

## **Southwest Fisheries Science Center Summary of Current Information Available on Coastal Pelagic Species with Emphasis on Northern Anchovy**

At the request of the Pacific Fishery Management Council (Council), the Southwest Fisheries Science Center (SWFSC) provides this summary of the most up to date survey information regarding the status of northern anchovy populations and other Coastal Pelagic Species (CPS) along the west coast. Here we present the most recent survey data, and where possible, we relate the survey results to the unusual environmental conditions observed in the California Current the last three years. The SWFSC has also updated the Council on the changing environmental conditions and the presence of the “Warm Blob” the pending El Niño, and its potential for continued effects on the biota of the California Current at its June 2014, November 2014, and March 2015 meetings. Some of the data and results have not yet been fully processed or finalized, or will appear in the CalCOFI “Status of the California Current (SOCC) 2014-2015: El Niño vs. the Blob”, which is currently “in press.” As such, relevant results of the SOCC report are presented below with the approval of the editor and the NOAA scientists that submitted the specific survey information for the SOCC report.

### **Northern Anchovy, Central Subpopulation update**

#### **Winter 2015 CalCOFI, Spring 2015 CalCOFI-CPS Survey**

(Used with permission of Sam McClatchie, Edward Weber, William Watson, Fisheries Resources Division, SWFSC)

Coastal pelagic fish egg abundance has declined off central and southern California in the last 15 years (2000–2015) (Figure 1). Sardine, anchovy, and jack mackerel eggs were found at very low concentrations in the spring of 2015. Although peak anchovy spawning was found to occur in December-February which is earlier than the March-April spring survey, the anchovy spawning that extends into spring shows the same trend to lower egg densities as do sardine and jack mackerel. Anchovy and jack mackerel are lightly fished, and although commercial catches of sardine are higher, the observed decline in egg densities of all three species suggests that environmental factors are likely to be the major cause of the decline in spawning of these forage fishes.

Conditions off central and southern California were unusually warm in winter and spring 2015. Few anchovy eggs were collected in the CUFES during the 2015 Winter CalCOFI survey in the southern California Bight (SCB); however, anchovy eggs > 10 eggs/m<sup>3</sup> were collected from Monterey to Half Moon Bay in water temperatures from 12-15°C similar to optimal anchovy spawning temperature ranges reported by Ahlstrom and Elbert (1959)(Figure 2A). In the Spring CalCOFI/CPS survey, anchovy eggs were collected in small amounts in the SCB (Figure 2B). Mackerel eggs were found in water with surface temperatures of 14–18°C. Sardine eggs are

rarely found north of San Francisco in the spring, **but in 2015 sardine spawned 445–556 km further north than usual** (Figure 3). Sardine spawning was centered near the California–Oregon border (41–43°N) in a band about 90–110 km from shore in surface water temperatures of 12–13°C. Egg densities off Oregon in spring 2015 were <1.5 eggs/m<sup>3</sup>, which are still low compared to spring 2000–2013.

During spring CalCOFI/CPS survey both larval anchovy and sardine ranging from 14–21mm were collected in many of the ichthyoplankton samples currently being processed (D. Sweetnam, personal observation). This would suggest that some additional spawning has occurred earlier in 2015 and outside the historical spawning period, although a large portion of the samples still needs to be processed. In addition, juvenile sardine measuring 14mm TL (Total Length) to 30mm TL were collected during the spring 2015 survey near Point Conception suggesting that sardine also spawned prior the spring survey and would not be counted in the CUFES survey.

Processing of ichthyoplankton samples from the CalCOFI cruises are normally backlogged by about a year due to prioritization of sorting and identification. The backlog has expanded to two years due to having to send laboratory staff out to sea to cover additional sea time for summer “SaKe” cruises for CPS. Spring CalCOFI samples have the highest priority due to their use in Pacific sardine, Boccaccio and cowcod stock assessments. The processing of winter CalCOFI samples, which normally would cover the peak of anchovy spawning, has been given a higher processing priority. However, there is evidence of some localized anchovy spawning from the fall 2012 CalCOFI survey (October 2012), suggesting that looking at historical areas of abundance and timing of these phenomena may no longer be appropriate under sustained warmer ocean conditions.

Recent shifts in CPS distributions in the CalCOFI data were reported in response to the 2013 Unusual Mortality Event (UME) of California Sea Lions (Figure 4). Pacific sardine have shifted distribution offshore during the period from 1996 to 2012, while the distribution of northern anchovy may have shifted slightly inshore from 2007 to 2011 as reported in [http://www.nmfs.noaa.gov/pr/health/mmume/casealion2013\\_investigation.htm](http://www.nmfs.noaa.gov/pr/health/mmume/casealion2013_investigation.htm). However, anchovy populations have always been associated with nearshore waters at both high and low population levels and in offshore waters at high abundance levels due to inshore habitat limitations and transport from nearshore upwelling areas (Reiss, et al. 2008; Kramer and Alhstrom, 1968; Hewitt, 1980).

### **2015 Summer “SaKe” synoptic survey of the California Current**

(Used with Permission of Dave Griffith, Fisheries Resources Division, SWFSC)

The summer 2015 “SaKe” survey using the FSV Shimada commenced on June 20<sup>th</sup> at the US/Mexico border and ended on September 6<sup>th</sup> near the Alaska/Canada border above the Queen Charlotte Islands. The total survey distance was approximately 5,393 nautical miles. Processing of acoustic data has not been completed for ATM biomass estimates; however, a total of 160 Nordic 264 trawls for adult fishes were accomplished with the following catch of

target species: Northern anchovy (*Engraulis mordax*) 91 kg, Pacific sardine (*Sagax sardinops*) 442 kg, Pacific mackerel (*Scomber japonicus*): 63 kg, Jack mackerel (*Trachurus symmetricus*) 1,958 kg, Market squid (*Dorytheuthis opalescens*) 2,694 kg, and Pacific hake (*Merluccius productus*) 170 kg. Northern anchovy juveniles and adults (91 kg total) ranging in size from 30mm SL to 150mm SL were collected in 47 out of 160 trawls (29% frequency of occurrence) and collected from San Diego to Vancouver Island (Figure 5). Pacific sardine juveniles and adults (442 kg total) ranging in size from 30mm SL to 270mm SL were collected in 21 out of 160 trawls (13% frequency of occurrence) and ranged from southern California to the Pacific Northwest.

A total of 941 CUFES samples were taken resulting in the following eggs being collected for target species: Northern anchovy: 943, Pacific sardine: 2,255, Jack mackerel: 16,626, Pacific hake: 73, and all other pelagic fish eggs: 73,728. Other biological and oceanographic samples taken include 123 CTDs associated with the trawls, 59 bongo tows and 51 neuston tows.

Densities and timing of anchovy eggs observed in the 2015 SaKe survey suggest that anchovy were spawning at multiple locations along the west coast as well as at different times during summer 2015. Anchovy eggs collected in three main concentrations suggest that anchovy spawning was occurring during June in the southern California Bight, in July off San Francisco, and off the Columbia River in August. In addition, Pacific sardine eggs were collected from southern California to the Pacific Northwest suggesting that sardine were spawning during June in the southern California Bight, in July off San Francisco, off central Oregon in July and off the Columbia River in August.

#### **Juvenile Rockfish Midwater Trawl survey for pelagic juvenile (young-of-the-year, YOY) rockfish - Central California Coast, May-June 2015**

(Used with Permission of John Field, Keith Sakuma, Fisheries Ecology Division, SWFSC)

Since 1983, the SWFSC has conducted an annual midwater trawl survey for pelagic juvenile (young-of-the-year, YOY) rockfish (*Sebastes* spp.) and other groundfish off of Central California (approximately 36 to 38°N) since 1983, and has enumerated most other pelagic micronekton encountered in this survey since 1990 (Ralston et al. 2013, Ralston et al. 2015)(Figure 6). Beginning in 2004, the survey, which is conducted in late spring (May-June), expanded the spatial coverage to include waters from the U.S./Mexico border north to Cape Mendocino. The primary objectives are to estimate the abundance of YOY rockfish and other groundfish for stock assessments and fisheries oceanography studies, but the survey also quantifies trends in the abundance and composition of other components of the micronekton forage assemblage (including other juvenile fishes, krill, coastal pelagic species, and mesopelagic species), as well as collection of oceanographic information (CTD casts, continuous data on surface conditions and productivity, and acoustic data) and seabird and marine mammal abundance data.

The abundance of adult Pacific sardine and northern anchovy remained very low, although larval catches for both species were at high or record levels in most areas (Figure 7). Average

adult northern anchovy catch-per-tow between 1983 and 2004 was 0.9, increasing to 2.12 in 2006, before declining to 0.19 in 2008. Between 1998 and 2014, average catch per tow of northern anchovy young-of-year (YOY) was low (0.0015). In 2015, the catch-per-tow of northern anchovy YOY increased to 2.6 and was at record levels over the 2015 sampling period, with the frequency of occurrence near 80% for the entire survey (Figure 8). This would suggest that 2015 summer anchovy spawning was widespread and not centered only in Monterey Bay.

## **Northern Anchovy, Northern Subpopulation Update**

### **Newport Oregon Line**

(Used with permission of Ric Brodeur, Fish Ecology Division, NWFSC)

The ichthyoplankton community in the central-northern coast of Oregon in June-July 2014 was similar to the average community structure found in the same area and season during the previous seven years in terms of composition and relative concentrations of the dominant taxa, with the exception of the unusually high concentration of northern anchovy, which dominated the ichthyoplankton at a mean concentration that was > 16x higher than that of the next highest taxon, myctophids (Figure 9). Larval northern anchovy and flatfish in 2014 were found in concentrations > 8x and > 2x higher, respectively, than those of the next highest year in the time series, 2011, while larval rockfish were found in concentrations > 2x lower than the next lowest year in the eight-year time-series, 2012.

Biomass of available fish prey for out-migrating juvenile salmon in 2015 is predicted to be above average based on the winter ichthyoplankton biomass index (Daly et al. 2013) primarily due to an anomalously high biomass of Northern anchovy, Pacific sardine, and rockfish larvae (Figure 10). This winter (January to March 2015) ichthyoplankton collections for 2015 were noteworthy in that: 1) three new offshore taxa were collected, 2) there were larvae present at all sampling stations, 3) and there were high concentrations and biomass of Pacific sardine larvae in February and March from NH-01 (most inshore station) to NH-25 (most offshore station), all of which had not occurred prior to 2015. While Northern anchovy larvae have previously been collected in January-March along the NH line (in March 1998 and 2003), their 2015 biomass was over 100x greater than in any previous year, and as with the Pacific sardine larvae, Northern anchovy larvae were present all across the shelf from inshore to offshore stations (NH-01 to NH-25) (Brodeur, personal communication).

## **Conclusions**

The SWFSC has not been able to formally comment on the specifics of the anchovy paper entitled “*Non-fishery collapse of northern anchovy off California*” by MacCall, Sydeman, Davison, and Thayer since the final version of the paper (to be published in *Fisheries Research*) has not been made available as of November 10, 2015. However, the SWFSC agrees with the draft MacCall, et al. paper as included in the Briefing Book, as well as Koslow, et al. (2015), that

this is not a fishery-related decline, and acknowledges that additional analyses of the complete CalCOFI dataset and other potential datasets is needed to fully document the extent of the decline. It appears that northern anchovy distribution as well as other species may have shifted both spatially and temporally out of the normal CalCOFI sampling area in recent years due to severe environmental changes (i.e., the “Warm Blob”, the Pacific Decadal Oscillation, early El Niño effects) suggesting that the historical CalCOFI sampling grid in the Southern California Bight may not be adequately tracking the northward shift in anchovy abundance and distribution.

Finally, evidence of multiple spawning locations and high numbers of potential recruits of both northern anchovy subpopulations and Pacific sardine along the west coast suggests that 2015 may be a better year for CPS than has been observed in the past few years. However, while the increased recruitment signals are positive, it is premature to assess their overall contribution to the stock without conducting a formal stock assessment. In Agenda Item H.4.a, SWFSC Report 2, the SWFSC will present information on data-limited stock assessment methods for CPS stocks, including the two anchovy subpopulations, and will discuss a prioritized assessment schedule to fulfill national mandates of updating assessments of U.S. fish stocks.

## REFERENCES

- Ahlstrom, E.H. and H. Elbert. 1959. "Vertical distribution of pelagic fish eggs and larvae off California and Baja California." US Fish & Wildlife Service, Fisheries Bulletin 60 (1959): 107-146.
- Auth, T.D. 2011. Analysis of the spring-fall epipelagic ichthyoplankton community in the northern California Current in 2004-2009 and its relation to environmental factors. Calif. Coop. Oceanic. Fish. Invest. Rep. 52:148-167.
- Daly, E.A., T.D. Auth, R.D. Brodeur, and W.T. Peterson. 2013. Winter ichthyoplankton biomass as a predictor of early summer prey fields and survival of juvenile salmon. Mar. Ecol. Prog. Ser. doi: 10.3359/meps10320.
- Hewitt, R. 1980. Distributional atlas of fish larvae in the California Current Region: Northern Anchovy, *Engraulis mordax* Girard, 1966 through 1979. CalCOFI Atlas No. 28. 101pp.
- Kramer, D. and E.H. Ahlstrom. 1968. Distributional atlas of fish larvae in the California Current Region: Northern Anchovy, *Engraulis mordax* Girard, 1951 through 1965. CalCOFI Atlas No.9. 269pp.
- Ralston, S. and I.J. Stewart. 2013. Anomalous distributions of pelagic juvenile rockfish on the U.S. west coast in 2005 and 2006. CalCOFI Reports 54:155-166.
- Ralston, S., K. M. Sakuma, and J. C. Field. 2013. Interannual variation in pelagic juvenile rockfish (*Sebastes spp.*) abundance—going with the flow. Fisheries Oceanography 22:4: 288-308.
- Ralston, S., J.C. Field and K.S. Sakuma. 2015. Longterm variation in a central California pelagic forage assemblage. Journal of Marine Systems 146: 26–37. <http://dx.doi.org/10.1016/j.jmarsys.2014.06.013>
- Reiss, C.S., D.M. Checkley Jr., and S.J. Bograd. 2008. Remotely sensed spawning habitat of Pacific sardine (*Sardinops sagax*) and Northern anchovy (*Engraulis mordax*) within the California Current. Fish. Ocean. 17:2, 126-136.
- State of the California Current (SOCC) 2014-2015: El Niño vs. the “Blob.” A.W. Leising, editor. I.D. Schroeder, S.J. Bograd, J. Abell, R. Durazo, G. Gaxiola-Castro, E. P. Bjorkstedt, J. Field, K. Sakuma, R.R. Robertson, R. Goericke, W.T. Peterson, R. Brodeur, C. Barceló, T. D. Auth, E. A. Daly, R.M. Suryan, A. J. Gladics, J.M. Porquez, S. McClatchie, E.D. Weber, W.Watson, J.A. Santora, W.J. Sydeman, S.R. Melin, F.P. Chavez, R.T. Golightly, S.R. Schneider, J. Fisher, C. Morgan, R. Bradley and P. Warybok. In press. CalCOFI Reports.

## Figures

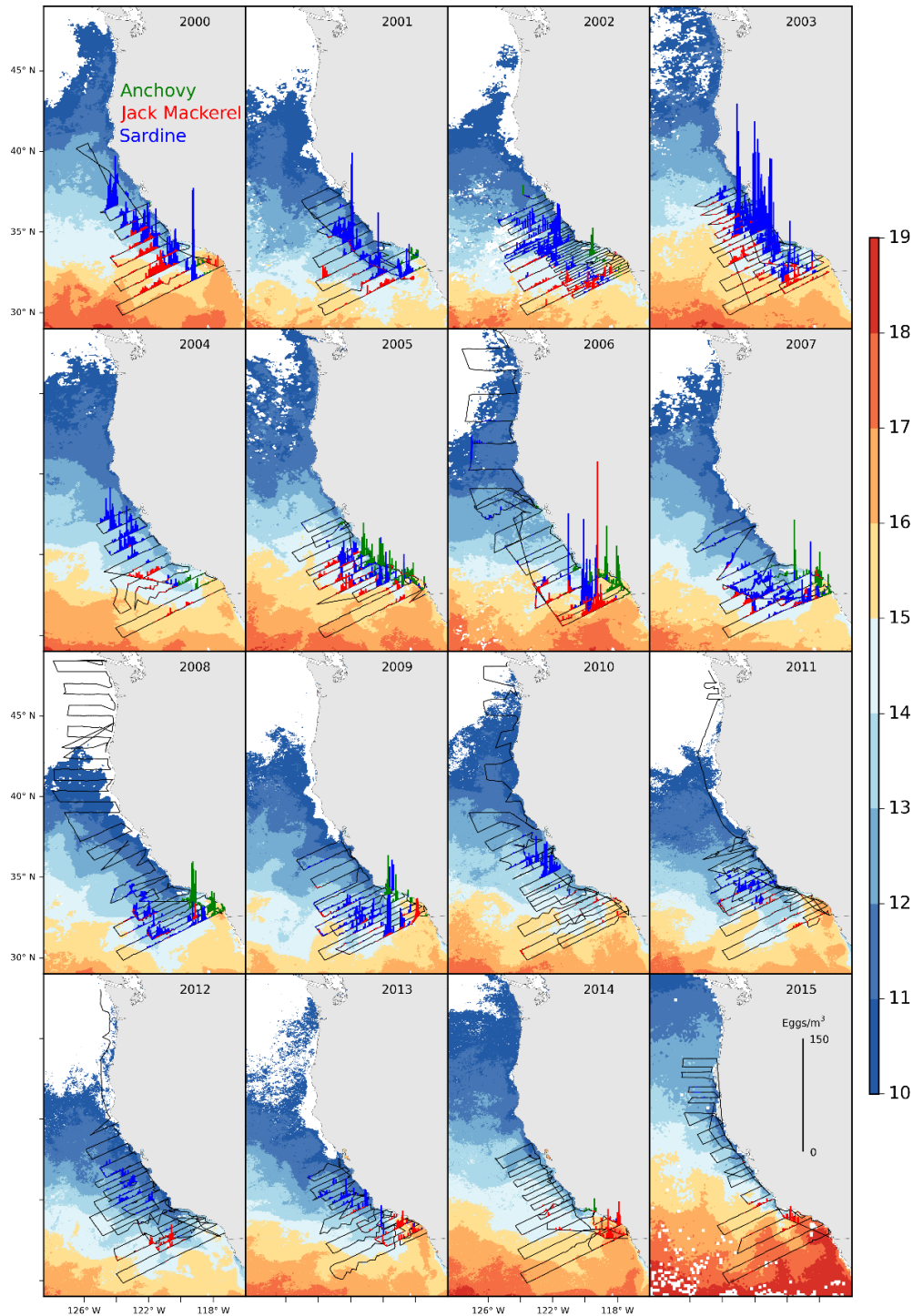


Figure 1. Density of eggs of sardine (blue), anchovy (green), and jack mackerel (red) collected with the Continuous Underway Fish Egg Sampler overlaid on satellite sea surface temperatures (°C) derived from a monthly composite of April Pathfinder 5.5-km resolution (2000-2008) or AVHRR 1.4-km resolution (2009-2015) imagery. Ship track is shown by the black line (<https://swfsc.noaa.gov/textblock.aspx?Division=FRD&ParentMenuId=218&id=1340>).

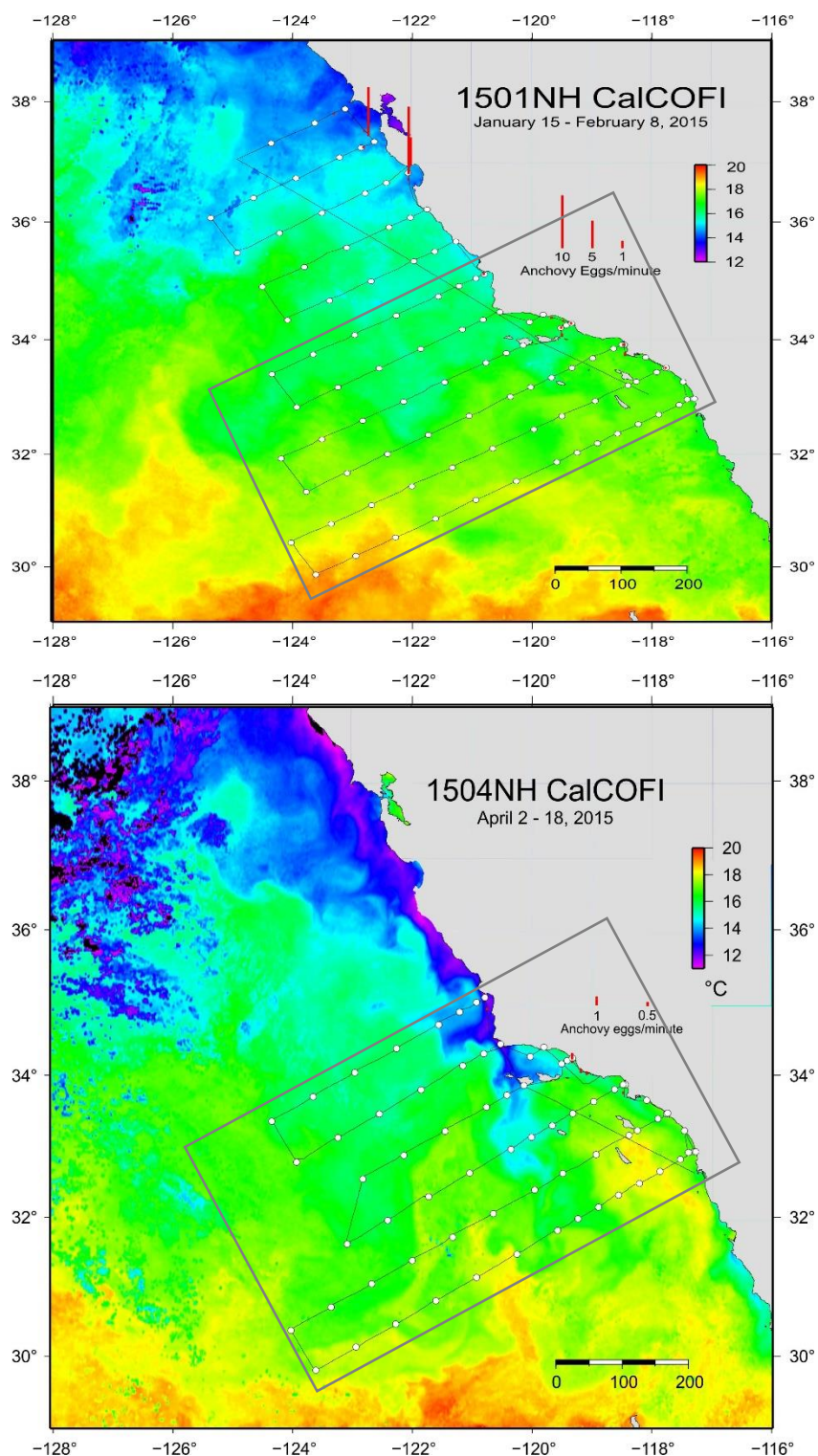


Figure 2. 2015 Winter (A. above) and Spring (B. below) CalCOFI CUFES sampling of northern anchovy eggs/minute plotted over Sea Surface Temperature (SST). Anchovy spawning temperatures normally are between 12-15 °C highlighted in dark blue and turquoise. The grey box represents the standard CalCOFI sampling grid

(<https://swfsc.noaa.gov/textblock.aspx?Division=FRD&ParentMenuId=218&id=1340>).

**FSV Bell M. Shimada and RV New Horizon  
29 March to 01 May 2015**

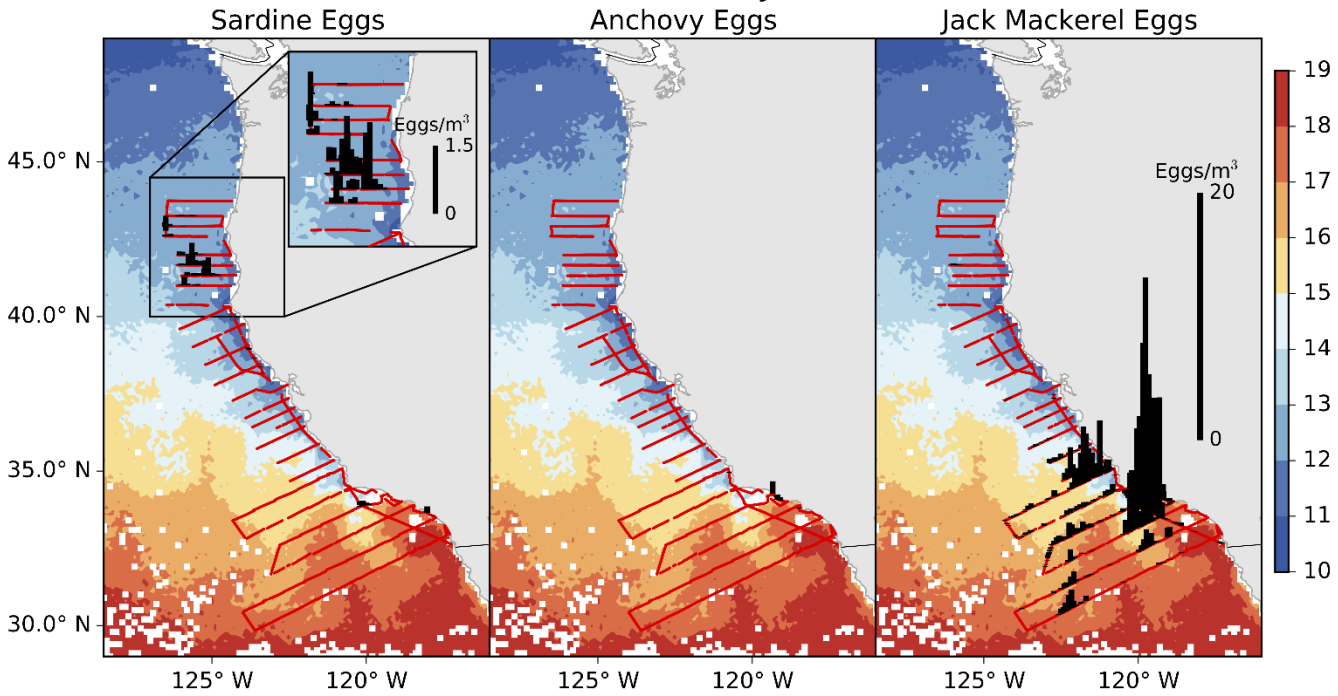


Figure 3. Density of eggs of sardine, anchovy, and jack mackerel collected with the Continuous Underway Fish Egg Sampler (CUFES) during the spring 2015 CalCOFI and Coastal Pelagic fish cruises overlaid on satellite sea surface temperatures (°C)

(<https://swfsc.noaa.gov/textblock.aspx?Division=FRD&ParentMenuId=218&id=1340>).

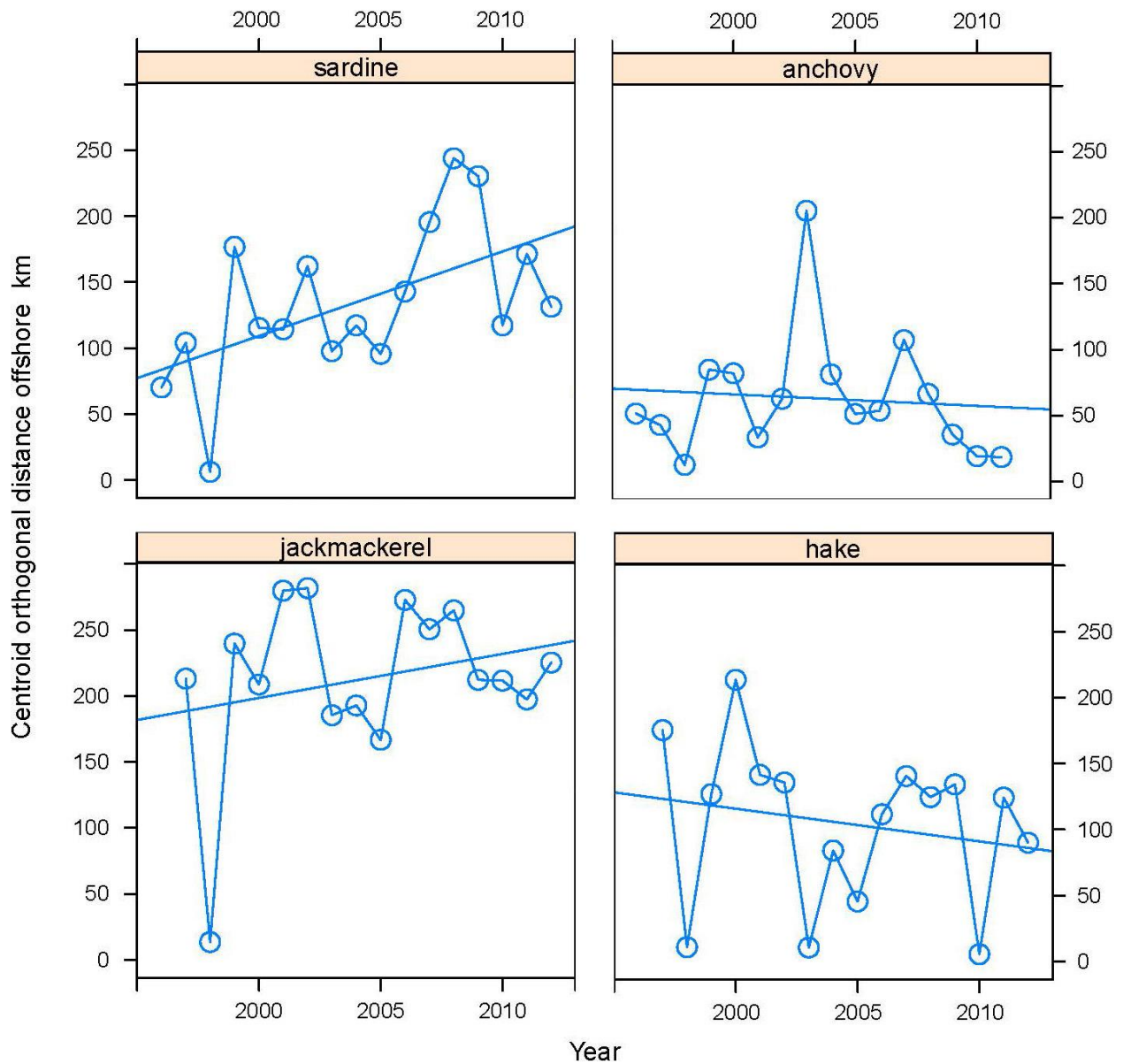


Figure 4: Distance from shore of spawning for four forage fish species (Pacific sardine, northern anchovy, jack mackerel, and hake) observed in the CalCOFI surveys from 1997 to 2012. Anchovy distribution has shifted dramatically inshore, while sardine spawning distribution has moved offshore over time, as shown by the trend lines

(see [http://www.nmfs.noaa.gov/pr/health/mmume/casealion2013\\_investigation.htm](http://www.nmfs.noaa.gov/pr/health/mmume/casealion2013_investigation.htm)).

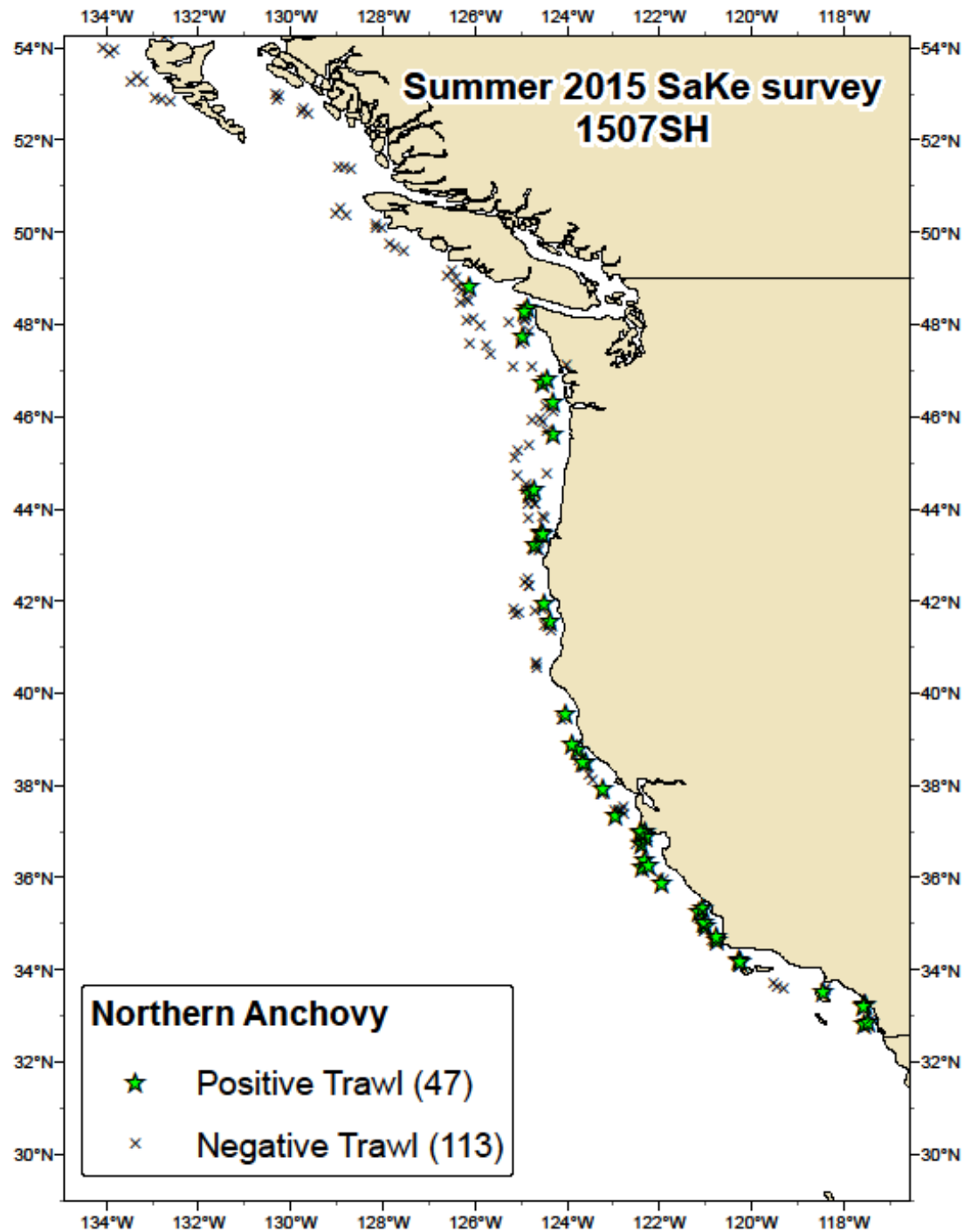


Figure 5. Juvenile and Adult anchovy collected in the 2015 summer “SaKe” Survey from June 20-September 6, 2015. Trawling occurred from south to north. Positive trawls are only indicated to represent positive trawls for northern anchovy and does not represent abundance (<https://swfsc.noaa.gov/textblock.aspx?Division=FRD&ParentMenuId=218&id=1340>).

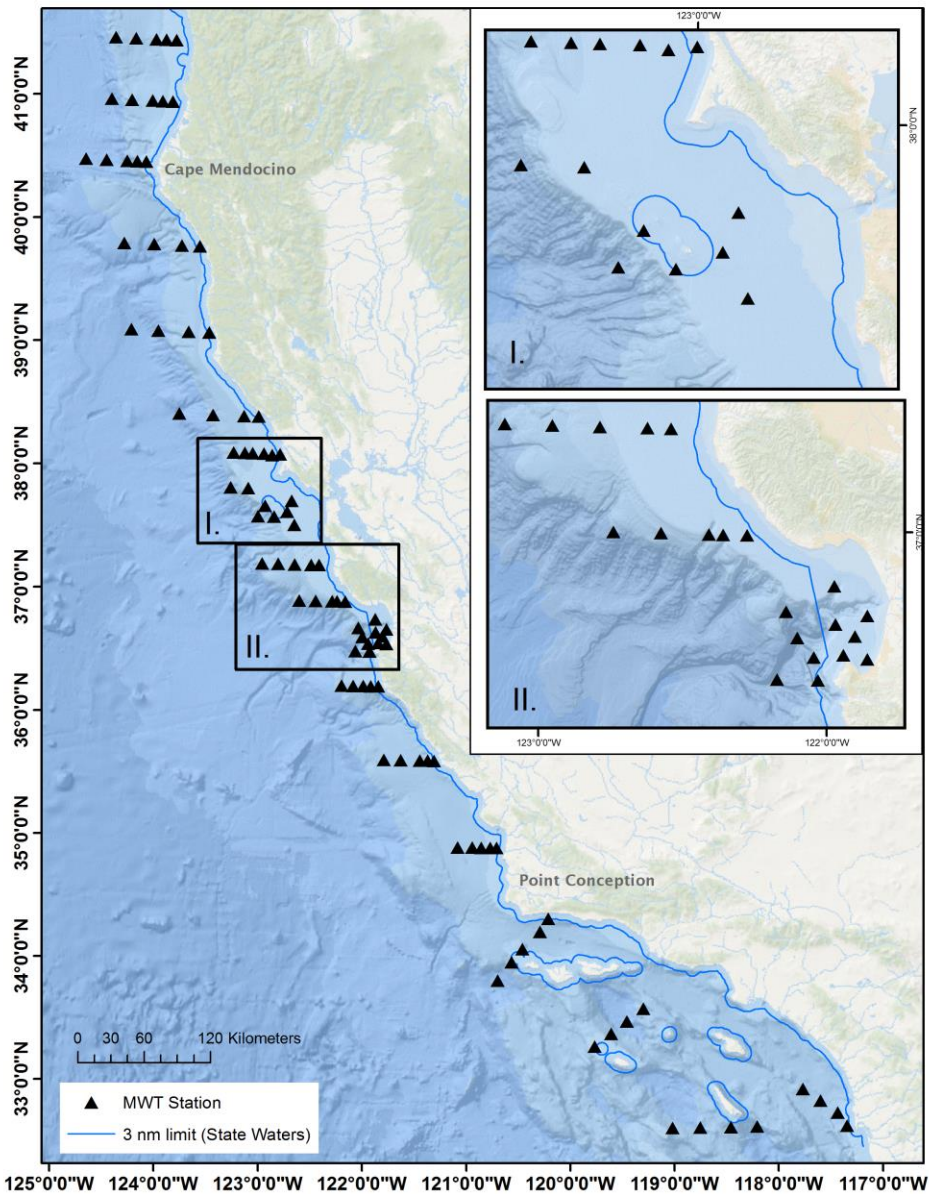


Figure 6. Rockfish Recruitment and Ecosystem Assessment Survey sampling map. Four to seven midwater trawls of 15-minute duration were conducted each night along each transect. A modified-Cobb midwater trawl was used at night. Core stations are from Point Reyes to Monterey (Boxes I and II), Stations north of Point Reyes are in the northern area, while stations south of Monterey are in the southern area (<https://swfsc.noaa.gov/textblock.aspx?Division=FED&ParentMenuId=54&id=20615>).

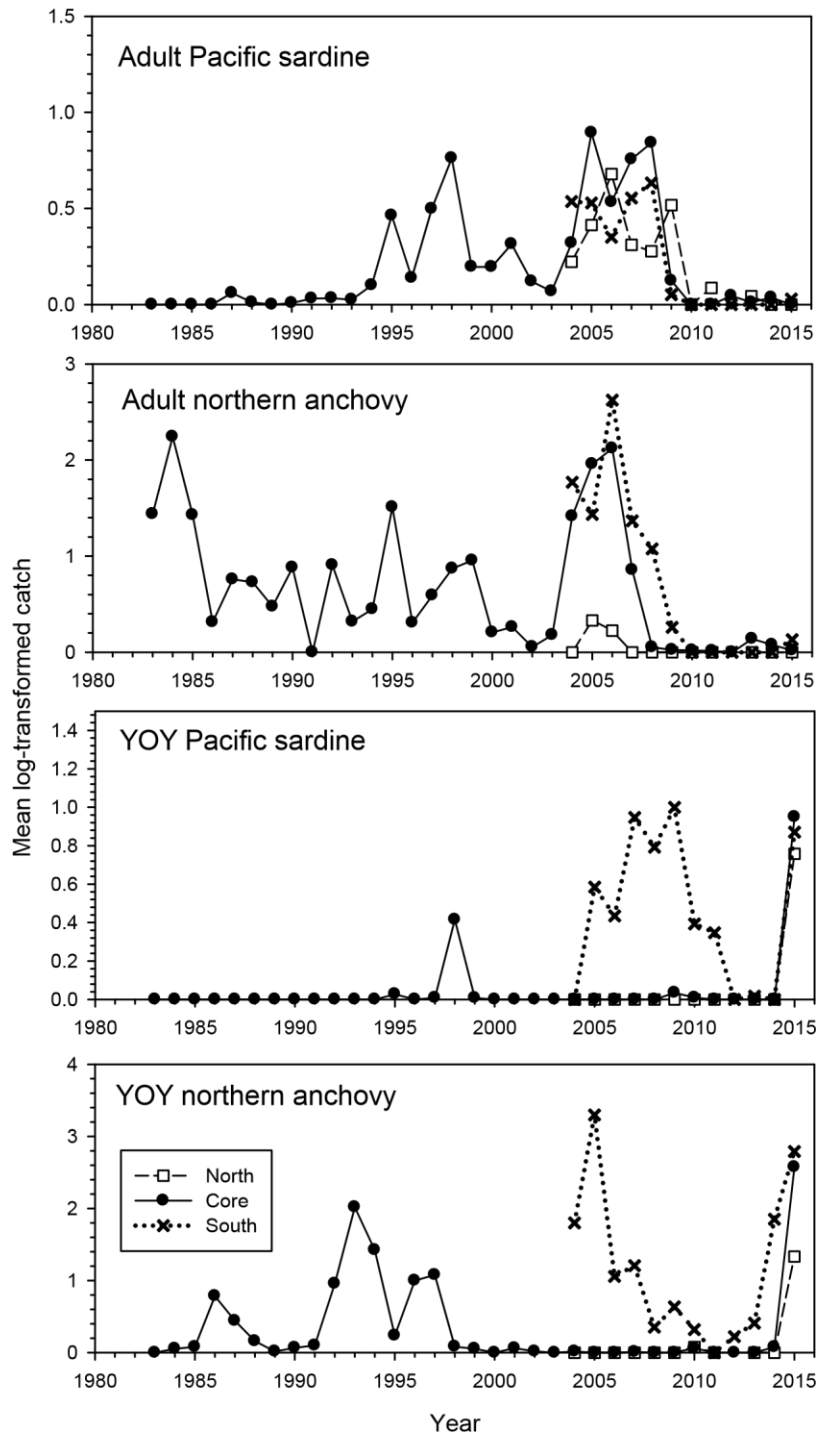
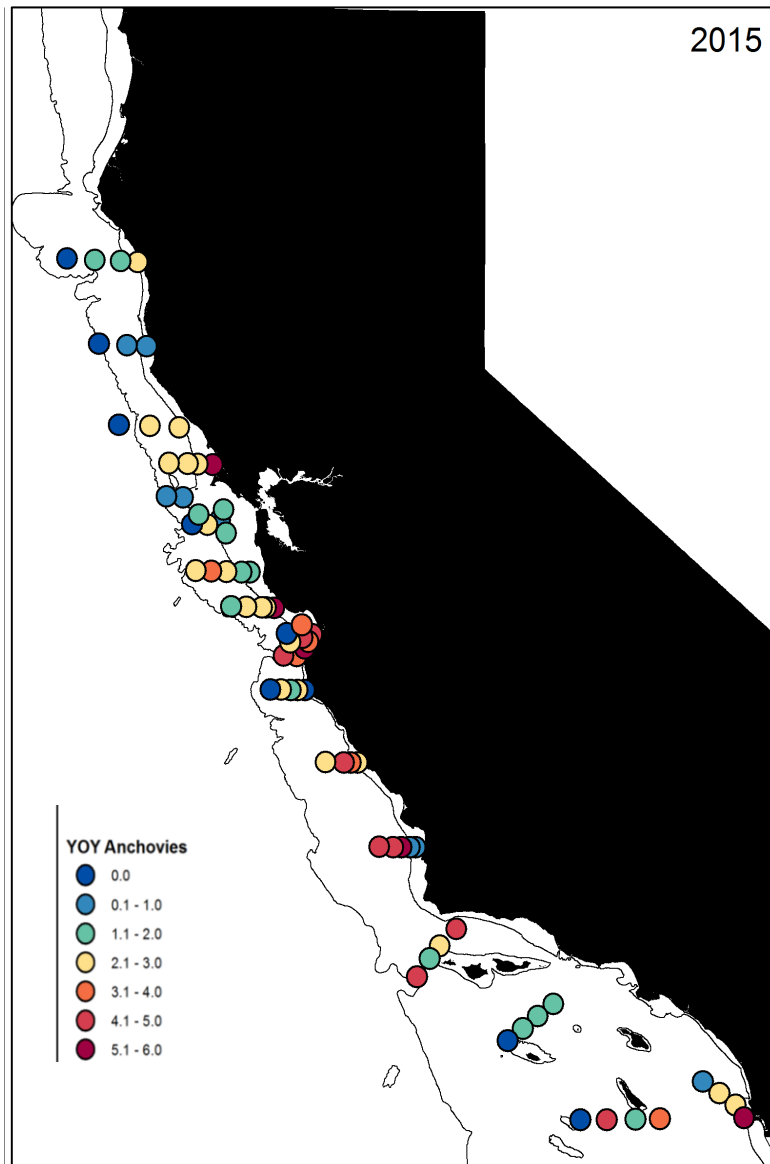


Figure 7. Abundance (mean log-transformed catch) of northern anchovy and Pacific sardine adults and young-of-the-year in the rockfish recruitment survey in the core (Central California) region (1990-2015) and the southern and northern California survey areas (2004-2015, excluding 2012 for the northern area) (<https://swfsc.noaa.gov/textblock.aspx?Division=FED&ParentMenuId=54&id=20615>).



## YOY Anchovies

Figure 8. 2015 Rockfish Recruitment and Ecosystem Assessment Survey catch (log transformed catch) of YOY northern anchovy at trawling stations (see <https://swfsc.noaa.gov/textblock.aspx?Division=FED&ParentMenuId=54&id=20615>, used with permission of John Field).

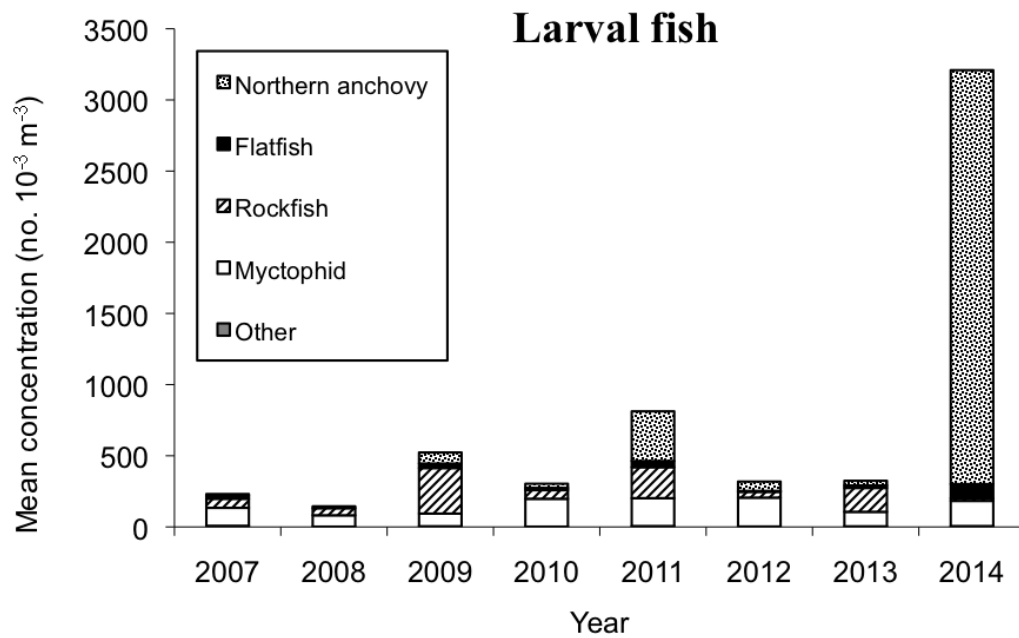


Figure 9. Mean concentrations (no.  $10^{-3} \text{ m}^{-3}$ ) of the dominant larval fish taxa collected during June-July in 2007-2014 along the Newport Hydrographic (NH; 44.65°N, 124.35-125.12°W) and Columbia River (CR; 46.16°N, 124.22-125.18°W) lines off the coast of Oregon. Figure reproduced from SOCC (2015), used with permission of Ric Brodeur.

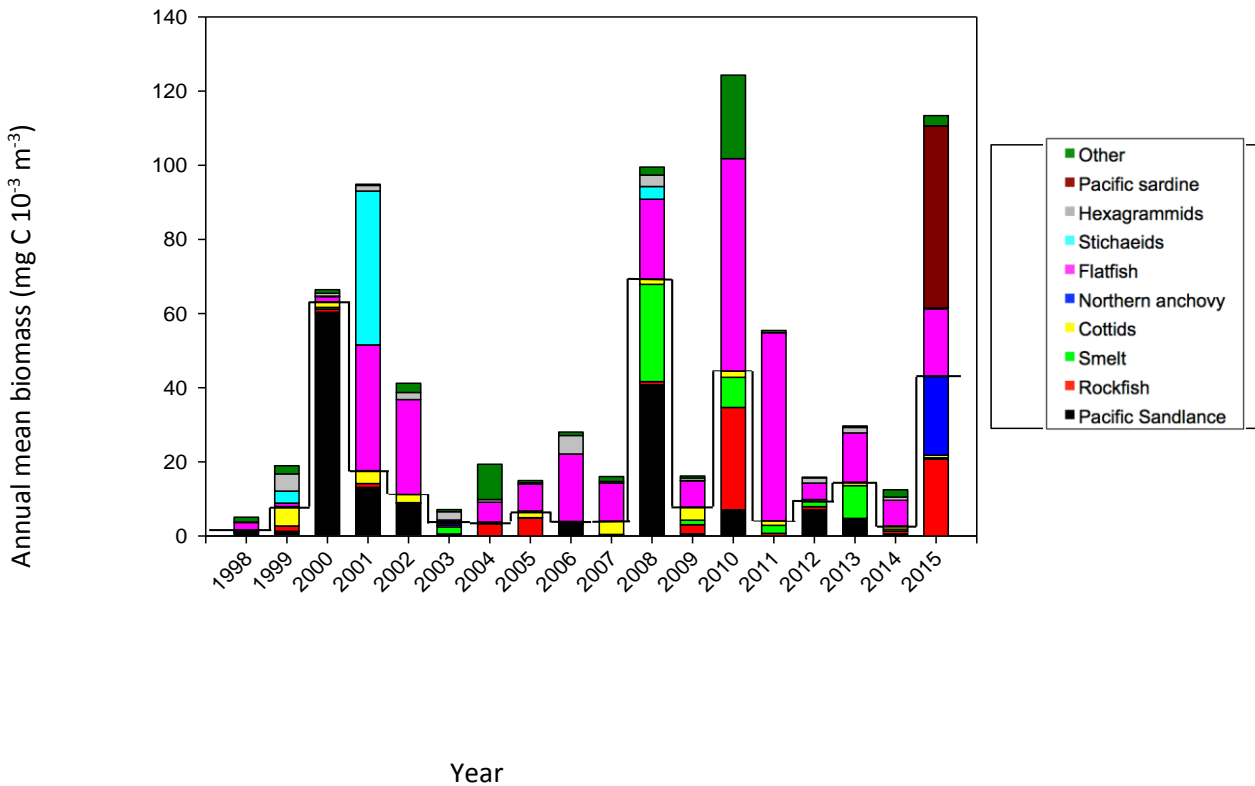


Figure 10. Annual mean biomass (mg C  $10^{-3} \text{ m}^{-3}$ ) of the five important salmon prey taxa (below solid line) and five other dominant larval fish taxa (above solid line) collected during winter (January-March) in 1998-2015 along the Newport Hydrographic (NH) line off the coast of Oregon (44.65°N, 124.18-124.65°W). Northern anchovy are highlighted in blue and Pacific sardine are highlighted in maroon. Figure reproduced from SOCC (2015) and used with permission of Ric Brodeur.