

Part I

REPORTS, REVIEW, AND PUBLICATIONS

REPORT OF THE CALCOFI COMMITTEE 2013

SIO HIGHLIGHTS

Four quarterly CalCOFI cruises occurred on the RV New Horizon (NH), RV Bell M Shimada (SH), and RV Ocean Starr (OS) in 2013: 1301SH (January 10–February 2), 1304SH (April 6–30), 1307NH (July 6–22), and 1311NH (November 9–26). Ancillary programs included measurement of carbon dioxide and related variables, in collaboration with the Pacific Marine Environmental Lab (NOAA) and Andrew Dickson (SIO); visual and acoustic observations of marine mammals, led by John Hildebrand (SIO); and seabird observations, led by Bill Sydeman (Farallon Institute for Advanced Ecosystem Research). CalCOFI continued to be augmented significantly by the California Current Ecosystem Long-Term Ecological Research (CCE-LTER) program led by Mark Ohman (SIO) and funded by NSF. Most data from these cruises have been rapidly made available on the Scripps CalCOFI, CCE-LTER, NOAA SWFSC, and CDF&W websites. Notable is the completion and activation of NOAA's ERDDAP website, which makes available CalCOFI hydrographic and ichthyoplankton databases from 1950 to the present in queryable form. More than 53 publications by SIO and other university scientists in 2012 were based on CalCOFI data and results, including four doctoral dissertations. Selected papers are mentioned below.

A number of papers focused on the physical oceanography and its relation to ecosystem function. High-frequency radar data were used to study subinertial currents, possibly coastally trapped waves, propagating poleward off the US West Coast (Kim et al. 2013). The California Undercurrent was the subject of two papers, one focusing on its variation in relation to temperature, salinity, and dissolved oxygen and effects on upwelled water (Meinville and Johnson 2013) and the other a numerical simulation of the coastal circulation of waters off Baja California, Mexico (Mateos et al. 2013). The timing of the spring transition and its effects on the California Current System (CCS) was modeled (Chenillat et al. 2013). General additive models were used to study the relation of nitrate concentration to temperature, salinity, and oxygen, relevant to biogeo-

chemistry and fisheries (Palacios et al. 2013). Nutrient enrichment of the subarctic Pacific pycnocline was characterized (Whitney et al. 2013).

The depth of winter mixing was shown to influence the depth of the chlorophyll maximum, with implications for assessing phytoplankton abundance and production from space (Navarro and Ruiz 2013). Dissolved oxygen and argon in the surface ocean were used to study the balance of production and respiration, and waters sampled by CalCOFI were shown to be autotrophic year-round and with an export efficiency similar to that of the open ocean (Munro et al. 2013). Particle abundance and flux in the upper 100–150m were estimated by use of the SOLOPC (Petrik et al. 2013). Midwater fish were shown to contribute significantly to the active vertical transport of carbon from the euphotic zone by the combined use of acoustics, trawling, and a bioenergetics model (Davison et al. 2013). CalCOFI data of various types were used in the Earth System Model at the NOAA's Geophysics and Fluid Dynamics Lab (Stock et al. 2014).

A number of papers were published on exploited fish, with implications for the management of their fisheries. Multivariate state-space reconstruction was used to assess the relation of sardine to the environment (Deyle et al. 2013). Earlier papers were re-examined to show that sardine dynamics are related to temperature measured at the Scripps pier but even more so to CalCOFI temperature (Jacobson and McClatchie 2013). The natural mortality rate (M , y^{-1}) of sardine, used in stock assessment, was characterized from past acoustic-trawl survey data, with the average value significantly higher than that generally assumed (Zwolinski and Demer 2013). Midwater trawl surveys of pelagic juvenile rockfish off the US West Coast showed 2005 and 2006 unusual in regard to both winds and rockfish distribution (Ralston and Stewart 2013). Models were used to investigate how the CCS ecosystem would respond to removal of significant portions of forage taxa, including small pelagic fish and euphausiids (Kaplan et al. 2013).

Climate effects on marine ecosystems were the subjects of a number of papers. Multivariate ocean-climate indicators were developed for north-central California

and compared with other indices of the environment (Sydeman et al. 2014). Principal components analysis of time series of CalCOFI ichthyoplankton documented major modes of variability of fish larvae and their relation to the environment (Koslow et al. 2013). Notable was PC1, representing midwater fish and related to midwater oxygen. This paper exemplifies a major strength of CalCOFI, i.e., the co-location, in time and space, of data and samples. Fluctuations of anchovy and sardine from both recent and prehistoric records was studied in relation to climate; differing life history characteristics were shown important in understanding the response of the two species to the environment (Lindgren et al. 2013). Isotopic analysis of planktonic foraminifera in sediments accumulated over the past 250y in the Santa Barbara Basin showed a range of time scales of change, including periods of enhance upwelling and subsurface equatorward flow along the Southern California Margin (Roach et al. 2013). A 24-year time series of sinking particulate organic carbon (POC) and requirements of the benthic communities, at a bottom site ~4,000m deep and west of Point Conception, showed episodes of high POC flux punctuate a common state of food deficit (Smith et al. 2013).

A commentary in *Nature* argued for the need for time series of marine biodiversity observations, citing CalCOFI as an example (Koslow and Couture 2013). An issue of *Oceanography* focused on the CCE-LTER program and its augmentation of CalCOFI (e.g., Ohman et al. 2013a,b, Franks et al. 2013). Finally, testimony was give to the California Fish and Game Commission on the value of CalCOFI to California in regard to fisheries management and education.

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NOAA HIGHLIGHTS

CalCOFI Ichthyoplankton Update

During the past year the SWFSC Ichthyoplankton Ecology group settled into its new laboratory and sample archive and began the task of working through the substantial sample backlog that developed during the move to the new facilities and a period of reduced staffing but high demand for time spent at sea. During that time our highest priorities in sample processing have been the spring CalCOFI, spring sardine, and SaKe surveys, and we have fallen behind in completing other cruises. However, we recently were able to hire additional plankton sorters and with the equivalent of three full time contract plankton sorters now on board in addition to NOAA staff, we are beginning to make progress in reducing the sample backlog. The ichthyoplankton group also has continued its project to retroactively update identifications of fish eggs and larvae to current standards. Identification of Pacific whiting (hake) and jack and Pacific mackerel eggs collected in the CalCOFI oblique net samples are now complete from the latter part of 1978 to the present, and larval identifications to current standards are complete from mid-1965 to present.

To enhance the increased effort directed to processing the formalin-preserved plankton samples, a substantial laboratory effort has focused on the ethanol-preserved bongo net samples (which can be used for genetic analyses) collected during Cowcod Conservation Area and CalCOFI surveys. Staff continued their collaboration with Ron Burton and his students at SIO on the development of a high-throughput system for molecular identification of ichthyoplankton, with the ultimate aim to provide accurate, near real-time identifications of fish eggs, many of which can be difficult or impossible to identify to species using traditional morphological characters. This method should ultimately enable scientists to accurately identify eggs of several taxa of sport or commercial fishery value such as Pacific hake, Pacific mackerel, white seabass, and California barracuda, and it will be applied to ethanol-preserved CalCOFI samples to develop a time series for eggs from 1997 to the present. In addition, one of Burton's students successfully defended her master's thesis from SIO that examined the distribution and abundance of genetically-identified fish eggs from CalCOFI samples between 2002 and 2004. During the past year staff finished sorting eggs and larvae from ethanol-preserved samples from winter cruises in 2004, 2011, and 2013 bringing the list of completed ethanol-preserved samples to 1998, 1999, 2002–05, 2011, and 2013. Further, we were awarded a FATE (NOAA's Fisheries and the Environment program) grant to use genetic meth-

ods to develop a time-series of rockfish species dynamics to inform rockfish stock assessment and Integrated Ecosystem Assessment. Parts of the FATE funds were used to hire a full-time technician to focus exclusively on processing the ethanol-preserved samples for the larval rockfish project. The lab has also added a master's student from University of San Diego who is working with rockfish larvae from the ethanol-preserved samples for his thesis.

To enhance understanding of how ichthyoplankton respond to environmental variability throughout the California Current system, an analysis of CalCOFI data together with ichthyoplankton and environmental data collected during IMECOCAL surveys is underway, in collaboration with Martín Hernández-Rivas and co-workers from CICIMAR. This study complements a similar, recently completed study using data collected by CalCOFI, Oregon State University and NWFSC between 1997–2011 in Oregon waters (Thompson et al. 2014, doi:10.3354/meps10801), and should help inform NOAA's California Current Integrated Ecosystem Assessment program.

Staff prepared a manuscript in collaboration with Sam McClatchie that evaluates how ichthyoplankton distributions have changed within the CalCOFI sampling frame over the past three decades. This work shows that the center of sardine spawning has shifted further offshore in recent years; the results of which have broad implications for the understanding of how the fish assemblage in the California Current system respond to climate change and the effect of these changes on population dynamics of high trophic level marine predators such as sea lions. We also prepared a manuscript examining the distribution of genetically-identified rockfish larvae collected at the relatively coarse CalCOFI spatial scale (lines separated by 74 km) and a finer scale (lines separated by 18 km) within and around the Channel Islands. Results from this work will inform placement of marine protected areas in Southern California.

Thompson A. R., T. D. Auth, R. D. Brodeur, N. M. Bowlin, and W. Watson 2014. Dynamics of larval fish assemblages in the California Current System: A comparative study between Oregon and southern California. *Marine Ecology Progress Series* 506: 193–212.

Spring Coastal Pelagic Species Cruise

The spring Coastal Pelagic Species (CPS) cruise relies on a 25 day ship charter plus a 25–30 day commitment of NOAA vessel time, of which the first 14–17 days are typically the spring CalCOFI cruise. Observations from CalCOFI including acoustics and CUFES often guide adaptive sampling for the daily egg production method (DEPM) and the acoustic trawl method (ATM). The spring CPS cruise carries out a subset of CalCOFI measurements along with acoustics, trawling, and adaptive

sampling of eggs and larvae to provide total and spawning biomass estimates for CPS stock assessments.

The spring CalCOFI was carried out before the spring CPS cruise this year, working the 75-station pattern south to north, March 28th to April 15th on the Ocean Starr. Departure was delayed by 3 days due to a malfunctioning winch used to tow plankton nets that was detected on the first stations occupied. A repair rather than a work-around solution was determined to be necessary to ensure crew safety. After obtaining a replacement part, the winch was repaired, the vessel sailed in calm weather, and the cruise end date was extended by 3 days to April 18th. The spring CalCOFI cruise (Ocean Starr leg 1) ended in San Diego, after occupying 70 of the 75 station pattern. Most of the missed stations were due to Navy exclusion areas.

The second leg of the Ocean Starr cruise began the spring CPS cruise departing on April 20th to conduct acoustic/ trawl and DEPM coastal pelagic survey off the southern California coast. Transects were shortened to focus on stations inshore of CalCOFI station 60 since no offshore CPS were detected on the CalCOFI cruise (Ocean Starr leg 1). Meanwhile, departure of Shimada on the spring CPS cruise was delayed due to engineering staffing problems. Shimada departed San Diego on Wednesday April 15th, headed for CalCOFI line 57 just north of San Francisco to begin working from north to south, while Ocean Starr leg 2 worked the spring CPS cruise from south to north.

The spring CPS cruise continued through May 2 on Shimada, but ended on Ocean Starr in San Francisco on April 30th. Trawl sampling on Ocean Starr was limited by high winds and seas on their second leg. Amy Hays reported that they were only able to trawl nearer to shore and were not able to complete many of their allocated transects.

There was a striking absence of sardine eggs in spring 2014, despite favorable potential habitat on the central coast. Sardine eggs sampled with the Continuous Underway Fish Egg Sampler (CUFES) were found only inshore in the Southern California Bight, in good habitat as predicted by the model, even after covering the entire central California coast south of San Francisco. Most of the eggs collected were jack mackerel. Preliminary temperature surfaces from the CalCOFI cruise leg showed some indications of anomalously warm water at 10 m depth, the California Current far offshore (shown by the 100 m depth cool temperature and fresh salinity anomalies), and low fluorescence voltages, except nearshore. Warm water anomalies at 50 m were not particularly strong or consistent at the time of the cruise. Nighttime trawl catches along the central coast caught few CPS, with intermittent small catches of squid and pyrosomes. The highest catch of sardine was less than 1kg, comprising 6 sardines.

CDFW HIGHLIGHTS

The California Department of Fish and Wildlife (CDFW) welcomed its new Marine Region Manager, Dr. Craig Shuman. Immediately before coming to CDFW, Dr. Shuman served as the Marine Advisor to the California Fish and Game Commission (FGC).

The CDFW held a Science Symposium in Sacramento in October, 2013, and staff presented papers and posters at the symposium on topics ranging from abalone translocation studies, abalone and Harmful Algal Blooms, sea cucumber research, the status of the Dungeness crab fishery, surfperch life history studies and hagfish trap study results.

Marine Regulatory Changes

The FGC took approximately a dozen marine-related actions in 2013, including: 1) reduced the catch of red abalone in northern California for 2014 due to declines in abalone density, primarily in Sonoma County; 2) upheld abalone closure in southern California, because survey results at San Miguel Island indicated densities are below the minimum viable population size as prescribed by the Abalone Recovery and Management Plan; 3) closed a loophole in the 2-ton incidental take allowance for market squid by requiring the landing or possession with other species and setting percentage catch limits; 4) upheld the current regulations and management measures for the central coast marine protected areas (MPAs) adopted by the commission in 2007, following a symposium summarizing results after 5 years of monitoring and management; and 5) approved changes to the spiny lobster report card period and fees to better track recreational lobster harvest and increase report card return rates.

Marine Life Protection Act

California's redesigned Marine Protected Area (MPA) network includes 124 MPAs and 15 special closures, covering approximately 16% of the state waters (over 9% are in no-take MPAs). CDFW collaborates with partners to provide oversight on all aspects of MPA monitoring to inform adaptive management. This includes developing monitoring plans that apply the statewide MPA monitoring framework, regional baseline monitoring programs, five-year monitoring and management reviews, and cost-effective continued monitoring programs based on results from baseline programs. CDFW continues to explore MPA effects on California's marine fisheries, maintains an interactive spatial marine and coastal data viewer called MarineBIOS, and conducts field investigations such as remotely operated vehicle survey projects.

In 2013, a three-day public symposium was held to present results from the central coast MPA baseline monitoring program. CDFW and California Ocean Science

Trust produced a summary report, titled *State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007–2012*. The monitoring summary report and symposium proceedings were provided to the California Fish and Game Commission to inform the management review of the central coast MPAs. In the north central coast and south coast, baseline monitoring data collection has been completed and is being analyzed. Baseline monitoring planning is nearing completion on the north coast.

Ocean Protection Council (OPC)

The OPC with the aid of their Science Advisory Team, and the California Ocean Science Trust administered the baseline MPA monitoring program for the north coast, starting with evaluating proposals. The MPA implementation process continued in 2013 in the rest of the state with a conference on the results from 5 years of monitoring and management along the Central Coast.

The OPC continued to support CDFW to draft the spiny lobster Fishery Management Plan. OPC partnered with the California Sustainable Seafood Initiative, on their seafood certification and marketing program.

Aquaculture and Bay Management

The Aquaculture and Bay Management Project completed its annual monitoring and assessment of the San Francisco Bay commercial Pacific herring fishery for the 2013–14 season. The spawning biomass estimate for the 2013–14 season was 60,600 tons, slightly above the historical average (1979–80 season to the present) of 52,300 tons. Over the past five seasons, the spawning biomass has steadily recovered from the historic low during the 2008–09 season of 4,800 tons. Since the fishery reopened for the 2010–11 season, harvest targets for Pacific herring have been set at less than five percent of the spawning biomass as a conservation measure to allow sustained recovery. This low level of fishing mortality allows roughly 95 percent of the spawning stock to be available as forage for a variety of species dependent on Pacific herring, and is aligned with the FGC's Forage Policy. CDFW is currently working with stakeholders to identify outside funding for the development of a Fishery Management Plan. CDFW is also working with the Centre for Environment and Fisheries Aquaculture Science to review a stock assessment model for Pacific herring.

Coastal Pelagic Species

CDFW conducted a collaborative Pacific sardine survey with the California Wetfish Producers Association as a fishery-independent index of abundance for the Southern California Bight. The Pacific Fisheries Management Council reduced the harvest guideline for Pacific sardine, which was set at 57,495 mt based on a biomass estimate

of 659,539 mt. The fishery, as of June 2014, was just shy of this harvest guideline. For the fourth year in a row, the commercial market squid fishery was projected to reach the seasonal catch limit of 107,050 mt before the season's end. During the 2013–14 season the fishery was closed early on October 18, and catch totaled 104,363 mt.

Invertebrate Fisheries Management

The Invertebrate Project's northern California abalone staff completed the regulation change process and began implementation of new regulations for the northern California recreational red abalone fishery. The FGC's new regulations lowered the annual limit from 24 to 18 abalone, prohibited fishing before 8AM, and closed Fort Ross to achieve catch reductions prescribed by the Abalone Management and Recovery Plan. These changes were triggered by reductions in the density of red abalone detected during fishery independent surveys at key index sites in the fishery. The FGC did not recommend opening a red abalone fishery at San Miguel Island after receiving a report from CDFW that the island's red abalone population is below the viable minimum defined in the state's Abalone Recovery Management Plan. Efforts continued toward refining management of the commercial sea cucumber fishery, with research focusing on determining the seasonal spawning cycle and determining sea cucumber age and growth. A survey was conducted with sea cucumber fishery participants to learn more about fishery practices and their concerns for fishery sustainability. Finally, this was the inaugural season of a crab trap limit program in the commercial Dungeness crab fishery.

Lobster

The Lobster Fisheries Management Plan (FMP) process entered its third year in 2013. CDFW worked closely with the Lobster Advisory Committee (LAC) to develop draft harvest control rules for the lobster fishery that include threshold reference points and possible regulator options that could be selected if the threshold reference points were to be exceeded. The LAC also discussed and addressed current issues facing the fishery, and developed a series of recommendations to be considered by the FGC when the Lobster FMP moves into the regulatory phase in 2015. Working with the South Coast MPA Baseline lobster project staff analyzed results from 25,000 tagged lobster and 100 dive surveys. This effort was a collaboration between CDFW, academics (SIO and SDSU), commercial fishermen, and the San Diego Oceans Foundation. The second year of the Collaborative Fisheries Research West-funded At-Sea Sampling program was completed, involving approximately 13 commercial fishermen, and academics from Sea Grant and UCSB and CDFW.

Ocean Salmon

The 2013 forecast of the abundance of both Sacramento River and Klamath River fall-run Chinook stocks allowed more fishing of California's commercial ocean salmon fisheries than in 2012. Commercial salmon fisheries were open for a total of 410 days, an increase of 35 days from the previous year. For the first time since 1984, commercial fishing in the Klamath Management Zone occurred during May, June, July, August and September. Total commercial landings exceeded 297,400 Chinook salmon (1,719 mt), caught in 17,300 days fished, an increase in catch of about 38% from 2012. Average nominal ex-vessel price was \$13.73/kg (\$6.23/lb), with an ex-vessel value of over \$23 million.

In order to protect ESA-listed endangered Sacramento River winter-run Chinook, California's recreational ocean salmon fisheries were more constrained than in 2012. From June 1 to July 9 in the San Francisco and Monterey port areas, recreational fishing was closed on Mondays and Tuesdays. There were a total of 729 fishing days for the season, 25 fewer than in 2012. During the 2013 recreational ocean salmon fishery, nearly 113,300 Chinook were landed in 143,800 angler-days for an 8% and 2% reduction in catch and effort, respectively, compared to 2012.

Groundfish

The Groundfish Project prepared documents for potential modifications to federal regulations for the 2015–16 recreational fishery. Modifications may include changes to bag limits for some species and/or species groups and season lengths in the five recreational management areas. In addition, documents were prepared for proposed modifications to federal regulations for the 2014 recreational Pacific halibut fishery in California.

California Recreational Fisheries Survey (CRFS)

Recreational finfish anglers took an estimated 5.4 million fishing trips in California's marine waters and landed about 8.2 million fish in 2013. Over 70 CRFS samplers interviewed nearly 61,000 anglers at more than 500 sites, and examined and identified roughly 223,000 fish. Additional fishing effort information was obtained from a telephone survey of licensed anglers (26,000 completed interviews) and from mandatory fishing logs

from commercial passenger fishing (CPFV) vessel operators (>30,000 logs).

The Pacific Fishery Management Council adopted provisions for adjusting mortality rates for rockfish released with a descending device in the recreational fishery. The CRFS collected species-specific data on the use of descending devices in 2013. These data will be applied retrospectively to the harvest estimates of canary rockfish (*Sebastes pinniger*) cowcod (*S. levis*) and yellow-eye rockfish (*S. ruberrimus*).

Fisheries Independent Assessment Project

The FGC implemented new sport fishing regulations for kelp bass, barred sand bass, and spotted sand bass, increasing the minimum size limit and reducing the bag limit in March of 2013. The project continues to collect data on the number, size, and health of discarded basses to evaluate the effectiveness of these new regulations. The project has ongoing studies of age, growth and reproduction in barred sand bass and kelp bass. Preliminary results on batch fecundity, spawning frequency, and periodicity were presented at a scientific conference.

Northern and Central California Finfish Research and Management Project

Staff in 2013 completed the sampling of commercial and recreational surfperch and California halibut fisheries for length, sex, and age composition. The commercial hagfish fishery was sampled for relative size composition. Research cruises were conducted in Monterey Bay to: 1) study bycatch and habitat impacts of light touch halibut trawl gear; and 2) the relationship of bucket trap hole diameter to percentage of immature hagfish. Staff continued a study to determine size and age at maturity and fecundity of California halibut in San Francisco Bay. There were collaborative agreements involving project staff, researchers, and commercial fishermen to: 1) sample the commercial night smelt fishery; and 2) MPA monitoring of nearshore soft bottom habitats, both along California's north coast.

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