CalCOFI Conference

9-11 December 2013

Southwest Fisheries Science Center
La Jolla, CA

Hosted by:

Southwest Fisheries Science Center, NOAA Fisheries

CalCOFI Coordinator: John Heine
Symposium Convener: Sam McClatchie

In association with:
Scripps Institution of Oceanography
California Department of Fish and Wildlife

CalCOFI Conference 2013

Southwest Fisheries Science Center
La Jolla, CA
Dec. 9-11

Monday, 9 December

12:30-1:30	Registration – Pacific Room, SWFSC
1:30-1:45	**Opening of the Conference** Welcome: Sam McClatchie, Southwest Fisheries Science Center
1:45-2:45	**Session I: Status of the California Current** Brian Wells, Southwest Fisheries Science Center, NOAA
2:45-3:00	Break. Registration continues
3:00-5:00	**Session II: Status of the Fisheries** Chair: Dianna Porzio, California Department of Fish and Wildlife
3:00-3:15	Highly Migratory Species – Leeanne Laughlin
3:15-3:30	Groundfish – Andrew Klein
3:30-3:45	Red sea urchin – Derek Stein
3:45-4:00	Pacific halibut – Caroline McKnight
4:00-4:15	Pacific herring – Ryan Bartling
4:15-4:30	Market squid – Julianne Taylor
4:30-4:45	Coastal pelagic species – Elizabeth Hellmers
4:45-5:00	Update on minor forage fish off California – Deb Wilson-Vandenberg

Poster Session

5:00-7:00	**Pacific Room, SWFSC.** Beer, wine, and non-alcoholic beverages, hors d'oeuvres, and dessert

P-1. **Pacific mackerel spawning habitat off Baja California between 2000-2005.** Valencia J. A. [1]*, Baumgartner T. [2], and Durazo R. [1]
[1] Facultad de Ciencias Marinas, Universidad Autónoma de Baja California.
[2] Departamento de Oceanografía Biológica, División de Oceanología, CICESE.

P-2. **Oceanographic factors that modulate the composition and abundance of Copepods: Analysis of sediment trap time-series, Ensenada, Mexico.** María Soledad Cota Meza[1], María del Roció Pacheco Chávez[1], Fernando Aguirre Bahena[2] and Felipe de Jesús García Romero[2]. [1]Departamento de Plancton y Ecología Marina [2], Departamento de Oceanología, CICIMAR – IPN, Centro Interdisciplinario de Ciencias Marinas.

P-3. **Variability of elemental composition and stable carbon isotopes in tropical northeastern Pacific during the last two thousand years**. Miryam Juarez, Alberto Sanchez and Soledad Cota, Centro Interdisciplinario de Ciencias Marinas, Instituto Politécnico Nacional.

P-4. **Update analysis of age, length, and maturity of Pacific mackerel *(Scomber japonicus)* collected off San Diego, CA 2009-2012.** Erin M. Reed and Beverly J. Macewicz, NOAA-NMFS, Southwest Fisheries Science Center.

P-5. **Supporting a spatial analysis of the distribution and size of rebuilding stocks in the Rockfish Conservation Area (RCA) through directed fishing and visual surveys.** [1]Donna Kline, [1]Rick Starr, [2]Mary Gleason, [3]John Field, [4]Huff McGonigal, [2]Steven Rienecke, [1]Christian Denney, [1]Anne Tagini, [1]Jahnava Duryea. [1]Fisheries and Conservation Biology Lab, Moss Landing Marine Laboratories, [2]The Nature Conservancy, [3]Southwest Fisheries Science Center, National Marine Fisheries Service, [4]Environmental Defense Fund.

P-6. **California Current predator diet database.** Amber I. Szoboszlai, Julie A. Thayer, William J. Sydeman, Farallon Institute for Advanced Ecosystem Research.

P-7. **Colony dynamics of Elegant Terns, *Thalasseus elegans,* in the southern California Bight in relation to oceanographic conditions and disturbance events.** C.J. Rankin and M.H. Horn, California State University, Fullerton, Department of Biological Science.

P-8. **Longterm variation in a central California epipelagic forage assemblage.** Stephen Ralston, John C. Field and Keith M. Sakuma, Fisheries Ecology Division, Southwest Fisheries Science Center, NMFS/NOAA.

P-9. **Dietary and stable isotope analyses reveal the role of a cryptic prey in the Elegant Tern (*Thalasseus elegans*) food web in southern California waters.** C. Whitcombe and M. Horn, California State University, Fullerton, Department of Biological Science.

P-10. **Comparison of dietary sampling methods for nesting California Least Terns (*Sternula antillarum browni)* at Alameda Point in San Francisco Bay and Purisima Point on the central California coast.** A.G. Leicht[1], D. Robinette[2], M. Elliott[2] and M. Horn[1], [1]California State University, Fullerton. Department of Biological Science. Fullerton, CA 92834. [2]Point Blue Conservation Science.

P-11. **Diverse Uses of the CalCOFI Component of the SIO Pelagic Invertebrates Collection.** Sala L.M. and Ohman M.D., Scripps Institution of Oceanography.

Tuesday, 10 December

8:00-8:30 Registration – Pacific Room, SWFSC

8:30 **Session III: The Symposium of the Conference: Forage Species and Assemblages in the California Current System**
Chair: Sam McClatchie, Southwest Fisheries Science Center

8:30-8:40 Introduction and overview. Sam McClatchie, Southwest Fisheries Science Center

8:40-9:10 S-1. **A historical perspective on the evolution of ecosystem-based fisheries management in the California Current.** John C. Field and Alec D. MacCall, Fisheries Ecology Division, Southwest Fisheries Science Center, NMFS/NOAA.

9:10-9:40 S-2. **Recommended rules of thumb for forage fish management: how are we doing in the California Current?** Selina S. Heppell, Oregon State University, Department of Fisheries and Wildlife.

9:40-10:10 S-3. **Climate, fishing, and fluctuations of sardine and anchovy in the California Current.** Martin Lindegren[1*], Tristan Rouyer[2], Alec D. MacCall[3], Nils Chr. Stenseth[4], David M. Checkley, Jr.[1]. [1]Scripps Institution of Oceanography, [2]UMR 212 EME, IFREMER (Institut Francais de Recherche pour l'Exploitation de la mer), Sète, France, [3]Southwest Fisheries Science Center, [4]Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biological Sciences, University of Oslo.

10:10-10:30 Break

10:30-11:00 S-4. **Simplifying ecosystem-based fisheries management in the CCS**. Sarah M. Glaser, University of Denver, Korbel School of International Studies.

11:00-11:30 S-5. **Distribution and abundance of forage fish species based on acoustic-trawl surveys between 2006 and 2013.** Juan P. Zwolinski[1], David A. Demer[2], George Cutter[2], Brian Elliot[2], Scott Mau[2], David Murfin[2], Josiah S. Renfree[2], Kevin Stierhoff[2], Thomas S. Sessions[2] and Beverly J. Macewicz[2]. [1] Institute of Marine Sciences, University of California, Santa Cruz, (Affiliated to SWFSC), [2] Fisheries Resources Division, Southwest Fisheries Science Center (SWFSC), National Marine Fisheries Service, National Oceanic and Atmospheric Administration.

11:30-12:00 S-6. **Trends in forage fish abundance in the southern California Current System: comparison of power plant intake and CalCOFI ichthyoplankton time series.** J. Anthony Koslow[1], Eric F. Miller[2], John A. McGowan[1]. [1] Scripps Institution of Oceanography, University of California, [2] MBC Applied Environmental Sciences.

12:00-12:45 **Lunch**

12:45-1:00 S-7. **Ontogeny as a factor affecting availability of mesopelagic fishes for predators.** Noelle Bowlin[1,2], Sam McClatchie[1], Andrew Thompson[1], Phil Hastings[2], and William Watson[1]. [1]NOAA, Southwest Fisheries Science Center, [2]Scripps Institution of Oceanography.

1:00-1:30 S-8. **Pelagic and demersal fish predators on juvenile and adult forage fishes in the Northern California Current: Spatial and temporal variations.** Richard D. Brodeur[1], Robert Emmett[2], and John Buchanan[1], [1]Northwest Fisheries Science Center, NOAA Fisheries, Newport, OR, [2]Northwest Fisheries Science Center, NOAA Fisheries, Hammond, OR.

1:30-2:00 S-9. **Secular and inter-annual changes in the spawning habitat of forage fish off California.** Sam McClatchie, Andrew Thompson and William Watson, NOAA Fisheries Service, Southwest Fisheries Science Center.

2:00-2:30 S-10. **The haves and have nots: Foraging behavior of lactating California sea lions during the 2013 unusual mortality event.** Sharon R. Melin, Robert L. DeLong, Jeffrey D. Harris, Anthony J. Orr, NOAA Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory.

2:30-2:45 S-11. **Female California Sea Lion summer diet and pup growth on San Miguel Island.** Jeff Laake, Sharon Melin, Robert DeLong, Anthony Orr, Jeff Harris, National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA Fisheries.

2:45-3:00 Break

3:00-3:30 S-12. **Temporal and spatial differences in the diet of California sea lions (*Zalophus californianus*) at San Clemente Island and San Nicolas Island during 1981-2007.** Mark S. Lowry, Alan R. Jackson, and Robert Holland, National Marine Fisheries Service, Southwest Fisheries Science Center.

3:30-3:45 S-13. **Spatiotemporal variability in the diet of nonbreeding Brandt's Cormorant (*Phalacrocorax penicillatus*) in the Monterey Bay region.** Lisa A. Webb and James T. Harvey, San Jose State University, Moss Landing Marine Laboratories.

3:45-4:15 S-14. **Meta-analysis of food habits of marine predators in the California Current over the past century.** Julie Thayer[1], Amber Szoboszlai[1], Laura Koehn[2], Tim Essington[2], William Sydeman[1], [1]Farallon Institute for Advanced Ecosystem Research, [2]University of Washington, School of Aquatic and Fishery Sciences.

Tuesday, 10 December (cont.)

Reception

5:00-7:00 Seaside Terrace, Scripps Institution of Oceanography. Beer, wine, and non-alcoholic beverages, hors d'oeuvres, desert.

Wednesday, 11 December

8:30 **Session III (cont.): The Symposium of the Conference: Forage Species and Assemblages in the California Current system**
Chair: Sam McClatchie, Southwest Fisheries Science Center

8:30-9:00 S-15. **Modeling spatial-temporal dynamics of the krill prey field in the central California Current.** Jeffrey Dorman[1], Ramona Zeno[1], Jarrod Santora[1], Steven Bograd[2], Marisol Garcia-Reyes[1], and William J. Sydeman[1], [1]Farallon Institute for Advanced Ecosystem Research, [2]NOAA, Southwest Fisheries Science Center.

9:00-9:15 S-16. **Evidence of increased cephalopod production in the eastern Tropical Pacific Ocean.** Mary E. Hunsicker[1], Timothy E. Essington[2], Robert J. Olson[3], Leanne M. Duffy[3], Felipe Galván Magaña[4]. [1]National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, [2]School of Aquatic & Fishery Sciences, University of Washington, Seattle WA, [3]Inter-American Tropical Tuna Commission, La Jolla, CA, [4]Instituto Politecnico Nacional, Centro Interdisciplinario de Ciencias Marinas, La Paz, Baja California Sur, Mexico.

9:15-9:45 S-17. **A 7-year climatology of underwater glider data along CalCOFI lines 66.7, 80 and 90.** Daniel L. Rudnick and Katherine Zaba, Scripps Institution of Oceanography.

9:45-10:05 Break

10:05 **Session IV: Contributed Papers (15 minutes with 5 minutes for discussion).** Chair: Laura Rogers-Bennett, California Department of Fish and Wildlife.

10:05-10:25 C-1. **Status and trends in the southern California Spiny Lobster fishery and population: 1980-2011.** Eric Miller, MBC Applied Environmental Sciences, Costa Mesa, CA.

10:25-10:45 C-2. **Age and growth of the Giant Sea Bass, *Stereolepis gigas*.** Allen, L.G. and H.A. Hawk, California State University, Northridge.

10:45-11:05 C-3. **Variations on a theme by Isaacs: "Some ideas and frustrations about fishery science."** Richard Parrish, Fisheries Biologist.

11:05-11:25 C-4. **Inter-annual and seasonal trends in cetacean distribution, density and abundance in waters off southern California.** Gregory S. Campbell[1], Katherine Whitaker[1], Len Thomas[2], Annie Douglas[3], John Calambokidis[3] and John A. Hildebrand[1]. [1]Marine Physical Laboratory, Scripps Institution of Oceanography, [2]School of Mathematics and Statistics, University of St Andrews, [3]Cascadia Research Collective, Olympia, WA, USA.

11:25-11:45 C-5. **Pacific sardine landings in the California Current System.** Roberto Félix-Uraga[1,3], Kevin T. Hill[2] and Martín E. Hernández-Rivas[1]. [1]Instituto Politécnico Nacional- CICIMAR, [2]NOAA-NMFS-SWFSC, [3] Becario SIBE y EDI.

11:45-12:45 Lunch

12:45 **Session V: Contributed Papers (15 minutes with 5 minutes for discussion).** Chair: David Checkley, Scripps Institution of Oceanography

12:45-1:05 C-6. **Diet of an adaptable seabird highlights the importance of prey-switching in response to dynamic preyscapes over two decades.** Ryan Carle, Michelle Hester, Jessie Beck, David Calleri, Oikonos Ecosystem Knowledge, Santa Cruz, CA.

1:05-1:25 C-7. **Vertical distribution of fish larvae and hydrographic conditions along the southwestern coast of the Peninsula Baja California (June 2010).** Susan Davies[1], Laura Sánchez-Velasco[1], Emilio Beier[2]. [1]CICIMAR –

IPN, Centro Interdisciplinario de Ciencias Marinas, Departamento de Plancton y Ecología Marina, [2]CICESE Unidad La Paz.

1:25-1:45 C-8. **Year-round spawning behavior of an invertebrate forage species: the market squid, *Doryteuthis opalescens*.** Navarro, Michael O. [1, 2], Ed Parnell [1], and Lisa A. Levin[1, 2]. [1] Integrative Oceanography Division, Scripps Institution of Oceanography, [2] Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography.

1:45-2:05 C-9. **Ichthyoplankton community composition as a predictor of Pacific Sardine (*Sardinops sagax*) recruitment success.** Edward D. Weber and Andrew Thompson, NOAA Fisheries Service, Southwest Fisheries Science Center.

2:05-2:25 C-10. **Inter-decadal changes in biodiversity in larval fish assemblages off southern California.** Andrew Thompson[1], William Watson[1], Noelle Bowlin[1], Thomas Adam[2,3], Sam McClatchie[1], and Ed Weber[1], [1] NOAA Fisheries, Southwest Fisheries Science Center, [2] NOAA Fisheries, Southeast Fisheries Science Center, [3] Department of Ecology, Evolution and Marine Science, UCSB.

2:25-2:45 Break

2:45 **Session VI: Contributed Papers (15 minutes with 5 minutes for discussion)**
Chair: Russ Vetter, Southwest Fisheries Science Center

2:45-3:05 C-11. **Indirect climate change impacts on fish species in the California Current.** Bryanda Wippel, University of Washington.

3:05-3:25 C-12. **Retention of juvenile fish in the Santa Barbara Channel Eddy: Using three-dimensional modeling to explain field observations.** Rachel D. Simons, Earth Research Institute, University of California, Santa Barbara, Mary Nishimoto, Marine Science Institute, University of California, Santa Barbara, Libe Washburn, Department of Geography, University of California, Santa Barbara, Kevin Brown, Biomedical Engineering, University of Connecticut, David Siegel, Earth Research Institute and Department of Geography, University of California, Santa Barbara.

3:25-3:45 C-13. **Seabird diet as an indicator of annual variability in juvenile anchovy and rockfish recruitment**. Dan Robinette*, Julie Howar, Meredith Elliott, and Jaime Jahncke, Point Blue Conservation Science, Vandenberg Field Station.

3:45-4:05 C-14. **Changes in forage fish community as indicated by the diet of the Brandt's Cormorant (*Phalacrocorax penicillatus*) in the California Current.** Meredith L. Elliott[1], Dan Robinette[1*], Annie Schmidt[2], Russ Bradley[1], and Jaime Jahncke[1], [1] Point Blue Conservation Science, [2] Department of Wildlife, Fish, and Conservation Biology, Graduate Group in Ecology, University of California, Davis.

4:05-4:25 C-15. **Foraging Ecology of Tunas and Opah in the California Current.** Owyn E. Snodgrass and Heidi Dewar, NOAA Fisheries, Southwest Fisheries Science Center.

4:25-4:45 C-16. **Resilience in California Current pelagic community structure: A sixty year study.** John McGowan, Filippo Alimonda, Leslie Lu, Dana McDaniel and Lani Villaneuva. Scripps Institution of Oceanography, University of California at San Diego.

Conference adjourned.

SYMPOSIUM ABSTRACTS

S-1. A historical perspective on the evolution of ecosystem-based fisheries management in the California Current

John C. Field and Alec D. MacCall

Fisheries Ecology Division
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The fisheries of the California Current have experienced a broad range of extremes, from collapse and recovery of major resources (Pacific sardine and many rockfish), to tremendous variation in physical conditions and regimes that have led to enormous variation in productivity and yield for key resources over short time periods (market squid and salmonids), to the future changes to the ecosystem likely under climate change (altered hydrographic regimes, expansion in the range of subtropical predators). The California Current can also be considered to be a leading indicator in the development of scientific advice to guide management, as a considerable fraction of contemporary fisheries theory and many new management approaches have evolved or first been implemented in the California Current. For example, surplus production curves and virtual population analysis both made their debut in efforts to understand the dynamics and productivity of the Pacific sardine population, as did the world's longest standing oceanographic monitoring system, the California Cooperative Oceanic and Fisheries Investigations program. Management of coastal pelagic species in recent years also led to innovative control rules that recognized the role of coastal pelagic species as forage, and quantified the role of the environment as a driver of population productivity to inform harvest management. Most recently, the global push for an ecosystem-based approach to fisheries management has to the adoption of a "Fisheries Ecosystem Plan" to help focus and coordinate ecosystem concerns by managers. We will review the history of California Current fisheries, fisheries science, and management systems, with a focus on the development of ecosystem information, insights and policy decisions, particularly as relevant to the management of lower trophic level species, over the past decade. We will close with our thoughts about potential (and perhaps, ideal) future of such management efforts over the decade to come.

S-2. Recommended rules of thumb for forage fish management: how are we doing in the California Current?

Selina S. Heppell

Oregon State University, Department of Fisheries and Wildlife

Two independent science review teams recently took a hard look at sustainability and management of forage fish fisheries: the Marine Stewardship Council (MSC) and the Lenfest Forage Fish Task Force (LFFTF). Both groups looked at a wide range of fisheries across multiple ecosystems and explored the impacts of forage fisheries on ecosystem components with ecosystem models. While the scope and methods of each project differed, the overall recommendations carried a common theme: the inherent natural variability of forage species and their critical role in ocean food webs requires highly conservative harvest policies to assure sustainability and to avoid declines of dependent predators, including fishes, seabirds and marine mammals. Both groups recommended harvest levels that maintain stocks at 70-80% of unfished biomass (defined in various ways), and the LFFTF recommended the use of biomass minima ("cutoffs") for harvest that would assure adequate forage for predators during periods of low stock abundance. In the federal waters of the California Current, forage fishes are managed through the Pacific Fisheries Management Council's Coastal Pelagics Fishery Management Plan, and two species (Pacific mackerel and Pacific sardine) are assessed regularly. In general, forage species in the California Current are harvested at low levels relative to many other parts of the world, and catches of sardine and mackerel are now much lower than historic exploitation rates. Pacific sardine are in decline, and may soon reach the Council's current "cutoff" of 150,000 mt. Pacific mackerel appear to be at low biomass relative to historic estimates, but likely increasing; however, there are many uncertainties in the assessment. Northern anchovy may be assessed soon, although there is a paucity of both biological and fishery data available for the species. The Council has recently passed an Ecosystem Management Plan that includes new initiatives for the management of other forage species on the west coast. Uncertainty in stock structure, natural mortality, and interactions with other forage species and predators, added to highly variable productivity in the California Current, makes single species and ecosystem modeling for forage species difficult. Nevertheless, the importance of forage species to upper trophic levels is well-recognized by scientists, the Council, recreational fishermen, and environmentalists alike, providing a valuable rallying point for efforts to monitor and manage marine resources with an ecosystem-level approach.

S-3. Climate, fishing, and fluctuations of sardine and anchovy in the California Current

Martin Lindegren[1*], Tristan Rouyer[2], Alec D. MacCall[3], Nils Chr. Stenseth[4], David M. Checkley, Jr.[1]

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Marine fish typically show multi-decadal fluctuations in abundance, mainly attributed to overexploitation, climate, or a combination of both. One striking example is the large-scale fluctuations of sardine and anchovy observed across the major upwelling areas of the world. Although ocean–atmosphere forcing is considered the main underlying driver, no generally accepted theory regarding sardine-anchovy fluctuations presently exists. We here model the underlying causes of these fluctuation, using the California Current Ecosystem (CCE) as a case study, and show that the dynamics, accurately reproduced since 1661 AD onwards, are explained by interacting density-dependent processes (i.e., through species specific life-history traits) and climate forcing. Furthermore, we demonstrate how fishing modifies the dynamics and show that the sardine collapse of the 1950s was largely unavoidable given poor recruitment conditions. Our approach provides unique insight into the origin of sardine-anchovy fluctuations and a knowledge base for sustainable fisheries management in the CCE and beyond.

S-4. Simplifying ecosystem-based fisheries management in the CCS

Sarah M. Glaser

University of Denver, Korbel School of International Studies

By now, there is widespread agreement that a move to ecosystem-based fisheries management (EBFM) is both desirable and inevitable. The scientific literature advocating for and designing ecosystem-based approaches is far ahead of implementation, however. The integration of EBFM into current fisheries management has been hindered by a variety of scientific, technical, legal and political factors. Two decades after the publication of "Implementing ecosystem-based management" by D.S. Slocombe, the vast majority of our fish stocks are still managed on a single-species basis. One challenge facing EBFM implementation is the question of complexity: at one end of the spectrum, including temperature as a control rule for managing Pacific sardine is a low-complexity example of EBFM, while at the other end, ecosystem models such as Ecopath and Atlantis provide highly complex models that may be difficult to translate into management policy. I suggest one possible approach to simplifying our study of CCS fisheries that attempts to find middle ground between single-species models and ecosystem models that contain hundreds of parameters. This approach relies on identifying key prey items through bioenergetics and verifying dynamic interactions using time series models.

S-5. Distribution and abundance of forage fish species based on acoustic-trawl surveys between 2006 and 2013

Juan P. Zwolinski[1], David A. Demer[2], George Cutter[2], Brian Elliot[2], Scott Mau[2], David Murfin[2], Josiah S. Renfree[2], Kevin Stierhoff[2], Thomas S. Sessions[2] and Beverly J. Macewicz[2]

[1] Institute of Marine Sciences, University of California, Santa Cruz, Earth and Marine Sciences Building, Rm A317, Santa Cruz, CA 95064, USA (Affiliated to SWFSC)

[2] Fisheries Resources Division, Southwest Fisheries Science Center (SWFSC), National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Drive, La Jolla, CA 92037, USA

Active underwater acoustic devices allow the collection of large volumes of data with high spatial and temporal resolution, detecting targets that range from plankton to fish. When used in combination with traditional trawl sampling - used to gather information on the species composition, sizes and biological parameters of the acoustic targets - combined acoustic and trawl surveys can provide invaluable information on the distribution, abundance and demography of multiple fish species.

Since 2006, the Southwest Fisheries Science Center has routinely surveyed the California Current Large Marine Ecosystem, from San Diego to southern Vancouver Island, and offshore to more than 200 miles using a combined acoustic-trawl method (ATM). While initially directed to Pacific sardine (*Sardinops sagax*), ATM surveys collect acoustic information from at least the upper 250 m of the water column, which comprises the habitat of other abundant or locally important species such as jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*) and Pacific herring (*Clupea pallasii*).

We present the recent developments in the ATM and results of ATM surveys since 2006, with emphasis on the inter-annual variations of the forage fish assemblage. We also discuss the future surveys of coastal pelagic fishes in the California Current Ecosystem, and the challenges faced to expand the scope of the surveys to include the monitoring of less abundant, but ecologically important species. This task will benefit from the arrival of NOAA's latest Fisheries Survey Vessel – *Reuben Lasker*, with its stealth capabilities and state-of-the-art acoustic and ancillary technologies – as well as from the development of remote, automated processing routines to deal with the rapidly increasing volume of acoustic data and the staffing requirements from additional days at sea.

S-6. Trends in forage fish abundance in the southern California Current System: comparison of power plant intake and CalCOFI ichthyoplankton time series

J. Anthony Koslow[1], Eric F. Miller[2], John A. McGowan[1]

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[2] MBC Applied Environmental Sciences, 3000 Red Hill Ave., Costa Mesa, CA 92626

Time series are a *sine qua non* to assess change in ecological communities. Koslow et al (2013) recently examined change in fish assemblages of the southern California Current using CalCOFI ichthyoplankton data as proxies for adult fish spawning biomass, and Miller and McGowan (2013) used power plant intake data to assess change in nearshore fish assemblages. These two sampling designs are complementary, since the power plant intakes are all nearshore and the CalCOFI sampling is generally seaward of ~35 m depth. Nonetheless, we found a high degree of congruence between the two time series, with a strong declining trend in an assemblage of forage and other dominant regional fishes, generally with cool water affinities, since about 1970. These changes are significantly negatively correlated with near-surface temperature and positively correlated with a measure for the advection of the California Current. These results indicate that the two time series are complementary: although they sample somewhat different components of the coastal fish assemblage, similar patterns are observed. These results also indicate that fishes in the California Current that share biogeographic and water mass affinities tend to vary coherently. Assessing the state of the California Current requires consideration of multi-species assemblages rather than only single-species dynamics.

S-7. Ontogeny as a factor affecting availability of mesopelagic fishes for predators

Noelle Bowlin[1,2], Sam McClatchie[1], Andrew Thompson[1], Phil Hastings[2] and William Watson[1]

[1]NOAA, Southwest Fisheries Science Center
[2]Scripps Institution of Oceanography

The mesopelagic zone (200-1000m depth) is one of earth's largest habitats and contains the highest abundance of marine vertebrates in the world. These fishes are likely an important prey resource for many commercially and ecologically important predators including pinnipeds, cetaceans, squids, seabirds, and highly migratory fishes. However, there are many uncertainties as to the relative importance of mesopelagic fishes as prey when compared with epipelagic (0-200m depth) forage species. One key issue is whether the mesopelagic fishes are available to various predators. Although the mesopelagic zone is often treated as one homogeneous unit, the studies to date that have evaluated mesopelagic assemblage structure suggest that many depth-specific niches are found within this region. Here we analyze depth-specific ontogeny in mesopelagic fishes in the central and southern California Current with the ultimate aim of better defining depth-specific niches. We discuss what is known about mesopelagic fishes as forage, and examine ontogeny as one aspect of vertical migration that affects exposure to predators over longer time scales than diel vertical migration. Quantifying depth-specific ontogeny will enhance understanding of when and where mesopelagic forage are likely to be available to predators. The co-occurrence of predators and forage determines, in part, the pathways of the forage resource through the foodweb.

S-8. Pelagic and demersal fish predators on juvenile and adult forage fishes in the Northern California Current: Spatial and temporal variations

Richard D. Brodeur[1], Robert Emmett[2], and John Buchanan[1]

[1]Northwest Fisheries Science Center, NOAA Fisheries, Newport, OR

[2]Northwest Fisheries Science Center, NOAA Fisheries, Hammond, OR

A requisite for reliable food web models and ecosystem-based management in regions such as the California Current is the availability of diet information on key predators. In ecosystems designated as 'wasp-waist" systems believed to be the situation in most upwelling ecosystems, much of the lower trophic level energy is transferred through a relatively small set of very abundant pelagic forage fish taxa, such as anchovies, sardines, smelts, herring, and to a lesser extent sauries, small squid and euphausiids. In addition, the pelagic juvenile stages of some important midwater (Pacific hake and mackerels) and demersal fishes (rockfishes, sablefish) may act as forage fishes during a more limited time period each year. In this paper, we review what is known about the utilization of these forage species by larger fish predators and elasmobranchs in the Northern California Current from northern Washington to northern California (Cape Mendocino) shelf to examine spatial and temporal variations in the kinds and sizes of forage fishes consumed. As many fish predator diets change as they increase in size, we attempt to examine ontogenetic or size-based changes as well. We also discuss factors (seasonal occurrence, aggregation patterns, energetic quality) that make these forage fishes attractive prey for these nektonic predators. We also highlight where diet information is poor or lacking and areas where regular fish diet monitoring could be useful for ecosystem-based management.

S-9. Secular and inter-annual changes in the spawning habitat of forage fish off California

Sam McClatchie, Andrew Thompson and William Watson

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An emerging paradigm in an era of changing climate is that the biogeographic distribution of many species may shift poleward. We tested this idea by examining spawning distribution centroids of four ecologically and commercially important small pelagic fishes off the coast of California. The spawning distribution centroids of Pacific sardine (*Sardinops sagax*) and Pacific hake (*Merluccius productus*) eggs off California have shifted further offshore between 1985 and 2011, while those of anchovy (*Engraulis mordax*) and jack mackerel (*Trachurus symmetricus*) eggs have not changed. During this time frame, offshore Ekman transport has generally increased, and transport correlates positively with spawning centroids of sardine and hake but not anchovy or jack mackerel. Although sardine spawning centroids move either inshore or offshore inter-annually, the rate of offshore movements is increasing, while the rate of onshore movements are constant. The spatial shifts in sardine and hake spawning centroids differ from the expected paradigm for changes in distributions of pelagic fish with warming in the California Current system. The shift in spawning centroids is offshore rather than poleward, and the forcing variable is wind rather than temperature. The differences between species in the spatial trends of forage spawning centroids indicate that secular and inter-annual trends are not necessarily correlated and should initially be examined on a species by species basis. These findings have important implications for the availability of forage fish to central place foragers.

S-10. The haves and have nots: Foraging behavior of lactating California sea lions during the 2013 unusual mortality event

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In March 2013, the National Marine Fisheries Service declared an Unusual Mortality Event (UME) in response to high numbers of stranded California sea lion (*Zalophus californianus*) pups on southern California beaches, high pup mortality at breeding rookeries and poor condition of surviving pups. To evaluate the possibility that reduced prey availability to lactating females contributed to the UME, we conducted a study to compare the attendance, foraging distribution and diving behavior of females at San Miguel Island (SMI) that were supporting dependent pups in good condition or poor condition in April 2013. We expected that differences in these behaviors between the two groups may explain the observed condition of their pups. No differences were detected for most of the parameters but seasonal foraging distributions were different for the two groups. Spring distribution of females with pups in good condition showed concentrated foraging activity northwest of SMI in coastal shelf or slope habitats. Females nursing pups in poor condition concentrated their activity northwest, south and southwest of SMI in slope and offshore habitats. Summer distribution of females nursing pups in good condition did not change from spring patterns but was more concentrated between Pt. San Luis and Pt. Conception. Females with pups in poor condition shifted to a more coastal distribution with activity concentrated between Santa Rosa Island and Pt. San Luis. Diet analysis from scats collected at SMI during the study indicated that juvenile Pacific hake (*Merluccius productus*), Pacific sardine (*Sardinops sagax*) and market squid (*Loligo opalescens*) were important prey in spring whereas juvenile Pacific hake, rockfish (*Sebastes* spp.) and market squid were important in summer. The seasonal distributions and diet were within the range of normal behavior for lactating females suggesting traditional foraging areas may not have supported sufficient prey for sea lions in spring and summer 2013.

S-11. Female California Sea Lion summer diet and pup growth on San Miguel Island

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We describe the diet of female California sea lions (*Zalophus californianus*) from scats collected during the summer on San Miguel Island for a sample of years from 1978 to 2011. We examine relationships between frequency of occurrence of some primary prey in the scat and estimates of abundance from stock assessment of those prey species. There is good correspondence between frequency of occurrence in the diet and abundance of market squid (*Loligo opalescens*), Pacific sardine (*Sardinops sagax*), and shortbelly rockfish (*Sebastes jordani*), but not with Pacific hake (*Merluccius productus*). Sea lion pup weights standardized to 1 Oct each year were modeled as a function of environmental variables (e.g., sea surface temperature) and age 0 and 1 sardine abundance. Pup weight decreases with increasing sea surface temperature and lower sardine abundance. An unresolved pattern in the residuals with recent observed pup weights lower than predicted weights for the last 4 years suggests another source of variability is influencing pup growth. One possibility is density dependent reduction in pup growth if the population has reached its carrying capacity after 40 years of population growth.

S-12. Temporal and spatial differences in the diet of California sea lions (*Zalophus californianus*) at San Clemente Island and San Nicolas Island during 1981-2007

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The diet of California sea lions (*Zalophus californianus*) at San Clemente Island and San Nicolas Island was studied to examine temporal and spatial differences in their diet. Seasonal scat collections at each island were conducted during 1981-2007. Prey species were identified from hard parts (i.e., fish otoliths, cephalopod beaks, elasmobranch teeth, and crustacean exoskeletal remains) recovered from the samples. Percent Split Frequency of Occurrence (SFO%) was used as the index for describing the composition of the diet. Of 133 prey identified to species the most common prey found in scat samples were market squid (*Doryteuthis [Loligo] opalescens*), northern anchovy (*Engraulis mordax*), Pacific hake (*Merluccius productus*), jack mackerel (*Trachurus symmetricus*), Pacific sardine (*Sardinops sagax*), shortbelly rockfish (*Sebastes jordani*), and Pacific mackerel (*Scomber japonicus*). Temporal shifts in the diet were found between these seven species, with anchovy being the dominant prey during the 1980's and market squid being the dominant prey during the 1990's and 2000's. Switch feeding between these common species was observed during the 1981-2007 time period. Significant seasonal differences ($p<0.05$) in SFO% were found for market squid, northern anchovy, Pacific sardine, Pacific hake, Pacific mackerel, and jack mackerel. Significant island differences ($p<0.05$) in SFO% were found for Pacific hake and shortbelly rockfish. Size of prey was estimated from measurements of fish otoliths and cephalopod beaks (adjusted to account for digestive erosion). Significant seasonal, annual, and island differences ($p<0.05$) in size were observed for most of their common prey.

S-13. Spatiotemporal variability in the diet of nonbreeding Brandt's Cormorant (*Phalacrocorax penicillatus*) in the Monterey Bay region

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Brandt's Cormorant (*Phalacrocorax penicillatus*) diet composition was investigated using pellets (n = 285) collected on 19 sampling days at 3 locations during the 2006-07 and 2007-08 nonbreeding seasons in the Monterey Bay region. The conventional diet method was used and efficacy of the all-structure technique was evaluated. Although 29 species were consumed, Northern Anchovy (*Engraulis mordax*) dominated the diet and Speckled Sanddab (*Citharichthys stigmaeus*) also was important. Few rockfishes (*Sebastes* spp.) and Market Squid (*Doryteuthis opalescens*) were consumed compared with previous studies in the region during the 1970s. El Niño and La Niña conditions during the study provided a unique opportunity to examine predator response. Greatest prey number and diversity occurred at locations within Monterey Bay during cooler ocean conditions whereas the outer coast location remained unchanged. Short-term specialization was observed, but mean prey diversity indicated a generalist feeding mode. Patterns of prey number and diversity within a nonbreeding season were not consistent among locations. This study demonstrates the importance of periodic sampling at multiple locations within a region to detect spatiotemporal variability in the diet of this opportunistic generalist.

S-14. Meta-analysis of food habits of marine predators in the California Current over the past century

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While it is well known that mid-trophic level forage species directly support marine bird, mammal and predatory fish populations, a synthesis of the relative contributions of particular forage species across taxa is lacking. Moreover, only about half of primary forage species in most marine ecosystems fits the traditional definition of "planktivorous coastal pelagics"; indeed, a variety of invertebrates and juveniles of large predatory fishes make up much of the forage assemblage and may be critical to predator population dynamics and fisheries services. Therefore, to better understand the importance of the array of forage species we assembled the California Current Predator Diet Database (CCPDD), a meta-database of the published and technical literature on diet composition of over 130 species of predatory fishes, seabirds and marine mammals (see Szoboszlai *et al*. abstract for details). Meta-analyses of the CCPDD reveal that the top forage species consistently include northern anchovy, euphausiid crustaceans ("krill"), market squid, Pacific herring, Pacific saury, and juvenile rockfishes (*Sebastes* spp.) and sanddabs. We present results of predator dependency on different proportions of forage in the diet. We also characterize how this forage dependency varies between predator groups, as well as spatially and temporally over the past century. These meta-analyses aim to characterize predator diet to assist with an ecosystem approach to forage fisheries. To that end, data from the CCPDD is being used to populate a diet matrix for an updated ECOPATH model of the CCS with specific detail on forage species, part of a study to examine trade-offs between the value of forage fish fisheries and other ecosystem services.

S-15. Modeling spatial-temporal dynamics of the krill prey field in the central California Current

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The spatial organization of prey resources is critical to the foraging success of predators. In the central California Current, krill form a key prey resource for a diverse array of predators from fish to seabirds and marine mammals. Previous research has shown that krill occur in large patches (or "hotspots") of abundance that are typically found downstream from centers of upwelling in this system (Santora et al. 2011). In this study, we use a coastal ocean model (ROMS), integrated with an individual-based model parameterized for *Euphausia pacifica,* to investigate if we could reproduce known krill "hotspots" in our time-space domain and if we can determine the importance of physical forcing in formation of these hotspots. In our experiment, we compared the resulting distribution of krill particles while varying the upper limit of vertical migration from 0 to 40 meters. Based on 90-day model runs initiated on February 15th and May 15th over 9 years (2000-2008), we found consistent aggregations of krill along the San Mateo coastline and off Monterey Canyon, both locations that were identified as hotspots via acoustics. Regions to the north of Point Reyes and south of Point Sur have fewer and more transient hotspots that correspond with physical forcing. This study highlights the role of transport and vertical migration in the maintenance of krill hotspots along the central California coast. The lack of particle retention in certain hotspots highlights the potential role of other factors (behavior, reproduction, predation, etc.) in the formation and maintenance of krill spatial structure in the California Current.

S-16. Evidence of increased cephalopod production in the eastern Tropical Pacific Ocean

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The rise in global and regional cephalopod landings over the past several decades has led to the hypothesis that cephalopod abundances have increased in response to fishery-induced alterations of marine food webs. However, this hypothesis has yet to be tested due to the absence of direct sampling of non-targeted cephalopod species. We used the feeding habits of pelagic predators as a proxy for cephalopod availability to identify whether there is evidence of increased cephalopod productivity in the eastern tropical Pacific Ocean (ETP). We tracked the frequency of occurrence of cephalopods in the stomachs of yellowfin tunas (*Thunnus albacares*) during the 1950s, 1970s, 1990s, and 2000s. We also evaluated the occurrence of cephalopods in the diets of various pelagic predators over the contemporary period (1990s and 2000s) to determine if changes were observed across multiple species. Our results revealed a notable increase in the frequency of occurrence of cephalopods in diets of yellowfin tunas from the 1950s to the present, suggesting an increase in cephalopod production in the ETP since the mid-20th century. The occurrence of cephalopods also increased across many predators' diets between the 1990s and 2000s, thus providing corroborating evidence of an increase in their productivity. The potential consequences of higher cephalopod production in the ETP, and in ecosystems worldwide, warrant further attention. Higher cephalopod abundances could have important implications for marine fauna, including commercially and ecologically valuable species.

S-17. A 7-year climatology of underwater glider data along CalCOFI lines 66.7, 80 and 90

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Autonomous underwater gliders offer the possibility of sustained observation of the coastal ocean. Since 2006 Spray underwater gliders have surveyed along CalCOFI lines 66.7, 80, and 90, constituting the world's longest sustained glider network, to our knowledge. In the California Glider Network, gliders dive between the surface and 500 m, completing a cycle in 3 h and covering 3 km in that time. Sections extend 350-500 km offshore and take 2-3 weeks to occupy. Measured variables include pressure, temperature, salinity, depth-average and depth-dependent velocity, chlorophyll fluorescence, and acoustic backscatter. The California Glider Network has amassed over 7300 glider-days, covering over 150,000 km with over 67,000 dives. We are creating a climatology on each of the three lines, with a goal of providing convenient access to the data. The climatology is produced by objective mapping to a uniform grid as a function of time, depth, and along-section position. We report on the current status of the climatology as a work in progress. Preliminary results include an examination of variability on the same time scales as El Niño.

CONTRIBUTED ABSTRACTS

C-1. Status and trends in the southern California Spiny Lobster fishery and population: 1980-2011

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The California spiny lobster (*Panulirus interruptus*) fishery in southern California ranks amongst the State's most economically important fisheries. An analysis of commercial harvest data confirms that the fishery was landing near-record catches in the late-2000s through early-2010s. Advances in recreational fishing technology likely tempered commercial fishery landings per unit effort. The commercial catch per trap pulled declined 15%/year, on average, in years after the introduction of a new rigid-style hoop net in the recreational fishery. Fishery-independent data sourced from power plant marine life monitoring recorded increased California spiny lobster abundance after 1989 with evidence of increased larval settlement beginning circa 1989. This timing was consistent with previously reported oceanographic changes in the North Pacific. Power plant abundance indices derived for lobsters approximately one year before recruiting into the fishery, as well as young-of-the-year, significantly predicted the commercial landings at index-appropriate temporal lags, i.e. one year for next year's recruitment. Carapace lengths measured during power plant surveys in Santa Monica Bay, where commercial fishing was prohibited, significantly declined for the total sample and females only after the introduction of the new rigid hoop net. Male carapace lengths were not significantly different between the two periods. The power plant data confirms that, as of 2012, the fishery appears healthy but warns of the need to monitor sublegal individuals and their dependence on oceanographic conditions. These analyses also indicate the urgency of monitoring the recreational fishery harvest, especially the potential effects of the new rigid hoop net.

C-2. Age and growth of the Giant Sea Bass, *Stereolepis gigas*

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The giant sea bass, *Stereolepis gigas*, is the largest bony fish that inhabits the southern California kelp forest community. According to the IUCN, *Stereolepis gigas* is a critically endangered species, yet little is known about its life history. This study marks the first attempt to construct an age-and-growth model for the giant sea bass. Overall, 64 samples were obtained for age-and-growth analysis through collaborative efforts with commercial fish landings and scientific gill-netting. Sagittae (otoliths) were cross sectioned and analyzed with digital microscopy techniques, resulting in the verification that *S. gigas* is a long–lived species attaining at least 76 years of age. Of the three growth models tested, the von Bertalanffy growth function resulted in the best fit with the lowest values calculated for both AIC and BIC diagnostics. Nearly 90% of the variation between age (years) and standard length (mm) was accounted for in the von Bertalanffy growth model ($R^2 = 0.895$). The growth coefficient ($K = 0.044$) indicate this species has a slow growth rate, however, the negative value for t_0 ($t_0 = -0.339$) is indicative of a species that grows rapidly in their first year of growth and then has a decreased growth rate in the years following. A predicted maximum length with indefinite growth ($L_{\infty} = 2026.2$ mmSL) agreed well with the recorded maximum size of giant sea bass. Long-lived species such as giant sea bass that are slow to reach maturity often have a low resilience to over-fishing. Therefore, it is of paramount importance that we continue to collect essential life history data on this species in order to more effectively protect and manage the *S. gigas* population.

C-3. Variations on a theme by Isaacs: "Some ideas and frustrations about fishery science"

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This paper revisits John Isaacs contribution to the 1976 CalCOFI Symposium "Fishery Science: Fact, Fiction and Dogma and assesses his ideas and frustrations with fishery science in view of present ecosystem-based and ecosystem model-based fishery science. The review suggests that there has been considerable improvement on about half of Isaac's ideas and frustrations and little improvement on others. Several of his 14 points including resolution of trophic level concepts, alteration of the concept of steady state environmental conditions and measurement of primary production have had some advances in knowledge but little application in fishery management. There has been little advance in knowledge concerning recruitment relationships with stock size or environmental conditions. Knowledge of the critical interactions during the first year of life is nearly as limited as it was in 1976 and young-of-the-year population dynamics of fishes has yet to be included in stock assessments or ecosystem models.

Reproductive success (recruitment) is considered to be the principal driver of the population dynamics of the majority of marine vertebrates and it is usually measured by the survival rate during the first year of life. The majority of marine fishes have a pelagic life-history stage that extends from several months to years and survival to age 1 is heavily dependent upon predation by zooplankton and vertebrates. The pelagic, early-life history stages of marine fishes are heavily dependent upon zooplankton for food from the time of first feeding until they either settle to their benthic habitat or become large enough to consume neckton. To date none of our analyses have been able to address the relative value of planktivorous, forage fishes, as food for the adults of higher trophic level species, versus the detrimental affects of their predation on the early life history stages of other fishes and/or the detrimental affects of their completion for the zooplankton consumed by the early-life history stages of higher trophic vertebrates.

Available stock assessments and results from ecosystem models are used to expand on Isaac's theme to demonstrate the importance of a small number of planktivorus fishes in the ichthyo-biomass of California Current fishes and to highlight the fact that present analyses and models are not designed to assess the interactions between species that occur during their first year of life. As Isaacs wrote, 'Copepods do eat tuna!'

C-4. Inter-annual and seasonal trends in cetacean distribution, density and abundance in waters off southern California

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Trends in cetacean abundance, density and distribution in the southern California Current System were assessed through visual line-transect surveys during thirty-five California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from July 2004-April 2013. From sightings of the six most commonly encountered cetacean species, seasonal, annual and overall abundance estimates were estimated. Blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*) were the most frequently sighted large whales with overall abundances of 472 (CV=0.29), 687 (CV=0.21), and 370 (CV=0.27) respectively. Blue whales were primarily observed during summer and fall while fin and humpback whales were observed year-round with peaks in abundance during summer and spring respectively. Short-beaked common dolphins (*Delphinus delphis*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) and Dall's porpoise (*Phocoenoides dalli*) were the most frequently encountered small cetaceans with overall abundances of 198,440 (CV=0.17), 6,635 (CV=0.28), and 10,160 (CV=0.23) respectively. Seasonally, short-beaked common dolphins were most abundant in summer whereas Pacific white-sided dolphins and Dall's porpoise were most abundant during spring. General Additive Modeling of annual trends in abundance within the CalCOFI study area for each of the six species indicated that blue whale abundance was stable and fin whales were increasing, while humpback whales, short-beaked common dolphins, Pacific white-sided dolphins and Dall's porpoise decreased in abundance over the course of the study. Variations in species-specific spatial distribution patterns were also apparent and indicative of species habitat preferences within the California Current Ecosystem. Observed variations in cetacean abundance and distribution are related to fluctuations in measured ecosystem parameters, particularly zooplankton abundance and sea surface temperature. The present study examines seasonal and inter-annual patterns in density, abundance and distribution on a longer continuous time scale with a higher rate of sampling than previous cetacean surveys off the California coast, particularly for the winter and spring periods, for which there are currently few data available.

C-5. Pacific sardine landings in the California Current System

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Accumulated landings of Pacific sardine (Sardinops sagax) from Vancouver to Gulf of California reached 8´833,602 mt from 1981 to 2012. In the same period but only in the Gulf of California 5´457,632 mt were landed, and 3´375,969 mt in the Pacific coast from Magdalena Bay until Vancouver. For this period, the Pacific sardine catches occurred earlier in southern fishing areas than in the northern. In Magdalena Bay and Cedros Island catches began in the 80´s, while in Ensenada, San Pedro and Monterey started in the 90´s, and in Oregon-Washington and Vancouver landings practically initiated in the first decade of 21 century. Accumulated landings of Pacific sardine by country from 1981 to 2012 were 1´886,847 mt for México, 1´386,652 mt for USA and 102,470 mt for Canada. Accumulated landings by sardine stock in same period was 5´805,161 mt for the warm stock (65.7%; catches obtained at SST > 22°C), 1´406,756 mt for the temperate stock (16.0%; SST $\geq$ 17°C $\leq$ 22°C), and 1´690,776 mt (18.3%; SST<17°C) for the cold stock. Accumulated landings by stock in México (without Gulf of California) were 347,528 mt (18.4%) for the warm stock, 1´176,392 mt (62.3%) for the temperate stock, and 362,979 mt (19.2%) for the cold stock. Accumulated landings by stock for USA + Canada were 1´257,999 mt (84.5%) for the cold stock and 230,414 mt (15.5%) for the temperate stock. The fishing zones of Ensenada and San Pedro are of particular interest for the stock assessment because in these places both temperate and cold sardine stocks are caught and landings corresponding to each stock must to be separate to each sardine stock can be evaluated independently. Accumulated landings of Pacific sardine in Ensenada of the temperate and cold stocks from 1981 to 2012, were 683,398 mt (65.3%) and 362,977 (34.7%) respectively. Sardine landings in San Pedro for same period were 426,738 mt (64.9%) for cold stock and 230,414 mt (35.1%) for temperate stock.

C-6. Diet of an adaptable seabird highlights the importance of prey-switching in response to dynamic preyscapes over two decades

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Long-term datasets of seabird diet can provide useful compliments to trawl data for perspective on forage fish dynamics, as well as providing valuable information on the ecology of top predators. Studies in the California Current have shown inter-annual variations in northern anchovies (*Engraulis mordax*) and juvenile rockfish (*Sebastes* spp.) availability are important to the reproductive success of many piscivorous predators. We monitored the crepuscular and nocturnal diet of a pursuit diving seabird, the Rhinoceros Auklet (*Cerorhinca monocerata*), at Año Nuevo Island (ANI) from 1993-2013. Thayer and Sydeman (2007) found a correlation between Rhinoceros Auklet chick growth and the amount of anchovy in chick diet at ANI. Here, we further explored the relationships between prey and breeding performance with nine years of additional data (2004-2013). Chick diet, chick growth, and auklet productivity (chicks fledged/breeding pair) were quantified annually and adult and chick diet was studied using stable isotopes in 2012 and 2013. Over the 21 year sampling period, auklets fed chicks 45 prey species (n = 2,243 individual fish) dominated by juvenile rockfish (*Sebastes* spp.), northern anchovy (*Engraulis mordax*), Pacific saury (*Cololabis saira*), and market squid (*Doryteuthis opalescens*). Juvenile shortbelly (*S. jordanii*) and widow (*S. entomelas*) were the most frequent of 13 rockfish species fed to chicks. In years with few anchovy and rockfish in chick diet, a diversity of other forage species was taken. Annual chick growth was positively correlated with the proportion of anchovy in chick diet, while annual productivity was positively correlated with the proportion of juvenile rockfish in chick diet. Annual chick growth and productivity were both negatively correlated with the proportion of market squid in chick diet. Stable isotope analysis showed that adult and chick diet was similar, indicating that chick diet may be representative of prey available to all age-classes of Rhinoceros Auklets during the summer rearing season. Overall, this predator's reproductive performance remained greater when anchovy and juvenile rockfish were available, despite their ability to successfully raise young on other forage fish and squid.

C-7. Vertical distribution of fish larvae and hydrographic conditions along the southwestern coast of the Peninsula Baja California (June 2010)

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The hydrographic conditions along the southwestern coast of the Peninsula Baja California influence the vertical distribution of fish larvae in summer June 2010. Along the stations line, from north (in front of Baja California coast at 24°N-112°W) to south (to the coast in front of Cabo San Lucas at 22.5°N-110.5°W), a hydrographic and zooplanktonic intensive sampling was made. Physical and chemical data were obtained using a CTD and LADCP. Zooplankton hauls were using closed-open-closed net (505 μm). The oblique hauls were every 15 m, in the first 45 m depth, and every 50 m, from 200 to 50 m depth. From a total of 1,741 collected fish larvae, there were identified 34 families and 73 taxa. The zooplanktonic biomass presented the higher values (> 500 mL/1000m^3) in the surface stratum with maximum surface oxygen values of 3-5 mL/L for the northern stations. The higher abundances of fish larvae (> 250 larvae/10m^2) are located at the southern stations, but opposite to the biomass, their distribution is between 0-200 m depth. The oxyplet of 1 mL/L was observed at ~70 m depth in front of Cabo San Lucas and deepens northward to ~220 m depth. A saline front (~34.4) was observed outward of the Gulf of California which breaks the surface and deepens up to 200 m depth. Northward of the salinity front, low salinity values (~33.6-34) and low temperatures values are observed (12-18°C). At the north of the front there are two habitats with low fish larvae abundance related to the California Current with *Triphoturus mexicanus* as dominant species. Southward of the salinity front, higher salinity values (~34.6-34.8) and low temperatures values are observed (12-22°C). Showing two tropical habitats with higher fish larvae abundance, one in the upper 50 m depth (with dominance of *Vinciguerria lucetia)* and the other below the oxyplet of 1 mL/L (dominated by *Diogenichthys laternatus)*. This strong heterogeneity in their vertical distribution reflects the variability of this convergence region, where the equatorward California Current water meets with the poleward Surface Tropical water moving northward.

C-8. Year-round spawning behavior of an invertebrate forage species: the market squid, *Doryteuthis opalescens*

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The market squid, *Doryteuthis opalescens*, represents a key ecological link in the nearshore ecosystem, is an important forage species for sustaining federally protected marine tetrapod populations, and constitutes the largest commercial fishery in California, USA (volume and ex-vessel value). Elusive and ephemeral, market squid can be difficult to sample which has led to an incomplete understanding of their population dynamics. For example, several hypotheses have been proposed to explain apparent patterns in fishery-dependent data including: (1) squid migrate between a northern and southern location, (2) squid migrate between deep (≥ 100 m) and shallow areas (< 100 m), and (3) squid reproduce continually in a conveyor-belt type behavior. Here we conducted the first known high-frequency (every month) observational study of a squid spawning ground at La Jolla, USA using SCUBA, and a drop-down camera (5-30 m depth) and ROVs (10-420 m depth). We collected embryo capsules representative of 18 cohorts from Aug 2011 through June 2013 on the continental shelf (20-45 m water depth) and measured [O_2], and temperature for from June 2012 through July 2013. Spawning occurred over a variety of habitats including sand, submarine canyon walls, and kelp and through a range of temperatures range of (10-19 °C) and [O_2] levels (75-240 µmol/kg). Further, these spawning squid displayed behavioral plasticity in their use of the shelf (e.g. depth) and their spawning aggregation size and type. Our results indicate that squid spawning occurs continuously throughout the year, transporting onto the shelf a year-round food source for benthic and pelagic predatory species.

C-9. Ichthyoplankton community composition as a predictor of Pacific Sardine (*Sardinops sagax*) recruitment success

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The environmental conditions that lead to particularly good or poor years for recruitment success of Pacific sardine may be viewed as ecological "disturbances" which are also likely to affect other species in the community. We tested the hypothesis that the species composition and abundance of the icthyoplankton community during spring could be used to predict future recruitment success of Pacific Sardine. Broad categories of recruitment success could be predicted moderately well. The model was somewhat limited by the fact that different types of poor years existed, and each had a unique community composition. Community-based indices of recruitment may be useful to predict changes in recruitment at a gross level before more precise estimates can be made as part of the stock assessment.

C-10. Inter-decadal changes in biodiversity in larval fish assemblages off southern California

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Previous analyses of CalCOFI time series indicated that ichthyoplankton species composition and oceanographic conditions differed substantially between "cool" (PDO-, 1951-1976) and "warm" (PDO+, 1977-1998) periods, but it is unclear how recent biodiversity patterns and assemblage structure compare with previous years. Here we dissect patterns and causes of variability in the ichthyoplankton species richness and assemblage structure of the core CalCOFI (southern California) region between 1951 and 2011. Highest average species richness was found in spring, followed by winter, summer, and fall. The location of high species richness also differed by season. Species richness hotspots were found in the northeast of the study area in winter, the south-central and west in spring, and the southwest in summer and fall. Within each season, species richness was lower in the last decade (1999-2011) relative to recent PDO- and PDO+ periods. Inter-annual fluctuation in winter species richness was correlated with the combined abundance of six non-fished pelagic species whose biogeographic center of distribution is north of the core CalCOFI region, while summer and fall species richness correlated with the abundance of six non-fished southern species. Abundance of the northern species declined dramatically in winter and spring in recent years relative to both recent PDO- and PDO+ periods. Southern species declined relative to the recent PDO+ period, but were still higher than the recent PDO- period during summer and fall. Multivariate analyses revealed that assemblage composition in recent years was distinct from both previous periods in winter and spring, but was similar to the recent PDO+ period in summer and fall. The dramatic change in winter and spring assemblage structure in recent years was driven largely by a declining influence of anchovy and hake. Our analysis of ichthyoplankton biodiversity and structure suggests that ichthyoplankton assemblages in the last decade are distinct from recent PDO- and PDO+ periods, and are characterized by overall lower species richness, driven by seasonal-specific declines in the abundance of fished and un-fished pelagic species with both northern and southern biogeographic affinities. This suggests that many of the pelagic species have moved out of the CalCOFI region in the last decade, regardless of their biogeographic distribution.

C-11. Indirect climate change impacts on fish species in the California Current

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Ocean acidification already impacts both ocean ecosystems and the humans who depend on them. Laboratory experiments continue to examine direct, species specific, impacts. Although studying the predicted direct effects of ocean acidification is important, studies examining larger scale, indirect, ecosystem-based effects are equally valuable and are lacking. It is vital to determine how indirect effects of ocean acidification might impact ecological systems, including fisheries. My work synthesizes findings from laboratory studies on biological effects of ocean acidification and combines this with known diets for fish species in the California current to predict which species will likely be impacted due to loss of prey. Diet data from published studies were entered into a the National Oceanic and Atmospheric Administration's (NOAA) diet database for California Current species, as part of NOAA's vulnerability assessment of California Current food webs and economics to ocean acidification. One commercially important fishery species, Dover sole (*Microstomus pacificus*), was identified as most at risk because roughly 42% of its prey items are highly susceptible to ocean acidification (mollusks and echinoderms). An existing economic equation was simplified and applied to determine the potential financial loss for the West Coast due to the loss of diet per ocean acidification for this species. Although simple, analysis such as this could be a helpful predictor of potentially hidden effects of ocean acidification for fisheries along the West Coast.

C-12. Retention of juvenile fish in the Santa Barbara Channel Eddy: Using three-dimensional modeling to explain field observations

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The role of the Santa Barbara Channel (SBC) eddy in the retention of juvenile fish is investigated. The SBC is a 500 m deep basin bounded to the north by the Southern California coast and to the south by the Northern Channel Islands. The SBC eddy is a cyclonic mesoscale eddy, which occurs predominantly in summer and fall in the SBC. In June 1998 and 1999, the eddy was surveyed for juvenile fish using net tows. In 1998, very high numbers of juvenile fish were caught in the center of the eddy, but not in 1999. To better understand the ocean conditions that lead to differences in abundance, we analyzed output from a three-dimensional, high-resolution ocean circulation model and used a particle tracking model to simulate the transport of larval and juvenile fish. We used an algorithm described by Nencioli et al. (2010) to detect the SBC eddy, which in turn allowed us to investigate its structure and persistence. We found that before and during the June surveys, the structure and dynamics of the simulated SBC eddy differed in 1998 and 1999. In 1998 the SBC eddy was larger, more symmetric, and more persistent when compared with 1999. This is consistent with observational results during these years as described by Nishimoto and Washburn (2002). By examining the relative vorticity at multiple depths, the SBC eddy was found to exhibit extended periods of near solid-body rotation in 1998, but not in 1999. The residence times of particles inside the eddy also differed between years. The average residence time inside the eddy was 45 days in 1998, but only 15 days in 1999. We hypothesize that in 1998, the SBC eddy's extended periods of near solid-body rotation along with its larger size and longer lifetime increased retention, explaining the higher abundance of juvenile fish observed in the eddy.

C-13. Seabird diet as an indicator of annual variability in juvenile anchovy and rockfish recruitment

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Northern anchovy (*Engraulis mordax*) and juvenile rockfish (*Sebastes sp.*) are staples in the diets of many marine predators and should be managed with an ecosystem-based approach that benefits both human and marine predator consumption. Such an approach should assess stocks from both the fishery's and predator's perspective. We investigated the California Least Tern (*Sternula antillarum browni*) as a potential indicator of juvenile recruitment in anchovy and rockfish populations. We studied diet at a breeding colony in central California for 13 years (2001-2013) and discovered a strong positive relationship between dietary anchovy and rockfish occurrence and annual tern reproductive success. Additionally, we compared annual diet to measures of regional anchovy and rockfish larval abundance at various temporal scales. We found positive correlations when larval abundances were measured during the fish spawning season prior to the tern breeding season. Finally, we compared tern diet to indices of regional oceanic productivity and found strong correlations when indices were averaged from the end of the fish spawning seasons through the tern breeding season. Anchovy occurrence was correlated with El Niño and Pacific Decadal Oscillation indices averaged from winter through summer, while rockfish occurrence was correlated with sea surface temperature averaged from spring through summer. Thus, Least Tern diet is responding to variability in both larval production and factors leading to larval survival. These results provide insight into oceanographic variables important to the survival of anchovy and rockfish larvae and suggest a potential for using seabird diet to detect variability in juvenile recruitment to adult populations.

C-14. Changes in forage fish community as indicated by the diet of the Brandt's Cormorant (*Phalacrocorax penicillatus*) in the California Current

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The offshore Southeast Farallon Island in Central California hosts the largest Brandt's cormorant (*Phalacrocorax penicillatus)* colony on the west coast of North America. Over 40 years annual breeding productivity data has shown that productivity co-varies with ocean productivity. However, since 2008, this species has experienced a dramatic population decline and anomalously low productivity unique to the time series, despite the return of productive ocean conditions. In contrast to the Farallones, the mainland Brandt's cormorant colony at Point Arguello has experienced an increasing population and higher productivity than the Farallones in the same recent time period. In addition, the populations of several other mainland colonies in central California have grown dramatically, suggesting favorable feeding conditions. We ask if the differences between mainland and island colonies can be explained by diet and prey availability.

Brandt's cormorant diet in the 1970s on the Farallones was dominated by juvenile rockfish (*Sebastes* spp.) and breeding productivity in most years was average to below average. In the 1990s and early 2000s, the diet was dominated by northern anchovy (*Engraulis mordax*) with the abundance of anchovy being positively correlated with breeding productivity. Since 2008, the diet has switched back to being dominated by rockfish and productivity has been anomalously low. Similar to the Farallones, diet at Point Arguello showed anchovy being consumed in 2007, followed by an increase in the amount of rockfish species in more recent years.

To better understand which species of rockfish were being consumed by seabirds in central California, we looked at the diet of the rhinoceros auklets (*Cerorhinca monocerata*), a species that yields samples of whole fish that can be identified to the species level. Rhinoceros auklet diet showed decreasing proportions of the offshore rockfish (*Sebastes jordani*) and increasing proportions of nearshore rockfish species (*S. flavidus*, *S. mystinus*, and *S. entomelas*) over time. Thus, while recent oceanographic conditions may favor rockfish productivity, the juvenile rockfish community appears to have switched from pelagic associated species to nearshore associated species.

Together, these results illustrate major shifts in the species composition of important forage fish. The availability of the once abundant northern anchovy has declined, reproductive output of the offshore shortbelly rockfish has waned, and the juvenile rockfish community appears to now be dominated by nearshore-settling species. This has resulted in reduced breeding productivity and an overall drop in the breeding population for the offshore Farallon cormorants. By contrast, more Brandt's cormorants are breeding at mainland colonies where the nearshore rockfish species are within a more suitable foraging range for breeding cormorants.

C-15. Foraging Ecology of Tunas and Opah in the California Current

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Tunas and opah in the California Current are important components of the local food web. To better understand the basic biology and ecology of tuna and opah caught in the Southern California Bight (SCB), which is also an important foraging ground for marine mammals, seabirds, and many fish, the Southwest Fisheries Science Center (SWFSC) has been collecting stomachs from albacore (*Thunnus alalunga*), bluefin (*T. orientalis*), yellowfin (*T. albacares*), and opah (*Lampris guttatus*) since 2007. Preliminary stomach content analysis shows that tuna forage almost exclusively on epipelagic juvenile fish and squid; for fish consumed, the average standard length was 53 mm and for squid the average mantle length was 61 mm. In 2007, small teleosts (primarily northern anchovy (*Engraulis mordax*)) comprised the dominant prey category by frequency of occurrence, %F (89%), followed by cephalopods (18%) and crustaceans (16%). In 2008, there was increase in prey diversity and a shift in prey composition with cephalopods [California market squid *(Loligo opalescens*)*;* jumbo squid (*Dosidicus gigas*)] playing a more important role by %F (86%), followed by teleosts (84%) and crustaceans (56%). Opah stomach contents included species of squid and fish typically associated with mesopelagic waters; thirteen (13) species of cephalopods were identified with 3 (*Loligo opalescens, Gonatus spp., Dosidicus gigas*) making up the most important prey items based on the IRI (index of relative importance). Prey found in opah stomachs tended to be larger than those found in tuna stomachs; squid ranged from 30 mm (*Gonatus spp.*) to over 266 mm mantle length (*D. gigas*). Inter-annual and interspecific analysis show shifts in prey composition in the diets of tuna providing insight into the dynamics of forage base in the California Current and SCB. For example, the apparent lack of readily available northern anchovy in 2008 may have been responsible for the apparent increase in species diversity in comparison to 2007. Over the same period, the moderate La Niña in the spring of 2008 may have increased the availability of cephalopods as cooler temperatures favor their recruitment. Changes in the available forage base likely influence the relative abundance of the different tuna species and opah in the California Current across years. This could potentially explain the difference in albacore landings by the Commercial Passenger Fishing Vessels Fleet, with 38,000 albacore landed in 2007 compared to only 4,705 albacore in 2008. Additional efforts to link changes in forage base to natural and anthropogenic environmental variability are ongoing.

C-16. Resilience in California Current pelagic community structure: A sixty year study

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We have determined the variations in abundance of 16 functional groups of California Current mesozooplankton and five species of larval fish over inter-decadal Spring and Fall periods spanning 60 years of sampling on CALCOFI line 90. We ask "What changes in community structure have occurred over this time period"?

Overall there is a log-normal distribution of group abundance. Larval fish are less than 2% of the total numbers. Bray-Curtis dissimilarity analyses showed that there were only minor changes in dominance structure, but there were cyclical changes in abundance. There was substantial agreement between functional groups as to when to be abundant and when to be rare. There were large physical disturbances during this time period and a substantial decline in zooplankton predators, the
Sardine and Anchovy.

We conclude that functional group community structure is highly resistant to perturbation and that is not regulated "Top Down"

POSTER TITLES AND ABSTRACTS

P-1. Pacific mackerel spawning habitat off Baja California between 2000-2005

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Pacific mackerel (*Scomber japonicus*) is the second most important coastal pelagic fish in commercial captures within the California Current. The region off Baja California in the Pacific is the principal habitat, although its presence in southern California needs to be confirmed. We use underway temperatures and CUFES samples taken on Investigaciones Mexicanas de la Corriente de California (IMECOCAL) surveys to investigate the character of the spawning habitat and detected stocks during the winter-spring series 2000-2005. The spawning habitat was found closely related with a transition front that delimited costal upwelling and oligotrophic oceanic waters. In winter, isotherms of 18-20 °C identified a region around Gulf of Ulloa to Bahia Magdalena [26.4 to 24.5°N; -113.3 to -112.1°W] with a large concentration of eggs associated with a northern stock. However, spawning occurred along the entire study area over a wider temperature range (12.5-21.5°C) in spring, which indicated a northward movement and offshore displacement of the stock due to the California Current intensification. By summer, the regional warming confines the stock to the northernmost sites, with high abundance in few stations.

Interannual variation during 2002 and 2003 suggests that the physical forcing controls the species dynamic habitat. In 2002, the number of eggs (5500) were found in about 15% of the stations and extended 200 km offshore southward to the area off northern Baja California. During 2003 the habitat shifted onshore in three patchy areas, and the total number of eggs (2919) dramatically reduced to ~11% of the area compared to April 2002. This suggests that the transitional habitat apparently is displaced during April 2003 by a compression of the more oceanic habitat towards the coast due to Ekman transport relaxation.

P-2. Oceanographic factors that modulate the composition and abundance of Copepods: Analysis of sediment trap time-series, Ensenada, Mexico

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The collected zooplankton by traps (or swimmers), can be studied in specific composition, for example in their size. An automated sediment trap (Technicap® PPS 3/3) with an opening area of 0.125m^2 was installed at 300 m depth with a resolution of 17 days (April 1st to October 15th 2012). This equipment was located in the adjacent area of Punta Banda, Ensenada, (31.64°N-116.74°W). The trap holds 12 collector bottles with contains a solution preserved with filtered seawater base (0.45μm) and formaldehyde at 4% buffered with sodium tetraborate. Initially the zooplankton was separated by a sieve with net size of 1000 μm. The copepods represented the 74 % of swimmers individuals identified in Punta Banda, followed by polychaetes with 12 %, ostracods with 6.0 %, and chaetognaths with 2%. The ctenophores and amphipods conformed less than 2%. From the copepods group present during the period between April through May (14–16°C), were identified the following species: *Chiridius poppei*, *Eucalanus californicus*, *Euchirella* sp (adults and juveniles), *Gaetanus pungens*, *G. pileatus*, *Gaetanus miles*, *Scaphocalanus echinatus*, *Scolecithricella* sp., *Scottocalanus persecans*. The specie *G. pungens* was persistent until the warm season (17–19°C). The compositions and abundance of copepods decreased at the end of the study period. Some of these zooplanktonic groups and other species of copepods, accompanying the marine snow can be considered part of the decomposer trophic chains and be part of the passive flow organic carbon in this area.

P-3. Variability of elemental composition and stable carbon isotopes in tropical northeastern Pacific during the last two thousand years

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Organic matter in the water columns and sediments of transitional environments and oceans is often described as a binary mixture of terrestrial and aquatic end members. Molar C:N ratios and d13C of samples and end members are often used in linear mixing equations to estimate the fraction of terrestrially derived organic matter (OM) in aquatic and sedimentary environments. In this paper we showed new data from the ratio C:N and d13C of marine sediment multi-core was raised from a water depth of 680 m on the open margin off the western coast of southern Baja California. The ratio C:N and d13C values of sedimentary organic matter showed a variability of centennial scale over the past 2000 years. The d13C values suggest that the origin of the organic matter was primarily dominated by phytoplankton source (i.e., diatoms) corresponding to periods of high solar activity. The variability of the sources of organic matter is apparently controlled by solar forcing.

P-4. Update analysis of age, length, and maturity of Pacific mackerel *(Scomber japonicus)* collected off San Diego, CA 2009-2012

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Pacific mackerel *(Scomber japonicus)* is mainly fished for bait along the west coast of Southern California with limited information on this particular stock since the 1980's. As part of an ongoing maturity study conducted by Southwest Fisheries Science Center La Jolla, the population off of San Diego (within approximately one mile from shore) was sampled using hook and line on pier, commercial passenger fishing vessels (CPFV), and recreational small boats from 2009-2012. Fishing efforts were grouped into four main locations, Imperial Beach (IB), Point Loma (PL), near shore La Jolla (NLJ) and SIO Pier La Jolla (SPLJ). These current data provide a preliminary look at the size ranges, ages, and maturity of the fish caught by local fisherman off San Diego pier or recreational fishing vessel. From 2009-2012, approximately 982 fish collected ranged in fork length (FL) from 144 to 414 mm. The majority of fish sampled were representative of the age classes 0 to 2 with the exception of IB which did not contain any age 0. NLJ and IB contained a wider range of age classes compared to the other two sample locations which tended to have ages between 0 and 2. The largest and oldest fish caught were off IB with a mean age of 2.94 and a mean FL of 316.06 mm. We updated previous reads with 200+ blindly read ages for validation of age. The representative age categories were improved in an effort to reduce ageing error and streamline observed age classes. The reproductive organs were staged visually using the SWFSC gross anatomical codes (Table 1) during dissection. For analytical purposes the fish were subsequently grouped into three classes: immature, intermediate, and mature. All three maturity classifications were observed in each age group until approximately age 3 (~ 290 mm FL) by which all fish were considered to be either in an intermediate stage or mature. Immature fish represented a wider than expected length range of 150 mm to 310 mm FL and most were between the ages of 0 and 1. Comparison of visual and histological stages will be discussed. These sampling methods indicate a relatively young age class that consists of a large proportion of immature and intermediate stage fish. Future work needs to be done to include additional histological data on maturity and a second reader for ageing otoliths to account for ageing error.

P-5. Supporting a spatial analysis of the distribution and size of rebuilding stocks in the Rockfish Conservation Area (RCA) through directed fishing and visual surveys

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Over the last ten years, the depth-based Rockfish Conservation Areas (RCAs) have been an important, though coarse-scale, tool to support rebuilding overfished species (OFS). However, there has been limited research on finer scale demographic and distributional patterns of rebuilding species that could allow fishermen to better target healthy populations (e.g. Chilipepper, Yellowtail, and Widow Rockfishes) while avoiding OFS (Cowcod, Canary, Yelloweye). The rocky habitats that many of these OFS prefer are under-sampled in the annual coast-wide trawl surveys. Consequently, we do not know enough about overfished stocks' distributions to inform bycatch avoidance plans and promote fishing opportunities for underutilized stocks. To address these issues, we assembled a broad partnership that includes fishermen, NGOs, fisheries agencies, and academics to conduct collaborative research focused on 1) modeling and mapping predicted OFS distribution based on existing fisheries data; 2) ground-truthing predictive maps through scientific sampling of encounter rates with OFS using directed fishing inside the trawl RCA, through an Exempted Fishing Permit; and 3) characterizing abundance, length, and habitat associations of OFS in those same locations using stereo-visual survey techniques. We have precisely calibrated the stereo-visual lander system with volume/area estimates ($25m^3/10m^2$), species accumulation curves (12min soak) and measurement accuracy estimates (SE $\pm$5% of TL). The first year of field surveys yielded 419 fishing sets and 242 lander drops in locations identified by finalized predictive distribution maps for the central California Coast. Directed fishing landed 16 species, primarily epibenthic and midwater rockfishes including two rebuilding species – Bocaccio and Canary. The ratio of target to rebuilding species was 8:1. Video observations included species landed with additional sightings of Cowcod and Yelloweye in areas fished. This work will provide new data and insights on distribution and abundance of both rebuilding and healthy fish populations that should ultimately enable improved access to healthy fish stocks by fishermen while maintaining effective conservation measures for rebuilding species.

P-6. California Current predator diet database

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Characterization of the diets of upper trophic predators is a key ingredient in management including the development of ecosystem-based fishery management plans, conservation efforts for top predators, and ecological and economic modeling of predator prey interactions. Here, we describe and conduct a gap analysis of the California Current Predator Diet Database (CCPDD). The CCPDD contains data from published records of predator food habits over the past century and includes information on 130 predator species representing over 14,000 predator-prey links based on 188 published citations. We included diet data for all predators that consume forage species: seabirds, cetaceans, pinnipeds, bony and cartilaginous fishes, and a predatory invertebrate; we focused on including data to represent discrete geographic regions within the CCS (Canada, WA, OR, CA-n, CA-c, CA-s, Mexico). Availability of diet data varied by 1) predator species: common/abundant species had more complete records than rare species, 2) geographic regions: some areas had better representation of taxonomic groups than other (e.g., Oregon: most fish species, Canada and central California: most seabird species, California: most cetacean species), 3) temporally: the bulk of data ranges from 1968-present; data for winter is limited compared to summer (especially for fish and mammals), individual predators tend to have more seasonal data when their diets are easily sampled (e.g., CA sea lion scat, birds that breed nearshore). The CCPDD represents one of the most spatially and temporally comprehensive compilations of data on forage species in California Current predator diet. Summaries from the database are being used to inform the management of forage species by improving how we understand the reliance of predators on forage species.

P-7. Colony dynamics of Elegant Terns, *Thalasseus elegans,* in the southern California Bight in relation to oceanographic conditions and disturbance events

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Coastal seabirds are prey generalists known to be influenced by oceanographic conditions related to productivity and affected by various kinds of disturbance. The Elegant Tern (*Thalasseus elegans*), a coastal colonial seabird, nests at three locations in Southern California yet is recognized as a single population in the region. Numbers of nesting pairs provide the first measure of reproductive success, and they fluctuate dramatically for this tern within and among years at the three sites. Recently (1998-2013), nest numbers have ranged from <100-20,000 at the San Diego Salt Works, 100-10,000 at the Bolsa Chica Ecological Reserve, and 0-20,000 at Los Angeles Harbor. What are the forces driving these marked fluctuations? We know that conditions related to temperature and productivity vary within the region, and that disturbance, which can cause colonies to abandon a site, also vary among the nesting locations. To address our question, we are first assessing oceanographic conditions in the region using both in situ and satellite data of chlorophyll *a* and sea surface temperature (SST). These data were collected from oceanographic cruises undertaken by the CalCOFI program, and from the Moderate Resolution Imaging Spectroradiometer (MODIS), a remote-sensing instrument aboard the Terra satellite. We are testing the relationship between chlorophyll *a* and SST and nest numbers using a bootstrapping regression analysis. Second, we are analyzing changes in nest numbers within a season in relation to the timing of disturbance from Peregrine Falcons (*Falco peregrinus*) and canids—specifically, coyotes (*Canis latrans*) and feral dogs (*Canis familiaris*). We expect Elegant Terns to be attracted to high chlorophyll *a* and low SST, conditions that increase prey availability. We also expect that disturbance can cause this tern to abandon a site during a given season. Our study should help tease apart the factors driving the striking fluctuations in nest numbers.

P-8. Longterm variation in a Central California epipelagic forage assemblage

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Since 1983 the NOAA Fisheries Southwest Fisheries Science Center has sponsored a midwater trawl survey during May-June in coastal waters off central California (36°30'–38°20' N lat.). While designed to estimate the abundance of pelagic juvenile rockfish for use as pre-recruit indices in stock assessments conducted in support of management of west coast groundfish fisheries, the survey also captures a wide variety of other epipelagic micronekton. Improved identification and resolution of a variety of important forage taxa was initiated in 1990. Since then 37 taxonomic categories have occurred in ≥ 1% of all trawls conducted (N = 4,258) and 20 taxa have occurred in ≥ 10% of all hauls. A principal components analysis of the latter subset indicates that 61% of survey catch variation is explained by the first three components (λs > 2.0). The primary dimension of variation in the composition of this forage assemblage reflects two alternative states, i.e., one dominated by young-of-the-year groundfish species (*Sebastes* spp., *Citharichthys* spp., *Merluccius productus*, *Ophiodon elongates*, and *Glyptocephalus zachirus*), krill, and market squid (*Doryteuthis opalescens*), and another state dominated by clupeoids (*Engraulis mordax* and *Sardinops sagax*) and deep-scattering layer species (*Diaphus theta*, *Tarltonbeania crenularis*, other mycthophids, and bathylagids). Consideration and analysis of a variety of oceanographic variables shows that AVISO sea level anomalies in the months leading up to the survey are significantly correlated with the biological outcomes.

P-9. Dietary and stable isotope analyses reveal the role of a cryptic prey in the Elegant Tern (*Thalasseus elegans*) food web in southern California waters

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Species composition of dropped fish collected at Elegant Tern (*Thalasseus elegans*) colonies in southern California shifted from mainly northern anchovy (*Engraulis mordax*) in the 1990s to >60% kelp pipefish (*Syngnathus californiensis*) in 2011. This change was unexpected as ELTE is an open-water forager, and the pipefish is assumed to be cryptic in kelp. In response, we tested the following hypothesis at the Los Angeles Harbor nesting colony in 2012: Kelp pipefish are incorporated into the ELTE diet based on dietary analyses—direct observations of prey transfer, regurgitated prey, and dropped prey— and a $\delta^{13}C$ and $\delta^{15}N$ isotope mixing model. Direct observations revealed that the ELTE chick diet comprised 8% kelp pipefish, while dropped fish comprised 47% pipefish. Regurgitations included no pipefish, but were collected on only one day. A stable isotope mixing model in R (SIAR) estimated 51% (95% CI: 36% - 66%) pipefish in chick blood tissue, 38% (95% CI: 0.03 – 0.72%) in adult blood tissue, and 32% (95% CI: 0.01-0.59%) in chick muscle tissue. The similarity of prey—northern anchovy, kelp pipefish, market squid (*Doryteuthis opalescens*), and California grunion (*Leuresthes tenuis*)—isotope values, however, hinders using mixing models to determine relative contributions of prey species to the ELTE diet, which could explain the large credibility intervals we observed. The prey deliveries and the mixing model support our hypothesis that pipefish are incorporated into the ELTE diet, although the proportions vary. A speculated increase in pipefish abundance in southern California waters is likely associated with increased kelp density over the past decade which may explain the growing importance of pipefish in the ELTE diet. Based on both field and laboratory observations pipefish are not limited to the kelp forest, and as a shallow plunge diver, ELTE likely captures pipefish when this fish approaches the surface to feed or mate.

P-10. Comparison of dietary sampling methods for nesting California Least Terns (*Sternula antillarum browni)* at Alameda Point in San Francisco Bay and Purisima Point on the central California coast

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The California least tern (*Sternula antillarum brownii*) is a small, colonial seabird that breeds in beach and estuarine habitats along the coast of California. Understanding the relationship between diet and reproductive success is important for the effective management of this endangered species. Accurate dietary data are crucial for assessing this relationship. However, past studies of least tern diet have used multiple sampling techniques, making it difficult to compare diet among nesting colonies and track changes through time. To better understand the benefits and shortcomings of different techniques, we compared least tern diet over the last decade at two colonies: Alameda Point (34° N, 120° W) in San Francisco Bay and Purisima Point (37° N, 122° W), on the central California coast. We analyzed diet for the first site using fecal samples and dropped fish for the years 2000-2012 and for the second site using fecal samples, regurgitated pellets and dropped fish for the same years. Based on Spearman rank correlations, fecal samples and dropped fish yielded similar results at Alameda Point (< 0.05) but different results at Purisima Point (> 0.1). At Purisima Point, the most frequently dropped prey items are deep-bodied surfperches (65% present in the dropped fish, while only 5% present in fecal samples), which might be difficult for the chicks to consume because of their size. Initial analysis of prey size for each sampling method at Alameda Point show that dropped fish are larger than those in present in fecal samples (two-tailed t-test, p-value ≤ 0.01). While species composition using the two methods is similar at Alameda Point, dropped fish might represent larger, more difficult to swallow prey. No correlation was found between the relative proportions of important prey species dropped each year and the breeding success of that same year at either site. This study should contribute to a greater understanding of dietary assessment methods for least terns.

P-11. Diverse Uses of the CalCOFI Component of the SIO Pelagic Invertebrates Collection

Sala L.M. and Ohman M.D.

The SIO Pelagic Invertebrates Collection serves as the world's largest repository for zooplankton samples with over 132,000 whole sample holdings. Notable within this distinguished collection is the CalCOFI time series sample set. The Pelagic Invertebrates Collection staff has been dedicated to maintaining the quality of this collection, developing digital databases, processing loan requests, and sorting and species identification of selected samples. Spring-time zooplankton abundances are enumerated and maintained through the Ohman Lab on the Cooperative Zooplankton Dataspace. Many other diverse projects have been completed as a result of maintaining this world-renowned collection of samples, including: semi-automated analysis of higher zooplankton taxa using Zooscan, studying functional groups present throughout the decades, further understanding larval dispersal in the CA spiny lobster and the market squid, stable N isotopes as tracers of food web perturbations, other evidence of climate change influences, etc. This sample set has also led us to some unsuspected discoveries such as the biological event that inspired Alfred Hitchcock's movie "The Birds" and uncovering and digitizing Martin Wiggo Johnson's lobster phyllosoma slide collection.