SUPPLEMENTARY MATERIALS

TO THE

CALIFORNIA CURRENT INTEGRATED ECOSYSTEM ASSESSMENT (CCIEA) STATE OF THE CALIFORNIA CURRENT REPORT, 2016

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Appendix A. List of acronyms used in this report

ATF	Arrowtooth Flounder
B_{MSY}	Biomass when at Maximum Sustainable Yield
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CCLME	California Current Large Marine Ecosystem
CCIEA	California Current Integrated Ecosystem Assessment
CPS	Coastal Pelagic Species
CPUE	Catch per Unit Effort
CSVI	Community Social Vulnerability Index
CUI	Cumulative Upwelling Index
DO	Dissolved Oxygen
ESI	Effective Shannon Index
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
F_{MSY}	Fishing mortality rate that produces Maximum Sustainable Yield
IEA	Integrated Ecosystem Assessment
LST	Longspine Thornyhead
MARSS	Multivariate Auto-Regressive State Space model
MEI	Multivariate El Niño Index
NOAA	National Oceanic and Atmospheric Administration
NPGO	North Pacific Gyre Oscillation
NWFSC	Northwest Fisheries Science Center
OA	Ocean Acidification
OFL	Overfishing Limit
ONI	Oceanic Niño Index (mentioned in Table 4.3.1)
PacFIN	Pacific Fisheries Information Network
PAH	Polycyclic Aromatic Hydrocarbons
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fishery Management Council
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
POP	Pacific Ocean Perch
RecFIN	Recreational Fisheries Information Network
s.d.	standard deviation
s.e.	standard error
SSC	Scientific and Statistical Committee
SSCES	Scientific and Statistical Committee Ecosystem Subcommittee
SST	Sea Surface Temperature (in most occurrences)
	Shortspine Thornyhead (Figure 4.4.1)
SSTa	Sea Surface Temperature anomaly
SWE	Snow-Water Equivalent
SWFSC	Southwest Fisheries Science Center
UI	Bakun Upwelling Index
UME	Unusual Mortality Event
YOY	Young-of-the-Year

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APPENDIX C. LIST OF FIGURE AND DATA SOURCES

Figure 3.1: Timeline of the warm temperature anomalies in the north (the "Warm Blob") and south of the CCE, and the El Niño event that nearly occurred (hashed bar) and later did occur (solid arrow).

Figure 3.1.1: Pacific Decadal Oscillation data are from Dr. Nate Mantua, University of Washington (http://research.jisao.washington.edu/pdo/).

Figure 3.1.2: Sea surface temperature anomalies were derived with HadISST product, obtained from the Met Office Hadley Centre (http://www.metoffice.gov.uk/hadobs/hadisst).

Figure 3.1.3: North Pacific Gyre Oscillation data were provided by Dr. Emanuele Di Lorenzo, Georgia Institute of Technology (http://www.o3d.org/npgo/).

Figure 3.1.4: Multivariate El Niño Index data are from NOAA's Earth System Research Laboratory, Physical Sciences Division (http://www.esrl.noaa.gov/psd/enso/mei/index.html).

Figure 3.2.1: Upwelling Index data were downloaded from the West Coast regional node of CoastWatch (http://coastwatch.pfel.noaa.gov/).

Figure 3.3.1: Dissolved oxygen data were provided by Dr. Bill Peterson (NOAA) for the Newport Line, or by the West Coast regional node of CoastWatch (http://coastwatch.pfel.noaa.gov/) for the CalCOFI region.

Figure 3.3.2: Aragonite saturation state data were provided by Dr. Bill Peterson (NOAA).

Figure 3.4.1: Snow-water equivalent data were derived from the California Department of Water Resources snow survey (http://cdec.water.ca.gov/) and the Natural Resources Conservation Service's SNOTEL sites in WA, OR, CA and ID (http://www.wcc.nrcs.usda.gov/snow/).

Figure 4.1.1: Copepod biomass anomaly data were provided by Dr. Bill Peterson (NOAA).

Figure 4.2.1: Pelagic forage data from the Northern CCE were provided by Dr. Ric Brodeur (NOAA) and were derived from surface trawls conducted as part of the BPA Plume Survey.

Figure 4.2.2: Pelagic forage data from the Central CCE were provided by Dr. John Field (NOAA) from the SWFSC Rockfish Recruitment and Ecosystem Assessment Survey (https://swfsc.noaa.gov/textblock.aspx?Division=FED&ParentMenuId=54&id=20615).

Figure 4.2.3: Pelagic forage data from the Southern CCE were provided by Dr. Andrew Thompson (NOAA) and were derived from spring CalCOFI surveys (http://calcofi.org/).

Figure 4.3.1: Chinook salmon escapement data were provided by Dr. Brian Wells and Dr. Thomas Wainwright (NOAA).

Table 4.3.1: Stoplight table of indicators and 2016 salmon returns provided by Dr. Bill Peterson (NOAA).

Figure 4.4.1: Groundfish stock status data were provided by Dr. Jason Cope (NOAA) and were derived from NMFS stock assessments.

Figure 4.4.2: Biomass ratio data are from the NMFS U.S. West Coast Groundfish Bottom Trawl Survey (http://www.nwfsc.noaa.gov/research/divisions/fram/groundfish/bottom_trawl.cfm) and were provided by Dr. Todd Hay and Ms. Beth Horness (NOAA).

Figure 4.5.1: California sea lion data were provided by Dr. Sharon Melin (NOAA).

Figure 4.6.1: Seabird species richness data are from CalCOFI surveys, courtesy of Dr. Bill Sydeman of the Farallon Institute (wsydeman@faralloninstitute.org).

Figure 4.6.2: Murre wreck data are courtesy of COASST (https://depts.washington.edu/coasst).

Figure 5.1.1: Data for commercial landings are from PacFIN (http://pacfin.psmfc.org). Data for recreational landings are from RecFIN (http://www.recfin.org/).

Figure 5.2.1: Data for total benthic habitat distance disturbed by bottom-contact fishing gears come from PFMC's Pacific Coast Groundfish 5-Year Review of Essential Fish Habitat.

Figure 5.3.1: Shellfish aquaculture production data are from the Washington Department of Fish and Wildlife, Oregon Department of Agriculture and California Department of Fish and Game. The only marine net-pen finfish aquaculture operations in the CCE occur in Washington State, and data came from the Washington Department of Fish & Wildlife (*2014 data are preliminary*).

Figure 5.3.2: Data for total (imported and domestic) edible and nonedible seafood consumption are from NOAA's "Fisheries of the United States" annual reports describing the utilization of fisheries products (http://www.st.nmfs.noaa.gov/st1/publications.html).

Figure 6.1.1: Fishery dependence and community social vulnerability index (CSVI) data were provided by Dr. Karma Norman (NOAA) and were derived from the U.S. Census Bureau (http://www.census.gov), the American Community Survey (ACS; https://www.census.gov/programs-surveys/acs/) and PacFIN (http://pacfin.psmfc.org).

Figure 6.1.2: Fishery dependence and community social vulnerability index (CSVI) data were provided by Dr. Karma Norman (NOAA).

Figure 6.2.1: Fishery diversification estimates were provided by Dr. Dan Holland and Dr. Stephen Kasperski (NOAA).

Figure 6.3.1: Personal use landings data are from PacFIN (http://pacfin.psmfc.org), and were compiled by Dr. Melissa Poe (NOAA, Washington Sea Grant).

APPENDIX D. CLIMATE AND OCEAN INDICATORS

Section 3 of the 2015 CCIEA State of the California Current report describes indicators of basin-scale and region-scale climate and ocean drivers. The plots in that section feature monthly or season-specific measures of the indices, which are concurrent with the typical periods of maximum upwelling, productivity, and the potential for periods of hypoxia or reductions in pH. Here we present additional indices to allow a more complete picture of these time series.

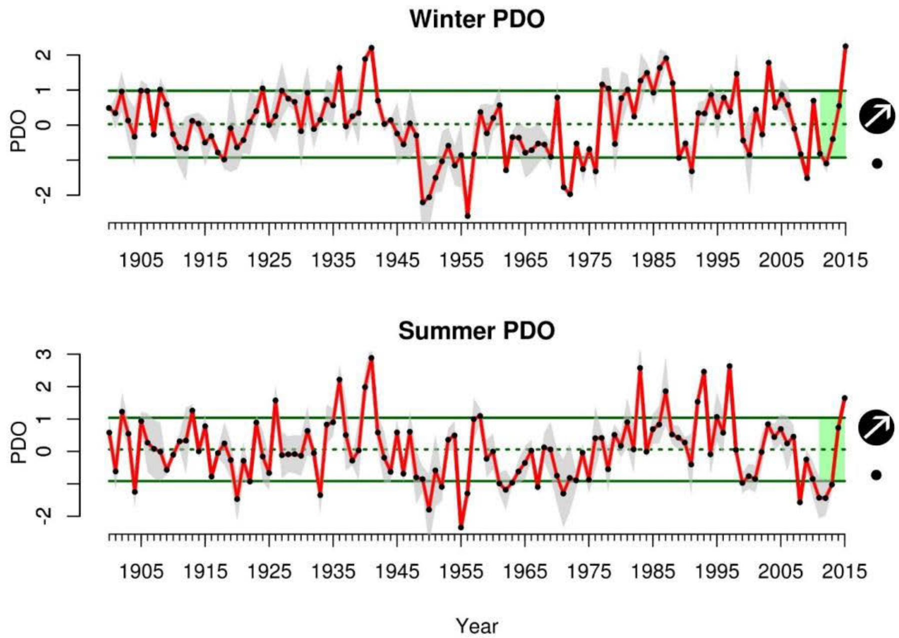


Figure D1. Winter and summer values of Pacific Decadal Oscillation (PDO) index, 1900-2015. Lines, colors and symbols are as in Figure 1.1.

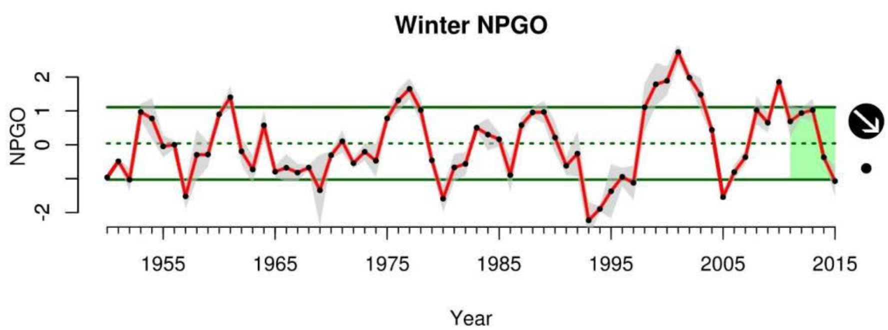


Figure D2. Winter values of North Pacific Gyre Oscillation (NPGO), 1950-2015. Lines, colors and symbols are as in Figure 1.1.

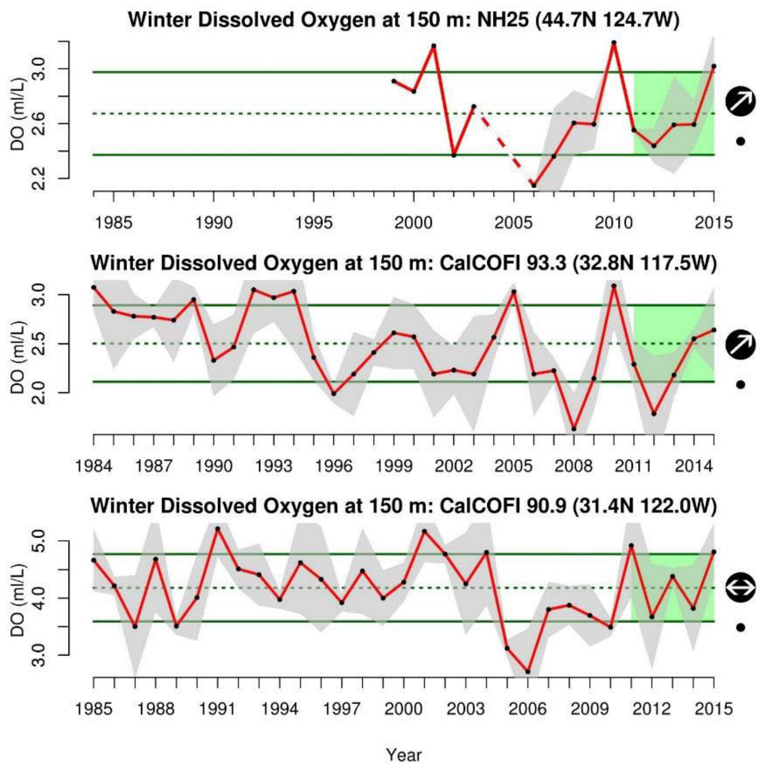


Figure D3. Winter values of dissolved oxygen (DO) at 150 m depth off Oregon (Newport Line station NH25) and southern California (CalCOFI stations 93.30 and 90.90). Stations 93.30 and NH25 are <50 km from the shore, while station 90.90 is >300 km from shore. Lines, colors and symbols are as in Figure 1.1; dashed red lines indicate data gaps >6 months.

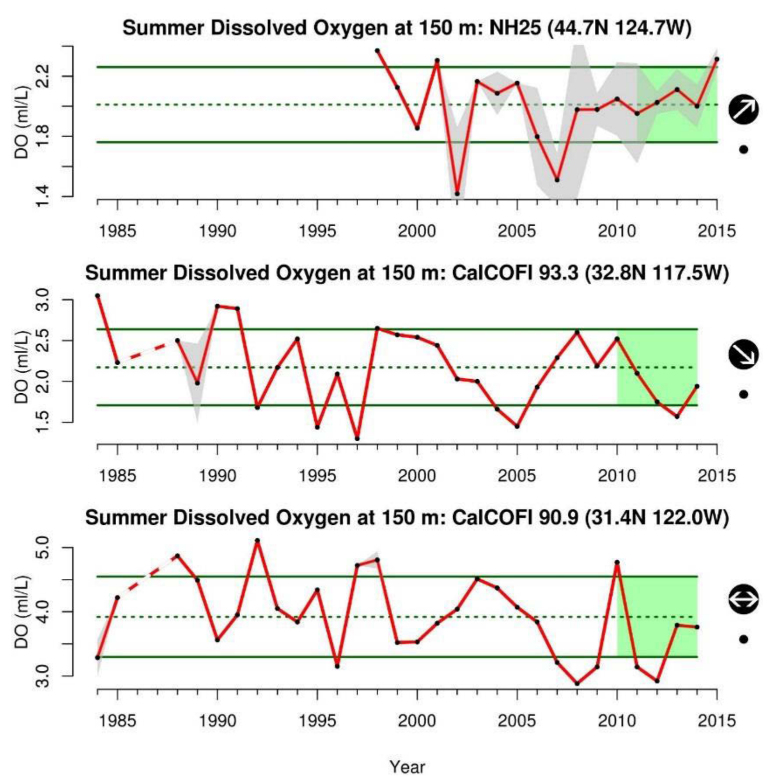


Figure D4. Summer values of dissolved oxygen (DO) at 150 m depth off Oregon (Newport Line station NH25) and southern California (CalCOFI stations 93.30 and 90.90). Stations 93.30 and NH25 are <50 km from the shore, while station 90.90 is >300 km from shore. Lines, colors and symbols are as in Figure 1.1; dashed red lines indicate data gaps >6 months.

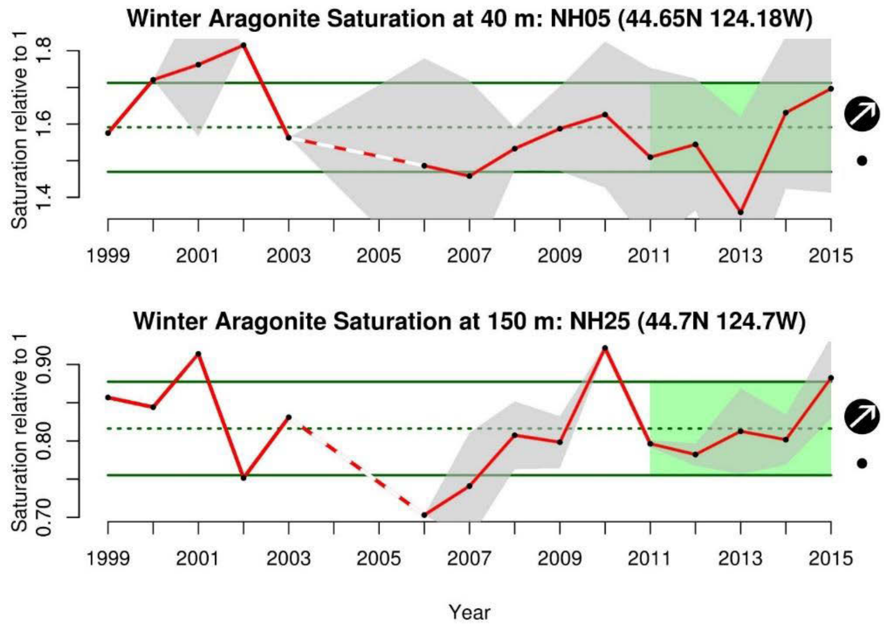


Figure D5. Winter values of aragonite saturation off of Newport, OR, 1998-2015. Lines, colors and symbols are as in Figure 1.1; dashed red lines indicate data gaps >6 months.

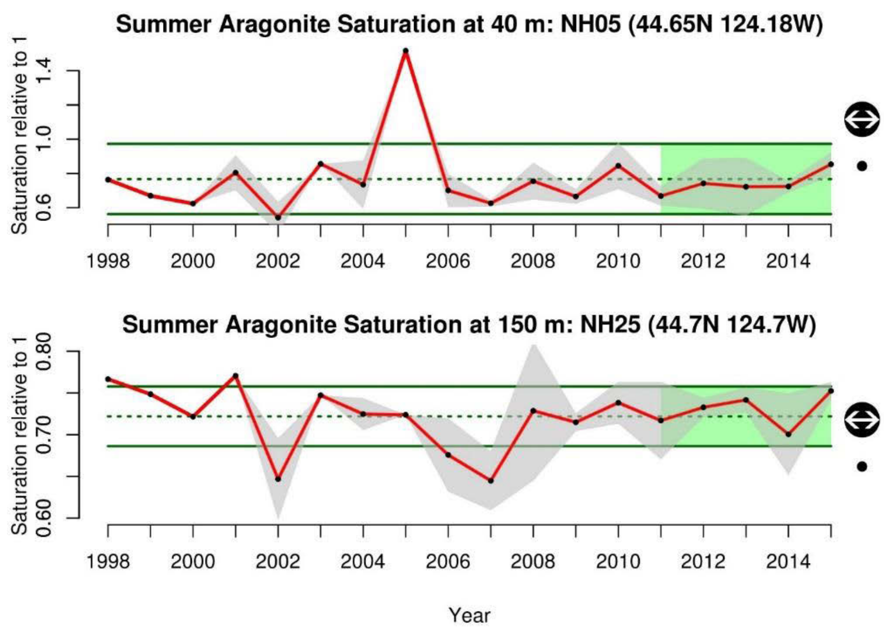


Figure D6. Summer values of aragonite saturation off of Newport, OR, 1998-2015. Lines, colors and symbols are as in Figure 1.1; dashed red lines indicate data gaps >6 months.

APPENDIX E. HABITAT INDICATORS: SNOW-WATER EQUIVALENT AND STREAMFLOW

Over the last year, development of habitat indicators in the CCIEA has focused on freshwater habitats. These habitats play a large role for salmon populations as well as having importance for estuarine-dependent marine fisheries such as certain flatfish stocks. For much of the coast, all three freshwater indicators point to poor conditions for fish migrating from or summering within rivers in 2015. In addition to freshwater conditions, deliberations over Essential Fish Habitat for Groundfish have highlighted the need for information on habitat disturbance by fishing gear. The most recent updates to this indicator point toward a decline in seafloor habitat disturbance since 2008, although some of this pattern can be explained by shifts in effort to deeper areas of the seafloor. In future years, additional indicators targeting estuarine and neashore marine, pelagic, and seafloor habitats will be included. For more information on habitat indicator selection, see the Phase III IEA report (www.noaa.gov/iea/Assets/iea/california/Report/pdf/9.Habitat_2013.pdf).

All habitat indicators are reported based on a hierarchical spatial framework. This spatial framework facilitates comparisons of data at the right spatial scale for particular users, whether this be the entire California Current, ecoregions within these units, or smaller spatial units. The framework we use divides the region encompassed by the California Current ecosystem into ecoregions, and ecoregions into smaller physiographic units. Freshwater ecoregions are based on the biogeographic delineations in Abell et al. (2008), and marine egoregions are based on those determined by Spaulding et al. 2008. Abell et al (2008) define six ecoregions for watersheds entering the California Current, three of which comprise the two largest watersheds directly entering the California Current (the Columbia and the Sacramento-San Joaquin Rivers). Within ecoregions, we summarized data using 8-field hydrologic unit classifications (HUC-8). Spaulding et al. (2007) define four marine ecoregions for the California Current, and within ecoregions, data are summarized by physiographic units: individual estuaries, shoreline littoral drift cells, and physiographic features like bathymetry breaks and substrate types.

Snow-water equivalent (SWE) is measured using two data sources: a California Department of Water Resources snow survey program (data from the California Data Exchange Center http://cdec.water.ca.gov/) and The Natural Resources Conservation Service's SNOTEL sites across Washington, Idaho, Oregon, and California (http://www.wcc.nrcs.usda.gov/snow/). Snow data are converted into SWEs based on the weight of samples collected at regular intervals using a standardized protocol. Measurements at April 1 are considered the best indicator of maximum extent of SWE; thereafter snow tends to melt rather than accumulate. We calculated standardized anomalies of data from each site and averaged these to anomalies for each freshwater ecoregion.

In the most recent five years, all ecoregions experienced a strong negative decline in SWE, and 2015 was universally the lowest year on record (Fig. E1). Of the five ecoregions with snowmelt datasets, only Oregon and Northern California Coastal exhibited a five-year mean outside the range of the long-term mean ± 1 SD. In late 2015, El Nino conditions resulted in substantial increases in snowpack across the region, including in Washington (where snowpack is often lower in El Nino years). As of February 1, SWEs were more than 2x, 4x, and 6x greater this year in Washington, California (in the Sierra Nevada), and Oregon, respectively, compared to the same date in 2015 (data from National Weather Services' National Operational Hydrologic Remote Sensing Center, http://www.nohrsc.noaa.gov/). Whether this means that April 1 snowpack will rebound is still uncertain; measurements this early are not well-correlated with measurements in April due to variable spring temperatures, and the region has experienced above average January temperatures this year.

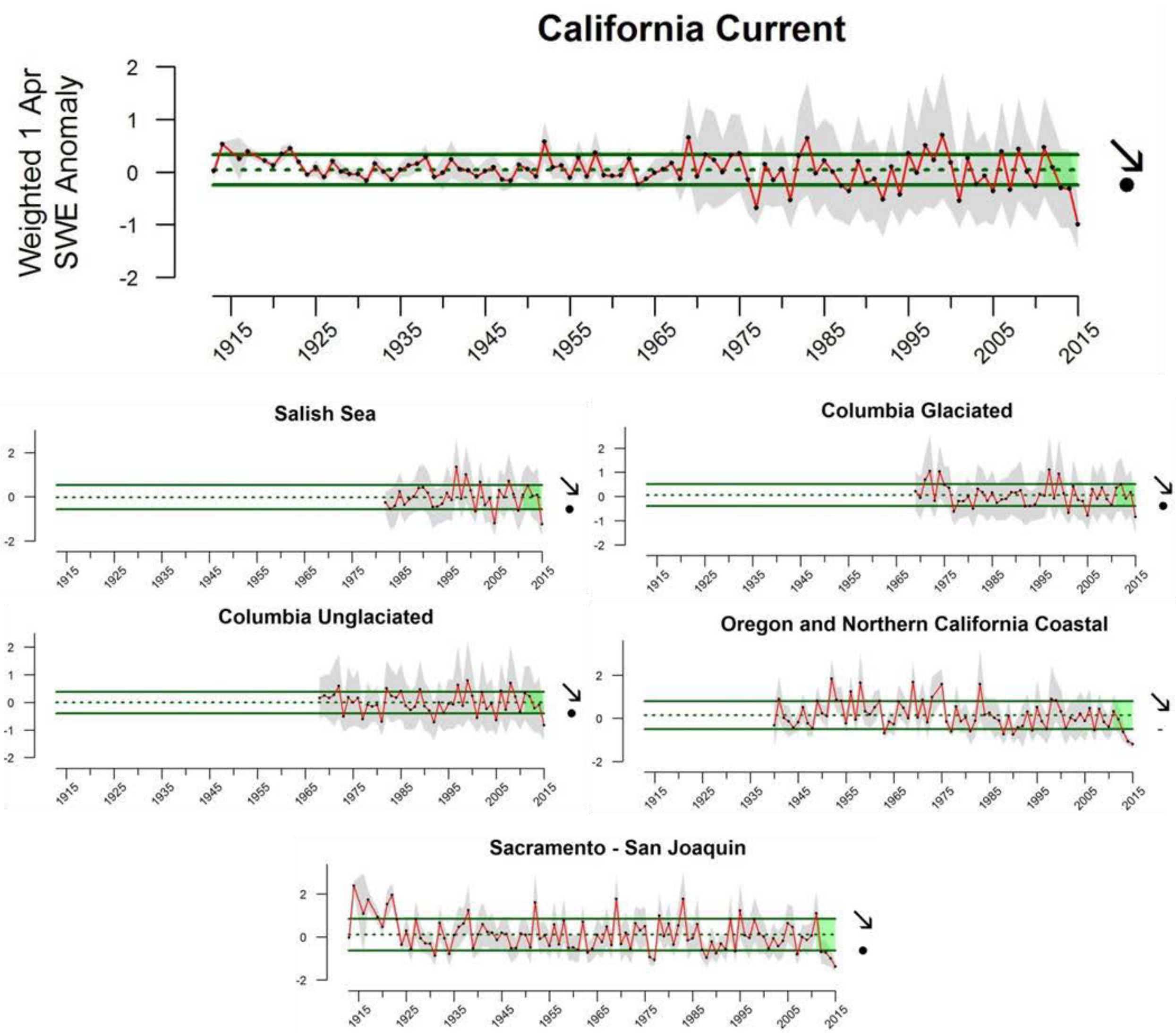


Figure E1. Anomaly of snow-water equivalent on April 1 measured at 445 sites in five ecoregions (small figures). The large graph shows the summary anomaly for the California Current, calculated as a weighted average of ecoregional data using ecoregion area as the weighting factor. As visible in ecoregional graphs, the apparent shift in variability in the California Current after 1965 is due to the fact that only the Sacramento-San Joaquin ecoregion was sampled prior to that year.

Streamflow is measured using active USGS gages (http://waterdata.usgs.gov/nwis/sw) with records that meet or exceed 30 years in duration. Average daily values from 213 gages were used to calculate both annual 1-day maximum and 7-day minimum flows. These indicators correspond to flow parameters to which salmon populations are most sensitive. Standardized anomalies of time series from individual gages were then averaged to obtain weighted averages for ecoregions (for which HUC-8 area served as a weighting factor) and for the entire California current (weighted by ecoregion area).

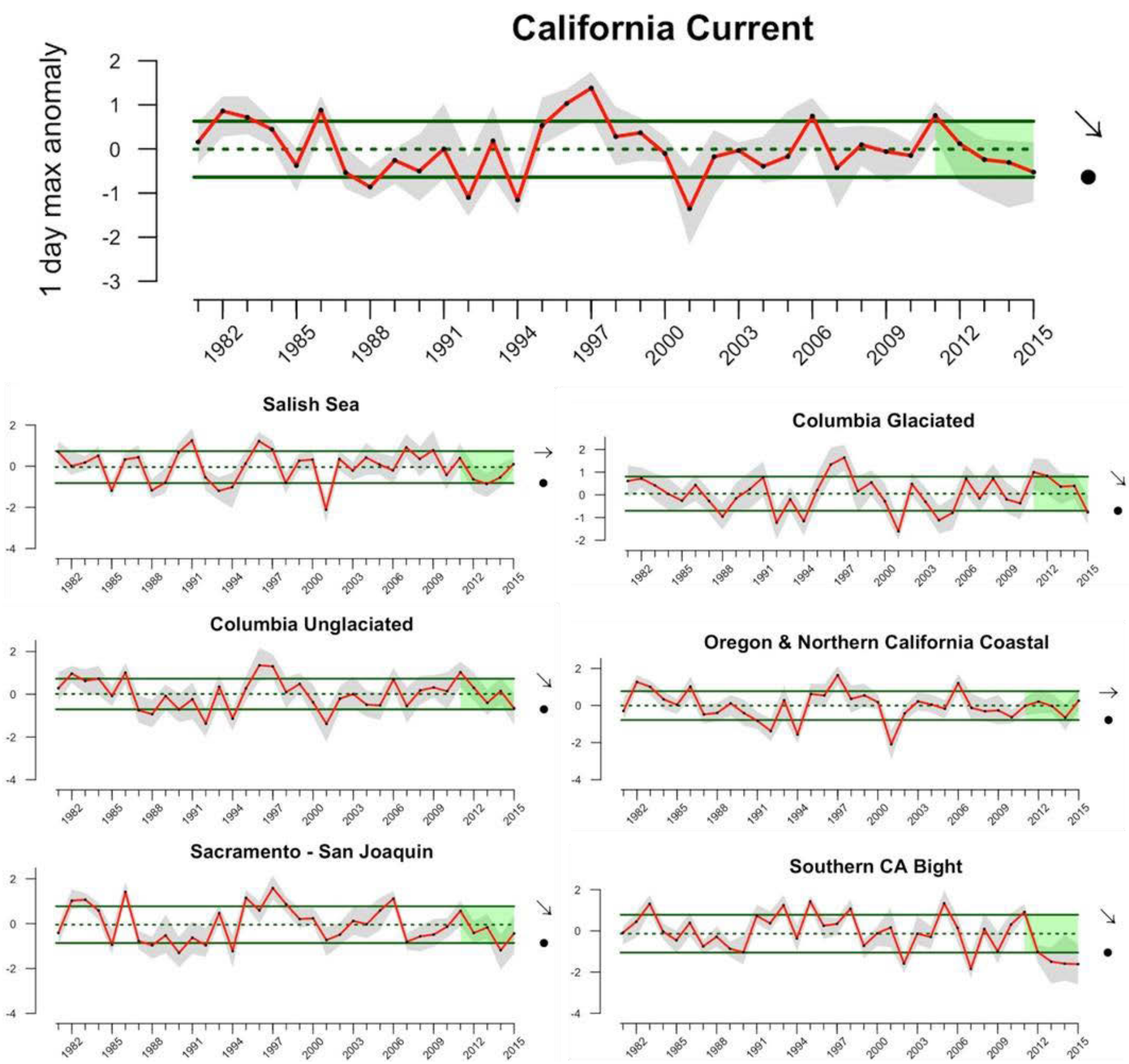


Figure E2 Anomaly of 1-day maximum annual streamflow measured at 213 gages in six ecoregions (small figures). The large graph shows the summary anomaly for the California Current, calculated as a weighted average of ecoregional data using ecoregion area as the weighting factor. Gages include both regulated (subject to hydropower operations) and unregulated systems, although trends were similar when these systems were examined separately.

Across the California Current, both maximum (Fig. E2) and minimum (Fig. E3) streamflow anomalies have exhibited strong declines in the most recent five years. For maximum streamflows, declines were particularly pronounced in the large inland rivers (Columbia and Sacramento-San Joaquin), as well as rivers in the Southern California Bight. Here, 2015 had the second lowest maximum flow in the last 34 years. Minimum streamflows have exhibited more consistent patterns across all ecoregions, although little variation exists for rivers in the Southern CA Bight. For this arid ecoregion, a metric such as the duration of low streamflow pulses might be a more informative indicator, and this metric (not shown) exhibited a positive five-year trend (longer periods of low flow) across all ecoregions.

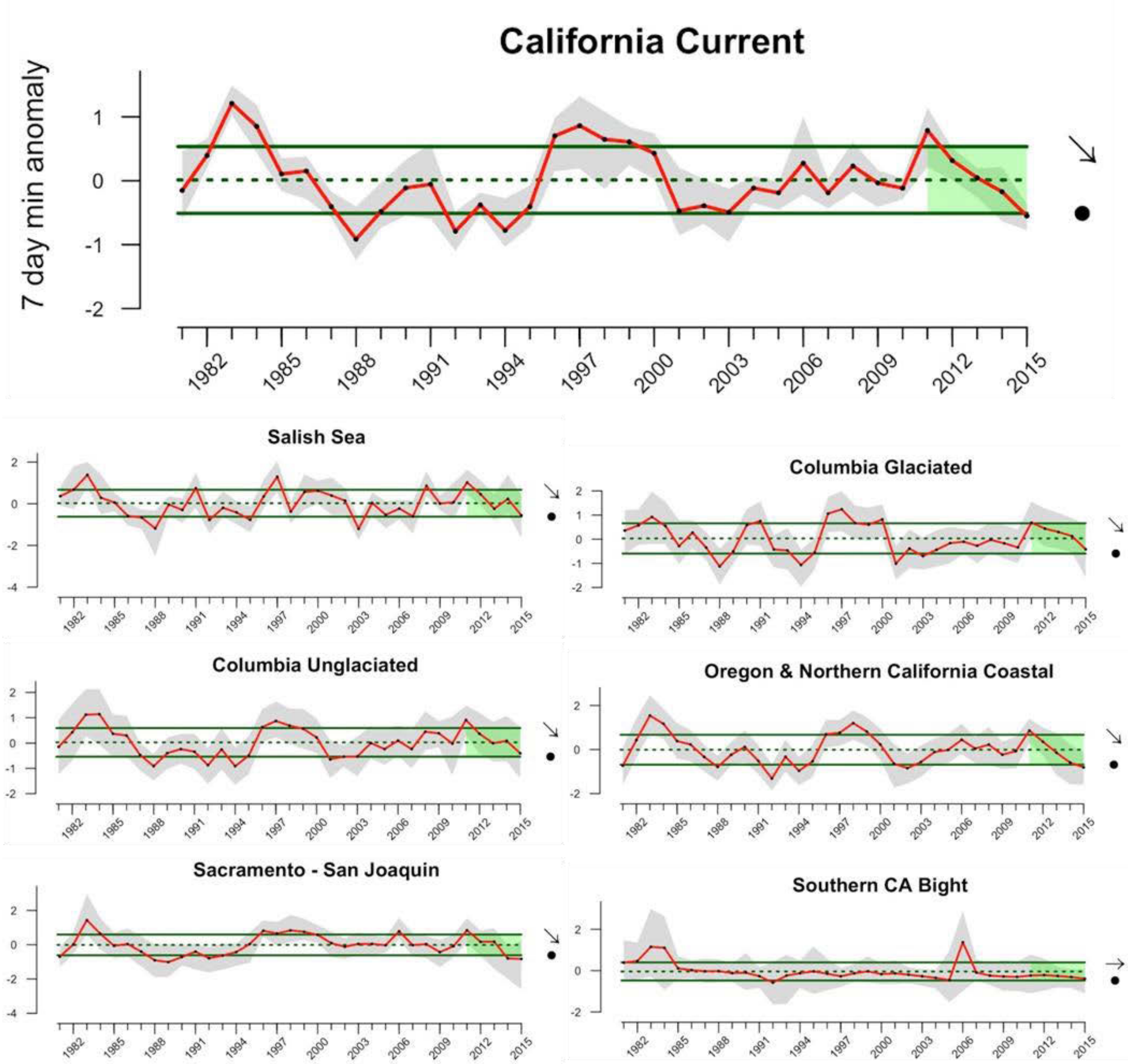


Figure E3. Anomaly of 7-day minimum streamflow measured at 213 gages in six ecoregions (small figures). The large graph shows the summary anomaly for the California Current, calculated as a weighted average of ecoregional data using ecoregion area as the weighting factor. Gages include both regulated (subject to hydropower operations) and unregulated systems, although trends were similar when these systems were examined separately.

APPENDIX F. REGIONAL FORAGE AVAILABILITY

Species specific trends in forage availability is based on research cruises in the northern, central, and southern portions of the CCE through spring/summer 2015. As noted in the main report, we consider these to be regional indices of relative forage availability and variability; these are <u>not</u> indices of absolute abundance of coastal pelagic species (CPS). Collection details and format are indicated in the respective figure legends.

Northern California Current:

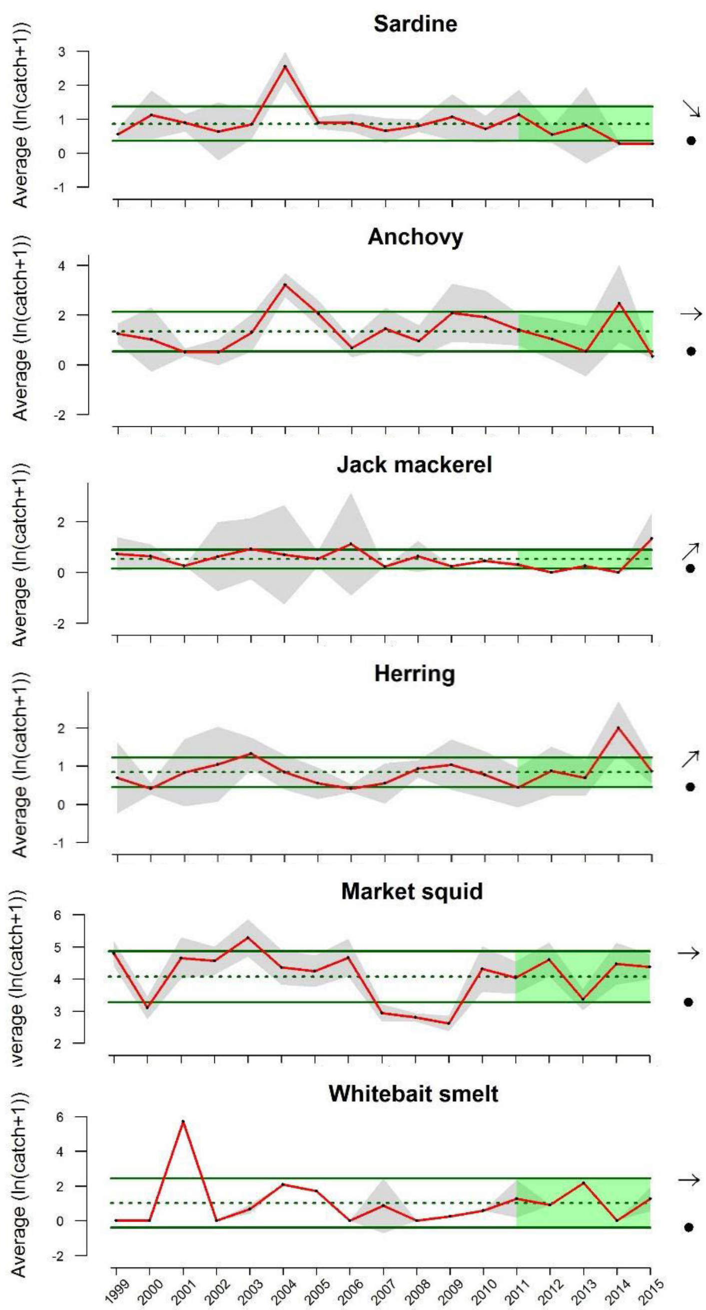
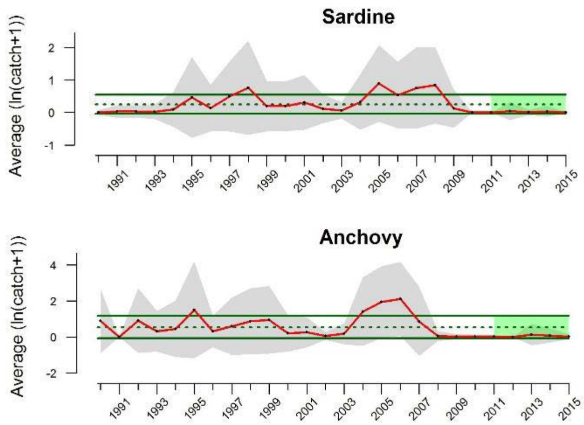


Figure F1. Geometric mean CPUEs (#/km^2) of key forage groups in the Northern CCE, from surface trawls conducted as part of the BPA Plume Survey, 1999-2015 (Dr. Ric Brodeur, NOAA, with the assistance of C. Barcelo, OSU Newport). Lines, colors and symbols are as in Figure 1.1 .

Pelagic forage groups are ordered from high (top) to low (bottom) based on relative measure of energy density, following Table 3 in: S.M. Glaser, 2010. Interdecadal variability in predator-prey interactions of juvenile North Pacific albacore in the California Current system. Marine Ecology Progress Series 414: 209-221.

Central California Current:



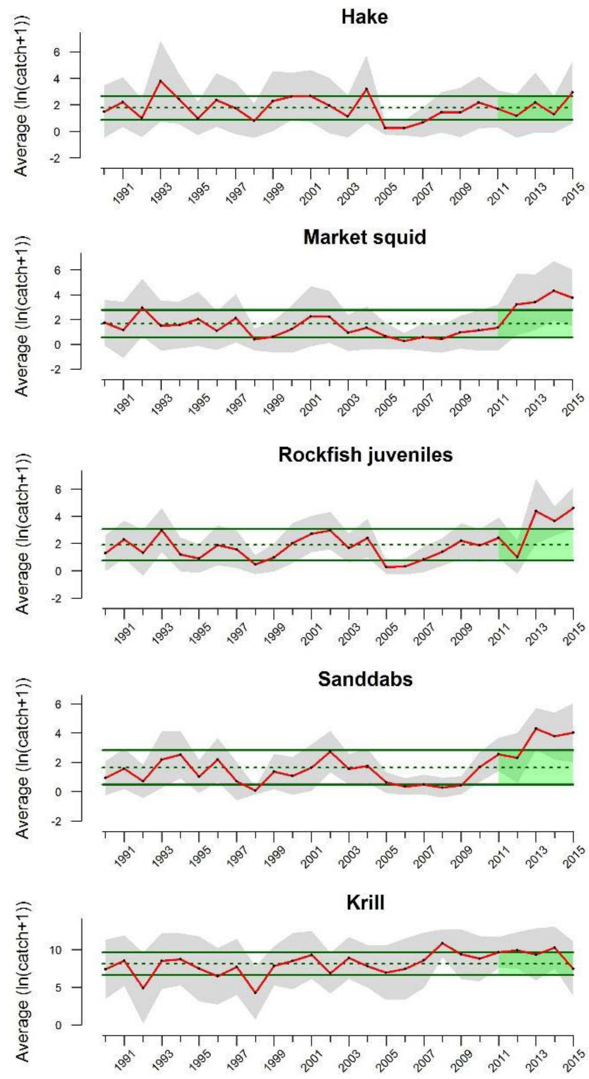


Figure F2. Geometric mean CPUEs (#/haul) of key forage groups in the Central CCE, from the SWFSC Rockfish Recruitment and Ecosystem Assessment Survey during 1990-2015 (Dr. John Field, NOAA). Forage groups are ordered from high (top) to low (bottom) based on relative measures of energy density, following Table 3 in Glaser (2010). High energy groupings are arranged in the left column and medium energy groupings in the right column; krill are considered separately but shown here at the bottom right. Lines, colors and symbols are as in Figure 1.1.

Southern California Current:

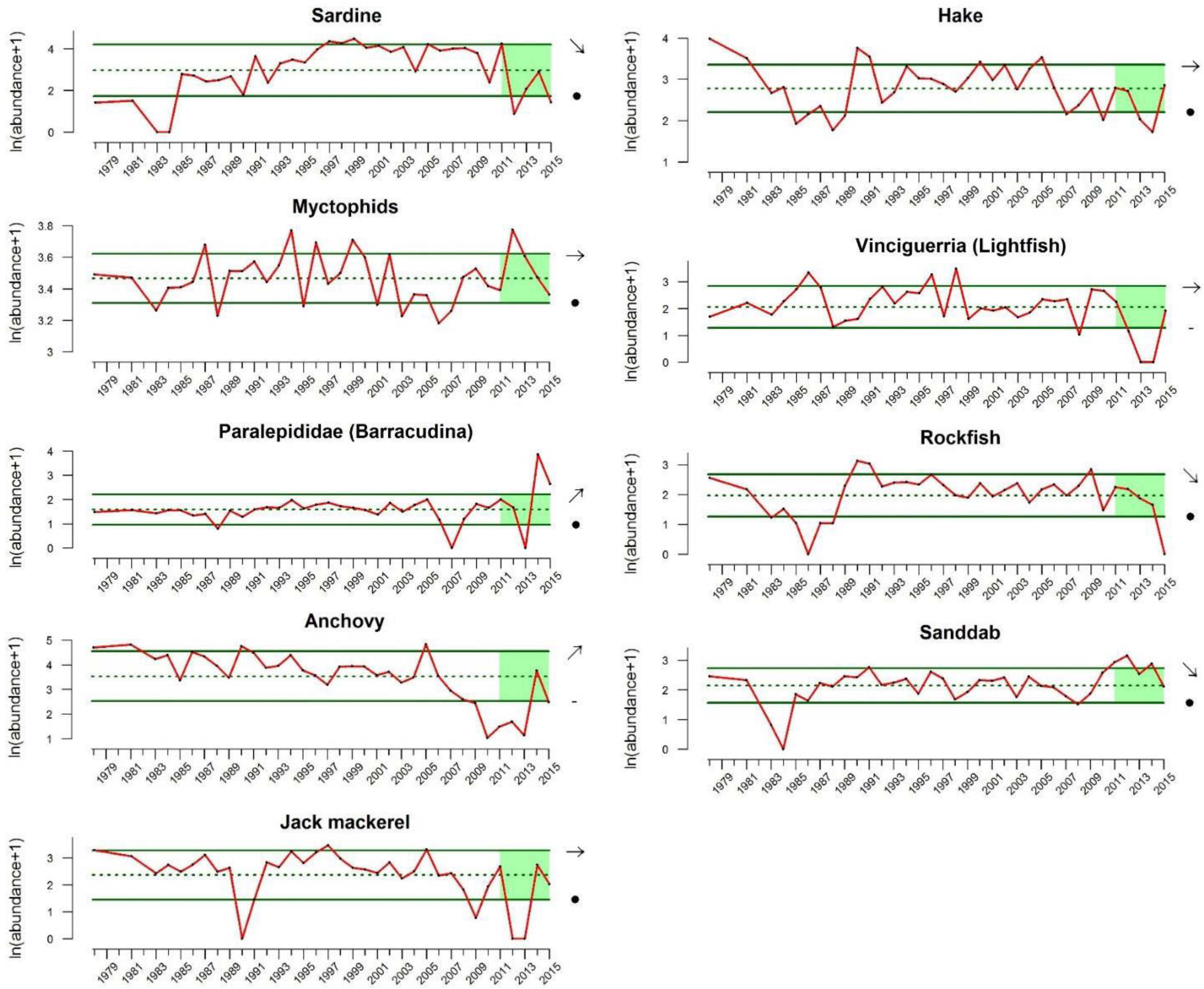


Figure F3. Relative abundance of key forage groups in the Southern CCE, from spring CalCOFI surveys during 1978-2015 (Dr. Andrew Thompson, NOAA). Forage groups are ordered from high (top) to low (bottom) based on relative measures of energy density, following Table 3 in Glaser (2010). High energy groupings are arranged in the left column and medium energy groupings in the right column. Lines, colors and symbols are as in Figure 1.1.

APPENDIX G. ADDITIONAL SEABIRD DATA AND THE 2015 COMMON MURRE MORTALITY EVENT

Sooty shearwater density in the southern CCE in spring has shown positive anomalies since 2013, with 2015 being the highest anomaly since in the time series (Fig. G1, top). The recent positive anomalies are surprising; sooty shearwaters are southern-hemisphere migrants with cold-water affinities, and warm-water conditions have persisted off southern California since 2014. The mechanism(s) behind the recent influx to the southern CCE remains undetermined.

Cassin's auklets are resident in the California Current year-round, and are most abundant in the southern California Current region during winter. Spring densities have been near the long-term average for last five years (Fig. G1, middle), even with the exceptionally high mortality of Cassin's auklets documented along much of the West Coast from late 2014 to early 2015.

Cook's petrels (Fig. G1, bottom) are southern hemisphere migrants and generally occur in hotspots associated with sub-tropical waters within the western edge of the CalCOFI grid. Strong peaks in Cook's Petrel anomalies, usually during summer surveys, are generally associated with El Niño years. However, recent density measures have been within ±1 s.d. of the long-term mean, despite warmer than normal conditions.

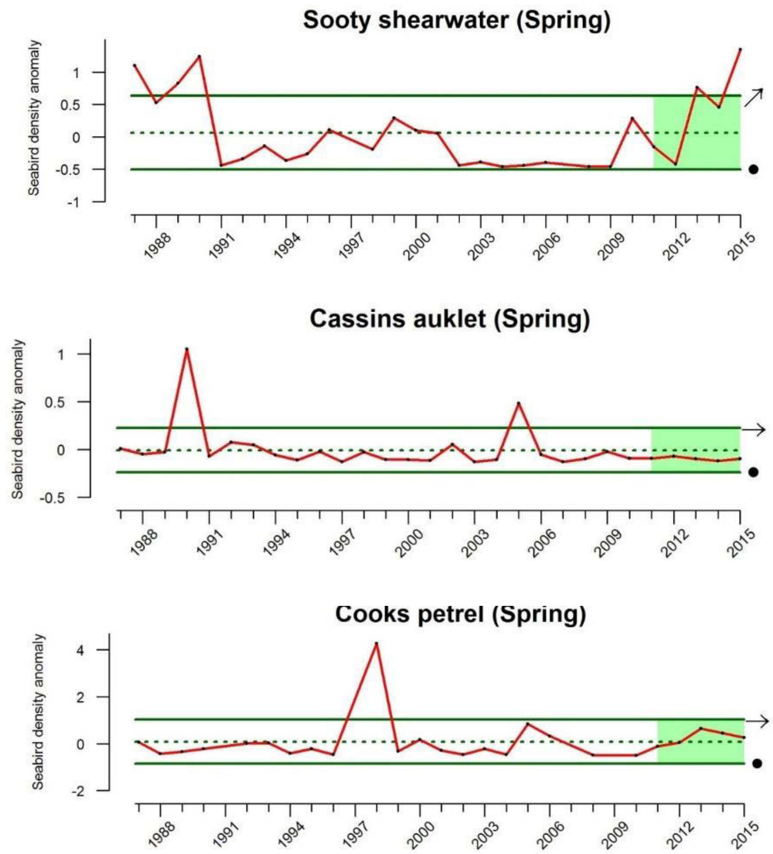


Figure G1. At-sea densities of sooty shearwaters, Cassin's auklets and Cook's petrels in spring from 1987-2015 in the southern CCE. Lines, colors and symbols are as in Fig. 1.1. Data courtesy of Dr. Bill Sydeman, Farallon Institute.

In addition to the 2015 common murre wreck data for Washington, Oregon and Northern California provided by COASST (Main Report, Figure 4.6.2), there have also been observations of an unusually large common murre mortality event in Central California. Beach survey data collected by the organizations Beach Watch (beachwatch.farallones.org) in Central California and Beach COMBERS (www.sanctuarysimon.org/monterey/sections/beachCombers) further to the south found dead murre counts that were substantially greater than the long-term averages, especially in September, October and November (Fig. G2).

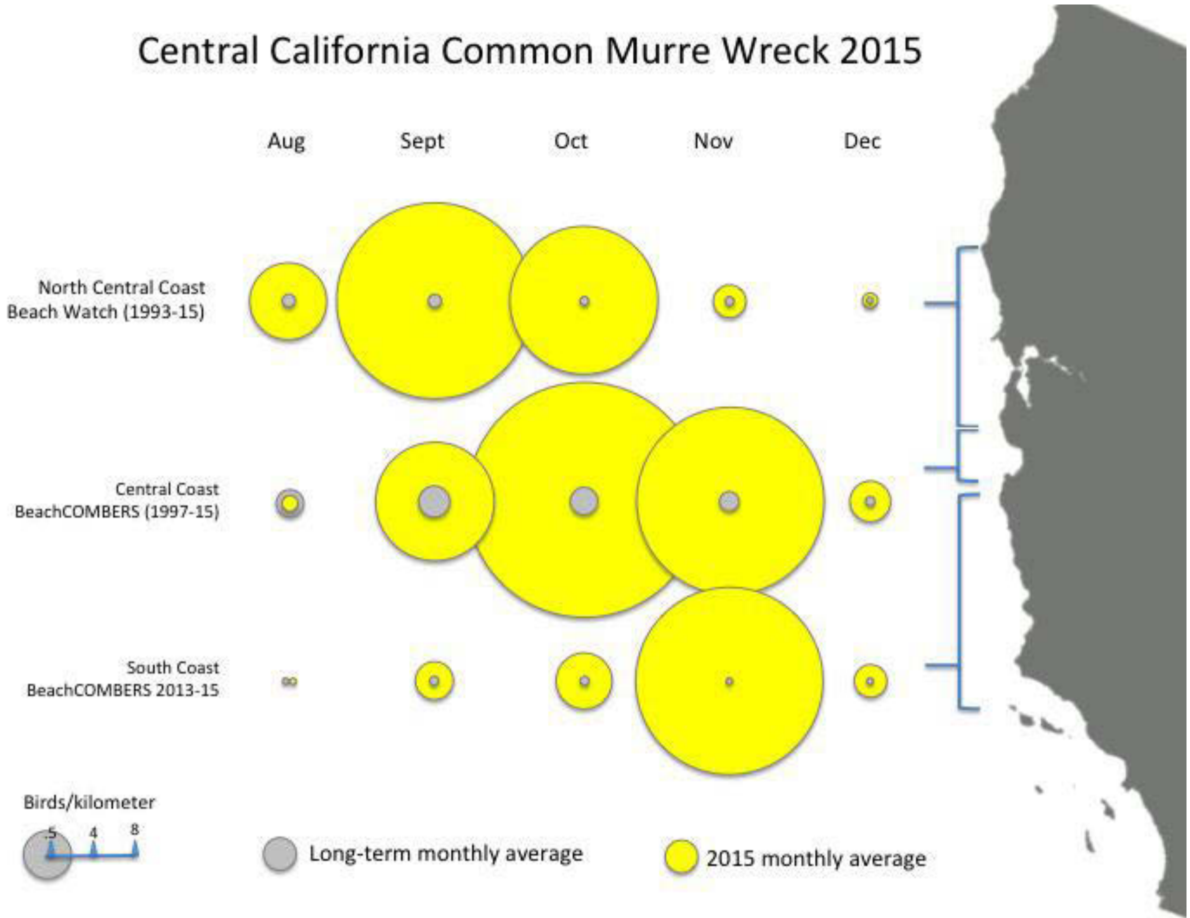


Figure G2. Common murre mortality encounter rates (carcasses/km) along beaches in central and southern California. Circle diameters are proportional to long-term average mortality (gray) and 2015 mortality (yellow) by month. Data are courtesy of the organizations Beach Watch and Beach COMBERS.

APPENDIX H. STATE-BY-STATE FISHERY LANDINGS

The best source for information on stock-specific fishery removals is typically stock assessments that report landings, estimate amount of discard, and evaluate discard mortality, but these are only available for assessed species. For non-assessed stocks, fishery removal data are best summarized in the Pacific Fisheries Information Network (PacFIN, http://pacfin.psmfc.org) for commercial landings and in the Recreational Fisheries Information Network (RecFIN, http://www.recfin.org/) for recreational landings. Landings provide the best long-term indicator of fisheries removals.

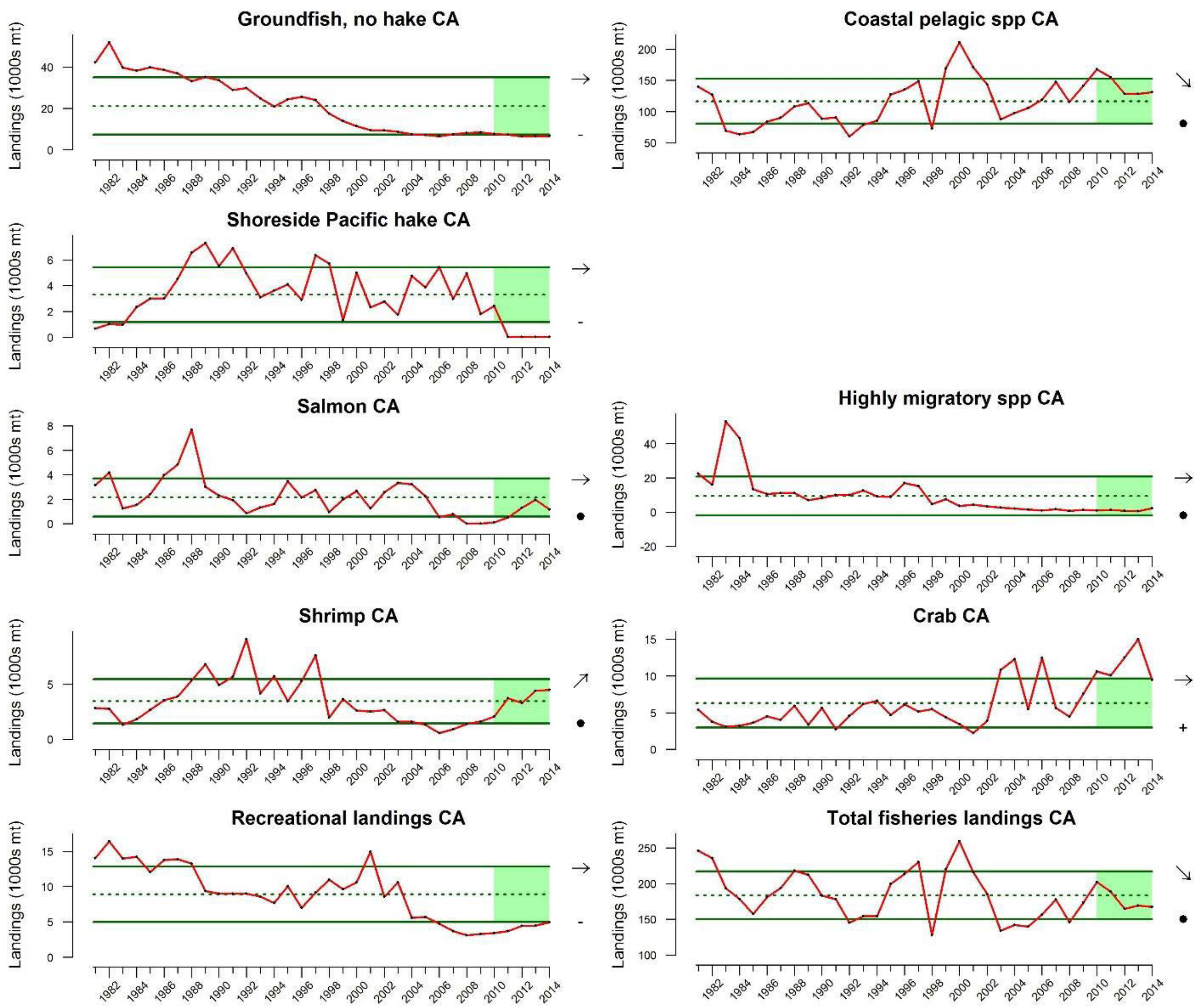


Figure H1: Annual landings of commercial (data from PacFIN) and recreational fisheries (data from RecFIN), including total landings across all fisheries from 1981-2014 in California. There were no "At-sea Pacific hake" fisheries landings in California. Lines and symbols are as in Figure 1.1.

Total fisheries landings in California decreased over the last five years and these patterns were driven almost completely by decreases in landings of coastal pelagic species (Fig. H1). Landings of groundfish (excluding hake), Pacific hake and recreational-caught species have been consistently at historically low levels over the last five years, while landings of crab were at historically high levels over the same period. Shrimp landings have increased over the last five years. Landings of salmon and highly migratory species have been relatively unchanged over the last five years.

Total fisheries landings in Oregon increased over the last five years (Fig. H2). These patterns appear to be driven by interactions in landings of Pacific hake, which have increased over the last five years for both shoreside and at-sea fisheries, landings of shrimp which have increased and were at historically high levels over the last five years, and landings of crab and coastal pelagic species, which have been highly variable but within historical averages over the last five years. Landings of highly migratory species have been consistently at historically high levels over the last five years, while groundfish (excluding hake) were near historically low levels. Commercial salmon landings remained relatively unchanged and within historical averages over the last five years. Similar to commercial fisheries landings, recreational fisheries landings also increased over the last five years.

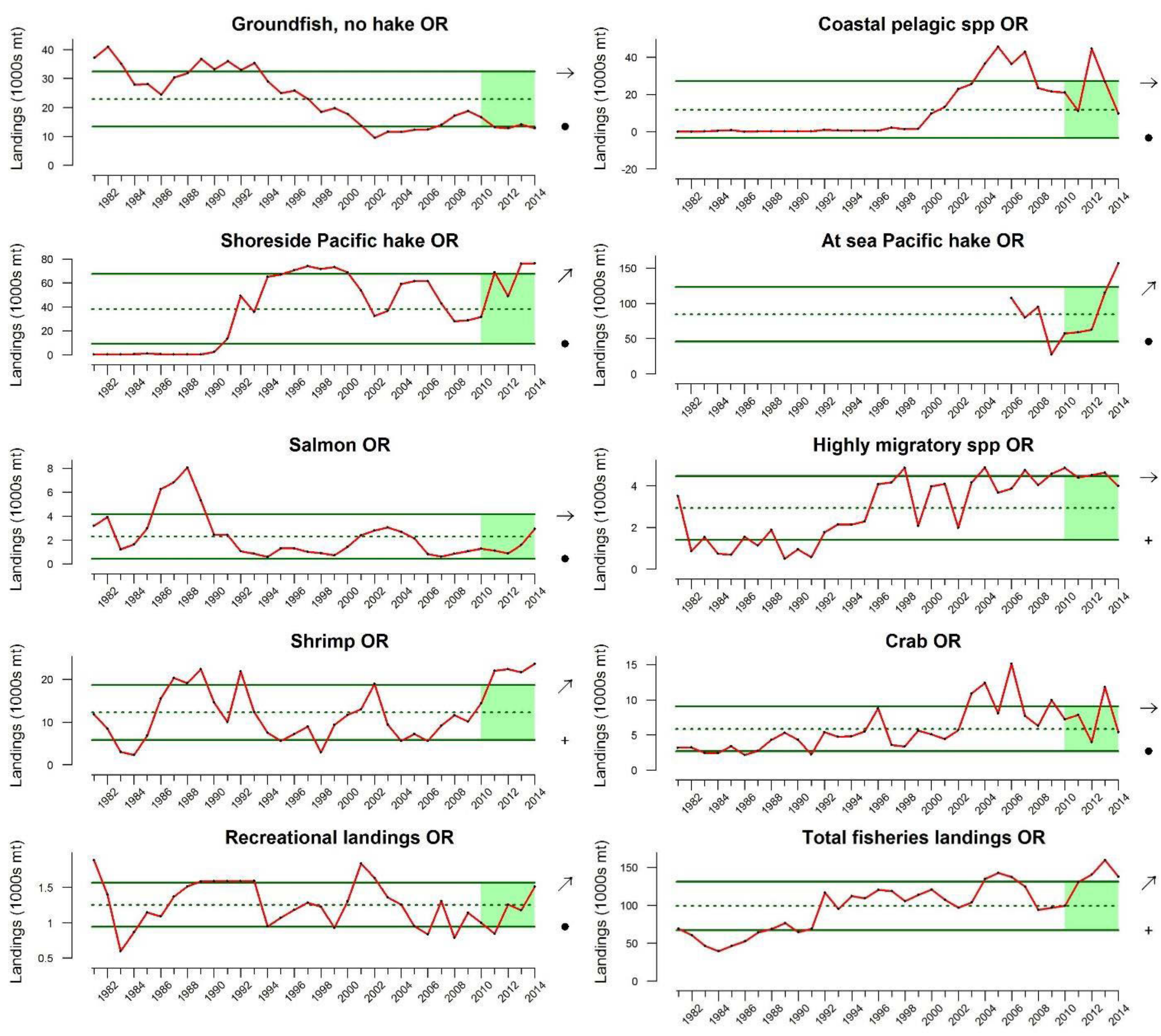


Figure H2: Annual landings of commercial (data from PacFIN) and recreational fisheries (data from RecFIN), including total landings across all fisheries from 1981-2014 (except "At-sea Pacific hake" is 2006-2014 (data from At-Sea Hake Observer Program) in Oregon. Lines and symbols are as in Figure 1.1.

Total fisheries landings in Washington were at historically high levels over the last five years, with particularly high landings in 2013 (Fig. H3). These patterns were driven primarily by historically high levels of landings of coastal pelagic species, salmon and crab. Landings of coastal pelagic species and highly migratory species were at historically-high levels over the last five years, while landings of groundfish (excluding hake) were at historically low levels. Landings of Pacific hake from shoreside fisheries were relatively unchanged, while landings from at-sea fisheries have declined over the last five years in Washington State. Landings of shrimp increased over the last five years. Commercial landings of crabs and salmon were highly variable but within historical averages, and landings of recreational catch were consistently within historical averages over the last five years.

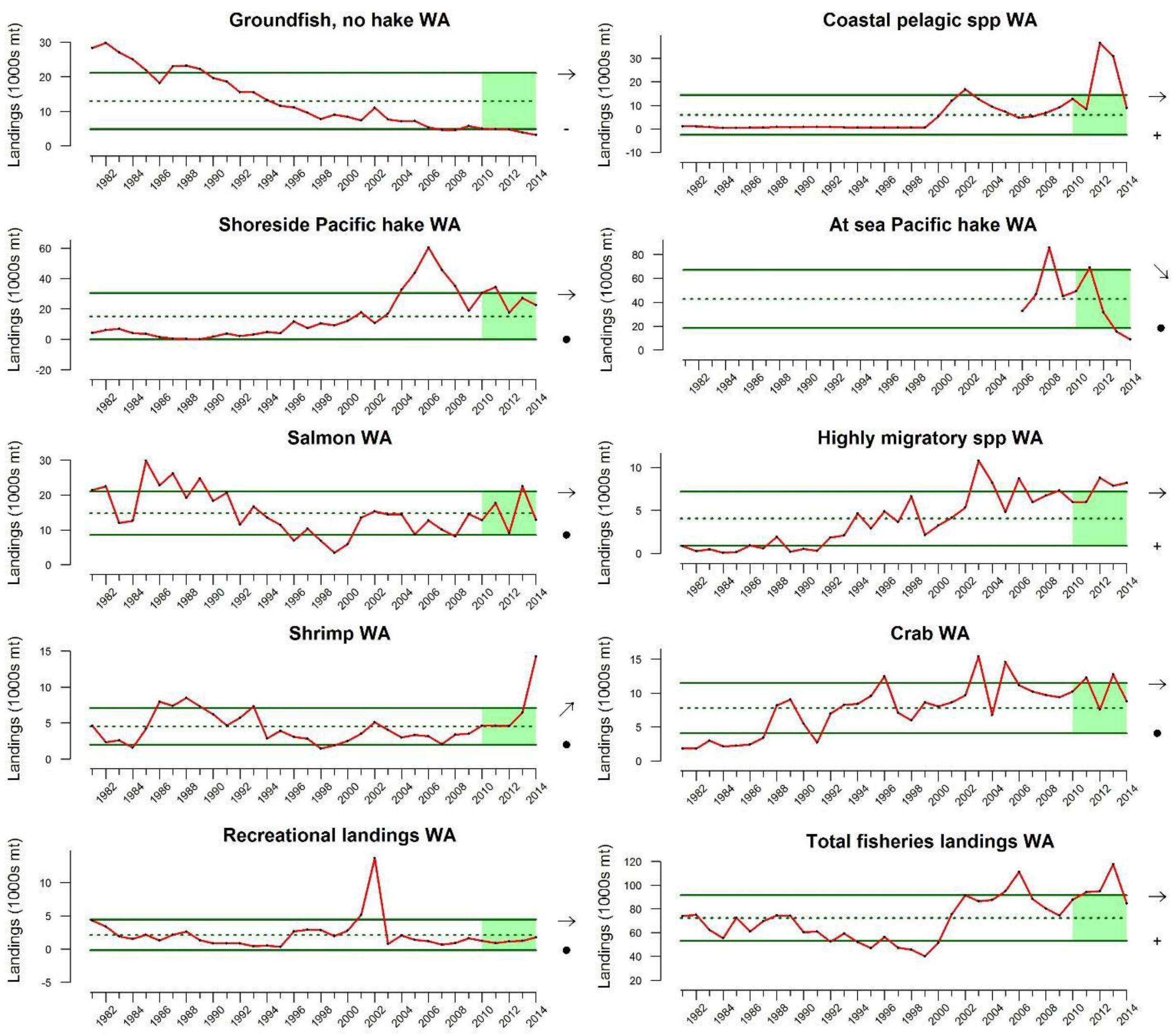


Figure H3: Annual landings of commercial (data from PacFIN) and recreational fisheries (data from RecFIN), including total landings across all fisheries from 1981-2014 (except "At-sea Pacific hake" is 2006-2014 (data from At-Sea Hake Observer Program) in Washington. Lines, colors and symbols are as in Figure 1.1.

APPENDIX J. SEAFLOOR DISTURBANCE BY FISHING GEAR

In the main body of the report (section 5.2), we presented the summary information for all distance of seafloor disturbed by bottom-contact fishing gear. Here, we present the data broken out into substrate types (hard, mixed, soft) and depth zones (shelf, upper slope, lower slope).

Benthic marine habitats can be disturbed or destroyed by geological (e.g., earthquakes, fractures and slumping) and oceanographic (e.g., internal waves, sedimentation and currents) processes as well as various human activities (e.g., bottom contact fishing, mining, dredging), which can lead to extirpation of vulnerable benthic species and disruption of food web processes. These effects may differ among physiographic types of habitat (e.g., hard, mixed or soft) and be particularly dramatic in sensitive environments (e.g., seagrass, algal beds and coral and sponge reefs). The exploration of resources (e.g., oil, gas and minerals) and marine fisheries often tend to operate within certain habitat types more than others, and long-term impacts of these activities may cause negative changes in biomass and the production of benthic communities. We used estimates of coast-wide distances trawled along the ocean bottom from 1999 – 2012. Estimates from 2002 – 2012 include estimates of habitat modified by bottom trawl and fixed fishing gear, while estimates from 1999 – 2002 include only bottom trawl data. Set and retrieval location of pot, trap and longline gear allowed for an estimate of the distance of bottom habitat disturbed for fixed gears. Data come from PFMC's Pacific Coast Groundfish 5-Year Review of Essential Fish Habitat.

Habitat modification declined coast-wide between 2008 – 2012 (Fig. J1). During this period, the vast majority of habitat modification occurred in soft, upper slope and shelf habitats. A shift in trawling effort from shelf to upper slope habitats was observed during the mid-2000's, which in part corresponded to depth-related spatial closures implemented by the Pacific Fishery Management Council. When compared to the mean for the entire time series, habitat modification across all habitats has been within historic levels. Reduced modification may not coincide with recovery times of habitat depending on how fast recovery happens, which is likely to differ among habitat types (e.g., hard and mixed habitats will take longer to recover than soft habitat).

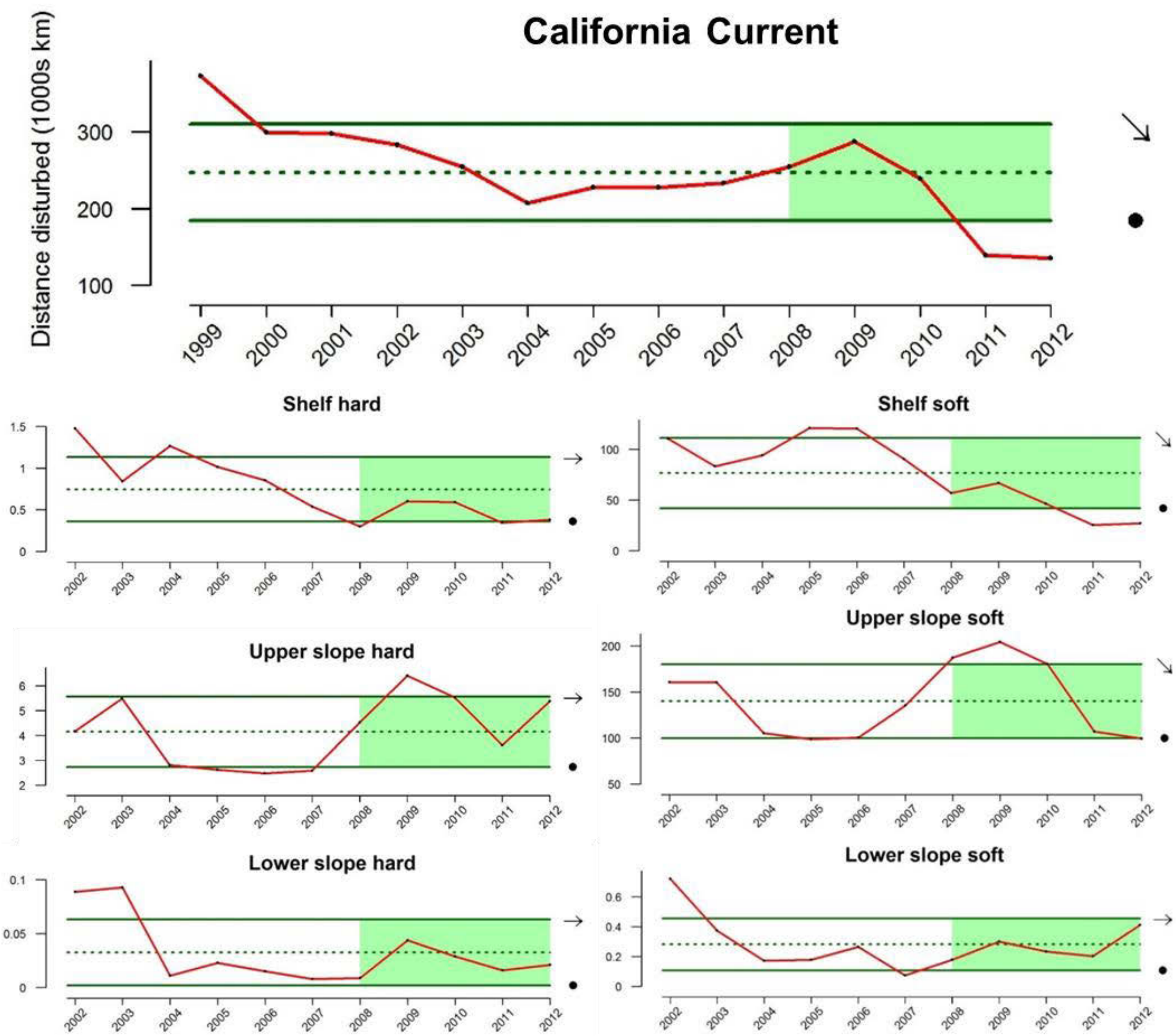


Figure J1. Cumulative distance of habitat disturbance across the entire California Current (large graph) and in six physiographic habitat classes (small figures): shelf (< 200 m depth), upper slope (200 m - 1288 m, and lower slope (1288 m- EEZ), and hard or soft substrate. Mixed substrates are not shown, but they exhibit similar trends as hard substrates.

APPENDIX K. OTHER NON-FISHERIES HUMAN ACTIVITIES INDICATORS

Approximately 90% of world trade is carried by the international shipping industry. The volume of cargo moved through U.S. ports is expected to double between 2001 and 2020. Fisheries impacts associated with commercial shipping include interactions between fishing and shipping vessels; ship strikes of protected species; and underwater noise that affects fish spawning, recruitment, migration, and communication.

Commercial shipping activity in the CCE was at historically low levels over the last five years of the dataset (Fig. K1). This contrasts with global estimates of shipping activity increasing nearly 400% over the last 20 years. Regional differences, lagging economic conditions and different data sources may be responsible for the observed differences.

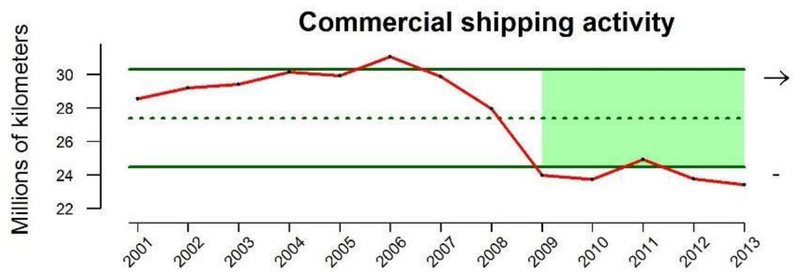


Figure K1: Distance transited by commercial shipping vessels in the CCE, 2001-2013. Lines, colors and symbols are as in Figure 1.1.

Nutrient loading is a leading cause of contamination, eutrophication, and related impacts in streams, lakes, wetlands, estuaries, and ground water throughout the U.S. Nutrient input declined over the last five years of the available dataset (2005–2010) but the short-term average was still >1 s.d. above the long-term mean (Fig. K2). Applications of nitrogen and phosphorus increased steeply from 1945 until 1980, followed by a relatively sharp, stepped increase in the 2000's. However, a large decrease occurred in 2009, leading to the short-term decline.

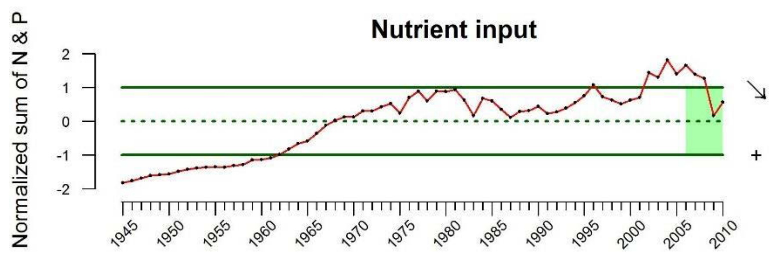


Figure K2: Normalized sum of nitrogen and phosphorus applied as fertilizers in WA, OR and CA watersheds that drain into the CCE from 1945-2010. Lines, colors and symbols are as in Figure 1.1.

Risks posed by offshore oil and gas activities include the release of hydrocarbons, smothering of benthos, sediment anoxia, benthic habitat loss, and the use of explosives. Petroleum products consist of thousands of chemical compounds, such as PAHs, which may impact marine fish health and reproduction. The effects of oil rigs on fish stocks are less conclusive, as rig structures may provide some habitat benefits.

Offshore oil and gas activity in the CCE occurs only off the coast of California and has been stable over the last five years, but the short-term average was more than 1 s.d. below the long-term average (Fig. K3). Oil and gas production has been decreasing steadily since the mid 1990's.

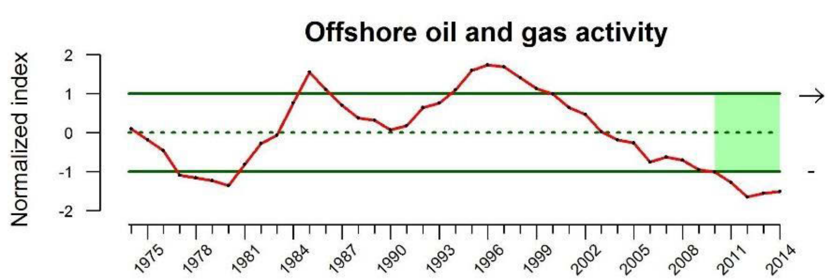


Figure K3: Normalized index of the sum of oil and gas production from wells off CA, 1974-2014. Lines, colors and symbols are as in Figure 1.1.

Appendix L. Fleet Diversity Indices: Effective Shannon Index for Major West Coast Ports

As is true with individual vessels, the variability of landed value at the port level is reduced with greater diversification of landings. Diversification of fishing revenue has declined over the last several decades for some ports (Fig. L1). Examples include Seattle and most, though not all, of the ports in Southern Oregon and California. However, a few ports have become more diversified including Bellingham Bay and Westport in Washington and Astoria in Oregon. Diversification scores are highly variable year-to-year for some ports, particularly those in Southern Oregon and Northern California that depend heavily on the Dungeness crab fishery which has highly variable landings.

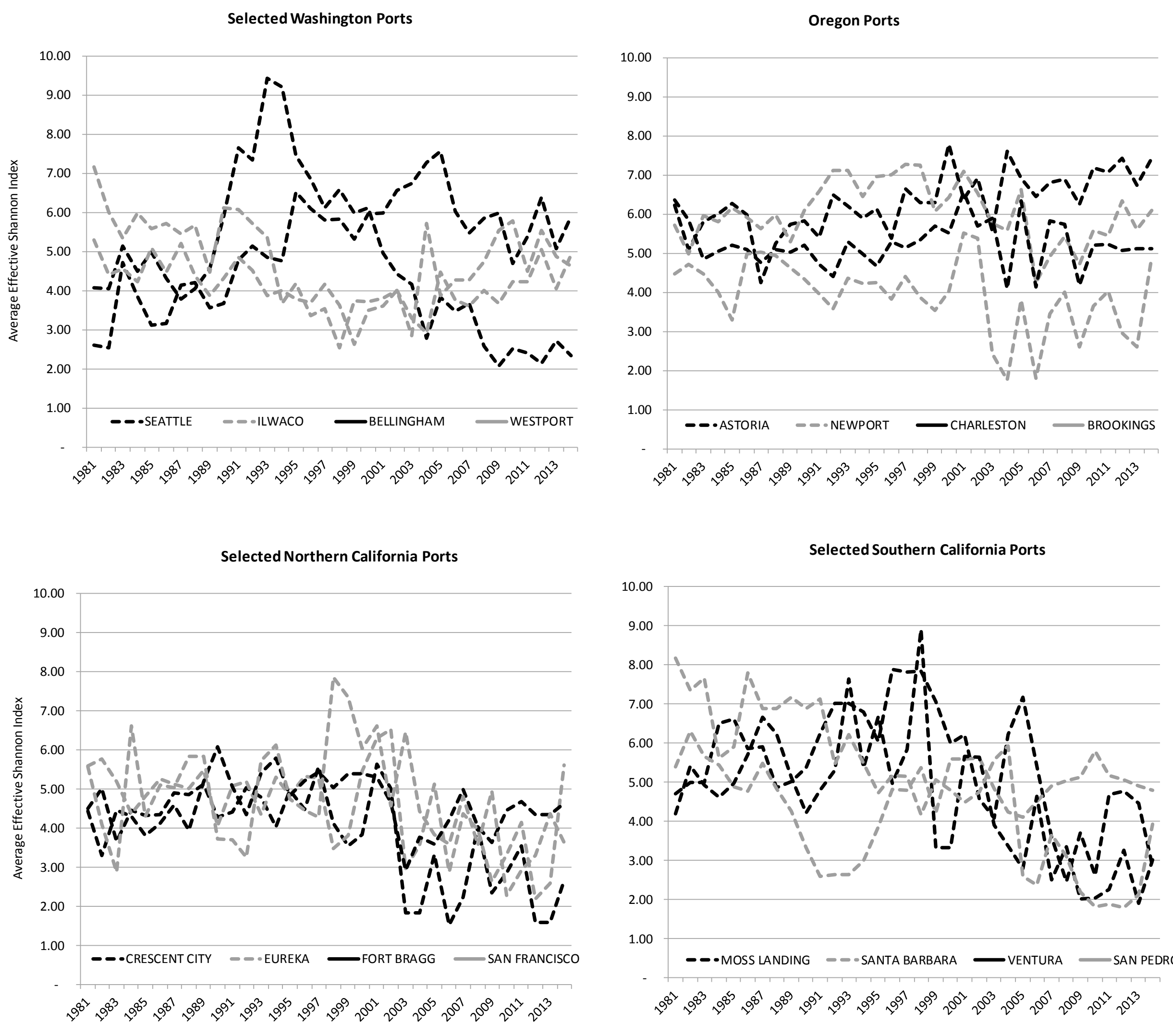


Figure L1. Trends in diversification for selected major West Coast ports in Washington, Oregon, and California.

APPENDIX M. PERSONAL USE INDICATORS

This section further documents the volume of fish and shellfish kept for personal use from commercial vessels in Washington (WA) and California (CA). Nearly 80.5% (33.6 million pounds) of the personal use removals are from tribal participants in Washington (Fig. M1), while the remaining personal use removals are from nontribal participants from Washington and California. Personal use is not recorded or reported in Oregon.

Roughly 95% of personal use catch retained by tribal participants is salmon, particularly chum (Fig. M1). Other top species retained by tribes include geoduck (GDUK), Dungeness crab (DCRB), and Pacific halibut (PHLB).

Nontribal participants retain a wider diversity of species than their tribal counterparts (Fig. M1); top species include market squid (MSQD), albacore (ALBC), bait shrimp (BSRM), Pacific sardine (PSDN), Dungeness crab, Pacific halibut, and salmonids. Much of this recent increase in non-tribal personal use (main document, Fig. 6.3.1) was driven by catch retained for personal use in California, particularly market squid. California ports record less personal use than Washington ports, but the species breadth in California is greater (Fig. M1).

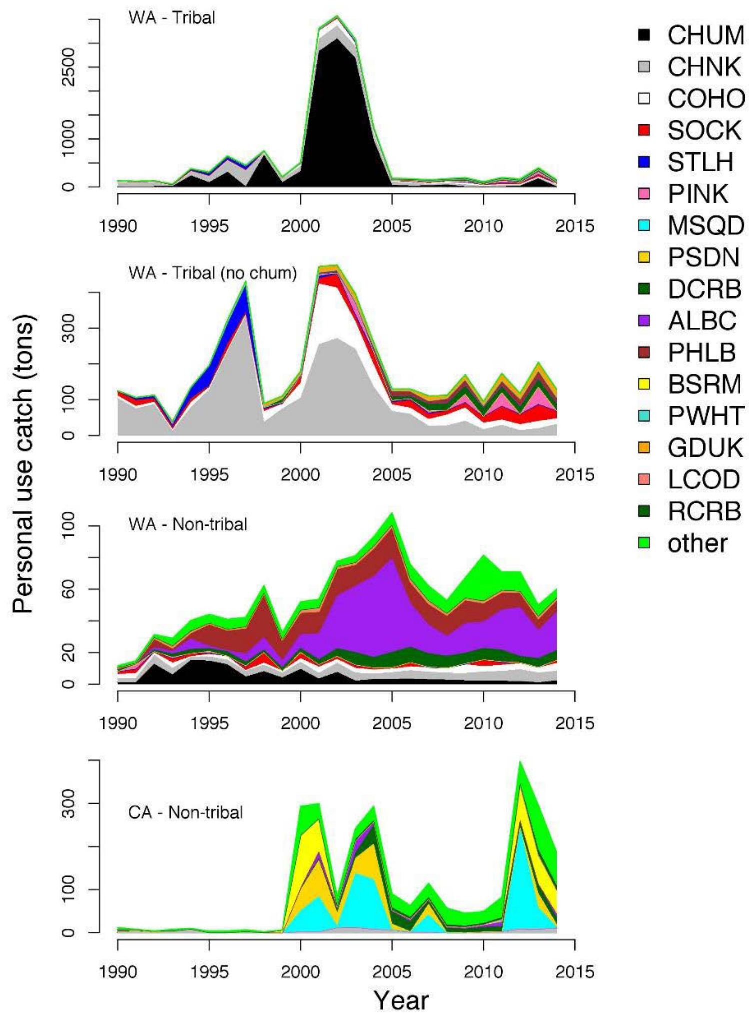


Figure M1. Catch, by species, retained for personal use from 1990 - 2014 in tons (2000 lbs). Axes are uneven in magnitude of catch by volume. Data source: Pacific Fisheries Information Network (PacFIN), 1990-2014. Data are from landings in 139 of 350 ports in WA and CA.