target fisheries from developing before information for stock assessment improves through increased data collection, analysis and monitoring.

Acknowledgements

This year the implementation of a special project within the Observer Program to identify skates to species was extremely successful, and for this I thank Duane Stevenson first and foremost for designing the project and the species identification key, along with Jay Orr and Jerry Hoff and other RACE division staff. I also thank the participating observers who brought back comments for improving the key as well as data. The improvement of species identification by observers is invaluable to this assessment and should provide much improved data in the future. The Observer Program as a whole has been very responsive this year to issues surrounding the developing skate fishery in the Gulf of Alaska and I appreciate their efforts, especially the midseason application of the skate key to as many observers as possible. I realize that this type of flexibility requires substantial effort, and that making a change midseason can be logistically difficult, especially for field staff. Thanks to you all for the extra hard work you put in!

In addition, new data are available from the EBS shelf, slope, and Aleutian Island surveys this year, including length frequencies for several other species. This data greatly improves knowledge of the current state of several major other species populations and is extremely useful to the assessment. I thank all participants in RACE trawl surveys who assisted in collecting this information, and especially Gary Walters, Mark Wilkins, Jerry Hoff, and Terry Sample for organizing these collections.

We gratefully acknowledge Gary Walters' timely and efficient work in estimating biomass and variance of biomass for each other species group from all Eastern Bering Sea trawl surveys back to 1975, including the historical slope surveys, and the 2004 slope survey. Likewise, Mark Wilkins kindly provided species specific and group specific "biomass estimates" from the pilot Bering Sea slope survey conducted in 2000. Jerry Hoff provided 2002 slope survey data and references on sculpin species. Ken Goldman (VIMS) provided information and references on shark species. Jay Orr and Jerry Hoff edited

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Tables

Table 16- 1. Other species and squids in the Bering Sea-Aleutian Islands, by scientific and common name; compiled from the AFSC survey database RACEBASE. This list should be considered preliminary.

BSAI Other Category	**Scientific name**	**Common name**
115 species codes		shark unident.
	Lamna ditropis	salmon shark
	Squalus acanthias	spiny dogfish
	Somniosus pacificus	Pacific sleeper shark
	Rajidae unident.	skate unident.
		skate egg case unident.
	Bathyraja sp. egg case	
	Raja sp.	
	Bathyraja sp.	
	Bathyraja spinosissima	white skate
	Bathyraja abyssicola	deepsea skate
	Raja binoculata	big skate
	Bathyraja interrupta	Bering skate
	Raja rhina	longnose skate
	Raja stellulata	starry skate
	Bathyraja taranetzi (=Rhinoraja longii)	mud skate
	Bathyraja trachura	black skate
	Bathyraja parmifera	Alaska skate
	Bathyraja aleutica	Aleutian skate
	Bathyraja lindbergi	commander skate
	Bathyraja maculata	whiteblotched skate
	Bathyraja minispinosa	whitebrow skate
	Bathyraja smirnovi	golden skate
	Bathyraja violacea	Okhotsk skate
	Cottidae	sculpin unident.
	Zesticelus profundorum	flabby sculpin
	Thyriscus anoplus	sponge sculpin
	Icelinus borealis	northern sculpin
	Icelinus tenuis	spotfin sculpin
	Gymnocanthus sp.	
	Gymnocanthus pistilliger	threaded sculpin
	Gymnocanthus tricuspis	Arctic staghorn sculpin
	Gymnocanthus galeatus	armorhead sculpin
	Radulinus asprellus	slim sculpin
	Clinocottus acuticeps	sharpnose sculpin
	Gymnocanthus detrisus	
	Artediellus sp.	
	Artediellus miacanthus	bride sculpin
	Artediellus pacificus	Pacific hookear sculpin
	Artediellus scaber	hamecon
	Artediellus uncinatus	Arctic hookear sculpin
	Bolinia euryptera	
	Malacocottus sp.	
	Malacocottus kincaidi	blackfin sculpin

Table 16- 1 Continued
BSAI Other Category

Scientific name	Common name
Malacocottus zonurus	darkfin sculpin
Hemilepidotus sp.	Irish lord
Hemilepidotus gilberti	banded Irish lord
Hemilepidotus spinosus	brown Irish lord
Hemilepidotus zapus	longfin Irish lord
Hemilepidotus hemilepidotus	red Irish lord
Hemilepidotus jordani	yellow Irish lord
Hemilepidotus papilio	butterfly sculpin
Archistes plumarius	
Triglops sp.	
Triglops forficata	scissortail sculpin
Triglops metopias	crescent-tail sculpin
Triglops scepticus	spectacled sculpin
Triglops pingeli	ribbed sculpin
Triglops macellus	roughspine sculpin
Microcottus sellaris	brightbelly sculpin
Myoxocephalus verrucosus	warty sculpin
Myoxocephalus niger	warthead sculpin
Myoxocephalus polyacanthocephalus	great sculpin
Myoxocephalus jaok	plain sculpin
Myoxocephalus stelleri	frog sculpin
Myoxocephalus sp.	
Megalocottus platycephalus	belligerent sculpin
Myoxocephalus quadricornis	fourhorn sculpin
Myoxocephalus scorpioides	Arctic sculpin
Leptocottus armatus	Pacific staghorn sculpin
Gilbertidia sigalutes	soft sculpin
Enophrys sp.	
Enophrys bison	buffalo sculpin
Enophrys lucasi	leister sculpin
Enophrys diceraus	antlered sculpin
Dasycottus setiger	spinyhead sculpin
Psychrolutes sp.	
Psychrolutes paradoxus	tadpole sculpin
Psychrolutes phrictus	blob sculpin
Blepsias bilobus	crested sculpin
Nautichthys pribilovius	eyeshade sculpin
Nautichthys oculofasciatus	sailfin sculpin
Nautichthys robustus	shortmast sculpin
Hemitripterus bolini	bigmouth sculpin
Hemitripterus villosus	sea raven
Eurymen gyrinus	smoothcheek sculpin
Triglops xenostethus	
Icelus spiniger	thorny sculpin
Icelus canaliculatus	porehead sculpin
Icelus euryops	
Icelus spatula	spatulate sculpin
Icelus uncinalis	uncinate sculpin
Rastrinus scutiger	roughskin sculpin
Jordania zonope	longfin sculpin
Icelus sp.	

Table 16- 1 Continued BSAI Other Category	**Scientific name**	**Common name**
	Paricelinus hopliticus	thornback sculpin
	Cephalopoda unident.	cephalopod unident.
		cuttlefish unident.
		octopus unident.
		pelagic octopus unident.
	Octopus leioderma	smoothskin octopus
	Opisthoteuthis californiana	flapjack devilfish
	Octopus dofleini	giant octopus
	Benthoctopus sp.	
	Vampyroteuthis infernalis	
		squid unident.
	Rossia pacifica	eastern Pacific bobtail
	Loligo opalescens	California market squid
	Gonatus sp.	
	Gonatus onyx	clawed armhook squid
	Berryteuthis magister	magistrate armhook squid
	Gonatopsis sp.	
	Gonatopsis borealis	boreopacific armhook squid
	Moroteuthis robusta	robust clubhook squid
	Taonius pavo	

Table 16- 2. Estimated total (retained and discarded) catches of other species (mt) in the eastern Bering Sea and Aleutian Islands by groundfish fisheries, 1977-2002. JV=Joint ventures between domestic catcher boats and foreign processors. Estimated catches of other species from 1977-98 include smelts.

Year	Eastern Bering Sea				Aleutian Islands				Grand Total
	Foreign	JV	Domestic	Total	Foreign	JV	Domestic	Total	
1977	35,902			35,902	16,170			16,170	52,072
1978	61,537			61,537	12,436			12,436	73,973
1979	38,767			38,767	12,934			12,934	51,701
1980	33,955	678		34,633	13,028			13,028	47,661
1981	32,363	3,138	100	35,651	7,028	246		7,274	42,925
1982	17,480	720		18,200	4,781	386		5,167	23,367
1983	11,062	1,139	3,264	15,465	3,193	439	43	3,675	19,140
1984	7,349	1,159		8,508	184	1,486		1,670	10,178
1985	6,243	4,365	895	11,503	40	1,978	32	2,050	13,553
1986	4,043	6,115	313	10,471	1	1,442	66	1,509	11,980
1987	2,673	4,977	919	8,569		1,144	11	1,155	9,724
1988		11,559	647	12,206		281	156	437	12,643
1989		4,695	298	4,993		1	107	108	5,101
1990			16,115	16,115			4,693	4,693	20,808
1991			16,261	16,261			938	938	17,199
1992			29,994	29,994			3,081	3,081	33,075
1993			20,574	20,574			3,277	3,277	23,851
1994			23,456	23,456			1,099	1,099	24,555
1995			20,923	20,923			1,290	1,290	22,213
1996			19,733	19,733			1,706	1,706	21,440
1997			23,656	23,656			1,520	1,520	25,176
1998			23,077	23,077			2,455	2,455	25,531
1999			18,884	18,884			1,678	1,678	20,562
2000			23,098	23,098			3,010	3,010	26,108
2001			23,148	23,148			4,029	4,029	27,178
2002			26,639	26,639			1,980	1,980	28,619
2003									28,703
2004*									26,298

*2004 open access catch reported through October 23, 2004 plus CDQ catch reported through November 4, 2004.

Data Sources: Foreign and JV catches-U.S. Foreign Fisheries Observer Program, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, BIN C15700, Bld.4, 7600 Sand Point Way NE, Seattle, WA 98115. Domestic catches before 1989 (retained only; do not include discards): Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, Portland, OR 97201. Domestic catches since 1989: NMFS Regional Office BLEND and CAS databases, Juneau, AK 99801.

Table 16- 3. Estimated total catch (t) of BSAI non-target species groups by FMP category, 1997-2002. Source: NORPAC observer database and year-end estimates of target species catch from the NMFS Regional Office BLEND database (see text for estimation methods). ***Note that this estimation method is different from the one used in Table 16-2, so Other species totals reported here do not match Table 16-2 totals for 1997-2002 exactly.

Group	1997	1998	1999	2000	2001	2002	6 year avg	cv	avg % of category
squid	1,573.40	1,255.80	501.76	412.93	1,810.37	1,742.13	1,216.07	0.51	
skates	17,747.37	19,317.86	14,079.84	18,876.53	20,570.46	21,278.69	18,645.12	0.14	70.76%
sculpin	7,477.84	6,285.46	5,470.00	7,086.45	7,669.76	7,176.18	6,860.95	0.12	26.04%
dogfish	4.09	6.38	4.95	8.88	17.33	7.27	8.15	0.59	0.03%
salmonshk	6.82	18.04	29.96	23.30	24.45	33.90	22.75	0.42	0.09%
sleepershk	304.07	336.00	318.68	490.43	687.27	433.17	428.27	0.34	1.63%
shark	52.77	136.08	176.40	67.61	34.97	44.40	85.37	0.67	0.32%
octopus	248.37	189.68	326.08	418.15	227.28	374.45	297.33	0.30	1.13%
Total Other Species	25,841.33	26,289.50	20,405.92	26,971.35	29,231.51	29,348.07	26,347.95	0.12	
smelts	29.76	36.57	45.30	51.68	80.12	18.64	43.68	0.49	88.32%
gunnel		0.02	0.04	0.00	0.01	0.02	0.02	0.68	0.04%
sticheidae	0.40	0.24	0.03	0.11	0.41	0.09	0.21	0.77	0.43%
sandfish	1.11	0.40	3.29	20.29	1.85	1.68	4.77	1.61	9.64%
lanternfish	0.42	0.40	0.02	0.11	0.29	2.75	0.67	1.55	1.35%
sandlance	0.10		0.02	0.00	0.14	0.28	0.11	1.03	0.22%
Total Forage Species	31.79	37.64	48.70	72.19	82.81	23.46	49.45	0.47	
grenadier	5,851.55	6,589.04	7,388.23	7,320.94	3,753.93	4,698.09	5,933.63	0.25	28.05%
otherfish	1,569.15	1,362.69	1,327.28	1,458.20	1,459.89	1,189.60	1,394.47	0.09	6.59%
crabs	303.78	185.92	108.86	142.69	144.18	134.15	169.93	0.41	0.80%
starfish	6,191.00	3,287.17	3,051.47	3,174.02	4,221.00	3,742.66	3,944.55	0.30	18.64%
jellyfish	8,849.21	7,147.51	7,153.25	10,491.25	3,861.50	1,897.49	6,566.70	0.48	31.04%
invertunid	1,608.58	638.35	140.08	1,121.43	923.35	784.41	869.37	0.56	4.11%
seapen/whip	2.61	2.40	4.96	4.96	8.16	13.60	6.12	0.69	0.03%
sponge	530.12	500.83	321.84	164.91	245.36	330.26	348.89	0.41	1.65%
anemone	182.96	113.73	171.52	347.24	209.24	229.16	208.97	0.37	0.99%
tunicate	1,793.67	728.06	372.01	1,055.72	1,525.29	1,273.77	1,124.75	0.46	5.32%
benthinv	672.70	531.37	226.43	365.96	556.36	371.70	454.09	0.36	2.15%
snails					0.00	0.60	0.30	1.41	0.00%
echinoderm	44.88	24.27	30.32	42.37	43.42	32.76	36.34	0.23	0.17%
coral	38.89	27.67	52.49	43.12	183.29	79.23	70.78	0.82	0.33%
shrimp	2.73	1.71	1.23	3.70	2.41	3.03	2.47	0.36	0.01%
birds	28.69	43.49	24.39	27.04	17.44	8.19	24.87	0.48	0.12%
Total Non-Specified	27,670.52	21,184.21	20,374.36	25,763.55	17,154.83	14,788.70	21,156.23	0.23	
Total Non-Targets	55,117.04	48,767.14	41,330.75	53,220.02	48,279.51	45,902.36	48,769.69	0.10	

Table 16- 4. Estimated biomass (t) of BSAI Other species from various AFSC surveys.

EBS shelf survey biomass estimates					EBS slope survey biomass estimates				
Year	**Sharks**	**Skates**	**Sculpins**	**Octopi**	**Year**	**Sharks**	**Skates**	**Sculpins**	**Octopi**
1975	0	24,349	111,160	6,129					
1976									
1977									
1978									
1979	692	58,147	284,228	30,815	1979	0	3,056	4,555	729
1980									
1981					1981	1	2,743	5,372	234
1982	0	164,084	340,877	12,442	1982	23	2,723	3,261	180
1983	379	161,041	292,025	3,280					
1984	0	186,980	252,259	2,488					
1985	47	149,576	182,469	2,582	1985	314	3,329	2,316	152
1986	0	251,321	303,671	480					
1987	223	346,691	195,501	7,834					
1988	4,058	409,076	233,169	9,846	1988	1,967	3,271	4,944	138
1989	0	410,119	215,666	4,979					
1990	0	534,556	219,020	11,564					
1991	0	448,458	272,653	7,990	1991	2,635	4,031	2,449	61
1992	2,564	390,466	239,947	5,326					
1993	0	375,040	215,922	1,355					
1994	5,012	414,235	260,994	2,183					
1995	1,005	391,768	218,693	2,779					
1996	2,804	423,913	187,817	1,746					
1997	37	393,716	215,766	211					
1998	2,378	354,188	197,675	1,225					
1999	2,079	370,543	146,185	832					
2000	1,487	325,292	161,350	2,041	2000	*pilot survey, no official biomass estimate*			
2001	0	419,678	143,555	5,407					
2002	5,602	410,573	176,728	2,435	2002	25,445	69,275	6,409	979
2003	734	386,339	199,351	8,264					
2004	3,121	427,713	210,509	4,902	2004	2,260	33,182	5,488	1,957

AI trawl survey estimates

Year	Sharks	Skates	Sculpins	Octopi
1980	800	10,123	33,624	757
1983	0	16,259	24,570	440
1986	0	19,491	32,211	781
1991	2,927	14,987	15,904	1,148
1994	421	24,964	17,192	1,728
1997	2,497	28,902	13,680	1,219
2000	2,663	29,206	13,037	775
2002	1,557	34,412	14,248	1,384
2004	1,017	53,047	16,781	4,099

Table 16- 5. Research catches of squid and Other species in the BSAI, 1977-1998 (tons).

	Skates			Sharks			Sculpins			Octopus			Squid		
Year	EBS	AI	BSAI	EBS	AI	BSAI	EBS	AI	BSAI	EBS	AI	BSAI	EBS	AI	BSAI
1977	0.97	-	0.97	0.00	-	0.00	5.80	-	5.80	0.10	-	0.10	0.00	-	0.00
1978	2.48	-	2.48	-	-	-	11.80	-	11.80	0.30	-	0.30	0.09	-	0.09
1979	5.63	-	5.63	0.03	-	0.03	19.15	-	19.15	2.11	-	2.11	9.10	-	9.10
1980	4.31	6.21	10.52	0.00	0.30	0.30	10.40	13.90	24.30	0.38	0.85	1.23	0.01	19.77	19.78
1981	9.60	-	9.60	0.07	-	0.07	17.19	-	17.19	1.08	-	1.08	7.45	-	7.45
1982	16.17	0.83	17.00	0.16	0.02	0.18	23.68	2.92	26.60	1.00	0.24	1.24	9.61	0.00	9.61
1983	8.86	6.21	15.07	0.01	0.26	0.27	18.67	12.27	30.94	0.16	0.15	0.32	0.06	14.86	14.92
1984	8.01	-	8.01	-	-	-	12.01	-	12.01	0.08	-	0.08	0.00	-	0.00
1985	19.57	-	19.57	0.59	-	0.59	19.91	-	19.91	0.64	-	0.64	4.87	-	4.87
1986	8.41	8.58	16.98	-	2.21	2.21	10.96	15.93	26.90	0.02	0.14	0.15	0.00	13.64	13.64
1987	13.04	-	13.04	0.01	-	0.01	7.42	-	7.42	0.27	-	0.27	0.01	-	0.01
1988	21.26	-	21.26	1.06	-	1.06	17.02	-	17.02	0.53	-	0.53	1.03	-	1.03
1989	23.47	-	23.47	0.07	-	0.07	11.79	-	11.79	0.32	-	0.32	0.05	-	0.05
1990	23.43	-	23.43	0.00	-	0.00	14.84	-	14.84	0.30	-	0.30	0.40	-	0.40
1991	27.01	3.18	30.19	0.56	0.52	1.09	20.58	3.24	23.82	0.36	0.32	0.68	0.69	2.26	2.94
1992	11.93	-	11.93	0.09	-	0.09	8.07	-	8.07	0.20	-	0.20	0.00	-	0.00
1993	15.27	-	15.27	-	-	-	9.00	-	9.00	0.07	-	0.07	0.01	-	0.01
1994	15.58	6.53	22.11	0.17	0.13	0.31	10.50	5.15	15.65	0.09	0.43	0.52	0.04	2.72	2.76
1995	13.78	-	13.78	0.04	-	0.04	8.51	-	8.51	0.12	-	0.12	0.01	-	0.01
1996	15.31	-	15.31	0.10	-	0.10	6.96	-	6.96	0.07	-	0.07	0.04	-	0.04
1997	15.39	5.63	21.02	0.11	0.42	0.52	8.01	2.53	10.54	0.01	0.22	0.23	0.07	0.44	0.51
1998	14.10	-	14.10	0.09	-	0.09	7.54	-	7.54	0.05	-	0.05	0.02	-	0.02
SUM	293.58	37.17	330.75	3.16	3.86	7.01	279.83	55.93	335.76	8.25	2.35	10.60	33.54	53.69	87.23

Table 16- 6. Estimated annual natural mortality (M) for Other species groups (see group sections).

Species	Area	Sex	Hoenig	Rikhter & Efanov	Alverson & Carney	Charnov	Roff
Arctic staghorn sculpin	W. Bering Sea	*males*	0.53				
	W. Bering Sea	*females*	0.47				
				0.41			
Common staghorn sculpin	Kamchatka	*males*	0.32	0.32			
	Kamchatka	*females*	0.25	0.26			
Red Irish Lord	Puget Sound		0.70				
Threaded sculpin	E. Bering Sea	*males*	0.42		0.36	0.65	
		females	0.47		0.58	0.40	
Armorhead sculpin	Kamchatka	*males*	0.38				
	Kamchatka	*females*	0.32				
Great sculpin	Kamchatka	*males*	0.47	0.32			
	Kamchatka	*males*		0.26			
	Kamchatka	*females*	0.32	0.22			
	Kamchatka	*females*		0.19			
Plain sculpin	Sea of Japan	*males*	0.35	0.41			
	Sea of Japan	*males*		0.32			
	Sea of Japan	*females*	0.28	0.26			
	Sea of Japan	*females*		0.22			
Big skate	Monterey Bay, CA	*males*	0.38				
	Monterey Bay, CA	*females*	0.35				
	Monterey Bay, CA			0.19			
	Monterey Bay, CA			0.16			
	Monterey Bay, CA			0.13			
	Monterey Bay, CA			0.12			
	Monterey Bay, CA			0.10			
Longnose skate	Monterey Bay, CA	*males*	0.32		0.31	0.44	0.23
	Monterey Bay, CA	*females*	0.35		0.45	0.29	0.03
	Monterey Bay, CA	*both*				0.31	
	Monterey Bay, CA			0.22			
	Monterey Bay, CA			0.19			
	Monterey Bay, CA			0.16			
	Monterey Bay, CA			0.13			
Pacific giant octopus	N. Pacific		1.42	0.98			
	N. Pacific		1.06	0.77			
	N. Pacific		0.85	0.53			
Red Squid	Sea of Okhotsk	*males*		1.90			
	Sea of Okhotsk	*males*		1.60			
	Sea of Okhotsk	*females*		1.63			
	Sea of Okhotsk	*females*		1.49			
	WBS, Sea of okhotsk		1.06				
Boreal clubhook squid	Central & Eastern	*males*		1.99			
	N. Pacific	*males*		1.60			
		females		2.18			
		females		1.60			

Table 16- 7. Recommended BSAI ABC and OFL by species group. These are Tier 5 estimates based on the sum of the following three biomass estimates: EBS shelf survey 10 year average by species group, EBS slope survey 10 year average by species group, and AI survey 10 year average by species group. Note that the EBS slope survey 10 year average actually only includes the 2002 -2004 surveys because the 2000 survey was not designed for official biomass estimation. Recent average catch uses estimates in Table 16-3 for the years 1997-2002.

	Sharks	Skates	Sculpins	Octopi
Avg Biomass	17,711	477,993	206,148	6,321
M (see text)	0.09	0.10	0.19	0.50
BSAI ABC	**1,195**	**35,849**	**29,376**	**2,371**
BSAI OFL	**1,594**	**47,799**	**39,168**	**3,161**
recent avg catch	545	18,645	6,861	297

Table 16-7, continued. Potential ABC and OFL for species groups within the Other species complex based on Tier 6 criteria applied to group specific catches estimated in Other species stock assessments between 1992-2002. This information is provided at the request of the Plan Team.

TIER 6 ESTIMATES based on 1992-2002 average catch				
	Sharks	Skates	Sculpins	Octopi
EBS ABC	386	12,110	4,481	212
AI ABC	48	1,711	1,263	66
BSAI ABC	434	13,821	5,744	278
EBS OFL	514	16,147	5,975	283
AI OFL	65	2,281	1,684	88
BSAI OFL	579	18,428	7,659	371

BSAI Squids

Introduction

Description, scientific names, and general distribution
Squids (order Teuthoidea) are cephalopod molluscs which are related to octopus. Squids are considered highly specialized and organized molluscs, with only a vestigal mollusc shell remaining as an internal plate called the pen or gladius. They are streamlined animals with ten appendages (2 tentacles, 8 arms) extending from the head, and lateral fins extending from the rear of the mantle (Figure 16-1). Squids are active predators which swim by jet propulsion, reaching swimming speeds of up to 40 km/hr, the fastest of any aquatic invertebrate. Members of this order (Archeteuthis spp.) also hold the record for largest size of any invertebrate (Barnes 1987).

The 18 squid species found in the mesopelagic regions of the Bering Sea represent 7 families and 10 genera (Sinclair et al. 1999). Less is known about which squid species inhabit the GOA, but the species are likely to represent both EBS species and more temperate species in the family Loligo, which are regularly found on the U.S. West Coast and in British Columbia, Canada, especially in warmer years (BC squid fishery thing). Squid are distributed throughout the North Pacific, but are common in large schools in pelagic waters surrounding the outer continental shelf and slope (Sinclair et al, 1999). The most common squid species in the Eastern Bering Sea are all in the family Gonatidae. Near the continental shelf, the more common species are *Berryteuthis anonychus* and *Berryteuthis magister*. Further offshore, the likely common species are *Gonatopsis borealis*, *Gonatus middendorfi* and several other *Gonatus* species, according to survey information collected in the late 1980's (Sinclair et al. 1999). In addition, marine mammal food habits data and recent pilot studies indicate that *Ommastrephes bartrami* may also be common, in addition to *Berryteuthis magister* and *Gonatopsis borealis* (B. Sinclair, ASFC, personal communication). Much more research is necessary to determine exactly which species and life stages are present seasonally in the BSAI and GOA.

Management Units
The squid species complex is part of the Other species FMP category. In the BSAI, catch of all squid species in aggregate is limited by a TAC, which is based on the average catch of squid between 1978 and 1995 (Fritz, 1999, Gaichas 2003). In the GOA, catch of squids is reported within the category “other” along with skates, sharks, sculpins, and octopus, and is limited by a TAC set for the entire complex. This GOA TAC for other species has been established as 5% of the sum of the TACs for all other assessed target species in the GOA (Gaichas et al., 1999). The squid TAC in the BSAI and the other species TAC in the GOA have never been exceeded. However, squid catch in the BSAI became a potential problem within the management of the Community Development Quota (CDQ) program. Because each CDQ group receives an allocation of groundfish which is 7.5% of the TAC set for each species, the groups would be required to restrict squid catch to a low level, potentially constraining target fisheries (NMFS 2000). This is more an example of the difficulties with managing very small TACs than with managing squid in particular, because the squid TAC is one of the smallest TACs in the BSAI (ref 2000 harvest specifications for BSAI groundfish). The NPFMC approved BSAI FMP amendment 66 to remove squid from the CDQ program in June 1999, and the Final Rule is pending (Federal Register, May 30, 2000). Under this rule, the catch of squid within the CDQ program is still monitored, and still counts against overall BSAI squid TAC, but CDQ groups will not be restricted to 7.5% of the squid TAC.

Life history and stock structure
Relative to most groundfish, squids are highly productive, short-lived animals. They display rapid growth, patchy distribution and highly variable recruitment (O'Dor, 1998). Unlike most fish, squids may spend most of their life in a juvenile phase, maturing late in life, spawning once, and dying shortly

thereafter. Whereas many groundfish populations (including skates and rockfish) maintain stable populations and genetic diversity over time with multiple year classes spawning repeatedly over a variety of annual environmental conditions, squids have no such “reserve” of biomass over time. Instead, it is hypothesized that squids maintain a “reserve” of biomass and genetic diversity in space with multiple cohorts spawning and feeding throughout a year and over a wide geographic area across locally varied environments (O’Dor 1998). Many squid populations are composed of spatially segregated schools of similarly sized (and possibly related) individuals, which may migrate, forage, and spawn at different times of year (Lipinski, 1998). Most information on squids refers to *Illex* and *Loligo* species which support commercial fisheries in temperate and tropical waters. Of North Pacific squids, life history is best described for western Pacific stocks (Arkhipkin et al., 1995; Osako and Murata, 1983).

The most commercially important squid in the north Pacific is the magistrate armhook squid, *Berryteuthis magister*. This species is distributed from southern Japan throughout the Bering Sea, Aleutian Islands, and Gulf of Alaska to the U.S. West coast as far south as Oregon (Roper et al. 1984). The maximum size reported for *B. magister* is 28 cm mantle length. The internal vestigal shell, or gladius, and statoliths (similar to otoliths in fish) were compared for ageing this species (Arkhipkin et al., 1995). *B. magister* from the western Bering Sea are described as slow growing (for squid) and relatively long lived (up to 2 years). Males grew more slowly to earlier maturation than females. *B. magister* were dispersed during summer months in the western Bering sea, but formed large, dense schools over the continental slope between September and October. Stock structure in this species is complex, with three seasonal cohorts identified in the region: summer-hatched, fall-hatched, and winter-hatched. Growth, maturation, and mortality rates varied between seasonal cohorts, with each cohort using the same areas for different portions of the life cycle. For example, the summer-spawned cohort used the continental slope as a spawning ground only during the summer, while the fall-spawned cohort used the same area at the same time primarily as a feeding ground, and only secondarily as a spawning ground (Arkhipkin et al., 1995).

Timing and location of fishery interactions with squid spawning aggregations may affect both the squid population and availability of squid as prey for other animals (Caddy 1983, O’Dor 1998). The essential position of squid within North Pacific pelagic ecosystems, combined with the limited knowledge of the abundance, distribution, and biology of many squid species in the FMP areas, make squid a good candidate for management distinct from that applied to other species (as has been done for Forage species in the BSAI and GOA). Because fishery interactions with squid happen in predictable locations (see below), squid may be a good candidate for management by spatial restriction rather than by quota.

Fishery

Directed fishery

Squid are generally taken incidentally in target fisheries for pollock but have been the target of Japanese and Republic of Korea trawl fisheries in the past. There are no directed squid fisheries in Alaskan waters at this time. Squids could potentially become targets of Alaskan fisheries, however. While there are no directed squid fisheries in the Eastern North Pacific, there are many fisheries directed at squid species worldwide, although most focus on temperate squids in the genera *Ilex* and *Loligo* (Agnew et al. 1998, Lipinski et al 1998). There are fisheries for *Berryteuthis magister* in the Western Pacific, including Russian trawl fisheries with annual catches of 30,000 - 60,000 metric tons (Arkhipkin et al., 1995), and coastal Japanese fisheries with catches of 5,000 to 9,000 t in the late 1970's-early 1980's (Roper et al. 1982, Osaka and Murata 1983). Therefore, monitoring of catch trends for species in the squid complex is important because markets for squids exist and fisheries might develop rapidly.

Bycatch and discards

Reported catches since 1977 are shown in Table 16- 8, along with historical ABC and TAC. After reaching 9,000 mt in 1978, total squid catches have steadily declined to only a few hundred tons in

1987-95. Thus, squid stocks have been comparatively lightly exploited in recent years. Discard rates of squid (discards/total squid catch) by the BSAI groundfish fisheries have ranged between 40% and 85% in 1992-1998 (NMFS Regional Office, Juneau, AK). Note that the 2001 estimated catch of squid, 1,810 t (Table 16-9), was the highest in the past five years and is much closer to the ABC of 1,970 t than any estimated catch since the 1980's. The estimated catch for 2002 was not far behind. Most squid have been caught as bycatch in the midwater trawl pollock fishery primarily over the shelf break and slope or in deep waters of the Aleutian Basin (subareas 515, 517, 519, 521 and 522).

The predominant species of squid in commercial catches in the EBS is believed to be the red squid, *Berryteuthis magister*, while *Onychoteuthis borealijaponicus*, the boreal clubhook squid, is likely the principal species encountered in the Aleutian Islands region. Because observers are not trained to identify individual species of squids, the majority (99%) of squid catch is reported as "squid unidentified". We summarize all available catch information for aggregated squid species, including annual catch and location of catch. We examined fishery data from 1997-2001 to determine total squid catch, catch in different gear types and target fisheries (Table 16-9), and observed location of squid catch (see spatial analysis below). Spatial analysis was done only for 1997-1999 because the pollock fisheries changed so much under Steller sea lion management measures in 2000-2001. Unlike skates, squids are rather delicate are almost certainly all killed in the process of being caught, regardless of gear type or depth of fishing.

We attempted to resolve which squid species are likely to be caught in the EBS pollock fishery by combining species distribution information from surveys with the observed fishery catch information from 1997-1999. While the surveys do not cover enough area to provide biomass estimates for squids, they do cover many of the areas where pollock fisheries catch squids. This analysis confirms that *Berryteuthis magister* is likely to be present in at least some fishery catches of squid (Figure 16-2). As will many other non-target species, identification of squids on past surveys was not always attempted, so records labeled below as "other squid" may or may not also represent *Berryteuthis magister*. It is clear from Figure 16-2 that fisheries catch squids mostly along the outer continental shelf, and that catch is concentrated in certain areas, especially around submarine canyons.

Survey Data

<u>Survey biomass in aggregate and by species</u>

The AFSC bottom trawl surveys are directed at groundfish species, and therefore do not employ the appropriate gear or sample in the appropriate places to provide reliable biomass estimates for the generally pelagic squids. Although midwater acoustic and trawl surveys are conducted in the EBS annually by the AFSC, all sampling on these surveys is directed at pollock. Squid records from these surveys tend to appear at the edges of the continental shelf, which is at the margin of the sampling strata defined for these surveys. The available information from 1988 and 1989 Japanese / U.S. pelagic trawl research surveys in the EBS indicates that the majority of squid biomass is distributed in pelagic waters off the continental shelf (Sinclair et al. 1999), beyond the current scope of the AFSC surveys. These midwater surveys provided the information we have to indicate which species might be found in the EBS, but they were characterized by extreme variability in species abundance between years. The bottom line is, there is no reliable biomass estimate for squids, either in aggregate or by species, for any year in any FMP area at this time. We have no information on absolute biomass for any North Pacific squid species, and therefore no way to know whether there is a rapidly declining biomass trend for any species within the squid complex at this time.

Analytic Approach, Model Evaluation, and Results

The available data do not support population modeling for squids in the BSAI, so none of these stock assessment sections are relevant, except for one:

Parameters Estimated Independently

An analysis was undertaken to explore alternative methods to estimate natural mortality (M) for squid species found in the BSAI. Several methods were employed based on correlations of M with life history parameters including growth parameters (Alverson and Carney 1975, Pauly 1980, Charnov 1993), longevity (Hoenig 1983), and reproductive potential (Roff 1986, Rikhter and Efanov 1976). No information was available for any squid stocks in the BSAI FMP area, so M was estimated using the methods of Hoenig (1983) and of Rikhter and Efanov (1976) as applied to data for Sea of Okhotsk red squid (*B. magister*) and Central North Pacific boreal clubhook squid (*Gonatopsis borealis*). The resulting estimates of M (Table 16-6) represent an attempt at determining stock productivity, although it may not be appropriate to apply these methods developed for teleost fishes to cephalopods. Because squid are managed under Tier 6, M estimates are presented for information only, and are not used in the current assessment.

While we do not have appropriate information to estimate squid biomass using standard population models, an alternative is to use the minimum biomass estimated to meet the consumption needs of predators within the ecosystem. Mass balance models of both the EBS and AI ecosystems have been constructed at AFSC, incorporating information on groundfish predation as well as marine mammal and bird predation, fishing, and production of lower trophic levels (see the Ecosystem Assessment SAFE chapter for this year). While there are many caveats associated with estimating aggregate squid biomass in this manner (including the fact that squid are voracious predators on other squid, which complicates computations), squid biomass is potentially in the hundreds of thousands of tons. By comparison, an estimated squid catch of one to two thousand tons annually does not appear excessive. However, spatial and temporal aspects of catch must be considered, both for squid and for their predators.

Projectons and Harvest Alternatives

Nontarget species would not have optimum yields estimated annually as for target species, because optimizing catch is not the goal for nontarget species. For some nontarget species it may still be most efficient to specify total allowable catches (TACs) to achieve the management goal of protecting those species from indirect fishery effects. However, for species in the squid complex, we do not have the minimal information required to set a TAC, because we do not have a reliable estimate of biomass. (While we set a TAC right now under status quo management for squid in the BSAI, this TAC is based on average catch, which is not necessarily related to the productivity of squid stocks. Under this alternative management regime we set slightly higher standards for TAC setting, so that our TACs would be biologically derived.) Just for fun, we briefly investigate the costs of obtaining a biomass estimate for squids to determine whether TAC would ever be a cost effective management tool.

In theory, a squid survey could be conducted with midwater trawls and or hydroacoustics. We have such a survey for pollock, but the existing survey would need to extend out across shelf break, at least, which would greatly expand the scope of the current survey. There is currently some interest in developing a mesopelagic trawl survey index which might begin this process. As far as seasonality, squid appear in the catch data during all pollock seasons in the areas around the shelf break. The highest observed fishery CPUE of squids might indicate when a survey would be most efficiently conducted. According to fishery information from 1997-1999, a peak in squid CPUE occurs in January, but it is also all in one location (Pribilof canyon), so it is difficult to tell if the high CPUEs are seasonally or spatially related. The life history information reported for western Bering sea *Berryteuthis magister* suggests that any survey for squids would have to occur over multiple seasons to fully assess the biomass available in a given year, and would require significant information on the life cycles and migratory routes of local squid to maximize efficiency. Lacking this information, a survey to provide the biomass estimates necessary for squid TAC setting would have to cover so much territory and so many seasons as to be prohibitively expensive, especially considering that there is no target fishery for squids in the FMP areas at this time. A more realistic approach might be to initiate smaller scale surveys, perhaps coordinated with the existing pollock surveys, to conduct squid species identification and life history investigations in our area to determine how a larger scale survey might be conducted in the future.

The rapid dynamics reported for squid species and their subpopulations indicates that the temporal and spatial scales for assessment of squids are different from the annual and basinwide scales we apply to most groundfish. Therefore, even if we had a reliable estimate of biomass, we would have to understand the relative composition of cohorts and their movements and different mortality rates in order to apply TAC management effectively. If we used a previous year's biomass estimate to set a TAC for the following year for squids (as we do for Target species), there would be a significant probability that this TAC would be far too high or low relative to the current year's biomass due to the great interannual variability of squid stocks (Caddy 1983). To avoid this problem, biomass would have to be estimated for a given species and TAC set and taken within a very short time period, potentially less than one year. Even this intensive management scenario would leave open the possibility that an entire seasonal cohort could be eliminated by fishing unless additional temporal or spatial management measures ensured that fishing pressure was distributed between cohorts. Both effort controls and closed areas and seasons have been suggested as more effective management tools than TAC setting for maintaining adequate levels of squid spawning stock biomass (Caddy 1983, O'Dor 1998). An understanding of the biology and dynamics of squid life cycles at the species level is essential for the application of any management tool (Lipinski et al 1998).

While biomass estimation and TAC setting for the squid complex appear daunting, especially when there is no current interest in targeting squids, a much simpler management scenario involves using time and area closures. Given that majority of squid catches occur in a few clearly defined areas across recent years (Figure 16-2), this option seems ideal for squid management. We therefore defined potential squid closed areas are based on observed squid catches from the years 1997-1999 (Figure 16-3). These closures could be applied only to pelagic trawl gear in the Bering Sea (almost exclusively the pollock fishery). Squid catch in each of these areas occurs in distinct seasons, but there is not enough fishing year round to determine if squids would be caught in each area in all seasons. Squids migrate throughout the area and populations are composed of multiple cohorts with different spawning seasons. Year-round closures in these areas would be the most conservative measure that would provide protection to all cohorts in the populations of each species that potentially occupies the area, and would minimize squid bycatch overall.

Ecosystem Considerations

Ecosystem Effects on Stock and Fishery Effects on Ecosystem

Fishery management should attempt to prevent negative impacts on squid populations not only because of their potential fishery value, but also (perhaps more so) because of the crucial role they play in marine ecosystems. Squid are important components in the diets of many seabirds, fish, and marine mammals, as well as voracious predators themselves on zooplankton and larval fish (Caddy 1983, Sinclair et al. 1999). Many squid populations are composed of spatially segregated schools of similarly sized (and possibly related) individuals, which may migrate, forage, and spawn at different times of year (Lipinski, 1998). The timing and location of fishery interactions with squid spawning aggregations may affect the availability of squid as prey for other animals as well as the squid populations themselves (Caddy 1983, O'Dor 1998). The essential position of squids within North Pacific pelagic ecosystems combined with our limited knowledge of the abundance, distribution, and biology of squid species in the FMP areas make squids a good case study to illustrate management of an important nontarget species complex with little information.

Summary

The squid complex in both the BSAI and GOA would be characterized as a nontarget complex which is both ecologically important and has potential fishery value. Management with TACs has been problematic in the past due to a lack of biomass estimates combined with small TAC management issues associated with the CDQ program in the BSAI. Therefore, management as a nontarget species complex would remove the requirement to develop TACs for this complex and could replace quota management with spatial management. Squid bycatch occurs in the same areas year after year and so could be controlled simply through limiting fishery access to those areas. Depending on the need to constrain squid catch, pollock or other pelagic fisheries could be excluded from designated shelf break and canyon regions during certain times of the year, all year, or only after a certain threshold level of squid complex catch had been reported by fishery observers. Management might consider improvements to the current monitoring of squid species within the complex such as getting observers to identifiy a subset of the bycatch to genus or species instead of using the current "squid unidentified" category. At the very least, classifying squid catch by size would be helpful to determine ecosystem effects (e.g., "large" squid the size of *Moroteuthis robusta* are more predator than prey in the ecosystem, while smaller squid species may be most important as prey). Because most squid catch in Alaskan groundfish fisheries is in Bering Sea pollock where there is nearly full observer coverage, it may be feasible for observers to devote time to this task if it becomes a priority. It might be important to be able to estimate the species composition of squid complex bycatch to determine relative impacts on marine mammals and other predators that depend on squids for prey, as well as relative impacts to the squid populations themselves.

> Using Tier 6 criteria, the recommended ABC for BSAI squid in the year 2004 is calculated as 0.75 times the average catch from 1978-1995, or **1,970 mt**; the recommended overfishing level for squid in the year 2004 is calculated as the average catch from 1978-1995, or **2,624 mt**. (This recommendation is unchanged from previous assessments.)

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Tables

Table 16- 8. Estimated total (retained and discarded) catches of squid (mt) in the eastern Bering Sea and Aleutian Islands by groundfish fisheries, 1977-2002. JV=Joint ventures between domestic catcher boats and foreign processors.

Year	Eastern Bering Sea				Aleutian Islands				Grand Total
	Foreign	JV	Domestic	Total	Foreign	JV	Domestic	Total	
1977	4,926			4,926	1,808			1,808	6,734
1978	6,886			6,886	2,085			2,085	8,971
1979	4,286			4,286	2,252			2,252	6,538
1980	4,040			4,040	2,332			2,332	6,372
1981	4,178	4		4,182	1,763			1,763	5,945
1982	3,833	5		3,838	1,201			1,201	5,039
1983	3,461	9		3,470	509	1		510	3,980
1984	2,797	27		2,824	336	7		343	3,167
1985	1,583	28		1,611	5	4		9	1,620
1986	829	19		848	1	19		20	868
1987	96	12	1	109		23	1	24	131
1988		168	246	414		3		3	417
1989		106	194	300		1	5	6	306
1990			532	532			94	94	626
1991			544	544			88	88	632
1992			819	819			61	61	880
1993			611	611			72	72	683
1994			517	517			87	87	604
1995			364	364			95	95	459
1996			1,083	1,083			84	84	1,167
1997			1,403	1,403			71	71	1,474
1998			891	891			25	25	915
1999			432	432			9	9	441
2000			375	375			8	8	384
2001			1,761	1,761			5	5	1,766
2002			1,334	1,334			10	10	1,344
2003									1,234
2004*									981

*2004 catch reported through October 23, 2004 and DOES NOT include CDQ squid catch.

Data Sources: Foreign and JV catches-U.S. Foreign Fisheries Observer Program, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, BIN C15700, Bld.4, 7600 Sand Point Way NE, Seattle, WA 98115. Domestic catches before 1989 (retained only; do not include discards): Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, Portland, OR 97201. Domestic catches 1989-2002: NMFS Regional Office BLEND database, Juneau, AK 99801. Domestic catches 2003-present: NMFS Regional Office Catch Accounting System, Juneau, AK 99801

Table 16-9 Estimated catch (t) of all squid species combined by target fishery, gear, and area, 1997-2002. Similar catch estimates are not available for 2003-2004; see text for explanation. Total squid catches in italics are calculated by the NMFS AK Regional Office Catch Accounting System, and are not comparable to catch estimates presented for 1997-2002.*2004 catch reported through October 23, 2004 and DOES NOT include CDQ squid catch.

Target fishery	**gear**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Arrowtooth	trawl	0.12	2.80	3.36	2.61	7.35	11.32		
Atka mackerel	trawl	15.82	8.01	5.24	2.68	3.30	6.66		
Flatheadsole	trawl	1.21	2.23	2.49	9.36	10.39	5.40		
OtherFlats	trawl	0.01	0.97	4.93	1.90	0.18	1.04		
Pacific cod	hook n line	0.00	0.01		0.01	0.00	0.00		
	pot		0.01	0.00		0.52			
	trawl	7.84	1.55	0.50	2.47	6.57	5.29		
Pacific cod Total		7.84	1.57	0.50	2.48	7.10	5.29		
Pollock	trawl	1,538.20	1,236.10	475.13	378.90	1,775.95	1,702.56		
Rock sole	trawl	0.00	0.00	0.00	0.00	1.38	0.03		
Rockfish	trawl	6.52	0.88	5.60	5.74	1.93	8.70		
Sablefish	hook n line			0.07			0.07		
	trawl		0.19	0.05		0.46			
Sablefish Total			0.19	0.12		0.46	0.08		
Turbot	hook n line				0.01	0.00			
	pot			0.01	0.00				
	trawl	3.65	2.55	4.22	9.13	2.19	0.89		
Turbot Total		3.65	2.55	4.23	9.14	2.20	0.89		
Yellowfinsole	trawl	0.02	0.49	0.17	0.12	0.14	0.16		
BSAI Total		1,573.40	1,255.80	501.76	412.93	1,810.37	1,742.13	*1,234*	*981**
FMP area	**area**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
AI	541	36.69	7.37	1.28	4.45	2.31	5.86		
	542	18.61	16.58	1.28	2.18	1.89	5.18		
	543	19.69	11.16	7.79	1.78	3.24	4.61		
AI Total		74.99	35.12	10.36	8.42	7.44	15.65		
EBS	509	3.35	2.21	0.31	1.68	0.01	0.79		
	513	0.28	3.77	0.24	0.69	0.40	2.26		
	516					0.02			
	517	1,168.00	704.42	434.89	281.85	792.18	1,083.43		
	518	0.47	0.82	0.23	0.29	0.38			
	519	319.52	445.55	8.22	93.70	994.48	637.72		
	521	6.65	20.25	47.34	19.97	14.18	2.18		
	523	0.04	3.18	0.11		1.12	0.09		
	524	0.10	40.48	0.07	6.34	0.16	0.00		
EBS Total		1,498.41	1,220.68	491.41	404.51	1,802.93	1,726.48		
BSAI Total		1,573.40	1,255.80	501.76	412.93	1,810.37	1,742.13	*1,234*	*981**
BSAI ABC		1,970	1,970	1,970	1,970	1,970	1,970	1,970	1,970
BSAI TAC		1,970	1,970	1,970	1,970	1,970	1,970	1,970	1,275

Figures

Figure 16-1 The magistrate armhook squid, *Berryteuthis magister*.

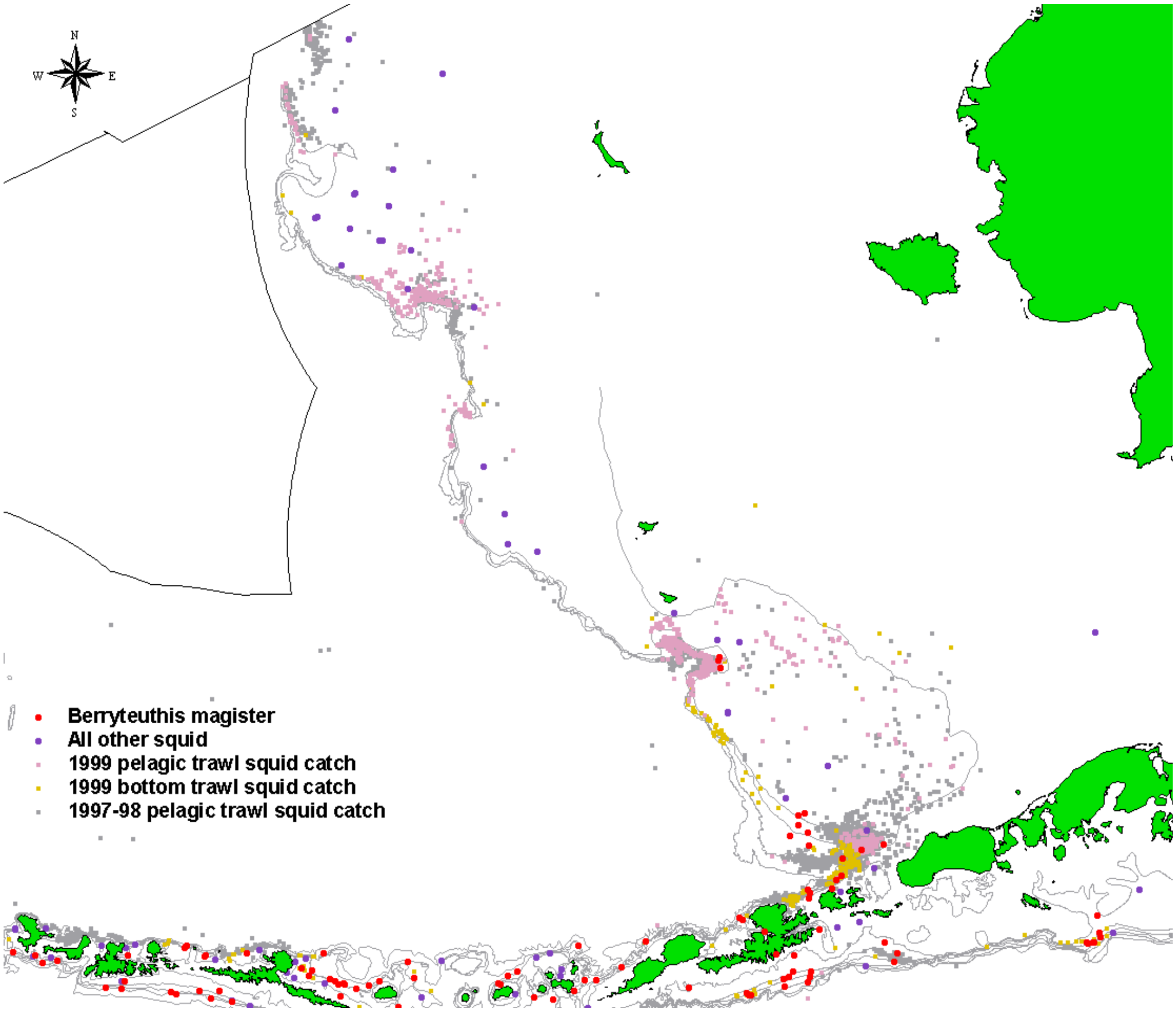

Figure 16-2 Distribution of squid species from bottom trawl and midwater surveys (dots) and catch (shaded squares), 1997-99.

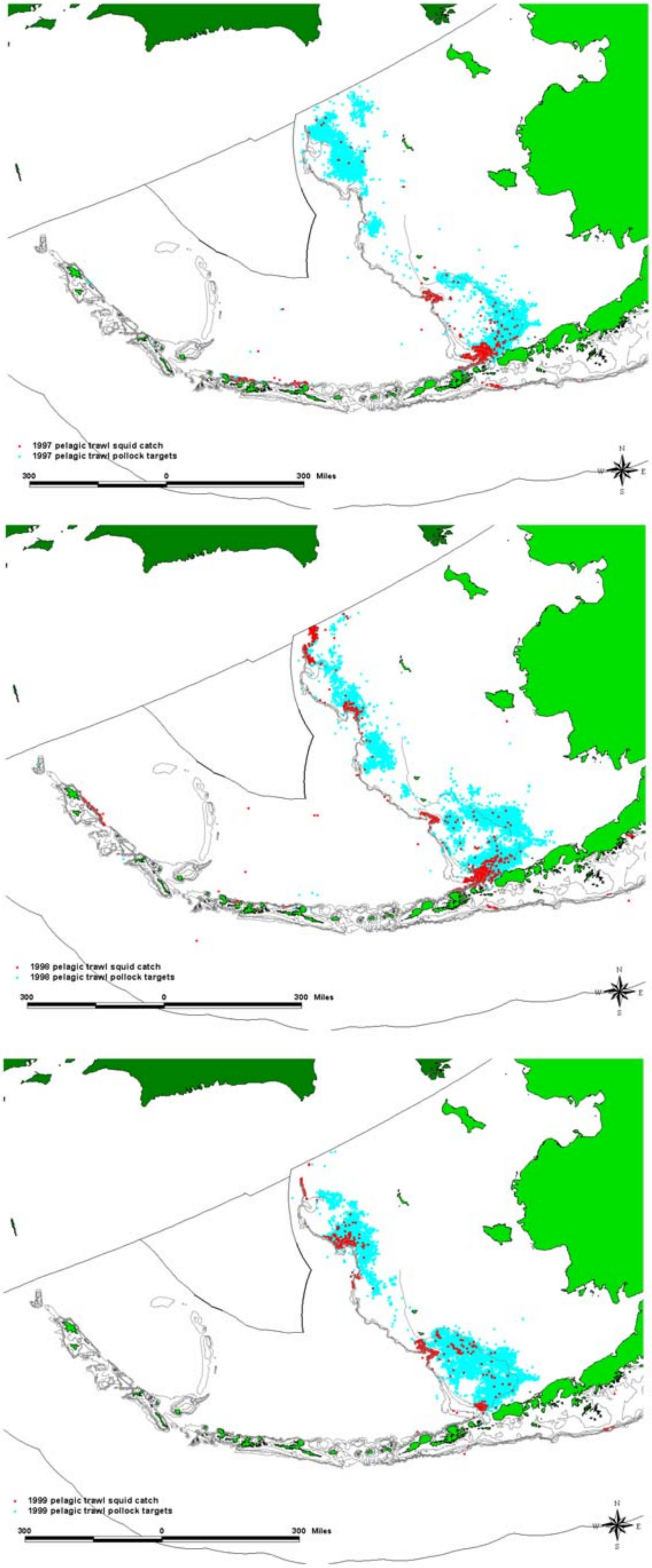

Figure 16-3. Eastern Bering Sea pollock fishery in light blue, areas of squid catch in dark red. Top--1997, center--1998, bottom--1999. Note that squid catches ocurr in the same places regardless of where the fishery operates.

BSAI Skates

Introduction

<u>Description, scientific names, and general distribution</u>
Skates (family *Rajidae*) are cartilaginous fishes which are related to sharks. They are dorso-ventrally compressed animals with large pectoral "wings" attached to the sides of the head, and long, narrow whiplike tails (Figure 16-4). Potentially 12-14 species of skates in two genera, *Raja* and *Bathyraja*, are distributed throughout the eastern North Pacific and are common from shallow inshore waters to very deep benthic habitats (Eschmeyer et al., 1983). Table 16-10 lists the species found in the BSAI and some life history characteristics, which are outlined in more detail below.

The species within this complex occupy different habitats and regions within the BSAI FMP area. The EBS shelf skate complex is dominated by a single species, the Alaska skate (*Bathyraja parmifera)* (Table 16-11). This species is distributed throughout the shelf (Figure 16-5). The Bering or sandpaper skate *(Bathyraja interrupta*) is the next most common species on the EBS shelf, and is distributed on the outer continental shelf (Figure 16-6). While skate biomass decreases somewhat on the EBS slope, skate diversity increases substantially (Figure 16-7). The Aleutian skate (*Bathyraja aleutica*) is found only on the outer EBS shelf (Figure 16-8), but it comprises the majority of the EBS slope skate biomass, with Bering and Alaska skates still quite common. The skate community in the AI appears to be different from that described for both the EBS shelf and slope (Figure 16-7). In the AI, the most abundant species is the whiteblotched skate, *Bathyraja maculata*. The whiteblotched skate is found primarily in the eastern Aleutians, and also very far out west (Figure 16-9). Alaska and Aleutian skates are also common in the AI. The mud skate, *Bathyraja tanaretzi*, is relatively common in the AI but represents a lower proportion of total biomass because it is a smaller skate. We note that the Alaska skate found in the Aleutians looks very different from the Alaska skate found on the EBS shelf (Figure 16-10), and there are some indications that it might actually be a separate species in the two areas (J. Orr pers. comm.). For now, we consider the Alaska skate a single species throughout its range until further taxonomic work is completed.

<u>Management units</u>
In the North Pacific, skate species are part of the "Other species" management category within the Bering Sea Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish Fishery Management Plans (FMPs). This means that their catch is reported in aggregate as "other" along with the catch of sharks, sculpins, and octopus (BSAI) and squid (GOA). (Because catch is officially reported within the Other species complex, estimates of skate catch must be made independently for each year using observer data; see below.) In the BSAI, catch of other species is limited by a Total Allowable Catch (TAC) which is based on an Allowable Biological Catch (ABC) estimated by the NPFMC SSC. Right now, skates are taken only as bycatch in fisheries directed at target species in the BSAI, so future catches of skates are more dependent on the distribution and limitations placed on target fisheries than on any harvest level established for this category. An FMP amendment was initiated by the NPFMC in 1999 to remove both skates and sharks from the Other species category to increase the level of management attention and control for these potentially vulnerable species groups; this action is still in the process of revision and review. In response to a developing fishery in the GOA, the GOA FMP was amended to remove skates from the other species category. This amendment did not affect other species or skate management in the BSAI.

Life history and stock structure (general)
Skate life cycles are similar to sharks, with relatively low fecundity, slow growth to large body sizes, and dependence of population stability on high survival rates of a few well developed offspring (Moyle and Cech 1996). Sharks and skates in general have been classified as "equilibrium" life history strategists (Winemiller and Rose 1992), with very low intrinsic rates of population increase implying that sustainable harvest is possible only at very low to moderate fishing mortality rates (King and McFarlane, 2003). Within this general equilibrium life history strategy, there can still be considerable variability between skate species in terms of life history parameters (Walker and Hislop, 1998). While smaller sized species have been observed to be somewhat more productive, large skate species with late maturation (11+ years) are most vulnerable to heavy fishing pressure (Walker and Hislop, 1998; Frisk et al 2001; Frisk et al 2002). The most extreme cases of overexploitation have been reported in the North Atlantic, where the "common" skate *Raja batis* has been extirpated from the Irish Sea (Brander, 1981) and much of the North Sea (Walker and Hislop, 1998) and the barndoor skate *Raja laevis* has disappeared from much of its range off New England (Casey and Myers, 1998). The mixture of life history traits between smaller and larger skate species has led to apparent population stability for the aggregated "skate" group in many areas where fisheries occur, and this combined with the common practice of managing skate species within aggregate complexes has masked the decline of individual skate species in European fisheries (Dulvy et al, 2000). Similarly, in the Atlantic off New England, declines in barndoor skate abundance were concurrent with an increase in the biomass of skates as a group (Sosebee, 1998).

Several recent studies have explored the effects of fishing on a variety of skate species in order to determine which life history traits might indicate the most effective management measures for each species. While full age structured modeling is difficult for many of these relatively information poor species, Leslie matrix models parameterized with information on fecundity, age/size at maturity, and longevity have been applied to identify the life stages most important to population stability. Major life stages include the egg stage, the juvenile stage, and the adult stage (summarized here based on Frisk et al 2002). All skate species are oviparous (egg-laying), investing considerably more energy per large, well protected embryo than commercially exploited groundfish. The large, leathery egg cases incubate for extended periods (months to a year) in benthic habitats, exposed to some level of predation and physical damage, until the fully formed juveniles hatch. The juvenile stage lasts from hatching through maturity, several years to over a decade depending on the species. The reproductive adult stage may last several more years to decades depending on the species.

Age and size at maturity and adult size/longevity appear to be more important predictors of resilience to fishing pressure than fecundity or egg survival in the skate populations studied to date. Frisk et al (2002) estimated that although annual fecundity per female may be on the order of less than 50 eggs per year (extremely low compared with teleost groundfish), there is relatively high survival of eggs due to the high parental investment, and therefore egg survival did not appear to be the most important life history stage contributing to population stability under fishing pressure. Juvenile survival appears to be most important to population stability for most North Sea species studied (Walker and Hislop, 1998), and for the small and intermediate sized skates from New England (Frisk et al 2002). For the large and long lived barndoor skates, adult survival was the most important contributor to population stability (Frisk et al 2002). Comparisons of length frequencies for surveyed North Sea skates from the mid and late 1900s led Walker and Hilsop (1998, p. 399) to the conclusion that after years of very heavy exploitation "all the breeding females, and a large majority of the juveniles, of *Raja batis*, *R. fullonica* and *R. clavata* have disappeared, whilst the other species have lost only the very largest individuals." Although juvenile and adult survival may have different importance by skate species, all studies found that one metric, adult size, reflected overall sensitivity to fishing. After modeling several New England skate populations, Frisk et al (2002, p. 582) found "a significant negative, nonlinear association between species total allowable mortality, and species maximum size." This may be an oversimplification of the potential response of skate populations to fishing; in reality it is the interaction of natural mortality, age at maturity, and the selectivity of fisheries which determines a given species sensitivity to fishing and therefore the total allowable mortality (ABC). While we strive to collect information on age at maturity, longevity, and size composition of catch for each skate species in the BSAI to apply it in future assessments, at present we are falling back on the general relationship of total mortality to total biomass (Tier 5), so Frisk's caution is warranted.

Life history and stock structure (Alaska-specific)

Currently there is little or no life history information available for skate species in the eastern North Pacific. Zeiner and Wolf (1993) determined age at maturity and maximum age for *Raja binoculata* and *R. rhina* from Monterey Bay, CA (estimates of maximum age for *R. binoculata* are 11 and 12 years, males and females respectively, and age at maturity 8-11 years; estimates of maximum age for *R. rhina* are 13 and 12 years, males and females respectively, and age at maturity 6-9 years.) However, these parameter values have not been verified for Alaskan stocks.

Given the need for improved stock assessment of skates, and the dearth of knowledge regarding their basic biology, two graduate students at the University of Washington have begun projects detailing aspects of life history and population dynamics of several Bering Sea species. Beth Matta is conducting a study on reproductive biology, age, and growth of *Bathyraja parmifera*, the most common skate species on the eastern Bering Sea shelf. Life history parameters estimated for stock assessment models will include maximum age, gonadosomatic index (GSI), instantaneous rate of natural mortality (M), and age at 50% maturity. She expects to complete her thesis work by spring 2006, although parameter estimates should become available during 2005.

Gerald Hoff is examining a complex of skates from the eastern Bering Sea slope in the genus *Bathyraja*. This research will investigate several potential skate nursery locations on the outer continental shelf of the southeastern Bering Sea, where fishery data suggests areas of heavy use by skates for the deposition of egg cases. The data collected will help define the habitat necessary for successful reproduction of eastern Bering Sea skates and add to the life history data needed for their stock assessment, conservation and management. Specifically, the study will help determine the diversity of species using the nursery areas, estimate the egg density, developmental state and duration, estimate female fecundity, describe habitat structure and biotic associations with egg cases, and evaluate non-skate species predatory interactions with skates in a nursery area. This study will entail a 10-day investigation aboard a chartered research vessel using bottom trawling as an investigative tool to develop a working hypothesis of what constitutes important habitat for skate reproduction and to characterize the skate population using the nursery area.

To date progress on the project has included procuring a research vessel (F/V Ocean Explorer), setting the charter dates, and assembling a team of six scientists that participate in data collection on the study. The charter began on July 27 in Dutch Harbor, Alaska and finished on August 5 in Dutch Harbor. A specific sampling protocol was designed and equipment was assembled to meet these data collection needs (a copy of the sampling protocol is attached). In addition the first of 4 seasonal samplings was conducted on September 10 to 12 aboard the F/V Nordic Fury. The seasonal sampling will continue to monitor the progression of the embryo development and skate reproductive state throughout the year to establish the temporal aspects of the nursery area use.

July-August initial skate nursery investigations were conducted aboard the F/V Ocean Explorer from July 26 to August 5. Bottom trawling was conducted at each of three sites to establish the species utilizing the area, egg spatial densities and extent of the nursery area. Three species specific skate nurseries were identified from the investigation including the Alaska skate *Bathyraja parmifera*, the Aleutian skate *B. aleutica*, and the Bering skate *B. interrupta*. September seasonal sampling of the nursery sites for *B. parmifera* and *B. aleutica* was conducted aboard the F/V Nordic Fury from September 10 to 11, 2004. Sampling included collecting skate egg cases from each of the two sites to determine the progress of embryo development since the July-August sampling; and to determine the reproductive status of mature skates utilizing the nursery area. In addition predatory species were examined for evidence of predation on newly hatched skates. The next research cruise is scheduled for November 16-20, 2004. We expect to incorporate the results of this research within the BSAI skate stock assessment as information becomes available.

Fishery

Directed fishery

In the BSAI, there is no directed fishery for skates at present; however, skates support directed fisheries in other parts of the world (Agnew et al 1999, NE stock assessment 1999, Martin and Zorzi 1993). A directed skate fishery developed in the Gulf of Alaska in 2003 (Gaichas et al, 2003). There has been interest in developing markets for skates in Alaska (J. Bang and S. Bolton, Alaska Fishworks Inc., 11 March 2002 personal communication), and the resource was economically valuable to the GOA participants in 2003, although the price apparently dropped in 2004. Nevertheless, we should expect continued interest in skates as a potential future target fishery in the BSAI as well as in the GOA.

Bycatch and discards

Skates constitute the bulk of the other species catches, accounting for between 66-96% of the estimated totals in 1992-1997. This trend has continued in 1997-2002 (Table 16-3). While skates are caught in almost all fisheries and areas of the Bering Sea shelf, most of the skate bycatch is in the hook and line fishery for Pacific cod, with trawl fisheries for pollock, rock sole and yellowfin sole also catching significant amounts (Table 16-12). (In this assessment, "bycatch" means incidental or unintentional catch regardless of the disposition of catch-it can be either retained or discarded. We do not use the Magnuson Act definition of "bycatch," which always implies discard.) When caught as bycatch, skates may be discarded (and may survive depending upon catch handling practices) although skates caught incidentally are sometimes retained and processed. Now that there is a market for skates in Alaska (see above), it is difficult to determine whether all retained skate catch was incidentally caught. Catch of all other species remains high.

Until 2004 the Other species TAC has never been exceeded in the BSAI or the GOA with the current composition of the category. In 2004, the BSAI open access TAC of 23,124 t was exceeded as of October 23 (AKRO Catch Accounting web page, http://www.fakr.noaa.gov/2004/car110_bsai.pdf), so all other species, including skates, were put on prohibited status (meaning no further retention is allowed, but catch and discard can continue up to the other species OFL of 81,150 t. In addition, the Other species CDQ reserve of 2,040 t was also exceeded as of November 4 (http://www.fakr.noaa.gov/cdq/daily/cdqctd04.pdf). We note that the TAC of other species was reduced from the ABC recommended by the SSC in December 2003, likely to keep the total catch of groundfish in compliance with the BSAI OY cap. However, if interest continues in developing fisheries within this category, the lower aggregate TAC may restrict retention and utilization of the more valuable components of the other species category (skates and octopus).

Historically, skates were almost always recorded as "skate unidentified", with very few exceptions between 1990-2002. However, due to improvements in species identification by fishery observers initiated by Dr. Duane Stevenson within the Observer program in, we can estimate the species composition of observed skate catches in 2004. A preliminary analysis of observer data collected during the first part of 2004 indicates that only about 60% of skate catch is now unidentified. This is largely because many skates are caught in longline fisheries, and if the animal drops off the longline as unretained incedental catch, it cannot be identified by the observer (approximately 80% of longline-caught skates were unidentified, and longline catch accounted for almost 75% of observed skate catch). Of the identified skates, approximately 79% were Alaska skates, *B parmifera*, as would be expected by their dominance of the overall skate biomass in the BSAI. The next most commonly identified were Aleutian, *B. aleutica*, at 5.5% of identified catch, followed by whiteblotched (*B. maculata*) and Bering (*B.*

interrupta) skates at approximately 3% each. These catches are out of proportion to overall BSAI biomass, and reflect differences in catch by area (with whiteblotched skates domintating catch in the AI and Aleutian skates more prevalant on the EBS slope). We are exploring several methods for catch estimation using spatial methods to apply survey species compositions to catch by area. However, surveys only describe summer species distributions, and between 1991 and 2003 only about 15% of skate catch was taken during the summer. We are awaiting a complete year of observer catch data to compare catch estimation methods and determine differences in survey and fishery selectivity.

Survey data

Survey biomass in aggregate and by species

The biomass of all skate species combined has shown an increasing trend from 1975-2004 (Table 16-13). Unfortunately, due to taxonomic uncertainty, we cannot evaluate individual species trends within the complex for surveys prior to 2000. Recent survey information is used to describe the varaible species composition of the skate complex within each of three areas, the EBS shelf, the EBS slope, and the Aleutian Islands. The EBS shelf skate complex is dominated by a single species, the Alaska skate (*B. parmifera)* (Table 16-11). This species is distributed throughout the shelf (Figure 16-5), and accounts for about 91% of the aggregate skate biomass estimated in 1999. The Bering or sandpaper skate *(B. interrupta*) was the next most common species on the EBS shelf, making up about 6% of aggregate skate biomass. It is distributed on the outer continental shelf (Figure 16-6). While skate biomass decreases somewhat on the EBS slope, skate diversity increases substantially (Figure 16-7). The Aleutian skate (*B. aleutica*) is found only on the outer EBS shelf (Figure 16-8), but it comprises the majority of the EBS slope skate biomass, with Bering and Alaska skates still quite common. The skate community in the AI appears to be different from that described for both the EBS shelf and slope (Figure 16-7). In the AI, the most abundant species is the whiteblotched skate, *B. maculata* (45% of aggregate biomass). The whiteblotched skate is found primarily in the eastern Aleutians, and also very far out west (Figure 16-9). Alaska and Aleutian skates are also common, composing about 30% and 15% of aggregate biomass, respectively. The mud skate, *B. tanaretzi,* is relatively common but represented a lower proportion of total biomass (~3%) because it is a smaller skate.

Analytic Approach, Model Evaluation, and Results

At present, the available data do not support population modeling for skates in the BSAI, so none of these stock assessment sections are relevant, except for one:

Parameters Estimated Independently

An analysis was undertaken to explore alternative methods to estimate natural mortality (M) for skate species found in the BSAI. Several methods were employed based on correlations of M with life history parameters including growth parameters (Alverson and Carney 1975, Pauly 1980, Charnov 1993), longevity (Hoenig 1983), and reproductive potential (Roff 1986, Rikhter and Efanov 1976). No information was available for any skate stocks in the BSAI FMP area, so M was estimated using the methods as applied to data for California Big skate (*Raja binoculata*) and Longnose skate (*Raja rhina*), which are found in the GOA but are rare in the BSAI. Considering the uncertainty inherent in applying this method to skate species and stocks not found in the BSAI, we elected to use the lowest estimates of M derived from any of these methods (M=0.10, Table 16-14). Choosing the lowest estimate of M is considered conservative because it will result in the lowest estimates of ABC and OFL under Tier 5. Until we find better information on skate productivity in the BSAI, this is the best interim measure balancing skate conservation and allowing for historical levels of incidental catch in target groundfish fisheries.

Projectons and Harvest Alternatives

Estimated skate bycatch in the BSAI groundfish fisheries has amounted to approximately 4% of survey biomass between 1997 and 2002, if we assume that biomass from each survey is additive for the entire BSAI FMP area (Tables 16- 13 and 16-14). Given the apparently stable biomass for the skate complex overall, this level of incidental exploitation does not appear to have negative impacts to the aggregate complex. However, we have shown that the distribution of species differs greatly by areas within the BSAI, and that overall catch is not necessarily in proportion to BSAI-wide biomass due to the distribution of fishing effort. Because skates represent a potentially valuable fishery resource as well as a potentially sensitive species group, we recommend that they be managed separately from the other species complex. There is a reliable biomass time series for the skate complex as a whole, and recently reliable estimates of biomass for each species within the complex. We feel that our conservative estimate of M (see above) is the best available for managing this species complex until the research initiated in the Bering Sea is completed.

For the time being, we recommend a Tier 5 approach be applied to the skate complex as a whole if the catch remains incidental and no target fishery develops. We further recommend using a 10 year average of aggregate biomass so that we may include multiple estimates from each of the EBS shelf, slope, and AI bottom trawl surveys, but capture recent biomass trends. Other options would include averaging biomass estimates from the entire time series, and using just the most recent estimate (Table 16-13). Applying the M estimate of 0.10 to the 10 year average of bottom trawl survey biomass estimates, we calculate an ABC of 0.75 * 0.10 * (EBS shelf + EBSslope + AI biomass) = 35,849 t. Using the same method to calculate OFL, 0.10 * (EBS shelf + EBSslope + AI biomass) = 47,799 t. Tier 6 options for skate management are not recommended, but are presented in Table 16-7 as an option for Plan Team and SSC consideration.

We recommend that each skate species be managed separately if target fisheries develop, and that directed fishing only be allowed when sufficient life history information becomes available to make reasonable species specfic estimates of productivity.

Ecosystem Considerations

Ecosystem Effects on Stock and Fishery Effects on Ecosystem

Skates are predators in the BSAI system, but some species are more piscivorous and others specialize in benthic invertebrates. The most common skate in the FMP area, the Alaska skate *B. parmifera*, eats primarily pollock (as do most other piscivorous animals in this system). Skate food habits information is more complete for the EBS than for the AI. We expect to learn more about the effects of predation on skates, especially as juveniles, with the completion of Jerry Hoff's research on skate nursery areas.

Summary

Estimated skate bycatch in the BSAI groundfish fisheries has amounted to approximately 4% of survey biomass between 1997 and 2002. Skates are a potentially valuable fishery resource, and a target fishery has developed for components of the skate complex in the GOA. We recommend a Tier 5 approach be applied to the skate complex as a whole if the catch remains incidental and no target fishery develops. Applying the M estimate of 0.10 to the 10 year average of bottom trawl survey biomass estimates, we calculate 0.75 * 0.10 * (EBS shelf + EBSslope + AI biomass) = **35,849 t = ABC**. Using the same method to calculate 0.10 * (EBS shelf + EBSslope + AI biomass) = **47,799 t = OFL**. We recommend that each skate species be managed separately if target fisheries develop, and that directed fishing only be allowed when sufficient life history information becomes available to make reasonable species specfic estimates of productivity.

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Tables

Table 16- 10. Life history information available for BSAI and GOA skate species.

Species	Common	Max Length (cm)[1]	Max Age	Age Length Mature[2]	Feeding mode[3]	n / egg case[1]	Depth range (m)[4]	Est. of M[6]
Raja binoculata	**big skate**	**180-240**	**?**	**8-12 yrs 109-130 cm**	**predatory?[1]**	**1-7**	**3-800[5]**	**0.10**
Raja rhina	**longnose skate**	**137**	**?**	**7-10 yrs 74-100 cm**	**?**	**1**	**25-675[5]**	**0.10**
Bathyraja interrupta	**Bering skate**	**86**	**?**	**?**	**benthophagic**	**1**	**50-1380**	**0.10**
Bathyraja tanaretzi	**mud skate**	**70***	**?**	**?**	**?**	**1**		**0.10**
Bathyraja trachura	**black skate**	**89**	**?**	**?**	**?**	**1**	**800-2050**	**0.10**
Bathyraja parmifera	**Alaska skate**	**61-91, 113***	**?**	**?**	**predatory**	**1**	**25-300**	**0.10**
Bathyraja aleutica	**Aleutian skate**	**120-150**	**?**	**?**	**predatory**	**1**	**300-950**	**0.10**
Bathyraja lindberghi	**commander skate**	**93***	**?**	**?**	**?**	**1**	**175-950**	**0.10**
Bathyraja maculata	**whiteblotched skate**	**120***	**?**	**?**	**predatory**	**1**	**175-550**	**0.10**
Bathyraja minispinosa	**whitebrow skate**	**82***	**?**	**?**	**benthophagic**	**1**	**100-1400**	**0.10**
Bathyraja violacea	**Okhotsk skate**	**150***	**?**	**?**	**benthophagic**	**1**	**25-500**	**0.10**

[1]Eschemeyer, 1983 (assuming that *B. kincaidii* = *B. interrupta*) and *species id notes by Jay Orr (AFSC,)[2]Zeiner and Wolf, 1993. [3]Orlov, 1998 & 1999 (benthophagic eats mainly amphipods, worms. Predatory diet primarily fish, cephalopods). [4]McEachran and Miyake, 1990b. [5]Allen and Smith, 1988. [6] Gaichas et al, 1999**.**

Table 16-11. Species composition of skate complex from most recent AFSC BSAI trawl surveys**.**

		2004 EBS shelf		**2004 EBS slope**		**2004 Aleutians**	
Skate species	**common**	**bio (t)**	**cv**	**bio (t)**	**cv**	**bio (t)**	**cv**
Bathyraja abyssicola	deepsea	0		164	0.72	0	
Bathyraja aleutica	Aleutian	2,463	0.41	15,039	0.14	11,518	0.45
Bathyraja interrupta	Bering	11,709	0.12	1,957	0.11	147	0.75
Bathyraja lindbergi	commander	0		4,167	0.15	0	
Bathyraja maculata	whiteblotched	0		3,433	0.16	26,246	0.25
Bathyraja minispinosa	whitebrow	0		1,771	0.22	34	1.00
Bathyraja parmifera	Alaska	413,061	0.05	4,248	0.33	12,742	0.22
Bathyraja taranetzi	mud	0		698	0.20	1,799	0.17
Bathyraja trachura	black	0		1,677	0.13	1	0.98
Bathyraja violacea	Okhotsk	0		8	0.99	0	
Raja binoculata	big	479	1.00	0		422	0.53
Raja rhina	longnose	0		0		0	
skate unid (all others)		1	1.32	20	0.52	142	0.38
Total skate complex		427,713	0.05	33,182	0.08	53,050	0.16

Table 16-12. Estimated catch (t) of all skate species combined by target fishery, gear, and area, 1997-2002. Similar catch estimates are not available for 2003-2004; see text for explanation.

Target fishery	gear	1997	1998	1999	2000	2001	2002
Arrowtooth	hook n line		0.65	9.72	1.31		0.49
	trawl	1.62	117.64	17.74	43.02	89.98	81.55
Arrowtooth Total		1.62	118.29	27.46	44.33	89.98	82.04
Atka mackerel	trawl	110.51	130.81	126.66	71.50	80.57	73.30
Flatheadsole	trawl	777.22	1,867.59	1,215.15	1,655.80	1,752.36	1,530.37
Other	hook n line		10.42	26.07	52.48	70.43	31.17
	trawl						8.82
Other Total			10.42	26.07	52.48	70.43	39.98
OtherFlats	trawl	39.18	103.15	69.22	115.16	20.09	58.48
Pacific cod	hook n line	13,298.81	13,534.64	9,651.09	12,975.65	14,116.58	14,059.10
	pot	1.50	0.01	0.11	0.06	0.10	0.00
	trawl	715.23	770.48	984.30	1,053.86	631.91	1,400.41
Pacific cod Total		14,015.53	14,305.12	10,635.50	14,029.56	14,748.59	15,459.51
Pollock	trawl	349.73	405.67	375.87	598.19	627.58	807.04
Rock sole	trawl	679.20	558.69	322.21	334.28	820.60	836.61
Rockfish	hook n line	110.27	6.73	0.69	1.70	4.42	0.84
	trawl	30.05	39.94	53.61	50.53	47.67	78.14
Rockfish Total		140.32	46.67	54.30	52.23	52.09	78.99
Sablefish	hook n line	266.00	110.10	109.54	115.86	194.11	233.13
	pot			0.09	0.01	0.06	0.01
	trawl		0.06			1.24	
Sablefish Total		266.00	110.16	109.63	115.87	195.41	233.14
Turbot	hook n line	140.82	280.84	319.92	317.36	187.07	120.80
	pot			1.22			
	trawl	16.13	18.67	17.34	23.92	16.66	7.76
Turbot Total		156.95	299.51	338.48	341.28	203.73	128.57
Unknown	hook n line	0.11	2.00	1.16	0.95	0.21	
	trawl		1.09		0.01	0.11	
Unknown Total		0.11	3.09	1.16	0.95	0.32	
Yellowfinsole	trawl	1,210.99	1,358.70	778.11	1,464.90	1,908.69	1,950.67
Grand Total		17,747.37	19,317.86	14,079.84	18,876.53	20,570.46	21,278.69

FMP area	area	1997	1998	1999	2000	2001	2002
AI	541	569.98	640.25	462.61	501.96	540.77	288.88
	542	200.87	369.17	239.96	608.31	422.64	217.74
	543	86.30	119.02	99.79	698.20	1,546.14	188.84
AI Total		857.15	1,128.45	802.36	1,808.47	2,509.56	695.46
EBS	509	1,920.87	2,317.12	2,033.62	2,830.27	3,092.09	3,112.51
	512	0.92		14.33		91.68	132.82
	513	2,572.53	2,605.18	1,993.53	2,641.56	2,726.15	4,036.76
	514	134.61	40.86	203.65	101.55	83.42	223.02
	516	74.26	73.35	199.06	122.64	249.95	336.13
	517	3,499.07	4,820.64	3,514.42	4,910.51	4,378.18	4,394.10
	518	49.00	82.65	80.14	52.09	101.80	65.00
	519	42.69	106.07	57.86	83.01	96.52	68.93
	521	7,066.94	7,205.81	4,420.95	5,724.41	6,517.25	7,327.22
	523	548.85	455.37	404.81	284.01	324.73	314.50
	524	980.48	482.36	355.11	318.01	399.14	572.23
EBS Total		16,890.22	18,189.41	13,277.48	17,068.06	18,060.90	20,583.23
BSAI Total		17,747.37	19,317.86	14,079.84	18,876.53	20,570.46	21,278.69

Table 16-13. Skate biomass time series from bottom trawl surveys in BSAI areas, 1975-2004, with options for setting Tier 5 ABC and OFL.

	year	**EBS shelf**	**EBS slope**	**AI**	
	1975	24,349			
	1976				
	1977				
	1978				
	1979	58,147	3,056		
	1980			10,123	
	1981		2,743		
	1982	164,084	2,723		
	1983	161,041		16,259	
	1984	186,980			
	1985	149,576	3,329		
	1986	251,321		19,491	
	1987	346,691			
	1988	409,076	3,271		
	1989	410,119			
	1990	534,556			
	1991	448,458	4,031	14,987	
	1992	390,466			
	1993	375,040			
	1994	414,235		24,964	
	1995	391,768			
	1996	423,913			
	1997	393,716		28,902	
	1998	354,188			
	1999	370,543			
	2000	325,292		29,206	
	2001	419,678			
	2002	410,573	69,275	34,412	
	2003	386,339			
	2004	427,713	33,182	53,047	
M est		*0.1*	*0.1*	*0.1*	
					BSAI all
average all		341,813	15,201	25,710	
ABC all		25,636	1,140	1,928	28,704
OFL all		34,181	1,520	2,571	38,272
average last 10		390,372	51,229	36,392	
ABC last 10		29,278	3,842	2,729	35,849
OFL last 10		39,037	5,123	3,639	47,799
most recent	2004	427,713	33,182	53,047	
ABC most recent		32,078	2,489	3,979	38,546
OFL most recent		42,771	3,318	5,305	51,394

Table 16-14. Estimates of M based on life history for skate species. "Age mature" was given a range for M estimates by the Rikhter and Efanov method to account for uncertainty in this parameter.

Species	Area	Sex	Hoenig	Age mature	Rikhter & Efanov	Alverson & Carney	Charnov	Roff
Big skate	CA	*males*	0.38					
	CA	*females*	0.35					
	CA			8	0.19			
	CA			9	0.16			
	CA			10	0.13			
	CA			11	0.12			
	CA			12	0.10			
Longnose skate	CA	*males*	0.32			0.31	0.44	0.23
	CA	*females*	0.35			0.45	0.29	0.03
	CA	*both*					0.31	
	CA			7	0.22			
	CA			8	0.19			
	CA			9	0.16			
	CA			10	0.13			

Figures

Figure 16-4 Five different skate (*Bathyraja*) species from one haul, 2000 Bering sea slope survey.

The following CPUE maps were created using data from the RACE Bering Sea Groundfish Survey. The survey data used spans from 1982 to 2004. However, identification problems were apparent for certain species during the early years of the survey. In this case, only the years in which we are confident the species were being identified correctly were used for these maps. The data shown is the average CPUE for each station for the appropriate years. All the CPUE data is in Kg/ha and the scale changes appropriately for each species.

Figure 16-5 Alaska Skate (*Bathyraja parmifera*)
Average CPUE 2001 - 2004

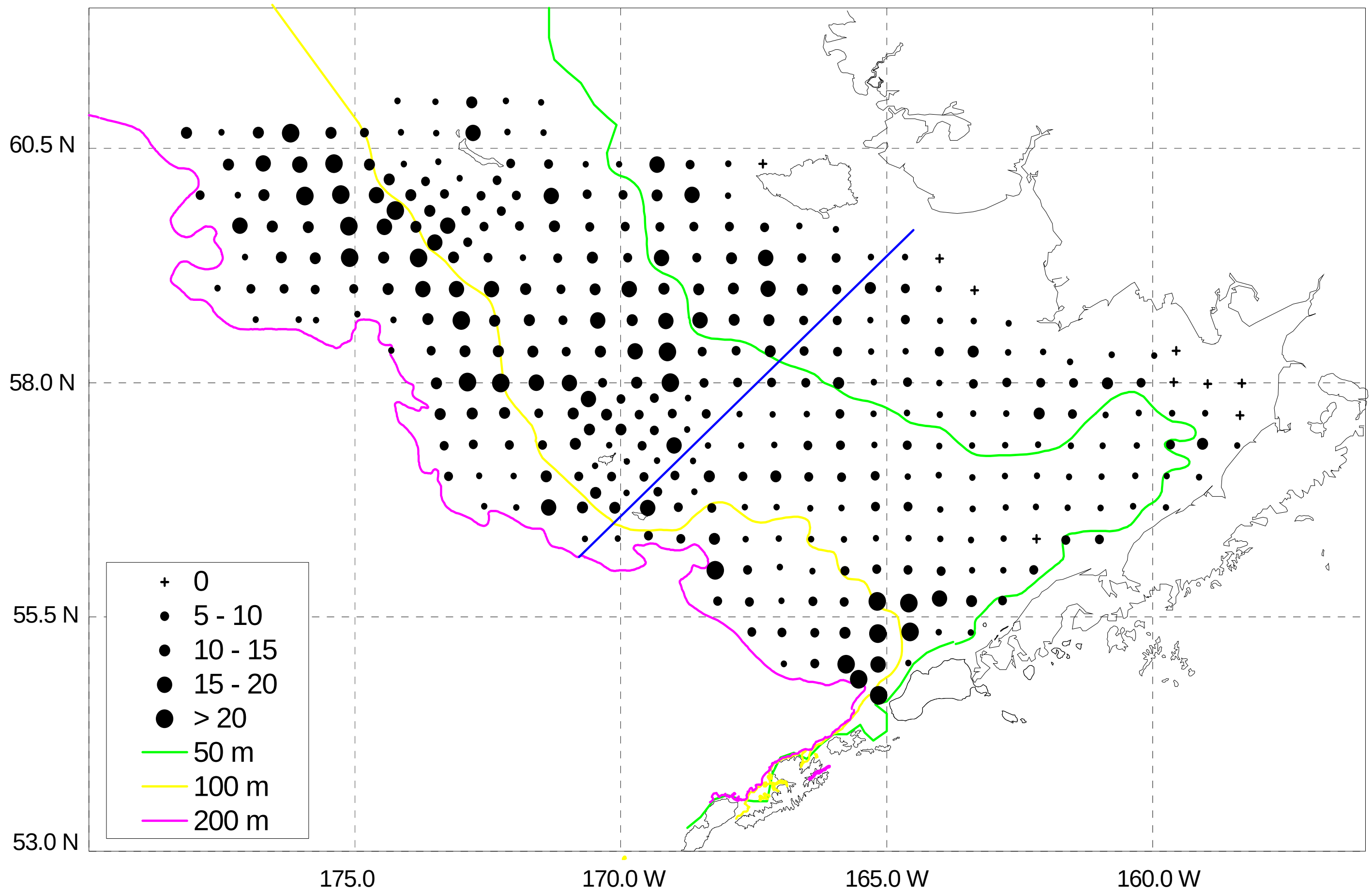
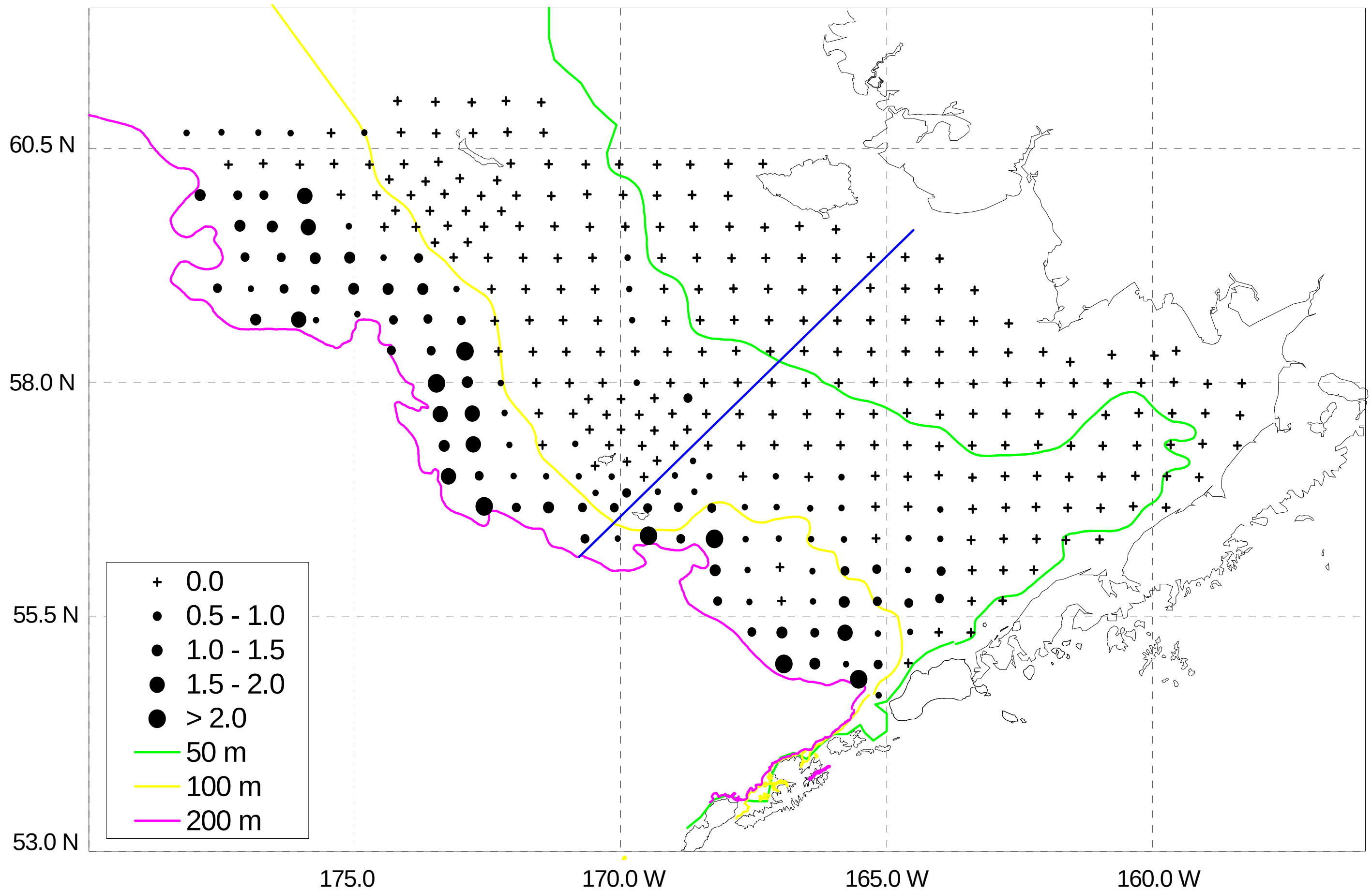


Figure 16-6. Bering Skate (*Bathyraja interrupta*)
Average CPUE 2001 - 2004



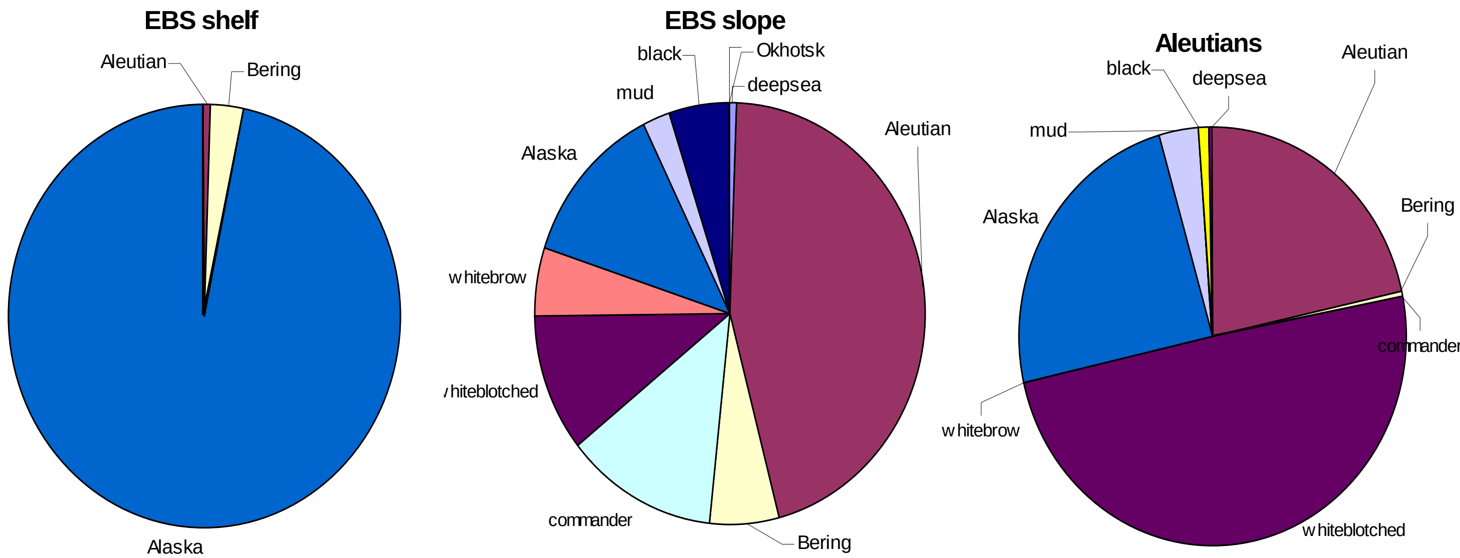
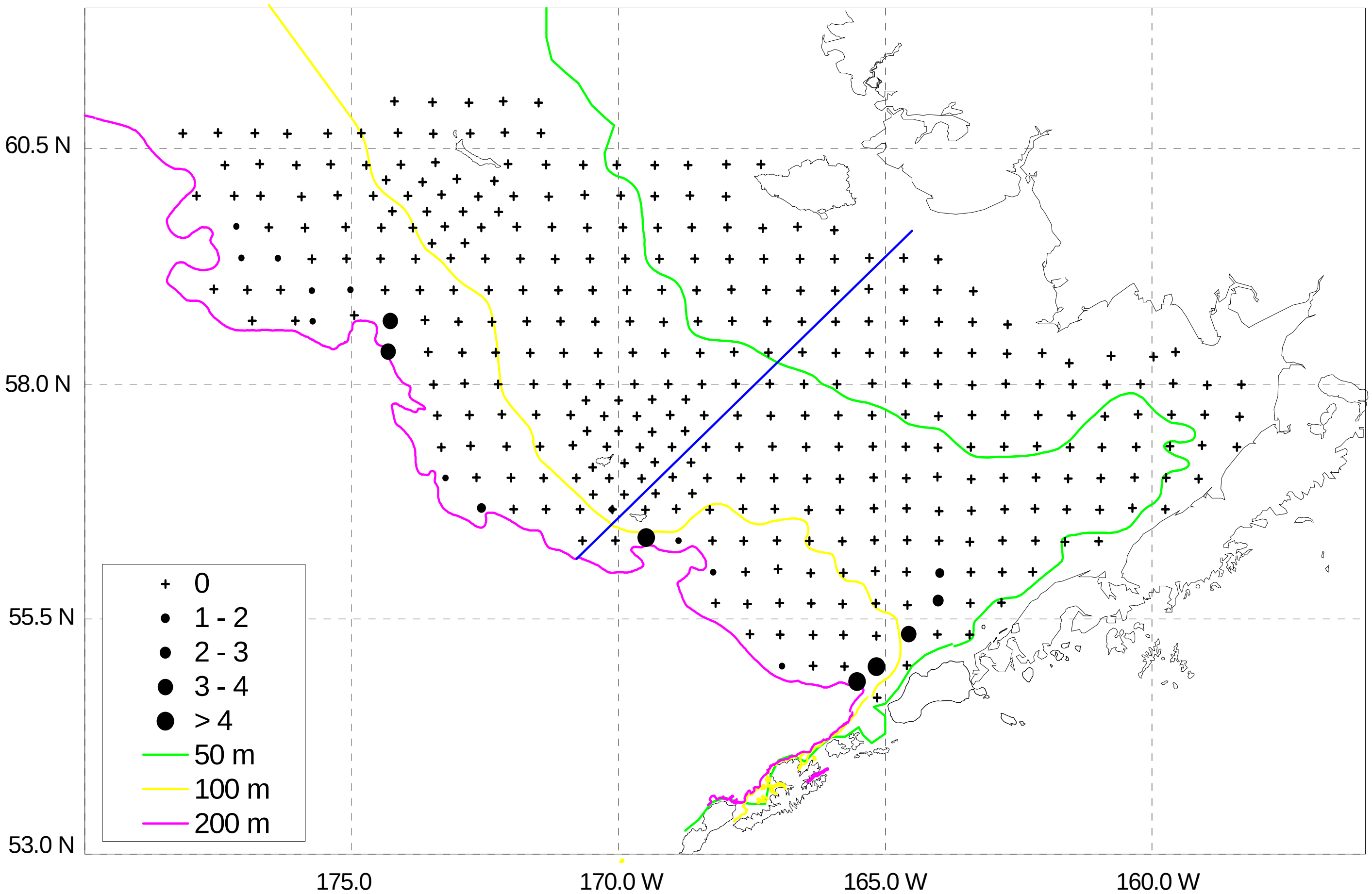


Figure 16-7. Skate diversity comparison between the EBS shelf, EBS slope, and AI areas. Species compositions are from 2004 bottom trawl survey results.

Figure 16-8. Aleutian Skate (*Bathyraja aleutica*)
Average CPUE 2001 - 2004



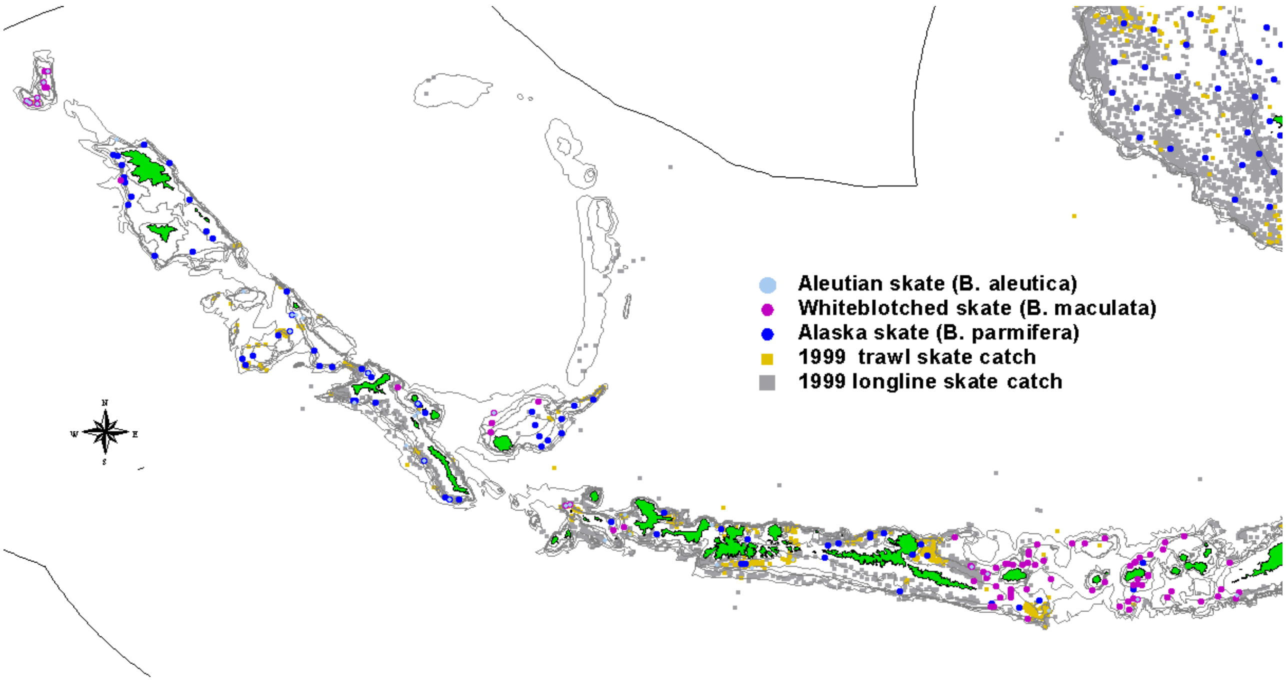


Figure 16-9 Distribution of skate species (1997 survey) and skate catch in the AI, 1999.

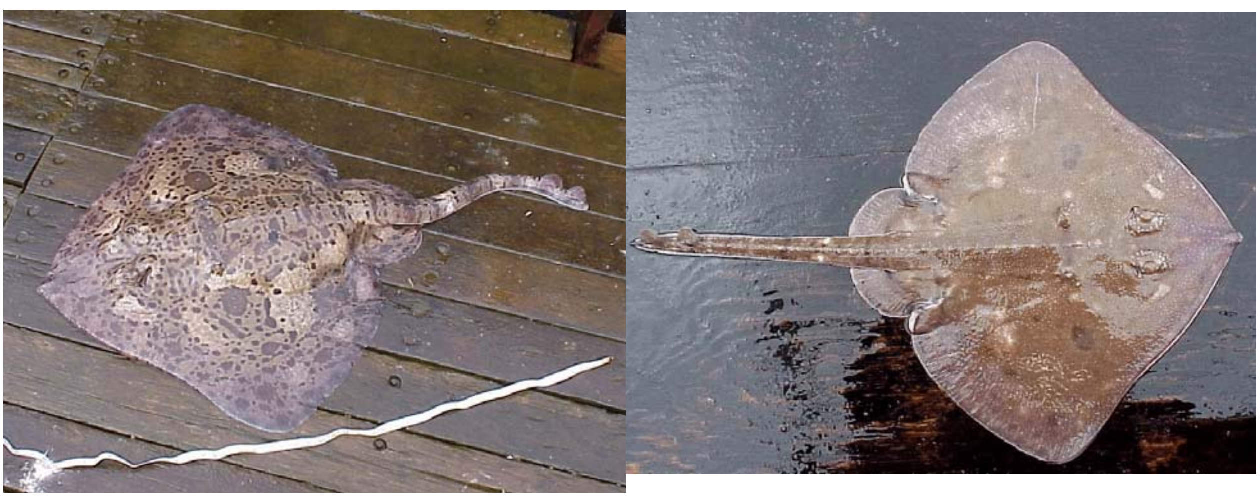


Figure 16-10 Alaska skate, *Bathyraja parmifera*, from the Aleutians (left) and EBS shelf (right).

BSAI Sculpins

Introduction

Description, scientific names, and general distribution

Sculpins (*Cottidae*) are relatively small, benthic-dwelling predatory teleost fish, with many species in the North Pacific (Figure 16-11). During the cooperative U.S.-Japan surveys, 41 species of sculpins were identified in the EBS and 22 species in the Aleutian Islands region (see Table 16-1). Sculpin diversity remains high in recent surveys of both areas (Table 16-15). Considered as a species complex, sculpins are distributed throughout all benthic habitats from shallow to deep, rocky to flat in the BSAI, such that they would cover any map of the area completely. In this assessment, we focus on a few species to illustrate distributions of biomass (Figures 16-12 through 16-24), and see discussion under Survey biomass section).

Management units

Sculpins are managed as part of the BSAI other species complex. This means that their catch is reported in aggregate as "other" along with the catch of sharks, skates, and octopi (BSAI) and squid (GOA). (Because catch is officially reported within the Other species complex, estimates of sculpin catch must be made independently for each year using observer data; see below.) In the BSAI, catch of other species is limited by a Total Allowable Catch (TAC) which is based on an Allowable Biological Catch (ABC) estimated by the average catch of all other species combined from 1977-present (Fritz, 1999). In the GOA, the TAC of other species has been established as 5% of the sum of the TACs for all other assessed target species in the GOA (Gaichas et al., 1999). Right now, sculpins are taken only as bycatch in fisheries directed at target species in the BSAI, so future catch of sculpins is more dependent on the distribution and limitations placed on target fisheries than on any harvest level established for this category.

Life history and stock structure (general)

Despite their abundance and diversity, sculpin life histories are not well known in Alaska. In terms of life history, sculpins are different from many target groundfish species in that they lay adhesive eggs in nests, and many exhibit parental care for eggs (Eschemeyer et al, 1983). Bigmouth sculpins, *Hemitripterus bolini*, lay eggs in vase sponges–however, it is unknown whether they are completely dependent on finding a particular type of sponge to reproduce. This type of reproductive strategy may make sculpin populations more sensitive to changes in benthic habitats than other groundfish species such as pollock, which are broadcast spawners with pelagic eggs. Some larger sculpin species such as the great sculpin, *Myoxocephalus polyacanthocephalus*, reach sizes of 70 cm and 8 kg in the western North Pacific. In the western Pacific, great sculpins are reported to have relatively late ages at maturity (5-8 years, Tokranov, 1985) despite being relatively short-lived (13-15 years), which suggests a limited reproductive portion of the lifespan relative to other groundfish species. Mean fecundities for great sculpin were 60,000 to 88,000 eggs per gram body weight (Tokranov, 1985). In addition, the diversity of sculpin species in the FMP areas suggests that each sculpin population might react to similar environmental changes (whether natural or fishing influenced) in different ways. Within each sculpin species, observed spatial differences in fecundity, egg size, and other life history characteristics suggest local population structure (Tokranov, 1985), which is very different from wide ranging species such as sharks. All of these characteristics indicate that sculpins as a group might be managed separately from the other species complex, and perhaps most efficiently within a spatial context rather than with a global annual aggregate TAC.

Fishery

Directed fishery

There is no directed fishing for any sculpin species in the BSAI at this time.

Bycatch and discards

Skates and sculpins constitute the bulk of the other species catches, accounting for between 66-96% of the estimated totals in 1992-1997. This trend has continued in 1997-2002 (Table 16- 3). Sculpins are caught by a wide variety of fisheries, but trawl fisheries for yellowfin sole, Pacific cod, pollock, Atka mackerel and rock sole catch the most (Table 16-16).

It is likely that the larger sculpin species (Irish lords, *Hemilepidotus* spp., great sculpin and plain sculpins, *Myoxocephalus* spp., and bigmouth sculpin *Hemitripterus bolini*) which contribute to the majority of sculpin biomass on surveys are the ones commonly encountered incidentally in groundfish fisheries. However, it is unclear which sculpin species were commonly taken in BSAI groundfish fisheries up to 2002, because observers did not regularly identify animals in these groups to species.At least 80% (by weight) of the observed sculpin catch in past years was recorded as "sculpin unidentified," with the remainder of catch identified to the genus level (*Hemilepidotus, Myoxocephalus, Gymnocanthus, Triglops*). Only small amounts (<2%) of sculpin catch in past years were identified to species.

With the initiation of an observer program species identification project in 2003-2004, sculpin catch is now being identified to genus for the larger sculpin species. Preliminary analysis of observed catch data for May-September of 2004 indicates that only about 10% of observed sculpin catch was unidentified (which includes genera not currently trained). Approximately 55% of the catch by weight was identified as *Myoxocephalus* spp., about 18% of the catch as *Hemilepidotus* spp., and about 16% of the catch as the bigmouth sculpin, *Hemitripterus bolini*. As with skates, we are waiting for a full year of catch identification to examine trends in fishery catch vs survey catch of sculpin species. This represents a major improvement in catch information for the sculpin complex; we appreciate the work on the part of Dr. Duane Stevenson and the entire observer program and encourage its continuation.

Survey data

Survey biomass in aggregate and by species

Aggregate sculpin biomass in the BSAI shows no clear trend (Table 16-17), and should probably not be used as an indicator of population status for a complex with so much species diversity. Trends in biomass are available for only a few sculpin species for the period 1982-2004 due to difficulties with species identification. We present trends for *Myoxocephalus* spp. (1982-1999, with individual species identification within the genus for 200-2004), bigmouth sculpin, *Hemitripterus bolini*, and the yellow Irish lord, , *Hemitripterus bolini* (Figure 16-12). The species composition of the sculpin complex as estimated by bottom trawl surveys of the EBS shelf, EBS slope, and AI demonstrates the diversity of this complex and the regional differences in its composition (Table 16-18.) The larger species dominate the EBS shelf, with *Myoxocephalus* spp being the most common, followed by bigmouth sculpins and yellow Irish lords. While bigmouth sculpins are still a large component of the EBS slope biomass, they share dominance with darkfin sculpins and other sculpin species not commonly found on the slope. In the Aleutians, yellow Irish lords account for the highest proportion of sculpin biomass, followed by darkfin sculpins and scissortail sculpins, a species not found on EBS surveys.

Sculpins show segregation in space within the EBS shelf. It may be possible to apply spatial catch estimation techniques using the species distributions shown in Figures 16-13 to 16-24) to estimate the species specific catch within genus-level identification provided by observers starting in 2004. For example, the distribution of *Myoxocephalus* spp. is throughout the EBS shelf (Figure 16-13). There is a clear spatial partitioning of *Myoxocephalus polyacanthocephalus* from *Myoxocephalus jaok*, the two most common species, with the former on the middle shelf (Figure 16-14)and the latter on the inner shelf (Figure 16-15) . Therefore, genus of catch combined with location allows identification to species. We expect to apply these techniques as soon as a complete year of catch identification is completed.

Analytic Approach, Model Evaluation, and Results

The available data do currently not support population modeling for sculpins in the BSAI, so none of these stock assessment sections are relevant, except for one:

Parameters Estimated Independently

An analysis was undertaken to explore alternative methods to estimate natural mortality (M) for sculpin species found in the BSAI. Several methods were employed based on correlations of M with life history parameters including growth parameters (Alverson and Carney 1975, Pauly 1980, Charnov 1993), longevity (Hoenig 1983), and reproductive potential (Roff 1986, Rikhter and Efanov 1976). Little information was available for sculpin stocks in the BSAI FMP area, so M was estimated using the methods as applied to data for Russian sculpin species. Considering the uncertainty inherent in applying this method to sculpin species and stocks not found in the BSAI, we elected to use the lowest estimates of M derived from any of these methods (M=0.19, Table 16-19). Choosing the lowest estimate of M is considered conservative because it will result in the lowest estimates of ABC and OFL under Tier 5. Until we find better information on sculpin productivity in the BSAI, this is the best interim measure balancing sculpin conservation and allowing for historical levels of incidental catch in target groundfish fisheries.

Projectons and Harvest Alternatives

Estimated sculpin bycatch in the BSAI groundfish fisheries has been approximately 4% of aggregate survey biomass (Table 16-16 and 16-17)) between 1997 and 2002. While this level of incidental exploitation appears small, we are unable to draw conclusions about the effects of fishing on components of the complex at this time, because we have only a partial year of species identification in the catch. However, leaving sculpins within the even larger aggregate other species complex provides no benefit to these fish or to the fisheries that might wish to retain some other species but cannot when the aggregate TAC is exceeded, as it has been this year. Because sculpins are such a diverse category themselves, and because their life history is so different from skates, sharks, and octopi as described above, we recommend that they be managed separately from the other species complex. There is a reliable biomass time series for the sculpin complex as a whole, and recently reliable estimates of biomass for each species within the complex. We feel that our conservative estimate of M (see above) is the best available for managing this species complex until the research initiated in the Bering Sea is completed.

For the time being, we recommend a Tier 5 approach be applied to the sculpin complex as a whole if the catch remains incidental and no target fishery develops. We further recommend using a 10 year average of aggregate biomass so that we may include multiple estimates from each of the EBS shelf, slope, and AI bottom trawl surveys, but capture recent biomass trends. Other options would include averaging biomass estimates from the entire time series, and using just the most recent estimate (Table 16-17). Applying the M estimate of 0.19 to the 10 year average of bottom trawl survey biomass estimates, we calculate an ABC of 0.75 * 0.19 * (EBS shelf + EBSslope + AI biomass) = 29,376 t. Using the same method to calculate OFL, 0.19 * (EBS shelf + EBSslope + AI biomass) = 39,168 t. Tier 6 options for sculpin management are not recommended, but are presented in Table 16-7 as an option for Plan Team and SSC consideration.

The 10-year survey biomass average was applied to groups within the other species complex as a default, but for sculpins a 5 year average may be more sensitive to population trends given their shorter lifespans. Appling the M estimate of 0.19 to the 10 year average of bottom trawl survey biomass estimates, we calculate an ABC of 0.75 * 0.19 * (EBS shelf + EBSslope + AI biomass) = 28,348 t. Using the same method to calculate OFL, 0.19 * (EBS shelf + EBSslope + AI biomass) = 37,798 t.

In the unlikely event that target fisheries develop for some sculpin species, we recommend that each targeted sculpin species be managed separately, and that directed fishing only be allowed when sufficient life history information becomes available to make reasonable species specfic estimates of productivity.

Ecosystem Considerations

Ecosystem Effects on Stock and Fishery Effects on Ecosystem

Little is known about individual sculpin species' food habits in the BSAI. Limited information indicates that the larger sculpin species prey on shrimp and other benthic invertebrates, as well as some juvenile pollock. Bigmouth sculpins can also feed on adult pollock and other fish. The smaller sculpin species are largely benthic invertebrate feeders, and are likely the prey of other groundfish, although further analysis of food habits information is required to clarify the role of both large and small sculpin species within the BSAI ecosystem.

Summary

Estimated sculpin bycatch in the BSAI groundfish fisheries has amounted to approximately 4% of survey biomass between 1997 and 2002. We recommend a Tier 5 approach be applied to the sculpin complex as a whole if the catch remains incidental and no target fishery develops. Applying the M estimate of 0.19 to the 10 year average of bottom trawl survey biomass estimates, we calculate 0.75 * 0.10 * (EBS shelf + EBSslope + AI biomass) = **29,376 t = ABC**. Using the same method to calculate 0.10 * (EBS shelf + EBSslope + AI biomass) = **39,168 t = OFL**. In the unlikely event that target fisheries develop for some sculpin species, we recommend that each targeted sculpin species be managed separately, and that directed fishing only be allowed when sufficient life history information becomes available to make reasonable species specfic estimates of productivity.

References

(please see the full reference section, pages 8-13 of this assessment)

Tables

Table 16-15 . Sculpin species observed during the years 1995-2003 on EBS bottom trawl surveys. Note that this is a subset of all possible species reported in Table 16-1.

Species Name	**Common Name**
Icelinus borealis	Northern sculpin
Gymnocanthus tricuspis	Arctic staghorn sculpin
Artediellus miacanthus	Bride sculpin
Malacocottus kincaidi	Blackfin sculpin
Eurymen gyrinus	Smoothcheek sculpin
Icelus euryops	Wide-eye sculpin
Gymnocanthus detrisus	
Enophrys diceraus	Antlered sculpin
Nautichthys oculofasciatus	Sailfin sculpin
Leptocottus armatus	Pacific staghorn sculpin
Psychrolutes paradoxus	Tadpole sculpin
Artediellus sp.	
Blepsias bilobus	Crested sculpin
Icelus spatula	Spatulate sculpin
Nautichthys pribilovius	Eyeshade sculpin
Hemilepidotus hemilepidotus	Red Irish Lord
Gymnocanthus pistilliger	Threaded sculpin
Malacoccottus zonurus	Darkfin sculpin
Myoxocephalus verrucocus	Warty sculpin
Artediellus pacificus	Pacific hookear sculpin
Triglops forficate	Scissortail sculpin
Triglops septicus	Spectacled sculpin
Triglops macellus	Roughspine sculpin
Gymnocanthus galeatus	Armorhead sculpin
Hemilepoidotus jordani	Yellow Irish Lord
Myoxocephalus polyacanthocephalus	Great sculpin
Dasycottus setiger	Spinyhead sculpin
Icelus spiniger	Thorny sculpin
Hemitripterus bolini	Bigmouth sculpin
Myoxocephalus jaok	Plain sculpin
Triglops pingeli	Ribbed sculpin
Hemilepodotus papilio	Butterfly sculpin

Table 16-16. Estimated catch (t) of all sculpin species combined by target fishery, gear, and area, 1997-

2002. Similar catch estimates are not available for 2003-2004; see text for explanation.

Target fishery	gear	1997	1998	1999	2000	2001	2002
Arrowtooth	trawl	0	17	14	33	30	13
Atka mackerel	trawl	290	310	294	261	1,212	714
Flatheadsole	trawl	401	666	631	769	745	653
OtherFlats	trawl	47	93	25	68	18	17
Pacific cod	hook n line	1,040	1,527	1,177	1,462	2,145	1,356
	pot	359	279	659	705	357	384
	trawl	1,616	1,511	1,024	1,537	851	1,056
Pacific cod Total		3,014	3,318	2,861	3,704	3,353	2,797
Pollock	trawl	109	188	67	185	199	188
Rock sole	trawl	478	143	250	458	372	314
Rockfish	trawl	32	20	24	23	19	58
Sablefish	hook n line	2	2	4	1	1	16
Turbot	hook n line	1	5	3	4	0	1
	trawl	3	5	9	11	2	1
Turbot Total		4	10	12	16	3	2
Yellowfinsole	trawl	3,099	1,517	1,287	1,569	1,716	2,403
Grand Total		7,478	6,285	5,470	7,086	7,670	7,176
FMP area	**area**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
AI	541	431	547	495	646	404	269
	542	205	442	316	388	298	174
	543	135	93	155	379	900	689
AI Total		771	1,081	967	1,413	1,603	1,133
EBS	508		0				
	509	1,726	1,362	1,102	1,909	1,554	969
	512	1		4		6	18
	513	2,343	1,385	1,268	1,476	1,734	2,496
	514	889	145	304	198	67	466
	516	22	14	66	12	74	79
	517	837	899	691	1,000	531	596
	518	7	7	29	10	26	7
	519	355	531	404	390	1,050	301
	521	466	829	614	585	976	941
	523	6	7	8	12	7	4
	524	56	25	12	80	40	167
EBS Total		6,707	5,204	4,503	5,673	6,067	6,043
Grand Total		7,478	6,285	5,470	7,086	7,670	7,176

Table 16- 17. Sculpin biomass time series from bottom trawl surveys in BSAI areas, 1975-2004, with options for setting Tier 5 ABC and OFL.

	year	EBS shelf	EBS slope	AI	
	1975	111,160			
	1976				
	1977				
	1978				
	1979	284,228	4,555		
	1980			33,624	
	1981		5,372		
	1982	340,877	3,261		
	1983	292,025		24,570	
	1984	252,259			
	1985	182,469	2,316		
	1986	303,671		32,211	
	1987	195,501			
	1988	233,169	4,944		
	1989	215,666			
	1990	219,020			
	1991	272,653	2,449	15,904	
	1992	239,947			
	1993	215,922			
	1994	260,994		17,192	
	1995	218,693			
	1996	187,817			
	1997	215,766		13,680	
	1998	197,675			
	1999	146,185			
	2000	161,350		13,037	
	2001	143,555			
	2002	176,728	6,409	14,248	
	2003	199,351			
	2004	210,509	5,488	16,781	
M est		*0.19*	*0.19*	*0.19*	
					BSAI all
average all		223,585	4,349	20,139	
ABC all		31,861	620	2,870	35,350
OFL all		42,481	826	3,826	47,134
average last 10		185,763	5,949	14,437	
ABC last 10		26,471	848	2,057	29,376
OFL last 10		35,295	1,130	2,743	39,168
most recer	2004	210,509	5,488	16,781	
ABC most recent		29,998	782	2,391	33,171
OFL most recent		39,997	1,043	3,188	44,228

Table 16-18. Species composition of sculpin complex from most recent AFSC BSAI trawl surveys.

		2004 EBS shelf		2004 EBS slope		2004 Aleutians	
Sculpin species	**common**	**bio (t)**	**cv**	**bio (t)**	**cv**	**bio (t)**	**cv**
Myoxocephalus jaok	plain	68,671	0.10	0		0	
Myoxocephalus polyacanthocephalus	great	58,505	0.11	5	0.93	1,519	0.30
Hemitripterus bolini	bigmouth	34,748	0.14	1,289	0.18	790	0.29
Hemilepidotus jordani	yellow irish lord	33,630	0.33	113	0.78	8,259	0.17
Myoxocephalus verrucosus	warty	10,089	0.18	0		0	
Gymnocanthus pistilliger	threaded	1,275	0.22	0		0	
Dasycottus setiger	spinyhead	1,019	0.20	701	0.14	72	0.91
Gymnocanthus galeatus	armorhead	785	0.57	0		506	0.31
Icelus spiniger	thorny	616	0.17	39	0.18	0	0.52
Triglops pingeli	ribbed	556	0.49	0		0	
Hemilepidotus papilio	butterfly	379	0.43	0		0	
Malacocottus zonurus	darkfin	122	0.99	1,798	0.21	4,487	0.14
Triglops macellus	roughspine	62	0.58	0		0	
Triglops scepticus	spectacled	29	0.45	57	0.67	1,040	0.21
Icelus spatula	spatulate	13	0.42	0		0	
sculpin unid (all others)		10	0.71	1,486	0.22	98	0.24
Artediellus pacificus	hookear sculpin	trace		0		0	
Triglops forficata	scissortail sculpin	0		0		2,073	0.47
Leptocottus armatus	staghorn	0		0		9	1.00
Enophrys diceraus	antlered	0		0		17	0.55

Table 16-19.Estimates of M based on life history for sculpin species. "Age mature" was given a range for M estimates by the Rikhter and Efanov method to account for uncertainty in this parameter.

Species	Area	Sex	Hoenig	Age mature	Rikhter & Efanov	Alverson & Carney	Charnov
Arctic staghorn sculpin	WBS	*males*	0.53				
	WBS	*females*	0.47				
	WBS			4	0.41		
Common staghorn sculpin	Kamchatka	*males*	0.32	5	0.32		
	Kamchatka	*females*	0.25	6	0.26		
Red Irish Lord	Puget Sound		0.70				
Threaded sculpin	EBS	*males*	0.42			0.36	0.65
		females	0.47			0.58	0.40
Armorhead sculpin	Kamchatka	*males*	0.38				
	Kamchatka	*females*	0.32				
Great sculpin	Kamchatka	*males*	0.47	5	0.32		
	Kamchatka	*males*		6	0.26		
	Kamchatka	*females*	0.32	7	0.22		
	Kamchatka	*females*		8	0.19		
Plain sculpin	Sea of Japan	*males*	0.35	4	0.41		
	Sea of Japan	*males*		5	0.32		
	Sea of Japan	*females*	0.28	6	0.26		
	Sea of Japan	*females*		7	0.22		

Figures

Figure 16-11. Selected sculpin species found in the BSAI (not to scale!!): clockwise from top left, bigmouth sculpin (*Hemitriperus bolini*), grunt sculpin (*Ramphocottus richardsoni*), yellow Irish lord (*Hemilepidotus jordani*), spinyhead sculpin (*Dasycotus setiger*), and in the lower left, the armorhead sculpin (*Gymnocanthus galeatus*).

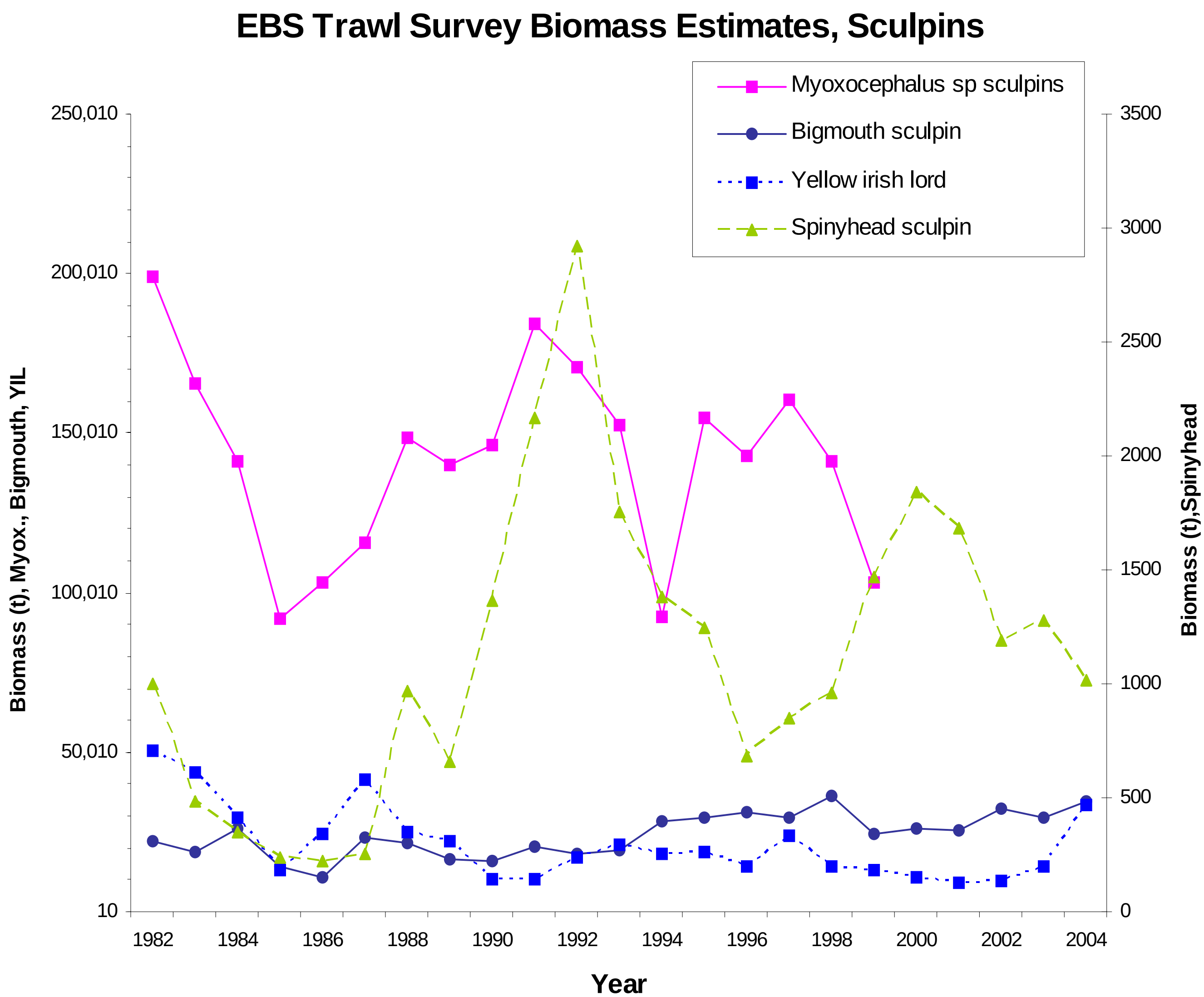


Figure 16-12. Biomass time series from EBS shelf bottom trawl surveys for selected sculpin species, 1982-2004.

Figure 16- 13. All *Myoxocephalus* sp.
Average CPUE 1982 - 2004

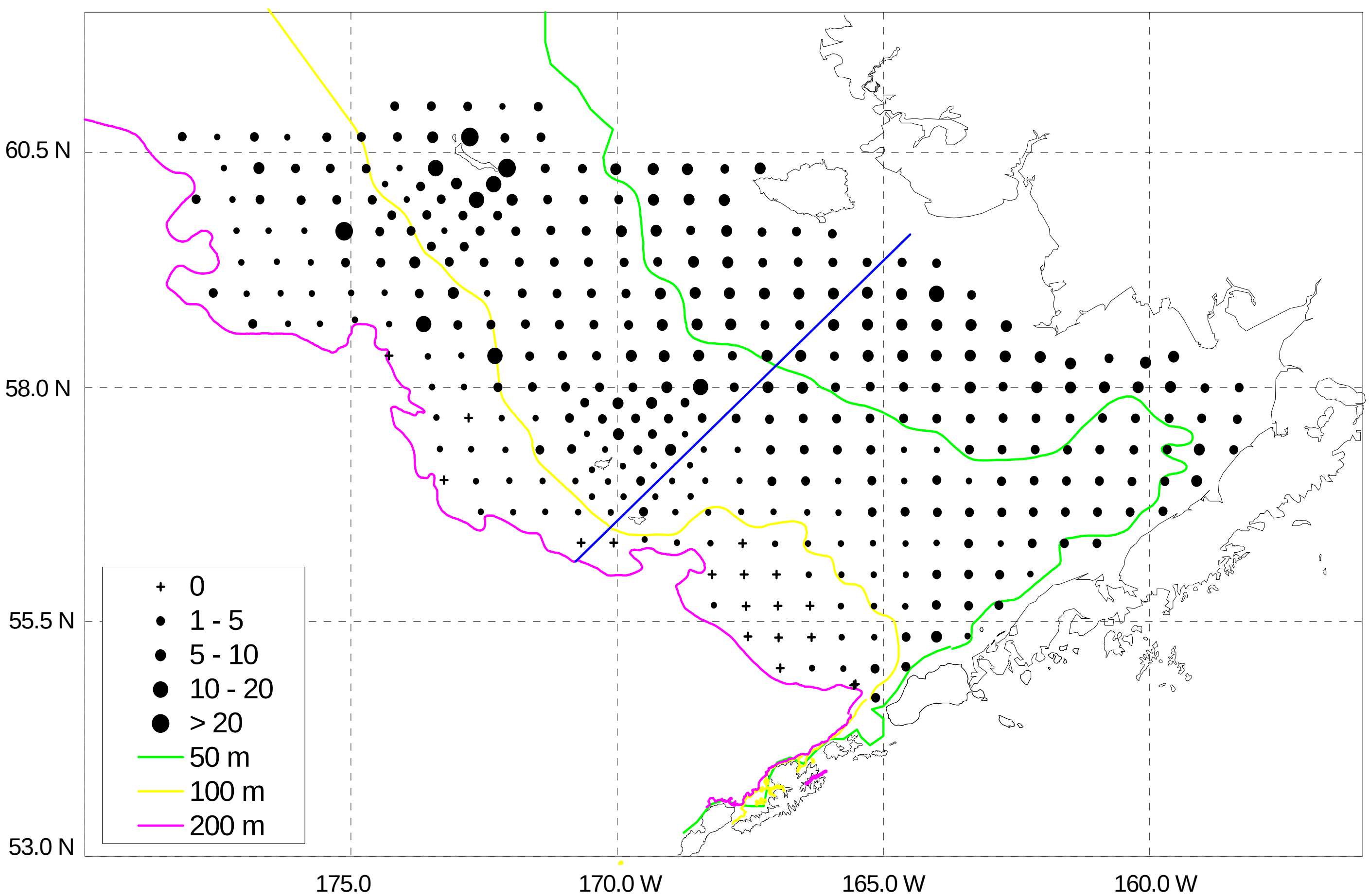


Figure 16-14. Great Sculpin (*Myoxocephalus polyacanthocephalus*)
Average CPUE 2000 - 2004

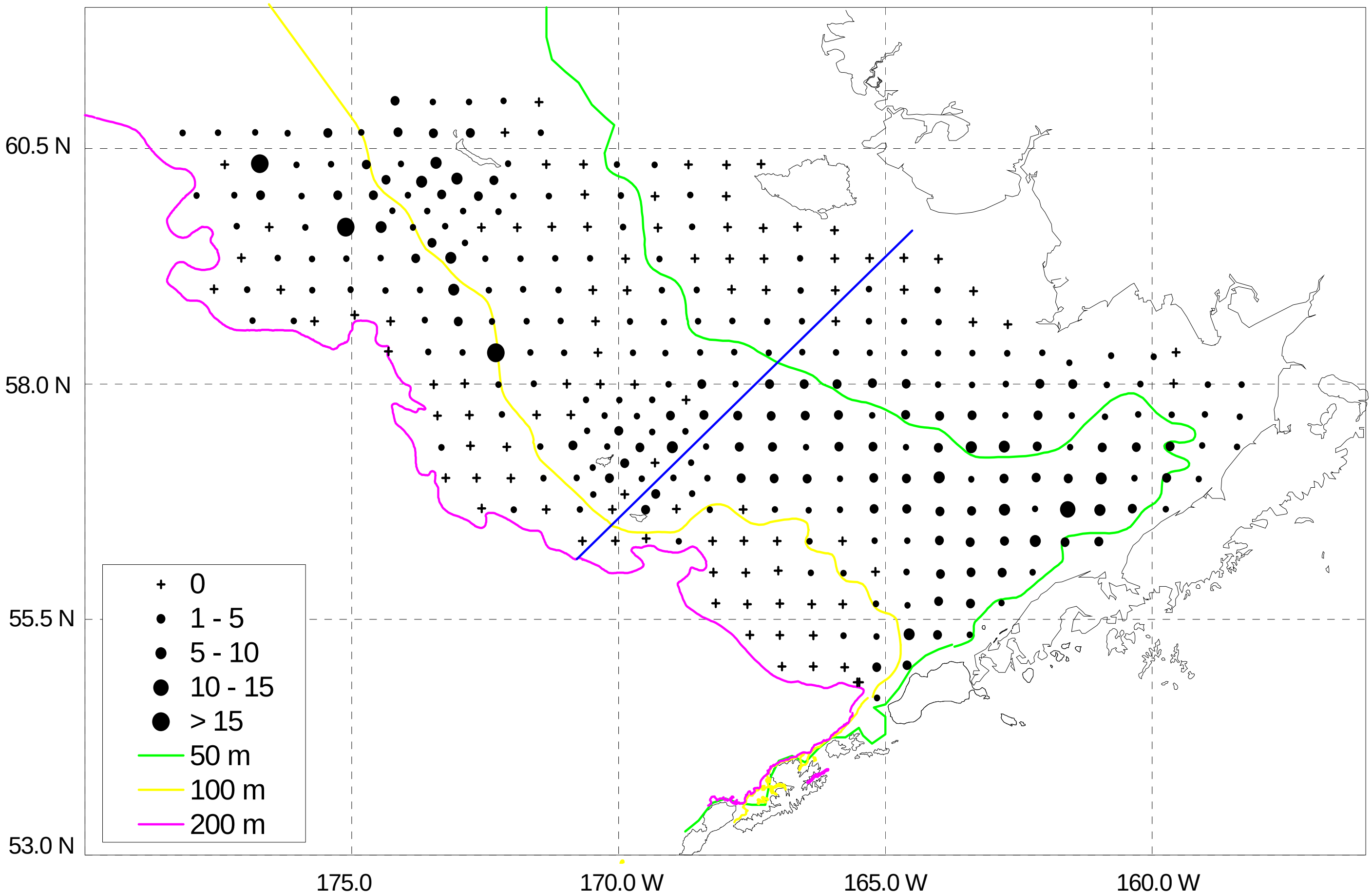


Figure 16-15. Plain Sculpin (*Myoxocephalus jaok*)
Average CPUE 2000 - 2004

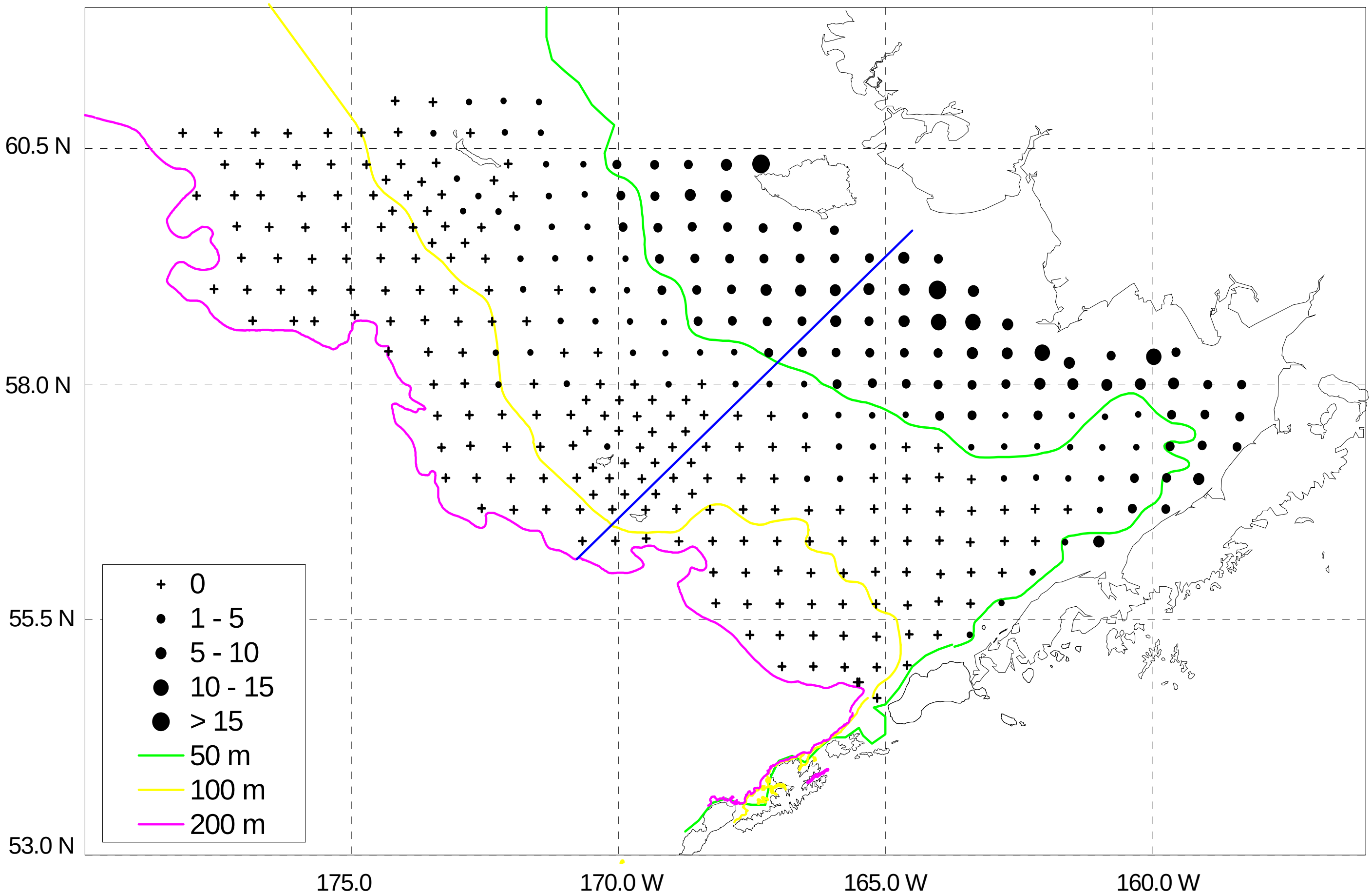


Figure 16-16. Warty Sculpin (*Myoxocephalus verrucosus*)
Average CPUE 2000 - 2004

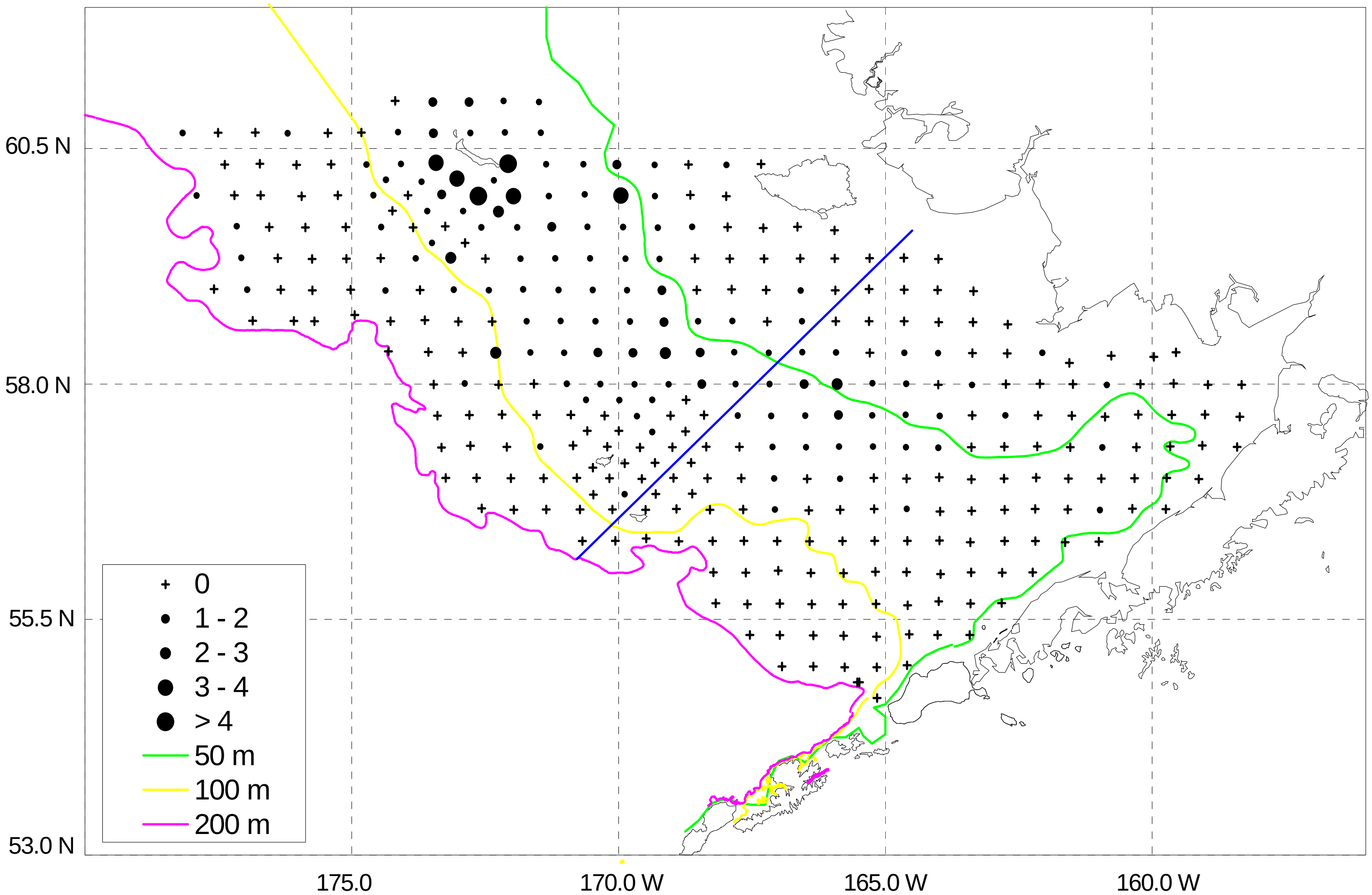


Figure 16-17. Bigmouth Sculpin (*Hemitripterus bolini*)
Average CPUE 1982 - 2004

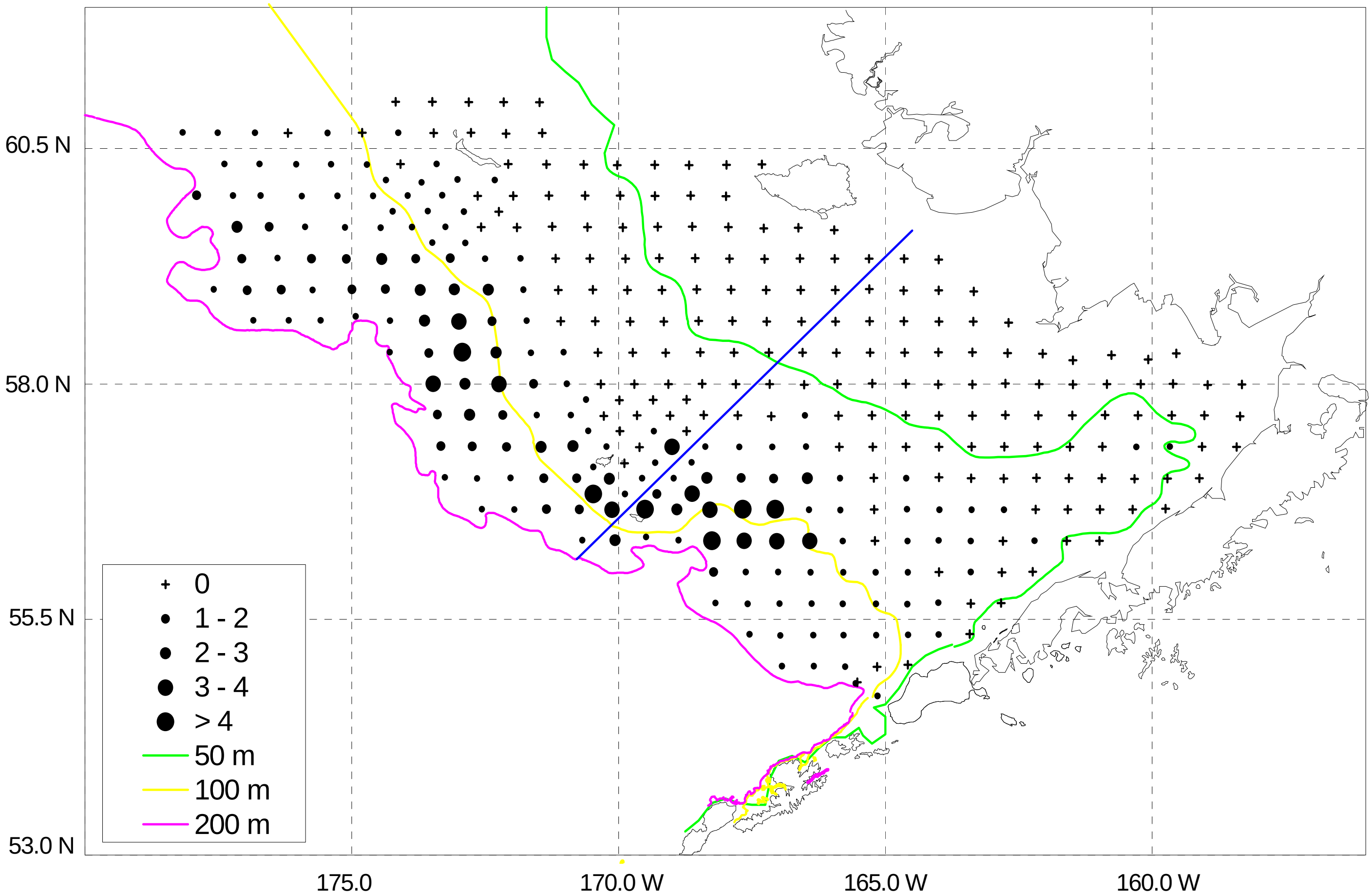


Figure 16-18. Yellow Irish Lord (*Hemilepidotus jordani*)
Average CPUE 1982 - 2004

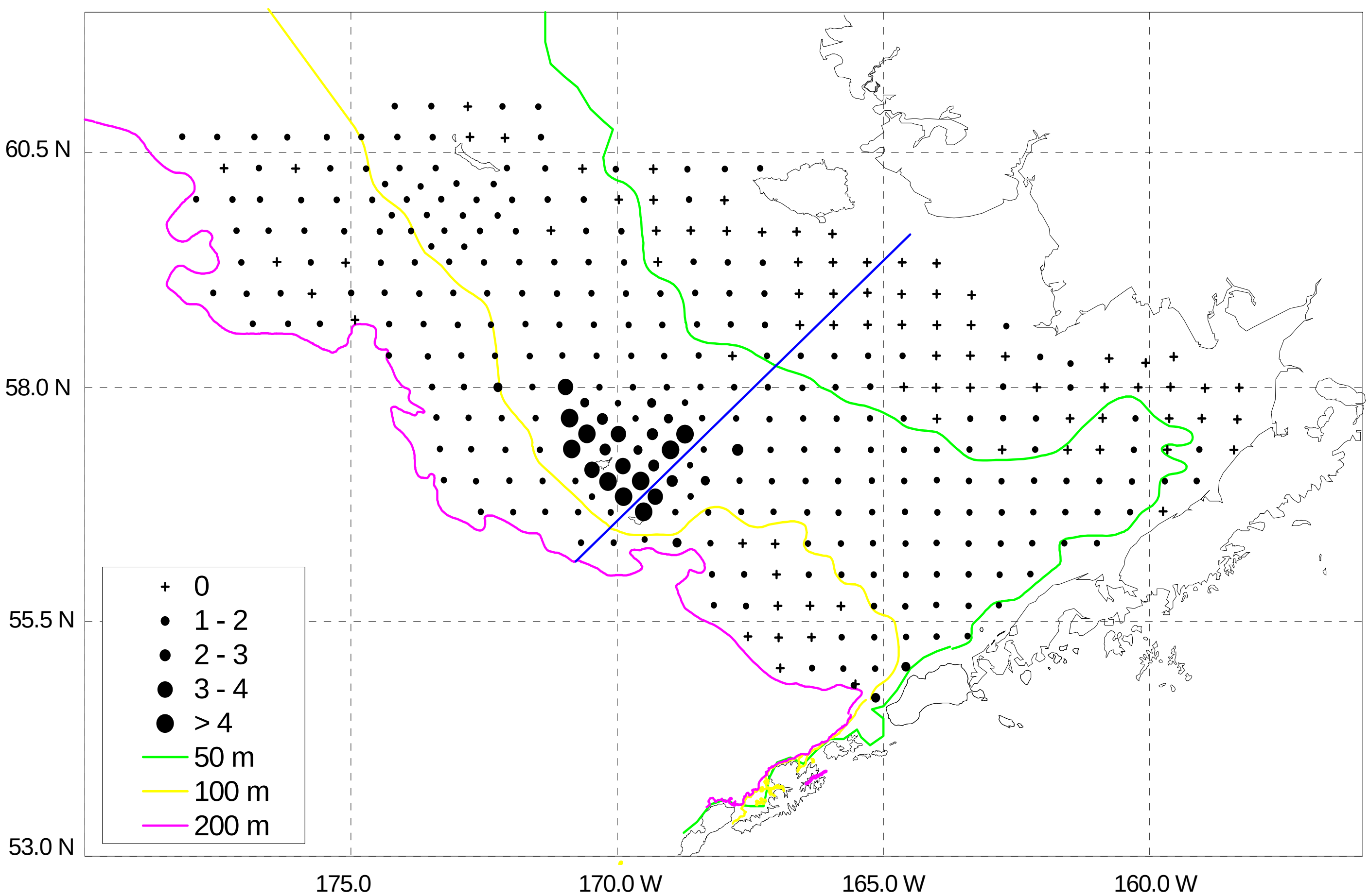


Figure 16-19. Butterfly Sculpin (*Hemilepidotus papilio*)
Average CPUE 1999 - 2004

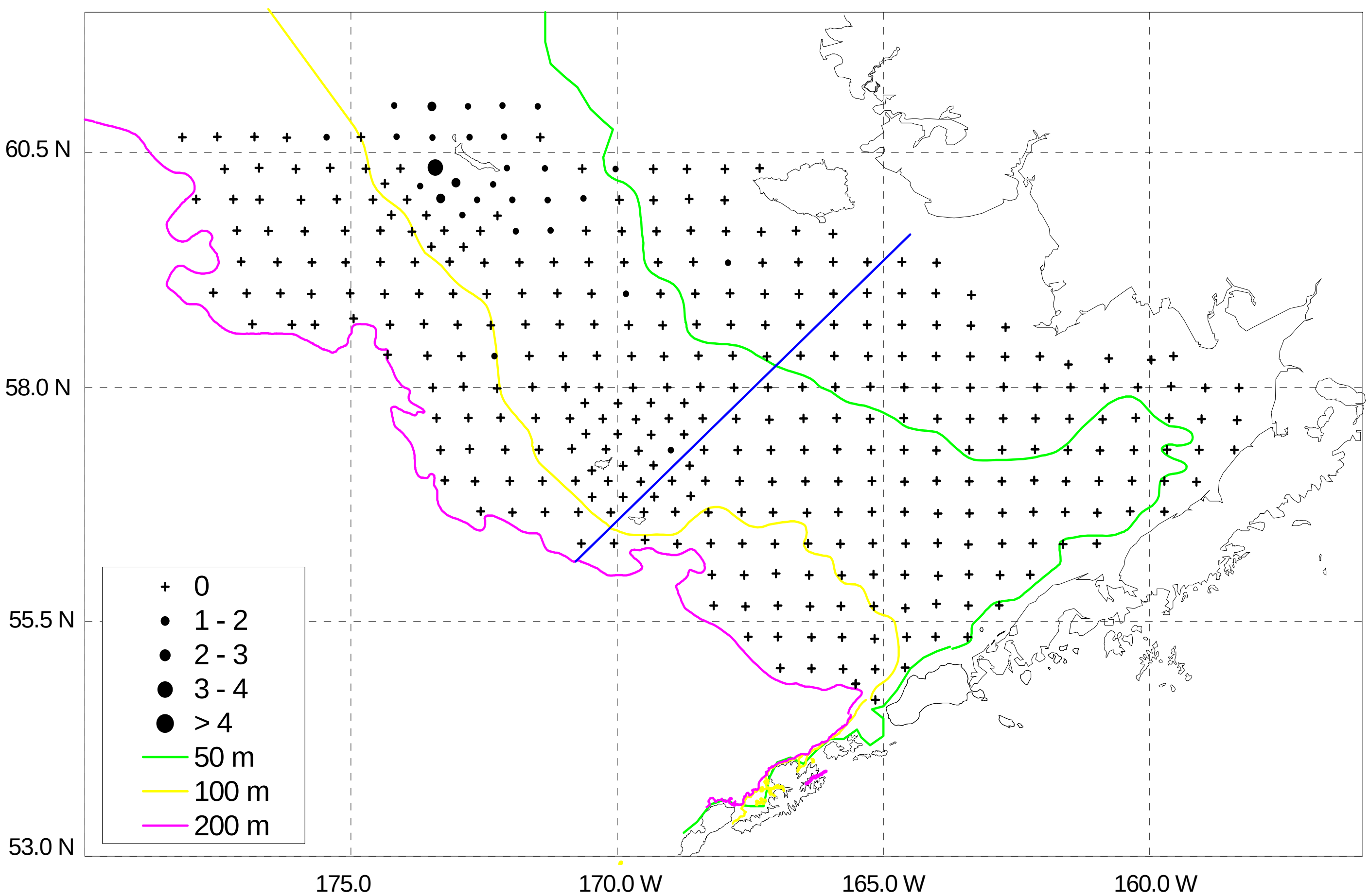


Figure 16-20. Threaded Sculpin (*Gymnocanthus pistilliger*)
Average CPUE 1997 - 2004

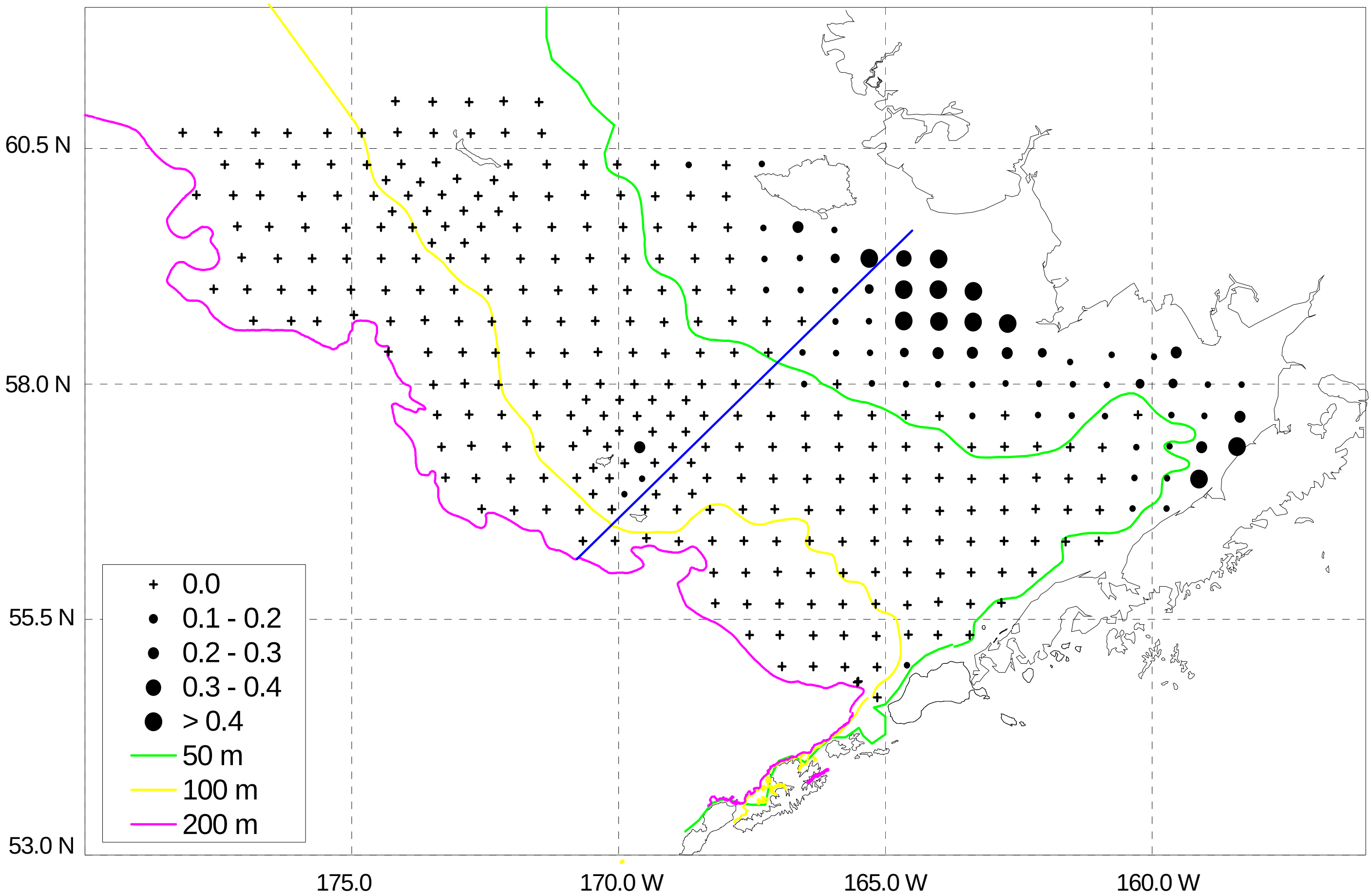


Figure 16-21. Spinyhead Sculpin (*Dasycottus setiger*)
Average CPUE 1982 - 2004

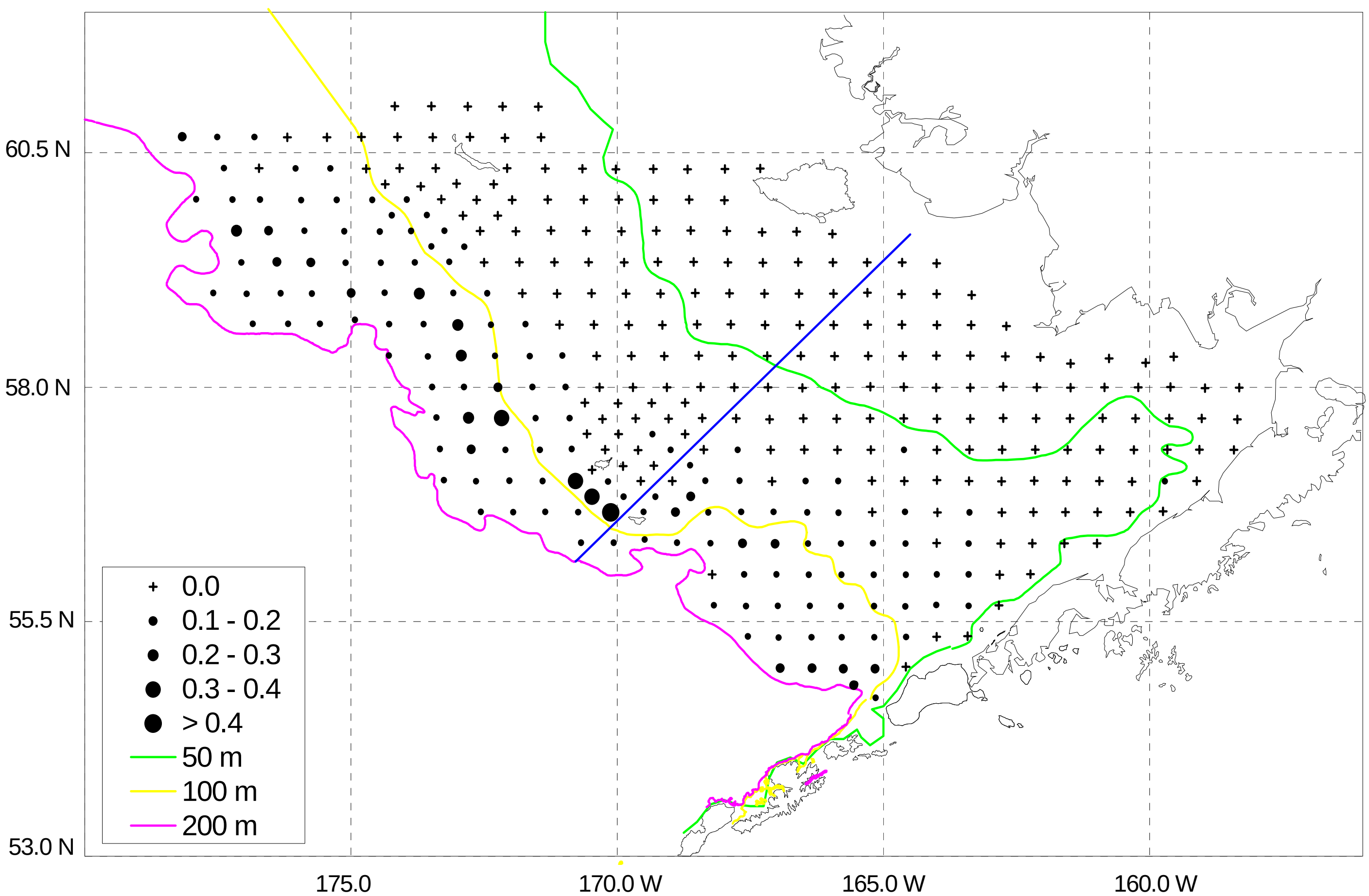


Figure 16-22. Thorny Sculpin (*Icelus spiniger*)
Average CPUE 1999 - 2004

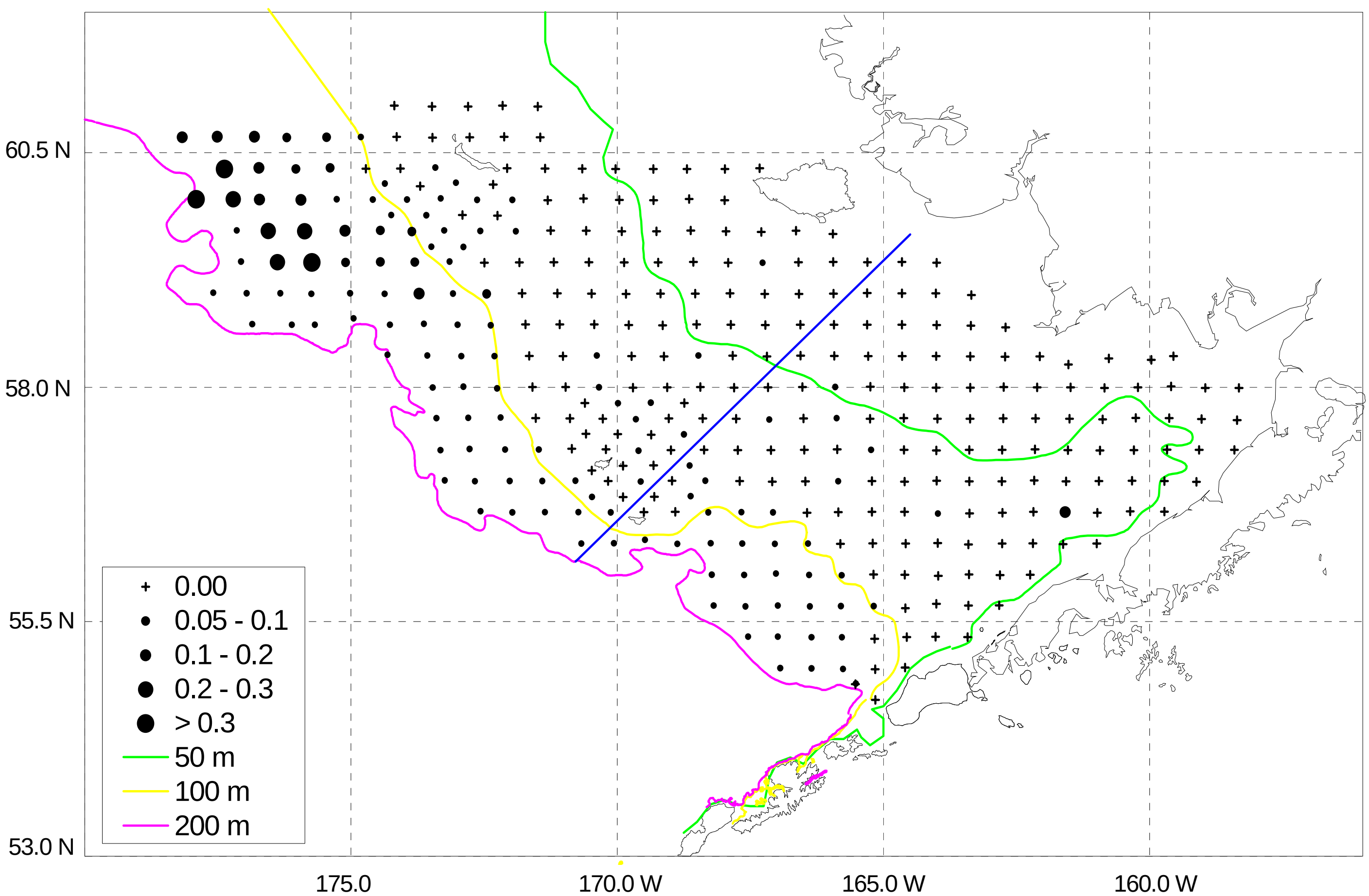


Figure 16-23. Ribbed Sculpin (*Triglops pingeli*)
Average CPUE 1998 - 2004

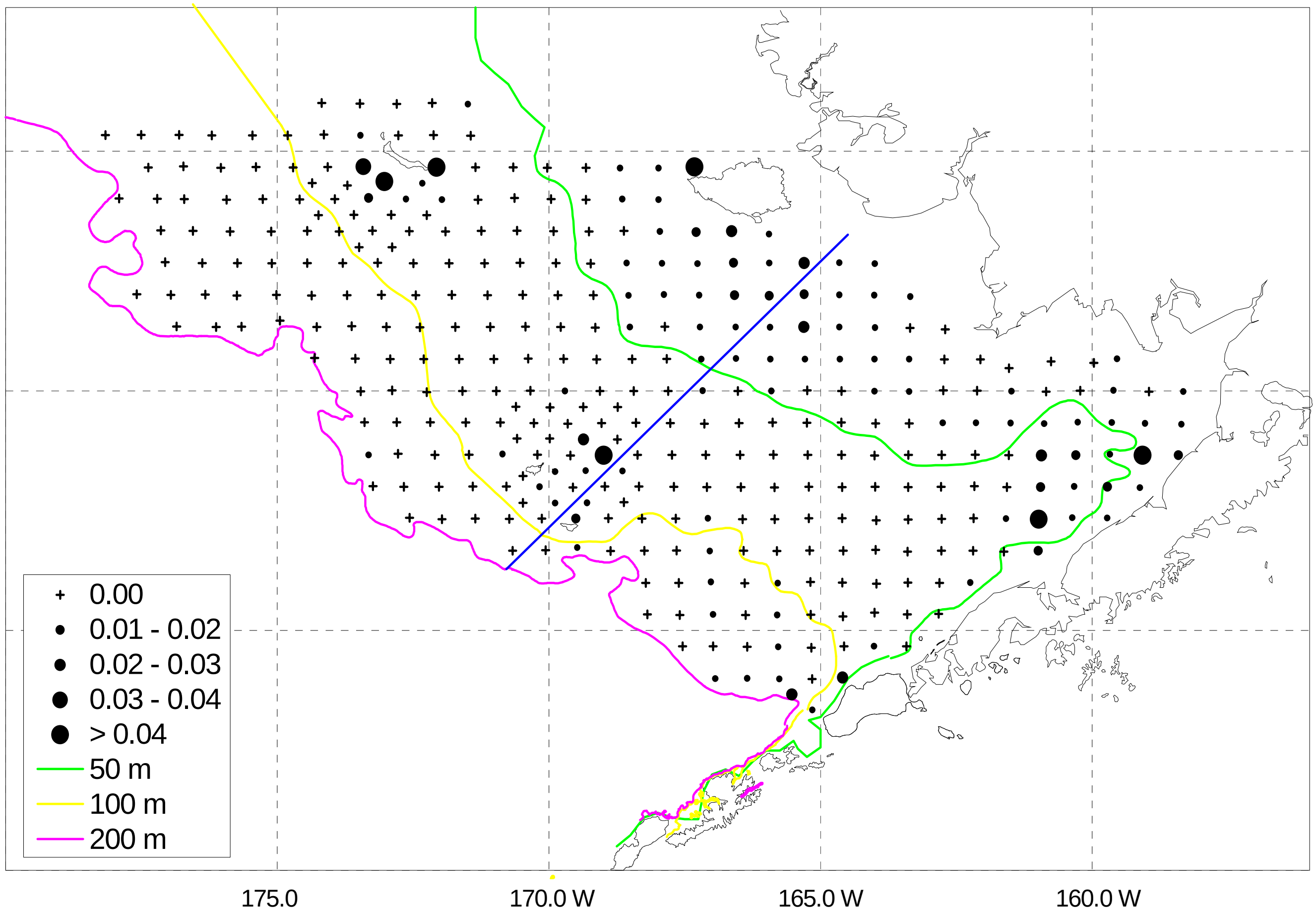
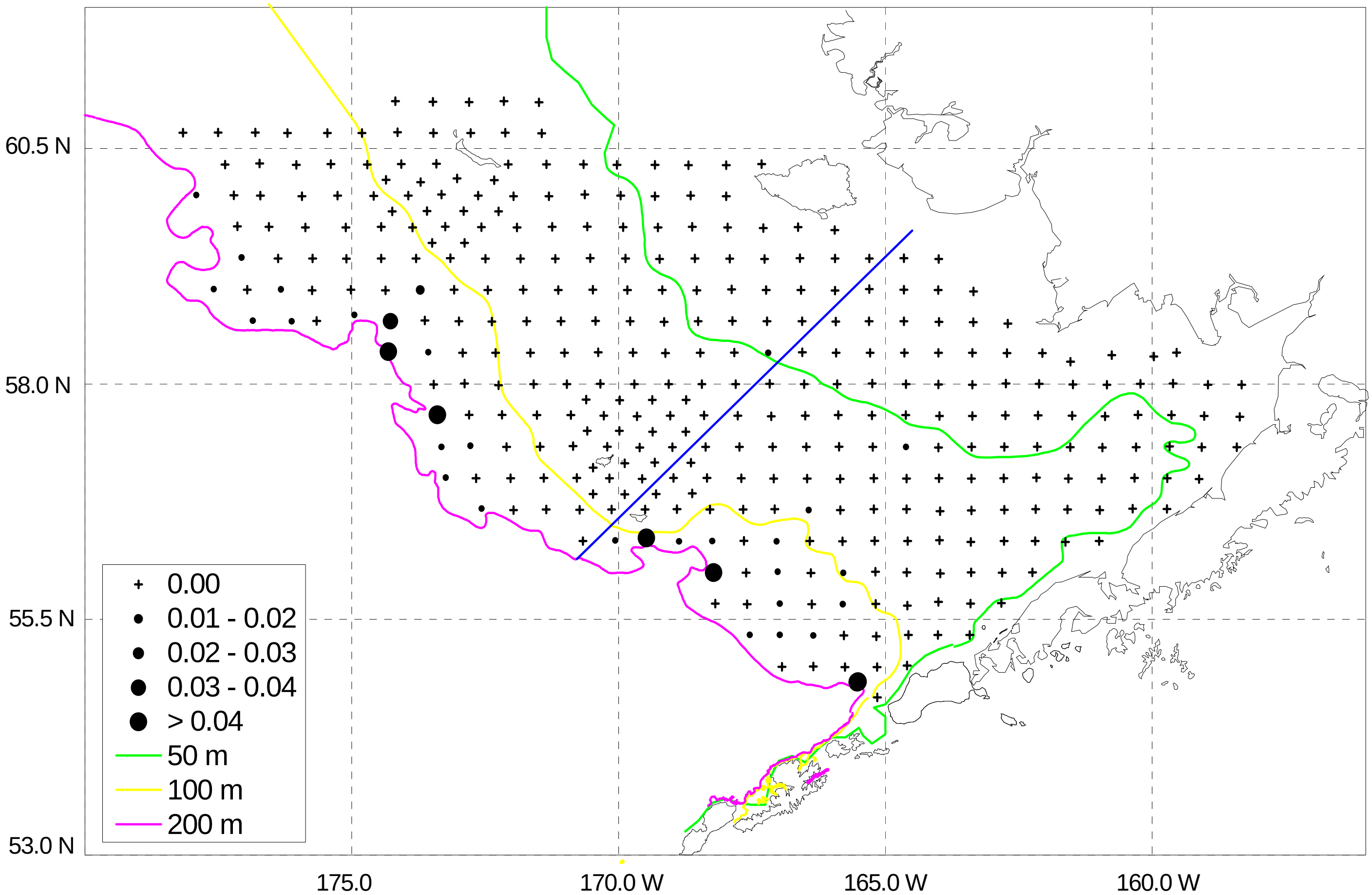


Figure 16-24. Spectacled Sculpin (*Triglops scepticus*)
Average CPUE 1998 - 2004



BSAI Octopi

Introduction

<u>Description, scientific names, and general distribution</u>
Octopi (order Octopoda) are cephalopod molluscs which are related to squids. They have 8 appendages (legs) attached to their head, but lack the fins and internal vestigal shell posessed by squid. Octopi range in size from tiny to huge, with the one of the largest species in the world inhabiting Alaskan waters. The North Pacific giant octopus, *Enteroctopus dofleini*, is the largest of all octopods (Figure 16-25, upper panel). It ranges from northern California to Japan in nearshore waters from low tide line to 200 m deep. While this species may dominate our image of the octopus species complex in the BSAI, there are many more octopus species found in the area, many of which are undescribed (Figure 16-25, lower panel). Considerable research is required to determine the species composition and distribution of octopi in the BSAI FMP area.

<u>Management units</u>
Octopi are managed as part of the BSAI other species complex. This means that their catch is reported in aggregate as "other" along with the catch of sharks, skates, and sculpins (BSAI) and squid (GOA). (Because catch is officially reported within the Other species complex, estimates of octopus catch must be made independently for each year using observer data; see below.) In the BSAI, catch of other species is limited by a Total Allowable Catch (TAC) which is based on an Allowable Biological Catch (ABC) estimated by the average catch of all other species combined from 1977-present (Fritz, 1999). In the GOA, the TAC of other species has been established as 5% of the sum of the TACs for all other assessed target species in the GOA (Gaichas et al., 1999). Right now, octopi are taken only as bycatch in fisheries directed at target species in the BSAI, so future catches of octopi are more dependent on the distribution and limitations placed on target fisheries than on any harvest level established for this category.

<u>Life history and stock structure (general)</u>
In general, short lifespans of 1 to 5 years with a single reproductive period are reported for octopod species (Boyle, 1983). In Japan, where octopus support directed fisheries, giant octopus *Enteroctopus dofleini*, life history has been extensively studied. Seasonal inshore-offshore migrations are reported, with mating occurring during autumn inshore in less than 100 m depth. Male octopus migrate back offshore and die, while females remain inshore, spawning 18,000 to 74,000 eggs in shallow water nests (< 50 m) on rocky or sandy bottom between May and July. Eggs are brooded for 6-7 months; female octopus do not feed during this period, and die soon after the eggs hatch. Hatchlings are about 10 mm long, and are planktonic until growing to 20 - 50 mm, settling out to benthos in about March of the year following hatching (Roper et al., 1984). Life history in the eastern North Pacific is not as well known, but spawning may be more common in winter months (Hartwick, 1983). It is thought that giant octopus require 3 years to grow to an adult (mature female) size of 10kg, and that they live 3-5 years. We found no specific information about the life history of the flapjack devilfish, *Opisthoteuthis californiana*, or the smoothskin octopus, *Octopus leioderma*. Because at least some octopus species migrate seasonally inshore and offshore, the sexes are often found in separate habitats. Therefore, the timing and location of fishery interactions with octopus populations may have differential effects on the sexes. More information is necessary to develop appropriate management for octopus species in Alaska, but the fact that they already have the highest estimated retention rates of any group in the other species complex suggests that management at the group level may be necessary in the near future.

Fishery
<u>Directed fishery</u>
There has been considerable interest in retaining incidentally caught octopus in the BSAI this year (2004)

due to high prices per pound (A. Smoker and R. Morrison, NMFS, personal communication). In addition, there is a small directed fishery for octopus in the Aleutian Islands and southwestern Bristol Bay regions. Directed octopus landings from 1988-95 have been less than 8 mt per year (Skip Gish, Alaska Department of Fish and Game, Dutch Harbor, pers. comm.). We are investigating landings for 2004 and hope to provide an estimate of catch during the plan team meeting.

Bycatch and discards

It is unknown which octopus species are caught in BSAI fisheries, although it is assumed that the majority of the catch is of the giant Pacific octopus, *Octopus dolfleni* (recently renamed *Enteroctopus dolfleni*, Hochberg 1998 as referenced in http://marine.alaskapacific.edu/octopus/factsheet.html). Bottom trawl pollock and all three of the fisheries for Pacific cod (pots, longlines and trawls) catch almost all of the octopus bycatch (Table 16-20). Octopus catches by groundfish fisheries in the BSAI estimated using observer bycatch rates ranged between 139-1,017 mt in 1992-96 (Fritz 1997), but have remained steady in the range of 200-500 tons between 1997 and 2002. We suspect that information collected by observers in BSAI crab fisheries might be of use to determine octopus bycatch rates in non-groundfish fisheries, but do not have access to this information at present.

Octopus are generally not identified to species in Alaskan groundfish fisheries. Octopus can only be recorded as "octopus unidentified," or "pelagic octopus unidentified" by fishery observers. Observers are presently instructed to devote resources to higher-priority target species and prohibited species data collection, so they have limited time to devote to other species identification. At present, fishery observers are not trained to identify octopus to species.

Survey data

Survey biomass in aggregate and by species

Survey biomass estimates for octopus species are highly variable from year to year (Table 16-21). We are unable to determine how much of this variability is due to octopus population dynamics vs. sampling variability arising from octopus distribution between trawlable and untrawlable habitat. Furthermore, the taxonomy of octopi in the BSAI is still being investigated (E. Jorgensen, personal communication), so we do not present infomation on species composition at this time.

While no estimate of octopus biomass is available, the feasibility of developing a pot survey for octopi could be evaulated using P. cod pot survey data from the AFSC REFM Fisheries Interaction Team (FIT) research program. Information on octopus bycatch in experimental pot sets could be used to to determine what catch rates might be like in commercial fisheries. We plan to collect biological information (size, sex ratio) on octopi during FIT cruises in 2005.

Analytic Approach, Model Evaluation, and Results

The available data do not support population modeling for octopi in the BSAI, so none of these stock assessment sections are relevant, except for one:

Parameters Estimated Independently

An analysis was undertaken to explore alternative methods to estimate natural mortality (M) for octopus species found in the BSAI. Several methods were employed based on correlations of M with life history parameters including growth parameters (Alverson and Carney 1975, Pauly 1980, Charnov 1993), longevity (Hoenig 1983), and reproductive potential (Roff 1986, Rikhter and Efanov 1976). No information was available for any octopus stocks in the BSAI FMP area, so M was estimated using the methods of Hoenig (1983) and of Rikhter and Efanov (1976) as applied to data for giant Pacific octopus (*Enteroctopus dolfleni*) in Japan (Table 16-22). Considering the uncertainty inherent in applying this method to cephalopods at all, let alone stocks outside the BSAI, we elected to use an M comparable to the lowest estimate of M derived from any of these methods, and one that has been used in other stock assessments for octopus species (M=0.50, Osako and Muruta 1983, Laguna 1989). Choosing the lowest estimate of M is considered conservative because it will result in the lowest estimates of ABC and OFL under Tier 5. Until we find better information on octopus productivity in the BSAI, this is the best interim measure balancing octopus conservation and allowing for historical levels of incidental catch in target groundfish fisheries.

Projectons and Harvest Alternatives

Harvest rates of octopus (defined as total removals divided by survey biomass) have ranged between 2-10% for each of the years from 1990-94. However, in 1995, removals of 977 mt of octopus from the eastern Bering Sea alone represented 35% of the octopus survey biomass of 2,779 mt. Octopus biomass in the eastern Bering Sea and Aleutian Islands regions is believed to be underestimated by the bottom trawl surveys due to undersampling in important nearshore, rocky habitats. It is clearly highly variable, whether it is biased or not. Productivity of octopi in general is likely to be high in terms of rapid growth to large size, but since they are semelparous species some research must be done on size at reproduction to determine appropriate size ranges for harvest.

We recommend that BSAI octopi be separated from the other species complex to better monitor and control their catches, especially given their apparently rising market value. While it is questionable whether we have a reliable estimate of octopus biomass, if we assume that bottom trawl surveys will underestimate octopus biomass, we may use the survey biomass to establish a relatively conservative Tier 5 ABC and OFL, especially in combination with the estimate of M in the lower end of the range. It is especially important to use an average of recent survey biomass estimates in this case to attempt to smooth the highly variable estimates.

For the time being, we recommend a Tier 5 approach be applied to the octopus complex as a whole if the catch remains incidental and no target fishery develops. We further recommend using a 10 year average of aggregate biomass so that we may include multiple estimates from each of the EBS shelf, slope, and AI bottom trawl surveys, but capture recent biomass trends. Other options would include averaging biomass estimates from the entire time series, and using just the most recent estimate (Table 16-21). Applying the M estimate of 0.50 to the 10 year average of bottom trawl survey biomass estimates, we calculate an ABC of 0.75 * 0.50 * (EBS shelf + EBSslope + AI biomass) = 2,371 t. Using the same method to calculate OFL, 0.50 * (EBS shelf + EBSslope + AI biomass) = 3,161 t. Tier 6 options for octopus management are also presented in Table 16-7 as an option for Plan Team and SSC consideration.

It appears likely that target fisheries may develop for some octopus species in the near future, given high reported market value. ***We do not recommend allowing a directed fishery for octopus species at this time, because the data are woefully insufficient for managment.*** When octopus species are identified in the catch and if sufficient life history information becomes available to make resonable species specfic estimates of productivity, then a directed octopus fishery should be considered.

Ecosystem Considerations

Ecosystem Effects on Stock and Fishery Effects on Ecosystem

Octopi are voracious predators on other benthic invertebrates, especially molluscs and crabs. They are also important prey of pinnipeds such as Steller sea lions and fur seals, cetaceans (belugas) and groundfish such as Pacific cod and sablefish. Much more investigation is necessary to determine the role of octopi in North Pacific ecosystems.

Summary

Estimated octopus bycatch in the BSAI groundfish fisheries has amounted to approximately 5-10% of survey biomass between 1997 and 2002. Octopi are a potentially valuable fishery resource, and a target fishery appears to be poised for development in the BSAI. *****We do not recommend allowing a directed fishery for octopus species at this time, because the data are woefully insufficient for managment.***** While we recommend that the octopus complex be removed from other species and managed for bycatch only, we recommend a Tier 5 approach be applied to the octopus complex as a whole if the catch remains incidental and no target fishery develops. Applying the M estimate of 0.50 to the 10 year average of bottom trawl survey biomass estimates, we calculate 0.75 * 0.50 * (EBS shelf + EBSslope + AI biomass) = **2,371 t = ABC**. Using the same method to calculate 0.50 * (EBS shelf + EBSslope + AI biomass) = **3,161 t = OFL**. We recommend that each octopus species be managed separately if target fisheries develop and if sufficient life history information becomes available to make resonable species specfic estimates of productivity. Finally, we recommend that a fishery data collection program be initiated for octopus species. The AFSC REFM Fisheries Interactions Team has agreed to provide information on octopus bycatch in experimental Pacific cod pot fisheries, and also to collect biological information. We highly encourage further research on Alaskan octopus species.

References

(please see the full reference section, pages 8-13 of this assessment)

Tables

Table 16-20. Estimated catch (t) of all octopus species combined by target fishery, gear, and area, 1997-2002. Similar catch estimates are not available for 2003-2004; see text for explanation.

Target fishery	gear	1997	1998	1999	2000	2001	2002
Arrowtooth	trawl			0	1		0
Atka mackerel	trawl	1	3	0	1	1	2
Flatheadsole	trawl	0	5	2	2	5	1
Pacific cod	hook n line	25	35	22	42	36	40
	pot	103	112	262	246	157	254
	trawl	31	21	25	70	18	40
Pacific cod Total		160	168	310	359	211	334
Pollock	trawl	1	5	0	1	5	8
Rock sole	trawl	85	7	11	51	3	18
Rockfish	trawl	0	0	0	0	0	1
Sablefish	hook n line	0	0	1	0	1	4
	pot			0	0	0	4
Sablefish Total		0	0	1	0	1	8
Yellowfinsole	trawl	0	0	1	3	1	1
Grand Total		248	190	326	418	227	374
FMP area	**area**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
AI	541	29	20	170	45	22	16
	542	9	20	28	15	10	6
	543	1	4	3	3	9	2
AI Total		39	44	202	63	41	24
EBS	509	112	27	30	112	20	52
	513	4	4	2	1	1	2
	516	0	0	6	0	0	7
	517	11	14	15	82	43	55
	518	2	3	7	2	1	0
	519	69	87	62	154	114	225
	521	10	9	4	3	7	9
	524	2	0	0	0	1	0
EBS Total		210	145	125	356	186	351
Grand Total		248	190	326	418	227	374

Table 16-21. Estimated biomass (t) time series from bottom trawl surveys in BSAI areas, 1975-2004, with options for setting Tier 5 ABC and OFL.

	year	EBS shelf	EBS slope	AI	
	1975	6,129			
	1976				
	1977				
	1978				
	1979	30,815	729		
	1980			757	
	1981		234		
	1982	12,442	180		
	1983	3,280		440	
	1984	2,488			
	1985	2,582	152		
	1986	480		781	
	1987	7,834			
	1988	9,846	138		
	1989	4,979			
	1990	11,564			
	1991	7,990	61	1,148	
	1992	5,326			
	1993	1,355			
	1994	2,183		1,728	
	1995	2,779			
	1996	1,746			
	1997	211		1,219	
	1998	1,225			
	1999	832			
	2000	2,041		775	
	2001	5,407			
	2002	2,435	979	1,384	
	2003	8,264			
	2004	4,902	1,957	4,099	
M est		*0.5*	*0.5*	*0.5*	
					BSAI all
average all		5,542	554	1,370	
ABC all		2,078	208	514	2,800
OFL all		2,771	277	685	3,733
average last 10		2,984	1,468	1,869	
ABC last 10		1,119	551	701	2,371
OFL last 10		1,492	734	935	3,161
most recer	2004	4,902	1,957	4,099	
ABC most recent		1,838	734	1,537	4,109
OFL most recent		2,451	979	2,050	5,479

Table 16-22. Estimates of M based on life history for octopus species. "Age mature" was given a range for M estimates by the Rikhter and Efanov method to account for uncertainty in this parameter.

Species	Area	Max age	Hoenig	Age mature	Rikhter & Efanov
Pacific giant octopus	N. Pacific	3	1.42	1.5	0.98
	N. Pacific	4	1.06	2	0.77
	N. Pacific	5	0.85	3	0.53

Figures

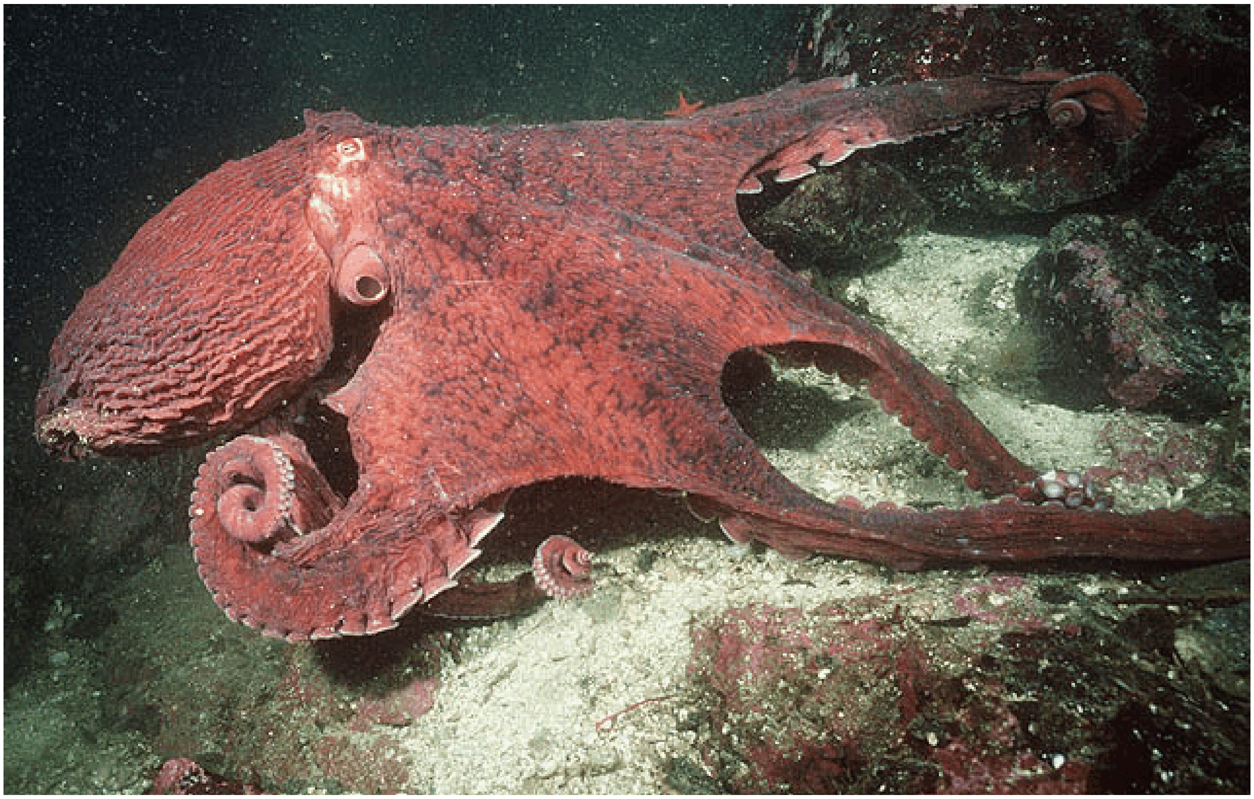


Figure 16-25. Giant Pacific octopus, *Enteroctopus dofleni* (above), and an unidentified octopus species (below).

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