SUPPLEMENTARY MATERIALS TO 2015 CCIEA PFMC REPORT

Appendix A. List of acronyms used in this report

ABC	Allowable Biological Catch
AFSC	Alaska Fisheries Science Center
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
CUI	Cumulative Upwelling Index
DO	Dissolved Oxygen
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
HHI	Herfindahl-Hirschman Index
IEA	Integrated Ecosystem Assessment
IFQ	Individual Fishing Quota
IOOS	Integrated Ocean Observing System
LST	Longspine Thornyhead
MARSS	Multivariate Auto-Regressive State Space model
MEI	Multivariate El Niño Index
NOAA	National Oceanic and Atmospheric Administration
NWFSC	Northwest Fisheries Science Center
OA	Ocean Acidification
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
SSC	Scientific and Statistical Committee
SSCES	Scientific and Statistical Committee Ecosystem Subcommittee
SST	Sea Surface Temperature (in most occurrences)
	Shortspine Thornyhead (in Groundfish section, Figure 3.4)
SWFSC	Southwest Fisheries Science Center
UI	Bakun Upwelling Index
UME	Unusual Mortality Event
YOY	Young-of-the-Year

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Appendix C. Conceptual models

The process of developing a science program in support of ecosystem-based management can benefit greatly from a set of conceptual models, perhaps as simple as box-and-arrow diagrams, that illustrate key ecosystem components, processes and connections. Such conceptual frameworks can help ensure that management goals and ecosystem properties are properly aligned and are associated with relevant indicators that can be monitored effectively (see Orians et al. 2012, http://www.washacad.org/about/files/WSAS_Sound_Indicators_wv1.pdf).

In 2013, the CCIEA team began developing a series of conceptual models related to the key drivers, habitats, ecosystem components, and human activities in the CCLME. We believe these conceptual models will help us to:

- Synthesize and clarify our understanding of the structure and function of the CCLME;
- Present hypotheses, data, and modeling results in a clear and engaging manner;
- Illustrate and convey the context and importance of ecosystem indicators;
- Provide effective communication and outreach to stakeholders, managers and policy makers.

All images below were created by Su Kim (NWFSC) with input from the rest of the CCIEA team.

Integrated Socio-Ecological System conceptual model

The CCIEA team regards the CCLME as an integrated socio-ecological system (Fig. C1). The focal components that we value (aspects of ecological integrity and human wellbeing) are heavily influenced by drivers and pressures (climate systems, oceanography, social forces) that are mediated through different habitat types, human activities, and social systems. Moreover, there are interactions within and between these components; species interact, human sectors augment or compete with one another, climate patterns affect social forces, etc.

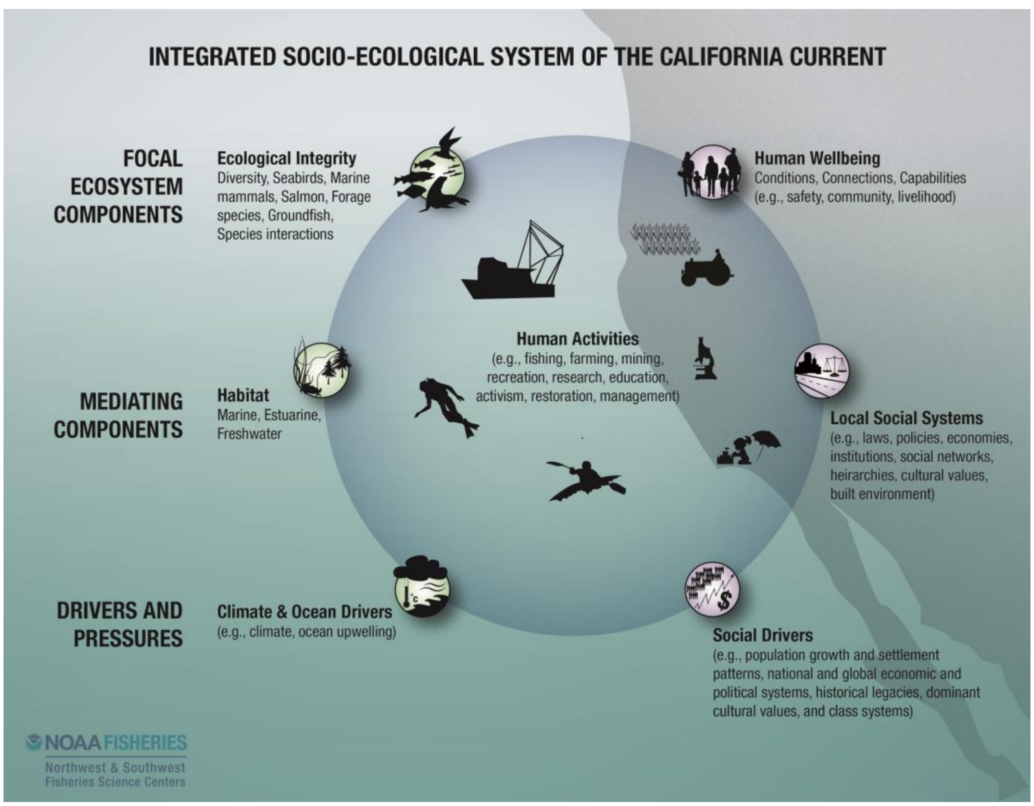


Figure C1. Conceptual model of the Socio-Ecological System of the California Current Large Marine Ecosystem.

Species-focused conceptual models

We have developed a series of models that focus on several major species groups or niches within the CCLME. Focal groups are:

- Coastal Pelagic Species
- Salmon
- Groundfish
- Marine mammals
- Seabirds

For each group, we developed 4 conceptual models:

1. *Overview:* a model linking the group to major drivers, pressures and ecosystem attributes;
2. *Environmental Drivers:* a model linking the group to physical processes, such as climate and oceanography, with a brief narrative;
3. *Ecological Interactions:* a model linking the group to prey, predators, competitors, and other key species groups, with a brief narrative; and
4. *Human Activities:* a model linking the group to key human activities and aspects of human wellbeing, with a brief narrative.

The groundfish conceptual models are shown below (Figs. C2-C5) in greater detail than in the main report; for other species group conceptual models, please contact Chris Harvey (Chris.Harvey@noaa.gov), Greg Williams (Greg.Williams@noaa.gov) or Su Kim (Su.Kim@noaa.gov).

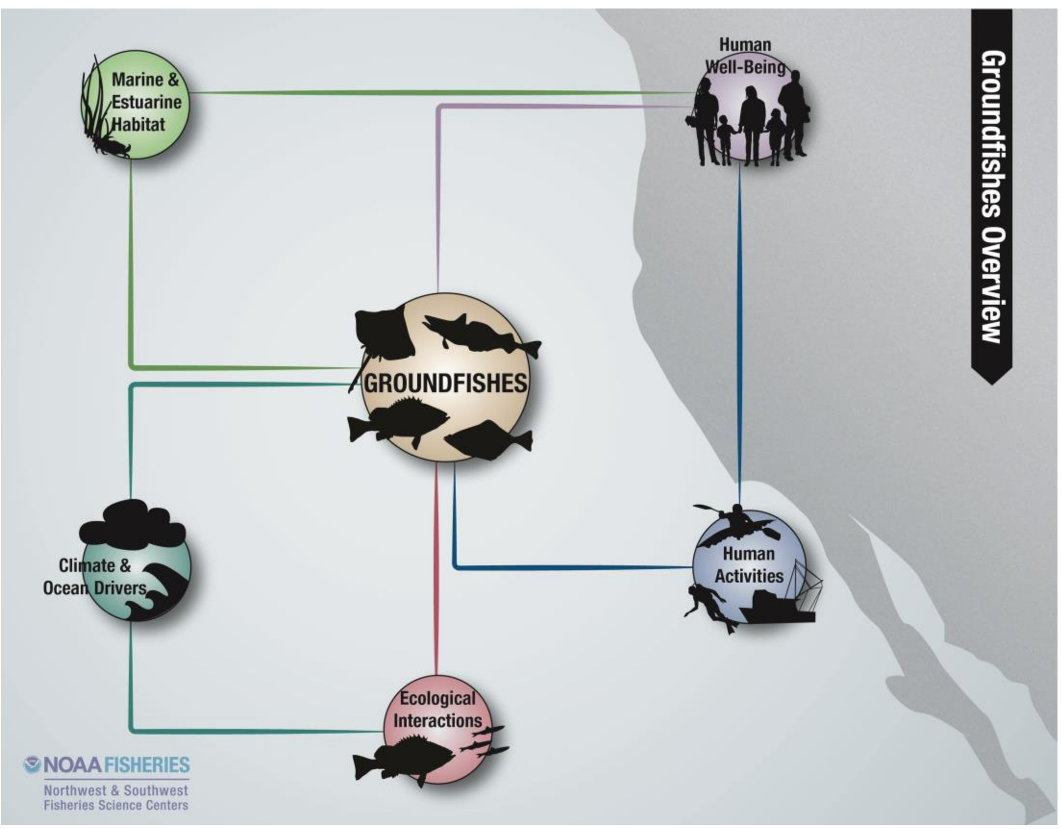


Figure C2. Groundfish Overview conceptual model.

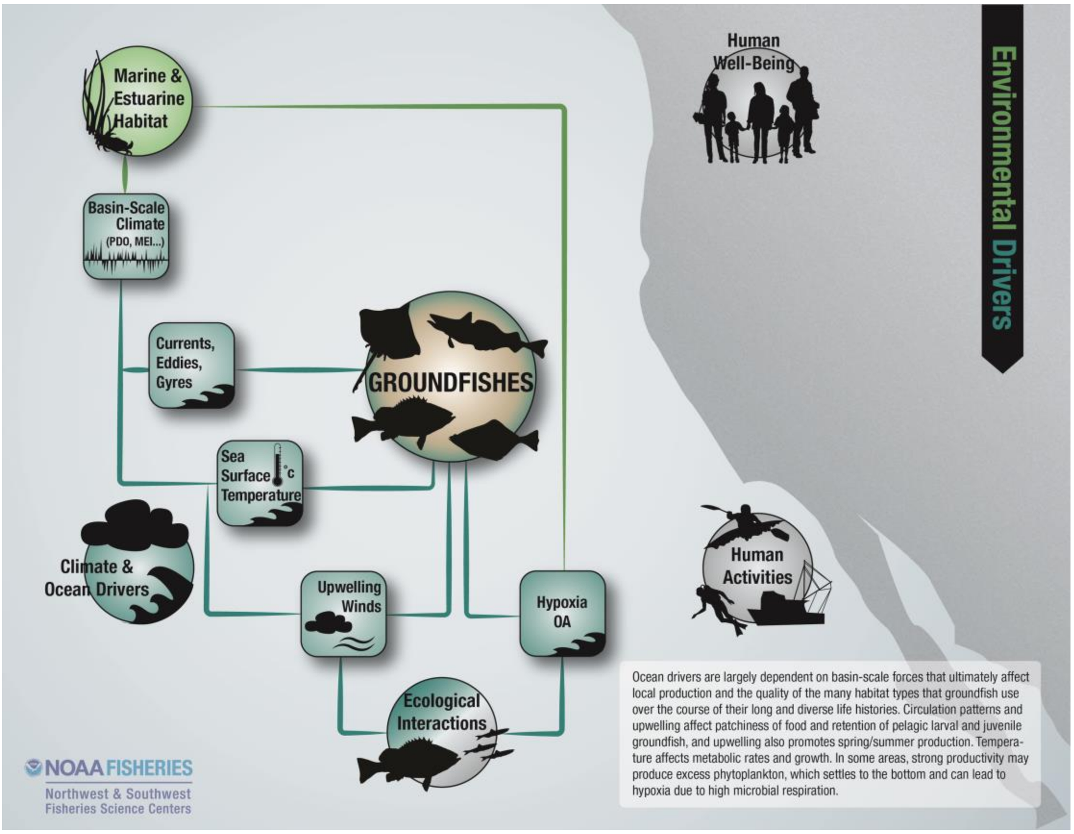


Figure C3. Groundfish Environmental Drivers conceptual model.

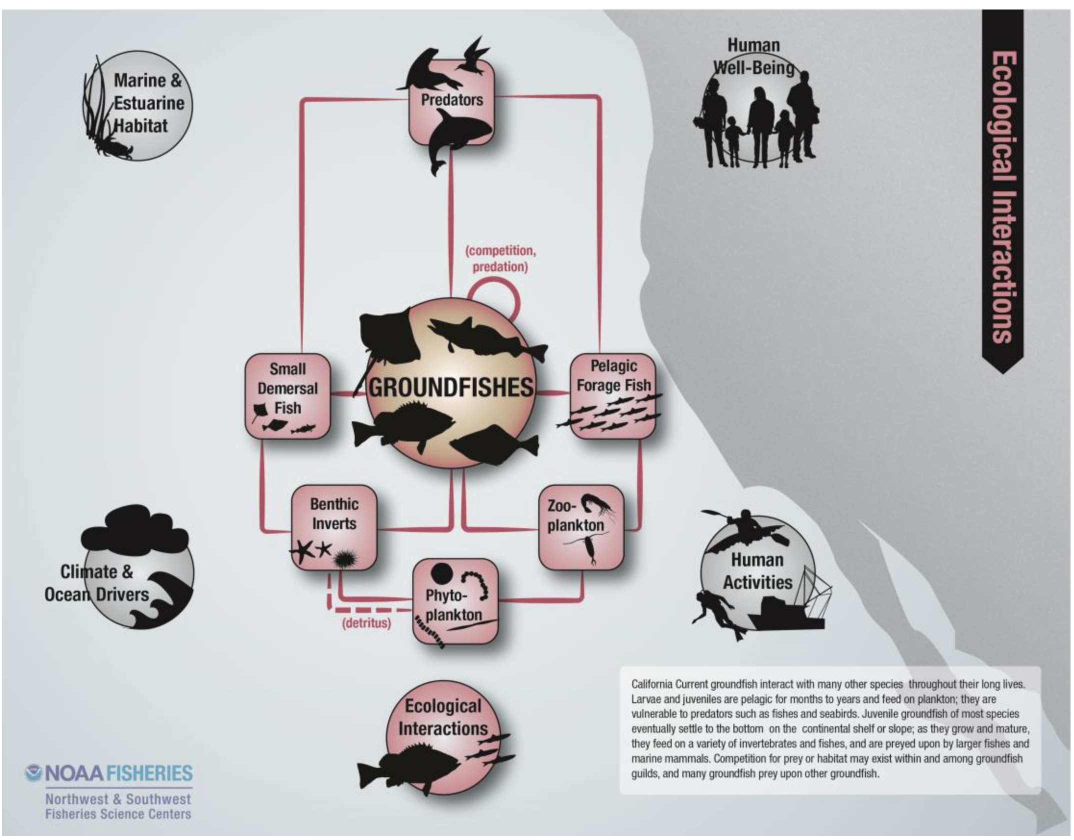


Figure C4. Groundfish Ecological Interactions conceptual model.

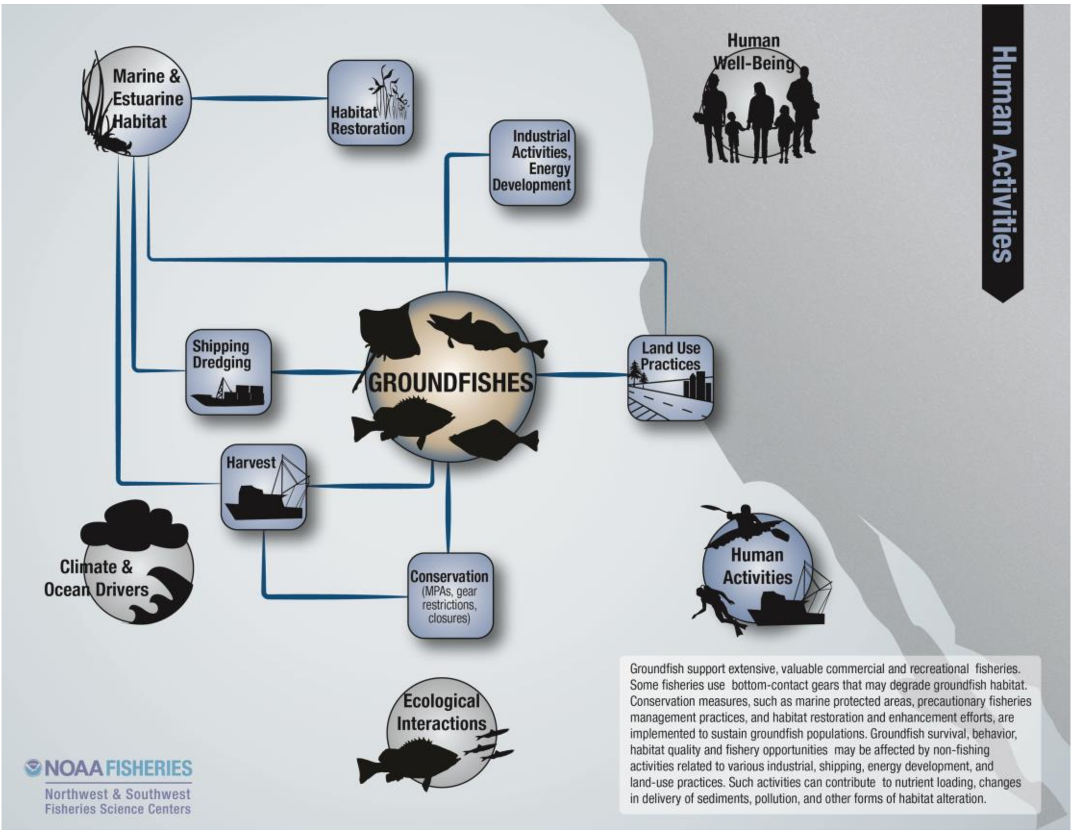


Figure C5. Groundfish Ecological Interactions conceptual model.

Habitat-focused conceptual models

In 2014 the CCIEA formally added a Habitat component and began identifying key indicators associated with different habitat types. In concert, the CCIEA team also developed conceptual models for each of four main habitat types in the CCLME basin:

- Freshwater Habitat
- Estuary/Nearshore Habitat
- Pelagic Habitat
- Seafloor Habitat

The habitat conceptual models are designed to highlight that habitats are the interface through which climate drivers and human activities influence biota, and the matrix through which ecological interactions occur. This connects the habitat conceptual models to the species-focused conceptual models, but it is important to have distinct habitat conceptual models because the habitats themselves can be the focal points of natural or human perturbations, management actions or targets, conservation activities, and human wellbeing.

The habitat conceptual models are shown below (Figs. C6-C10); for more information, please contact Chris Harvey (Chris.Harvey@noaa.gov), Greg Williams (Greg.Williams@noaa.gov), Correigh Greene (Correigh.Greene@noaa.gov) or Su Kim (Su.Kim@noaa.gov).

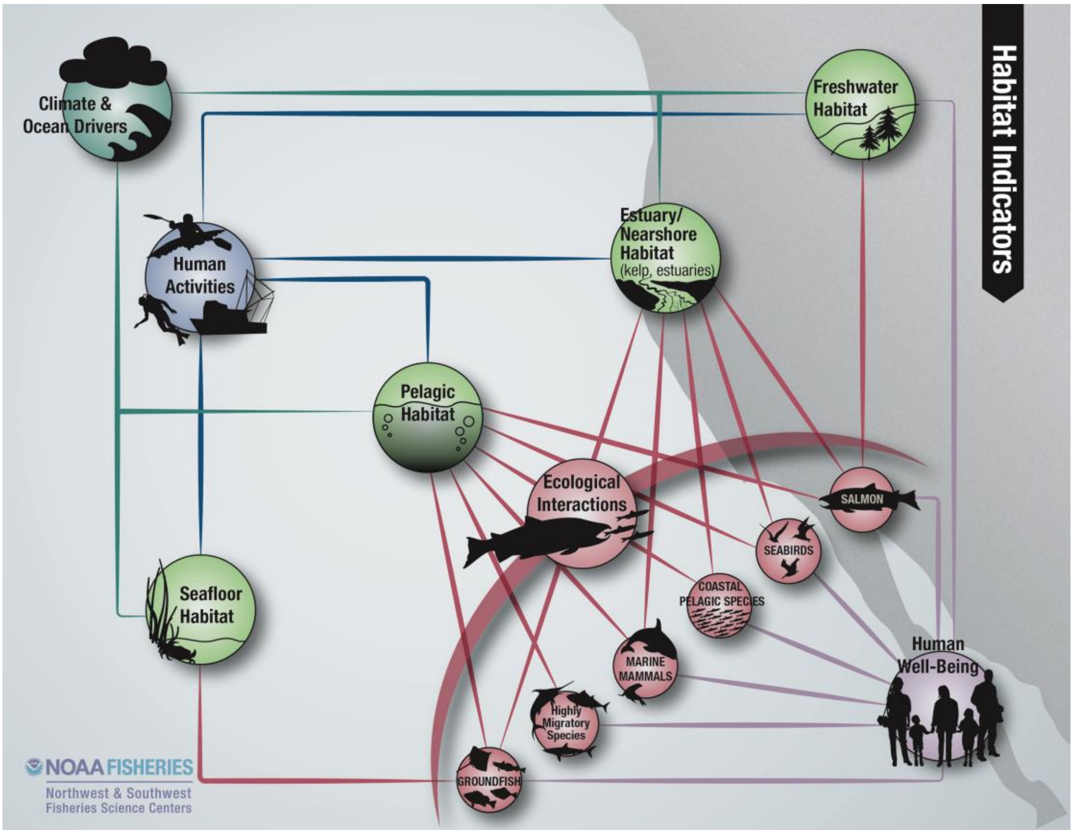


Figure C6. Habitat Overview conceptual model.

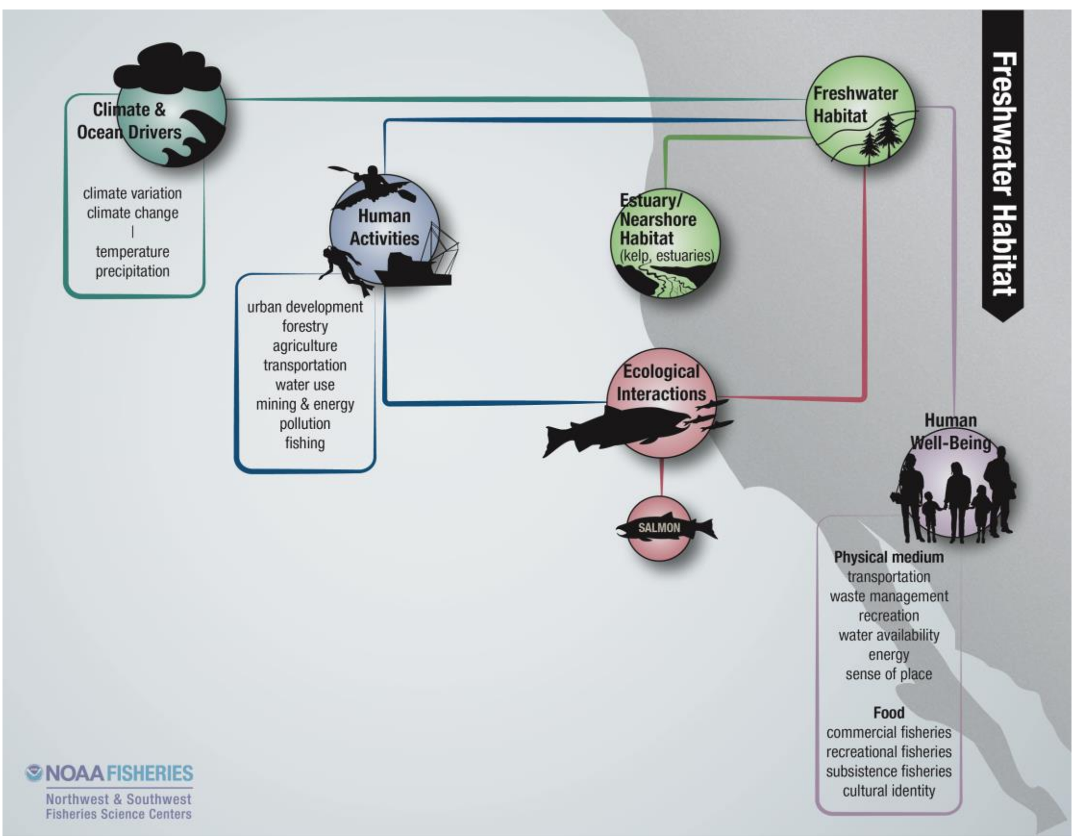


Figure C7. Freshwater Habitat conceptual model.

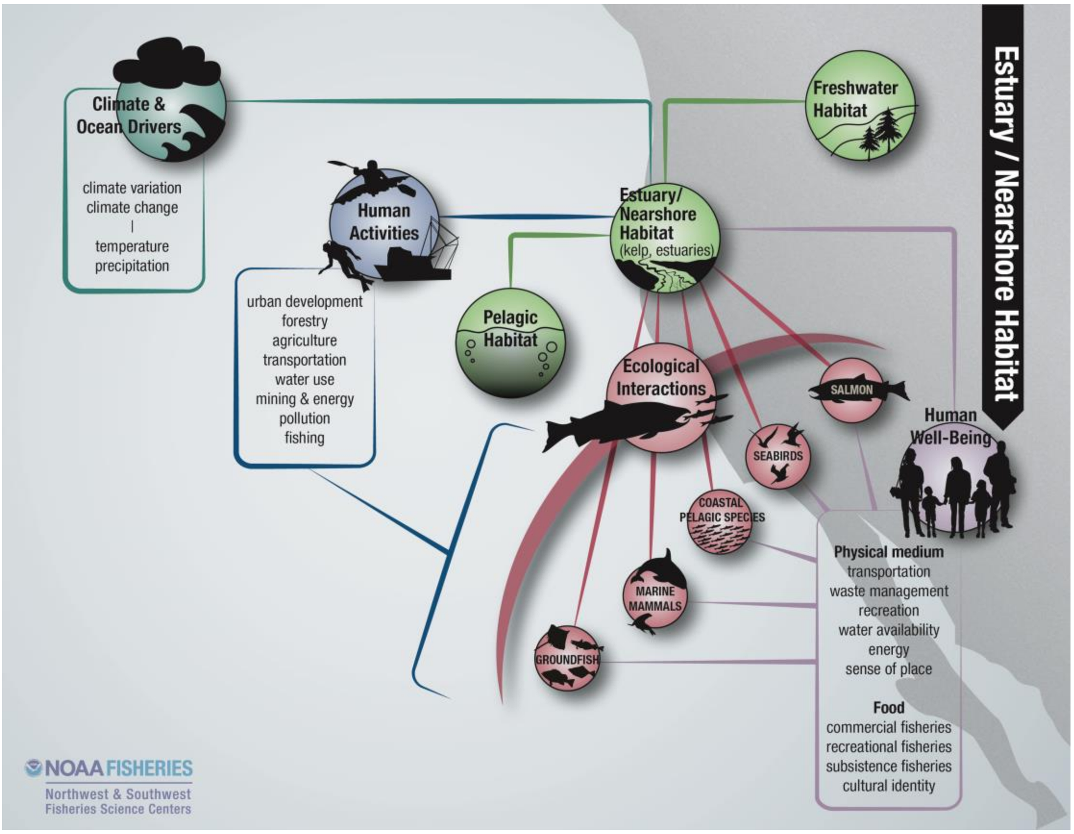


Figure C8. Estuary/ Nearshore Habitat conceptual model.

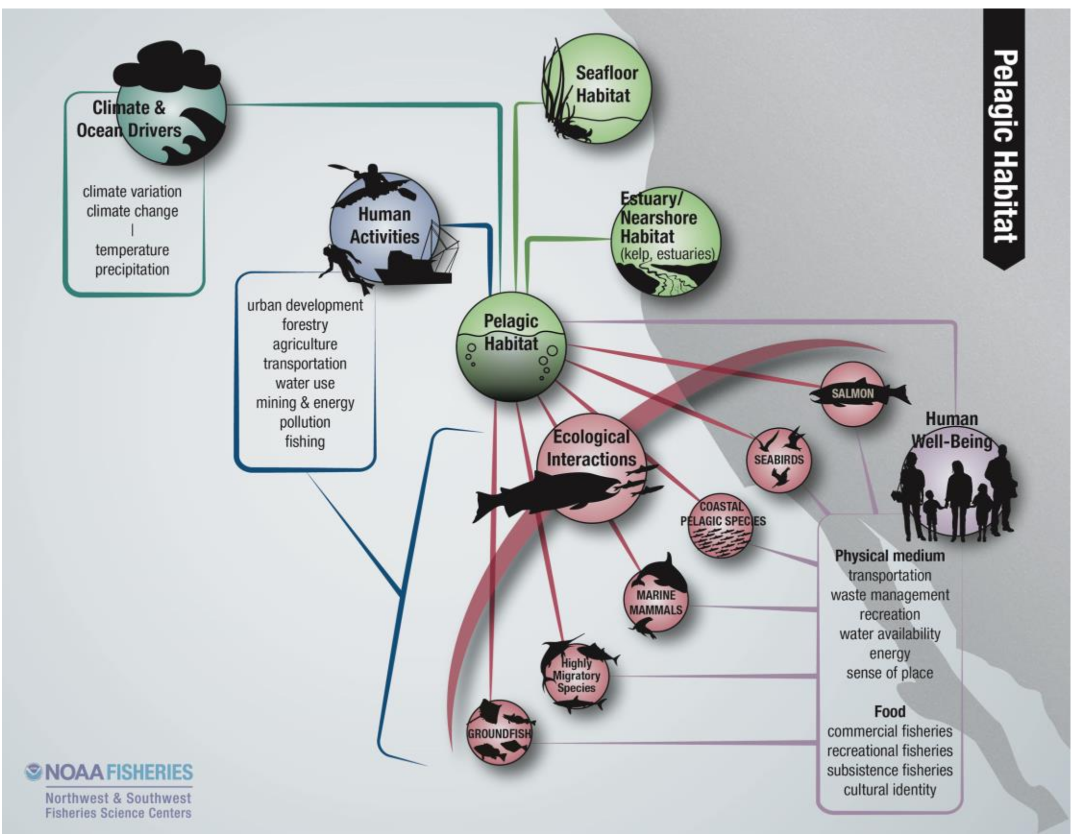


Figure C9. Pelagic Habitat conceptual model.

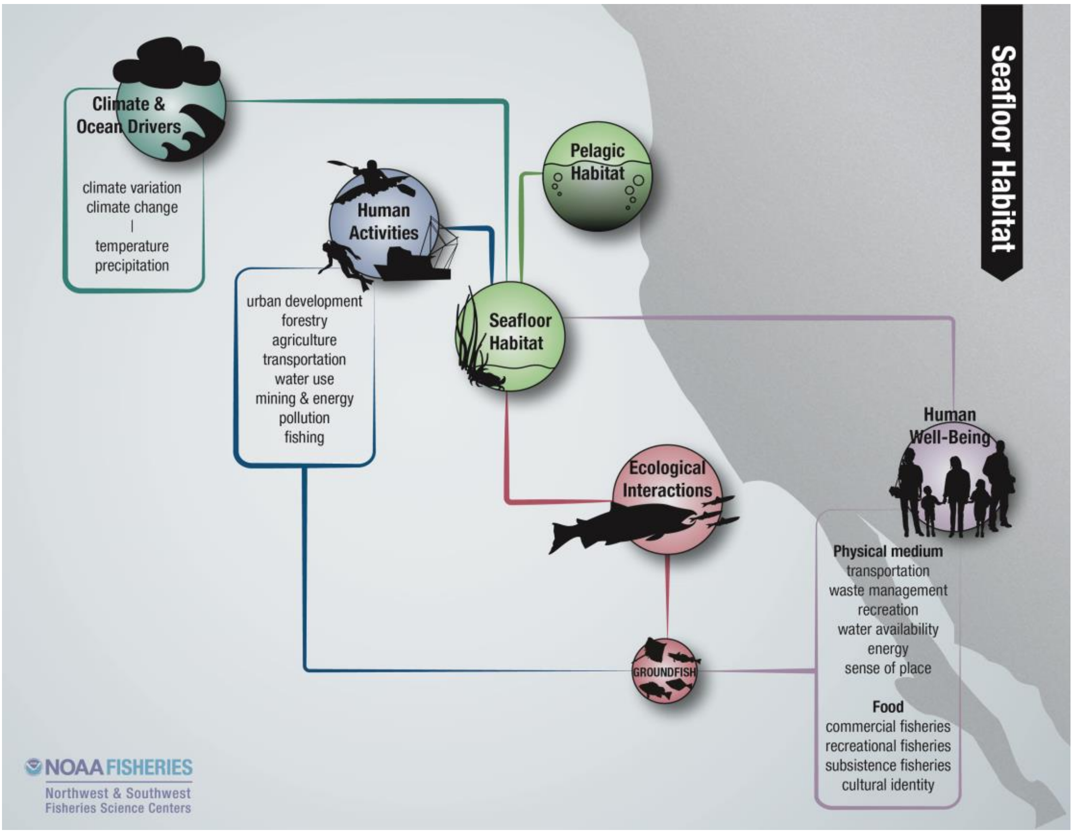


Figure C10. Seafloor Habitat conceptual model.

Appendix D. Climate and Ocean Indicators, Winter

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 summertime 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 the wintertime indices to allow a more complete picture of these time series.

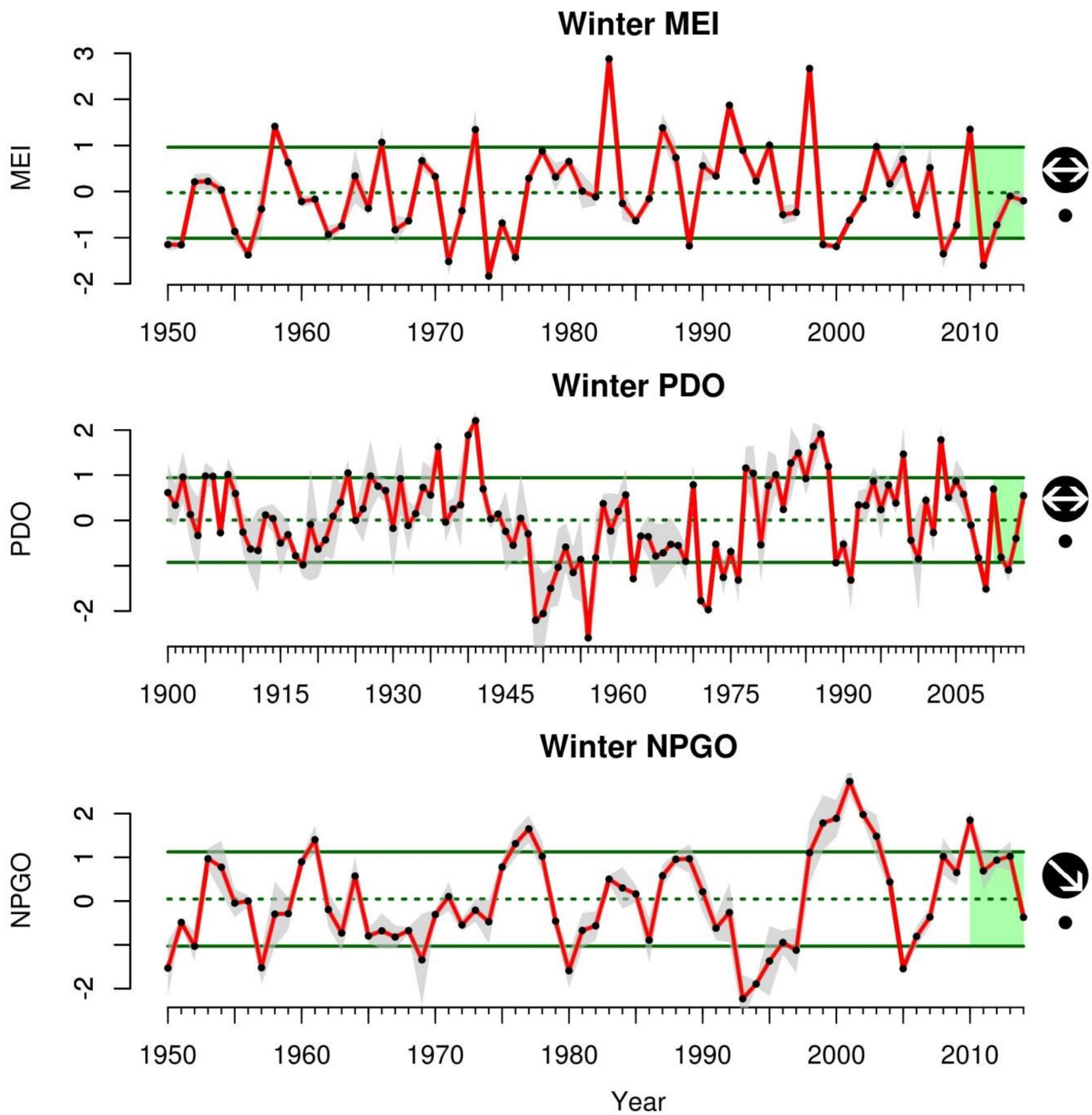


Figure D1. Winter values of basin-scale climate indicators used to assess environmental variability impacts in the California Current ecosystem. The three time series are Multivariate ENSO Index (MEI), Pacific Decadal Oscillation (PDO), and North Pacific Gyre Oscillation (NPGO). Lines, colors and symbols are as in Figure 1.1.

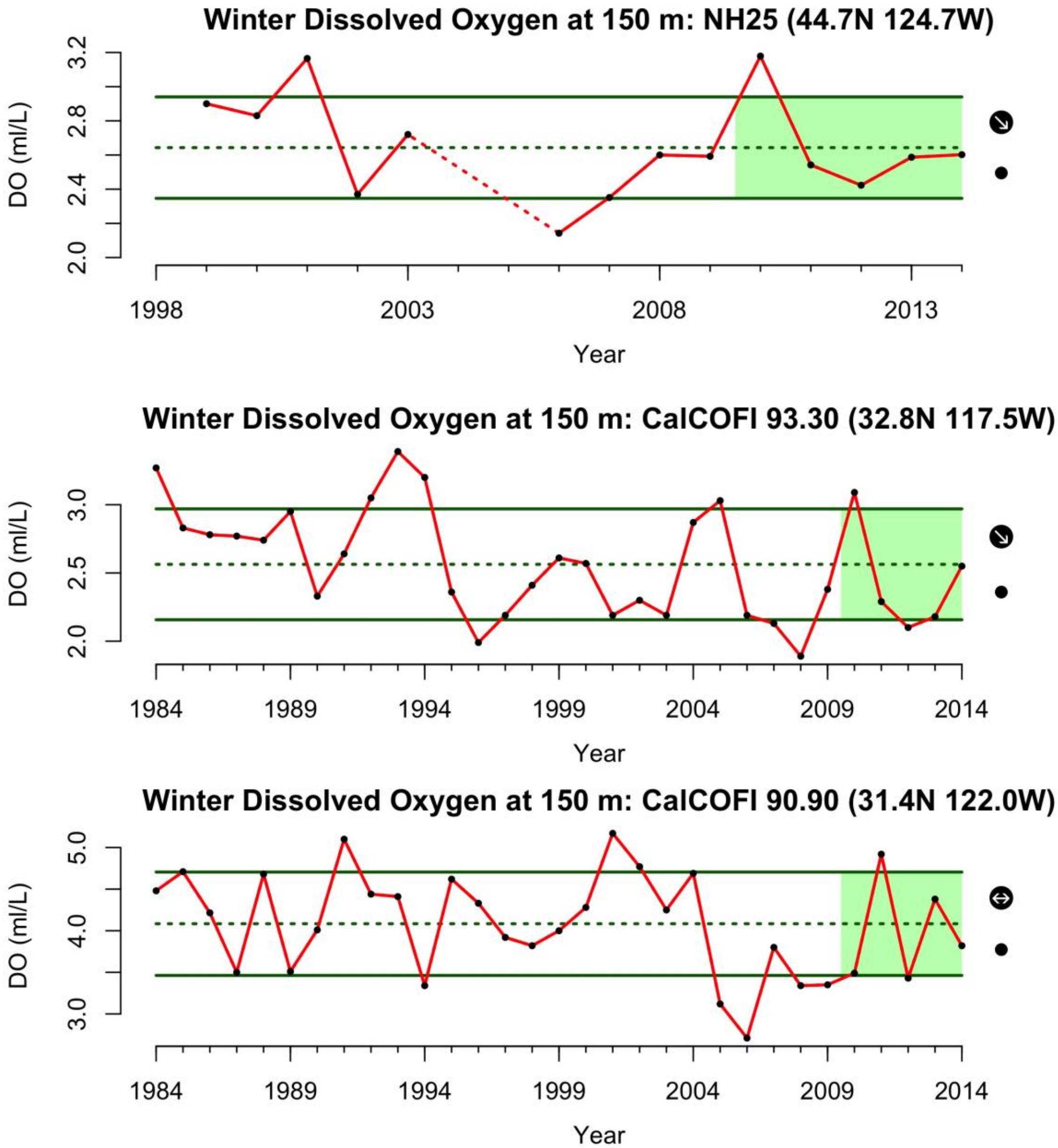


Figure D2. Winter values of dissolved oxygen in the CCE. Lines, colors and symbols are as in Figure 1.1. Dissolved oxygen was measured at 150 m depth off of Oregon (Newport Line station NH25) and southern California (CalCOFI stations 93.30 and 90.90). Stations 93.30 and NH25 are located within 50 km from the shore, while station 90.90 is located over 300 km from shore. Note: the CalCOFI time series do not have 2014 values.

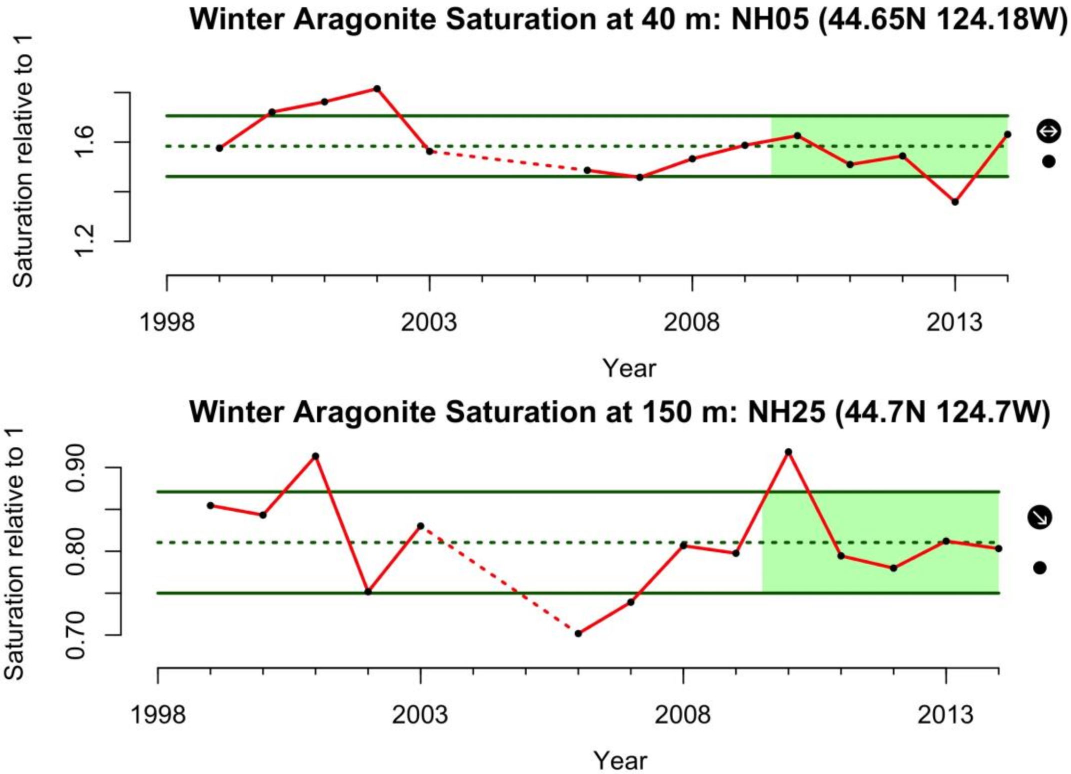


Figure D3. Winter values of aragonite saturation in the northern CCE, 1998-2014. Lines, colors and symbols are as in Figure 1.1 of the main document. The time series for station NH25 is similar to the DO data shown in Figure D2 because aragonite saturation is calculated in part from oxygen data.

Appendix E. Fact sheet for Cassin's auklet mortality event

More information on the recent West Coast mortality event of Cassin's auklets can be found at http://depts.washington.edu/coasst/news/breaking_news/Cassins%20Auklet%20factsheet%206Jan15.pdf.

Appendix F. State-by-state fishery landings

At the CCIEA team's presentation to the Council in March 2014, Council members requested that we include fishery landings data on a state-by-state basis. Those time series are presented here.

Total landings in California were available from PacFIN (Pacific Fisheries Information Network; http://pacfin.psmfc.org) for shoreside commercial landings and from RecFIN (Recreational Fisheries Information Network; http://www.recfin.org/) for recreational landings. Total fisheries landings in California varied within historical averages over the last five years and these patterns were driven almost completely by landings of coastal pelagic species (Fig. F1). Landings of groundfish (excluding hake) and recreational-caught species have been consistently at historically low levels over the last five years, while landings of Pacific hake have decreased to historically low levels and crab have increased to historically high levels over the last five years. Shrimp and salmon landings have increased over the last five years. Highly migratory species and other commercially-landed species have been relatively unchanged over the last five years.

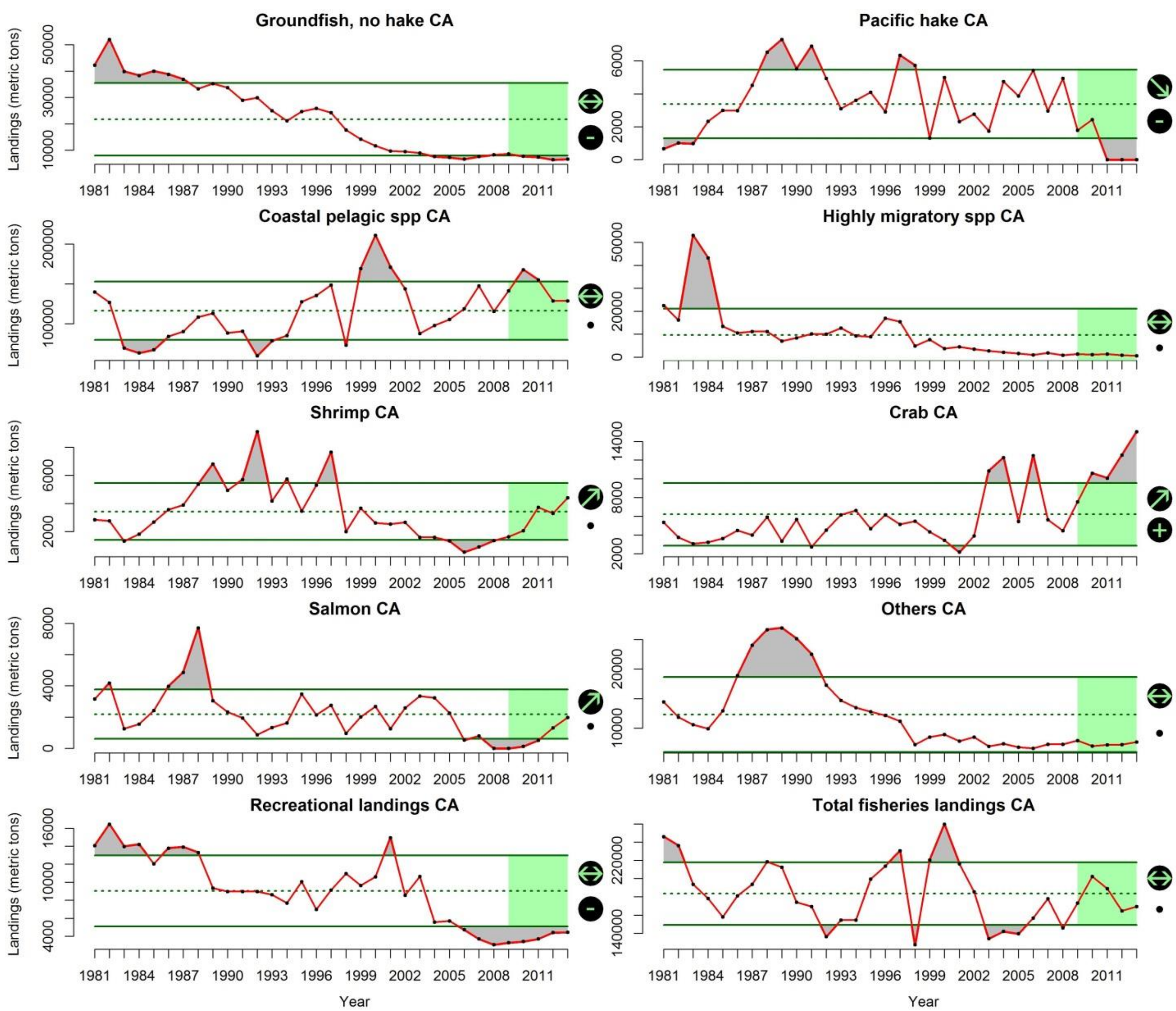


Figure F1. Annual landings of eight major West Coast commercial fisheries, recreational landings, and total landings from commercial and recreational fisheries (data: PacFIN and RecFIN) from 1981-2013 in California.

Commercial and recreational fisheries landings in Oregon were available from PacFIN for shoreside commercial landings and from RecFIN for recreational landings. Total fisheries landings in Oregon increased over the last five years (Fig. F2). These patterns appear to be driven by interactions in landings of Pacific hake, which have increased over the last five years, and coastal pelagic species, which have been highly variable over the last five years. Landings of shrimp have increased to historically high levels over the last five years and landings of highly migratory species have been consistently at historically high levels over the last five years. Landings of groundfish (excluding hake), crab, salmon, other species, and recreationally-caught species have not changed over the last five years.

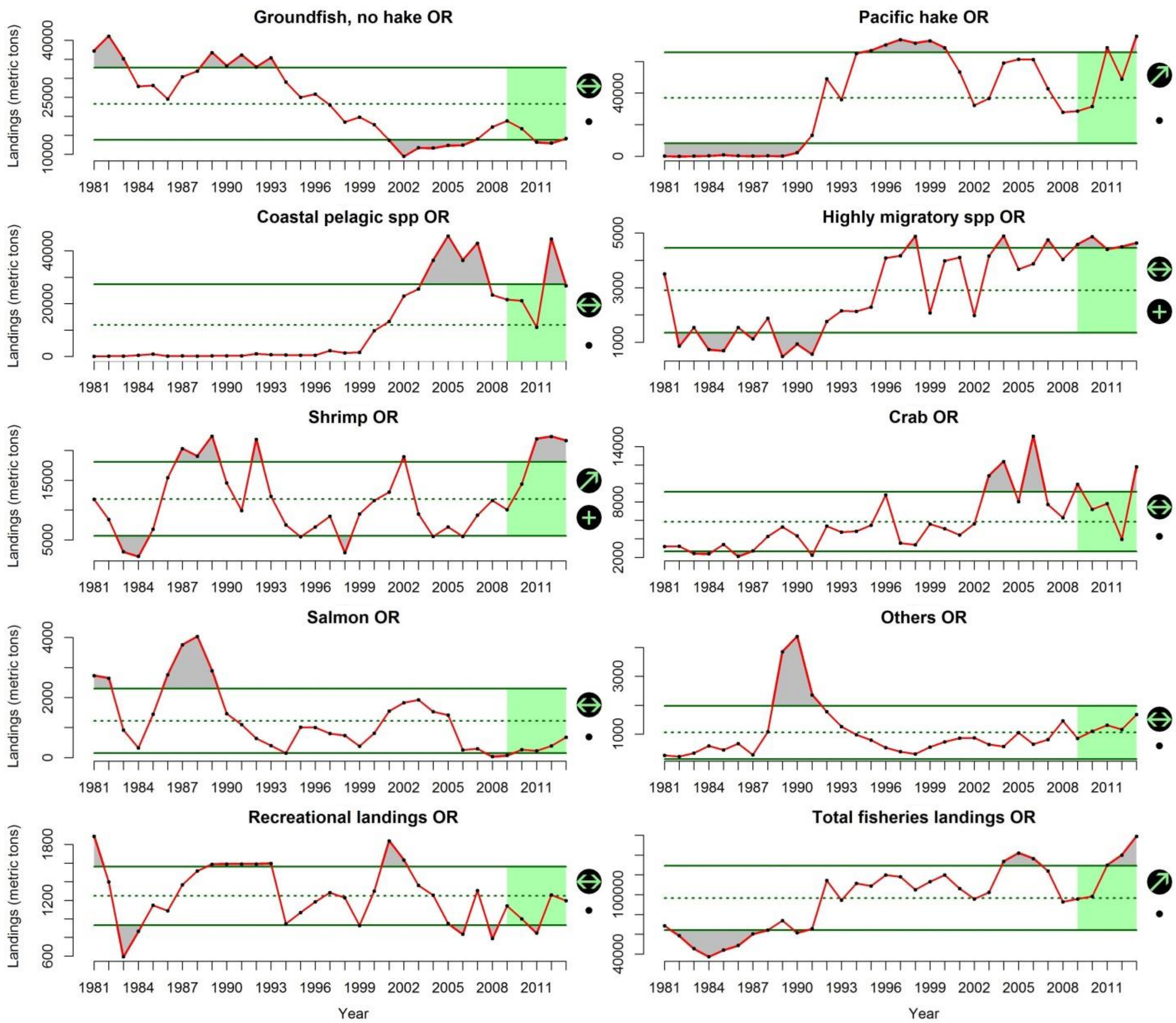


Figure F2. Annual landings of eight major West Coast commercial fisheries, recreational landings, and total landings from commercial and recreational fisheries (data: PacFIN and RecFIN) from 1981-2013 in Oregon.

Commercial and recreational fisheries landings in Washington were available from PacFIN (Pacific Fisheries Information Network; http://pacfin.psmfc.org) for shoreside commercial landings and from RecFIN (Recreational Fisheries Information Network; http://www.recfin.org/) for recreational landings. Total fisheries landings in Washington increased to historically high levels over the last five years (Fig. F3). These patterns were driven primarily by the interaction of landings of coastal pelagic species and Pacific hake. Landings of coastal pelagic species and other species increased to historically-high levels over the last five years, while landings of highly migratory species were consistently at historically-high levels and groundfish (excluding hake) were consistently at historically low levels. Landings of shrimp increased over the last five years. Landings of crabs and Pacific were highly variable but within historical averages, while landings of salmon and recreational catch were consistently within historical averages over the last five years.

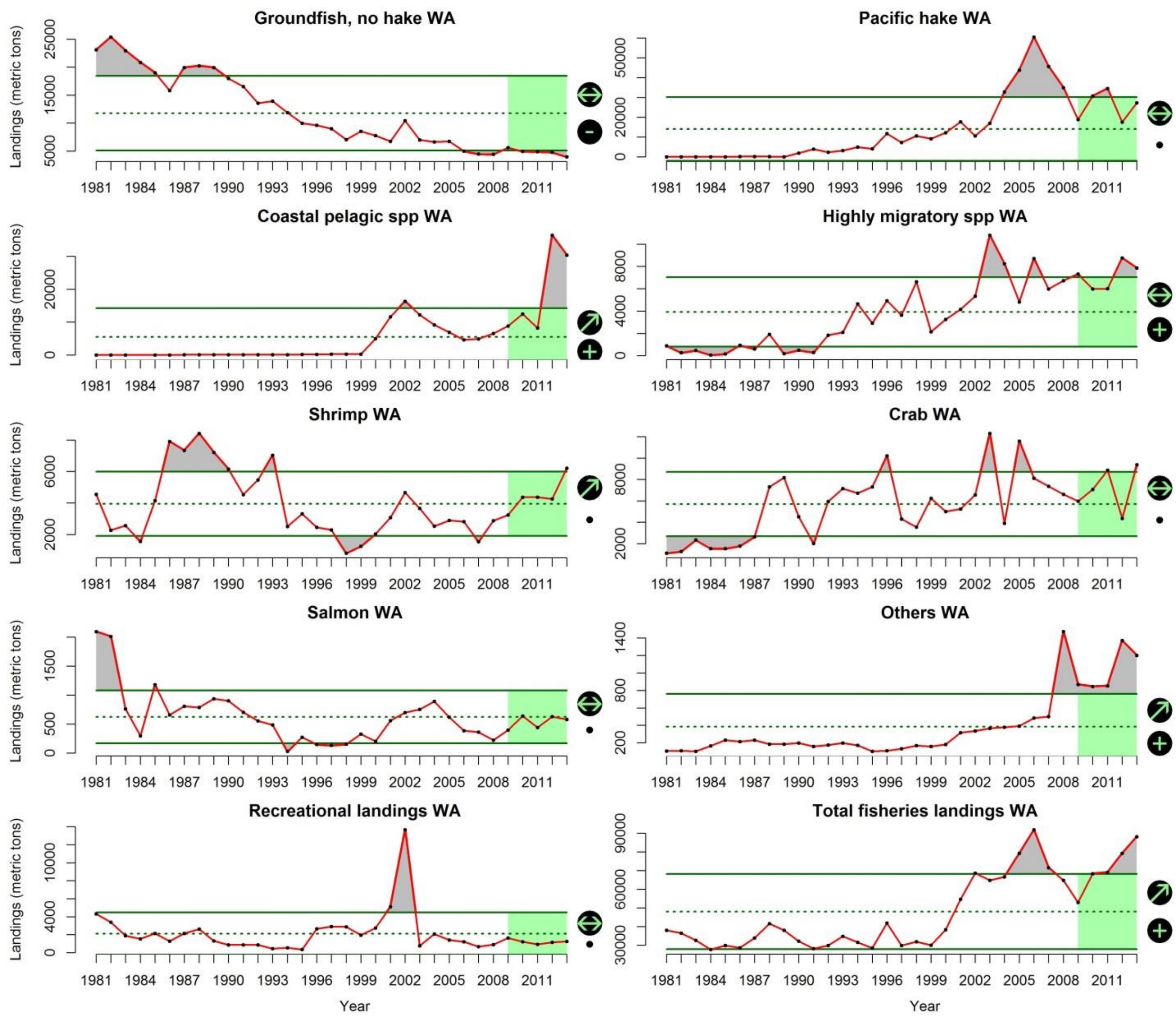


Figure F3. Annual landings of eight major West Coast commercial fisheries, recreational landings, and total landings from commercial and recreational fisheries (data: PacFIN and RecFIN) from 1981-2013 in Washington.

Appendix G. Coastal community vulnerability indicators

Section 6.2 of the CCIEA Annual Ecosystem Summary described work on coastal community vulnerability indicators, and specifically presented information on the extent of dependence upon commercial fishing in coastal communities of Washington, Oregon and California. The sensitivity of any one of these communities to changes in commercial fishing conditions is not just a function of fishing dependence, however; fishing dependence in any coastal community occurs within the broader social context of that community. Thus, we must examine overall indices of community vulnerability in order to fairly assess the implications of fishery dependence.

In order to asses and track coastal community vulnerability for the inhabited shoreline areas adjacent to the California Current Large Marine Ecosystem (CCLME), this section uses a set of variables that were drawn from extant community-level data and subjected to factor analyses in generating vulnerability indices. This process determined which communities are potentially most dependent on fisheries and marine ecosystems, and which among these are the most socioeconomically vulnerable (Fig. G1). While this approach has been successfully developed and implemented for coastal communities on the U.S. East Coast (Jacob et al. 2012; Jacob et al. 2010; Colburn and Jepson 2012), the method of measuring and evaluating socioeconomic resilience is still in the early stages of data collection, organization and analysis for the communities of the U.S. West Coast (i.e. the coastal portion of the California Current Large Marine Ecosystem).

Commercial Fishing Dependence Indices

- Commercial Fishing Reliance
- Commercial Fishing Engagement

Social Vulnerability Indices

- Personal Disruption
- Population Composition
- Poverty
- Labor Force Structure
- Housing Characteristics
- Housing Disruptions

Figure G1. Indices of fishing dependence and social vulnerability for CCLME communities. Adapted from Jepson and Colburn (2013) by Miller (2014).

As shown in Section 5.2 of the main report, a factor analysis approach was applied to available and relevant fisheries data for 2010 to reveal which CCLME communities were relatively dependent on commercial fishing. Once a set of fishing dependent communities is established, the factor analysis approach pioneered by Jepson and Colburn (2013) allows for the use of sociodemographic data from the 2000 and 2010 censuses, as well as the annual American Community Survey (ACS) updates and other secondary sources, to develop indices of social vulnerability. For the major fishing dependent communities in each California Current state (WA, OR and CA), we can measure social vulnerability with respect to six relevant indices (personal disruption, population composition, poverty, labor force structure, housing characteristics, and housing disruption) and compare communities according to each index (Figs. G2-G8).

Composite scores representing social vulnerability of communities were calculated by summing the factor scores (reversed factor scores were used for housing characteristics and labor force structure) and categorizing communities into low, moderate, and high levels of vulnerability based upon less than 20%, 20-80%, and greater than 80% percentiles, respectively. This approach follows that of the Hazards and Vulnerability Research Institute approach (2014) and Himes-Cornell and Kasperski (*In Press*), where counties or communities were classified as having vulnerability levels of low, medium, and high vulnerability as those in less than 20%, 20-80%, and greater than 80%

percentiles in of the total distribution, respectively. A composite score for social vulnerability among West Coast coastal communities is represented in Figure G9.

For more information, please contact Dr. Karma Norman, Karma.Norman@noaa.gov.

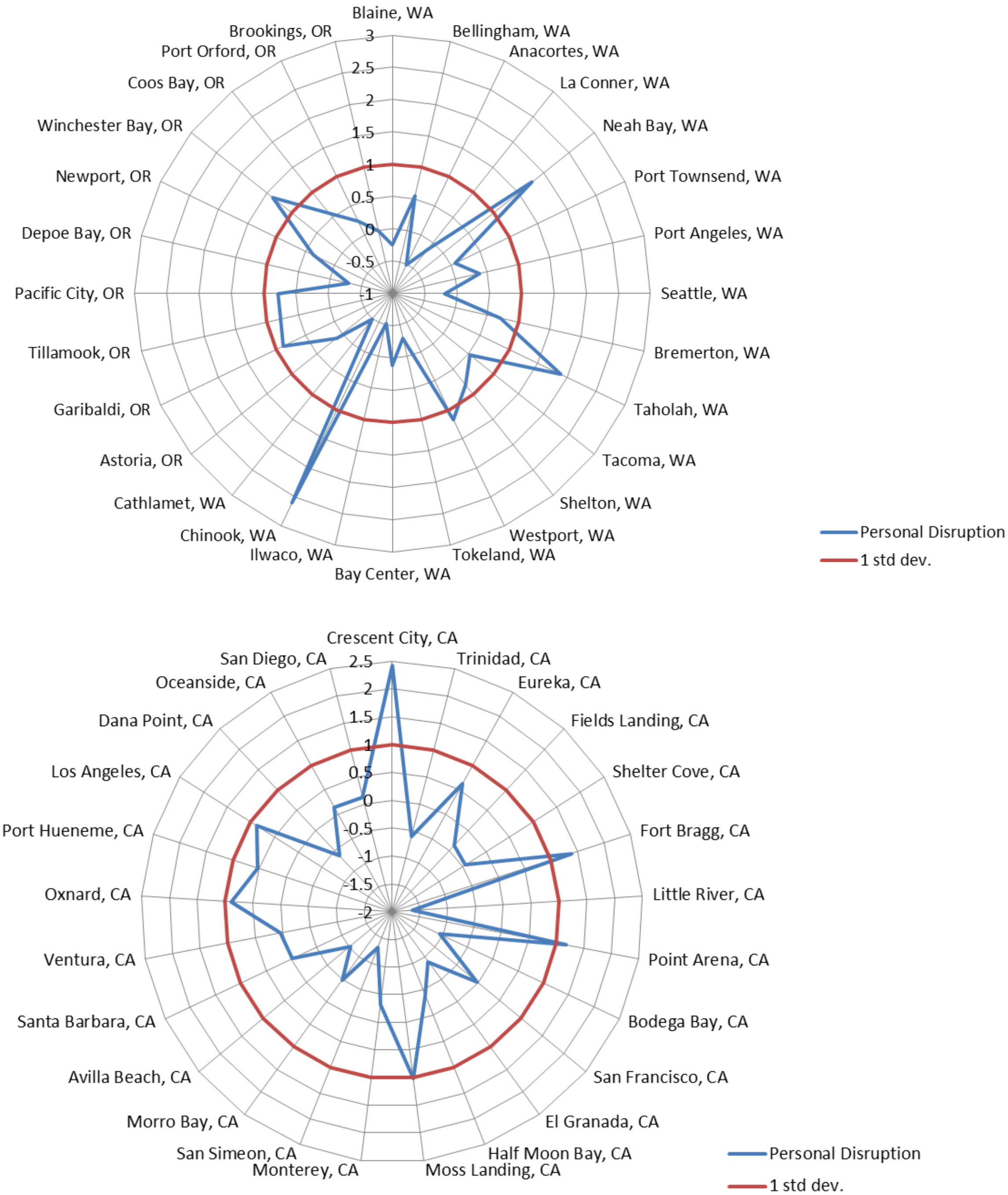
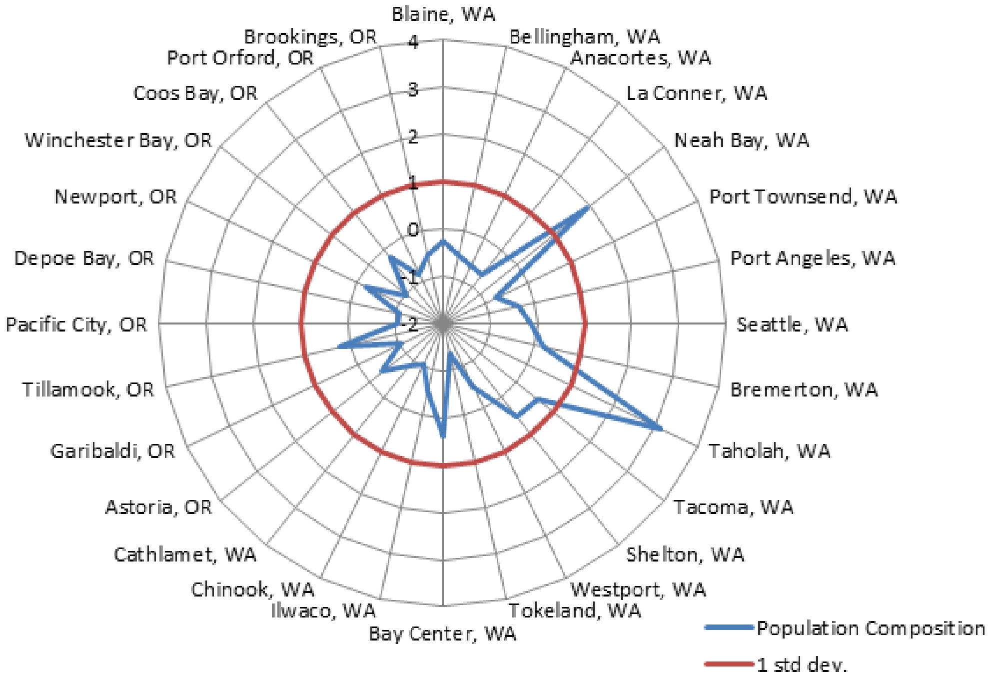


Figure G2. Relative comparisons for the personal disruption index among (top) Washington and Oregon communities and (bottom) California communities.



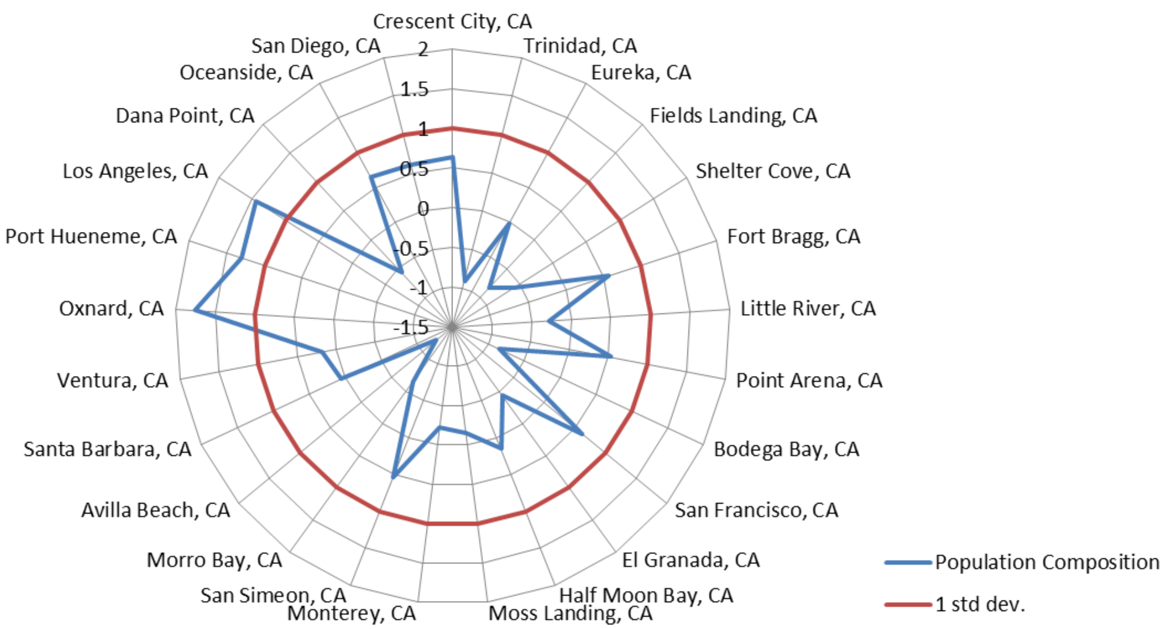
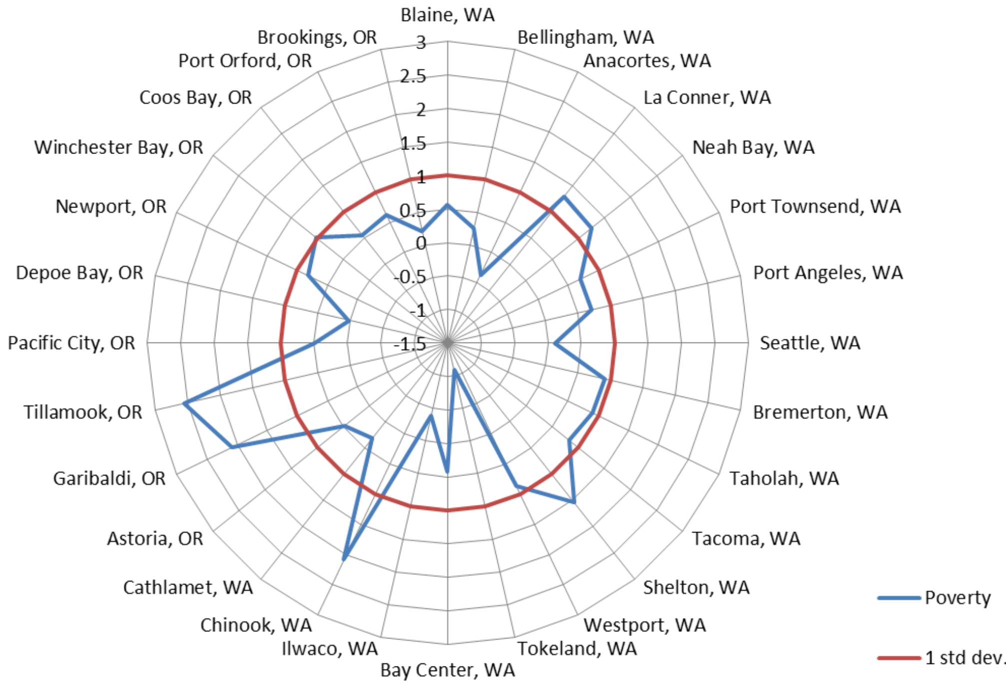


Figure G3. Relative comparisons for the population composition index among (top) Washington and Oregon communities and (bottom) California communities.



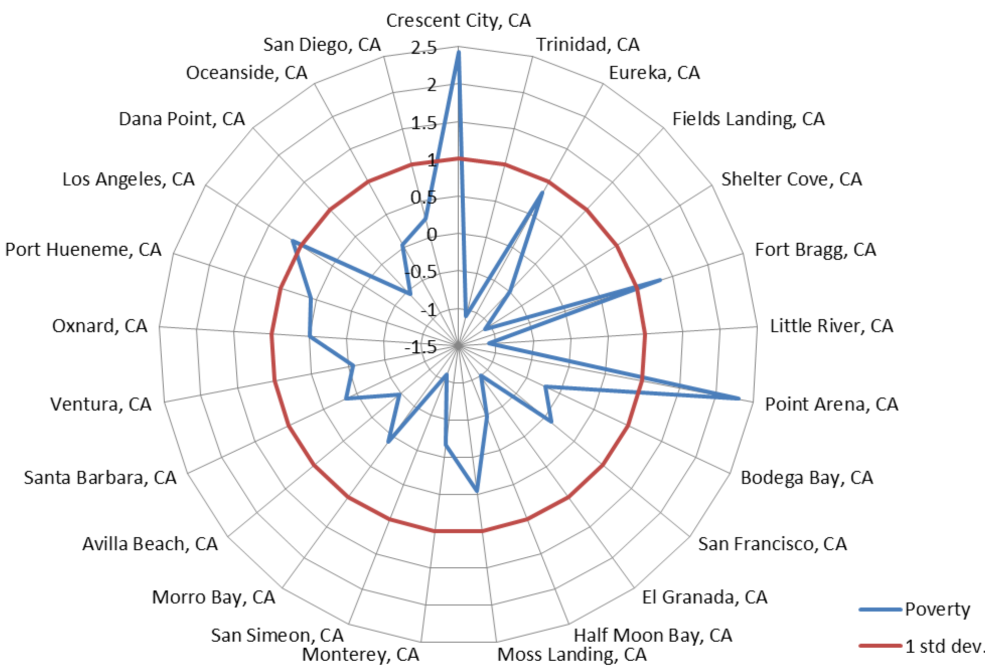


Figure G4. Relative comparisons for the poverty index among (top) Washington and Oregon communities and (bottom) California communities

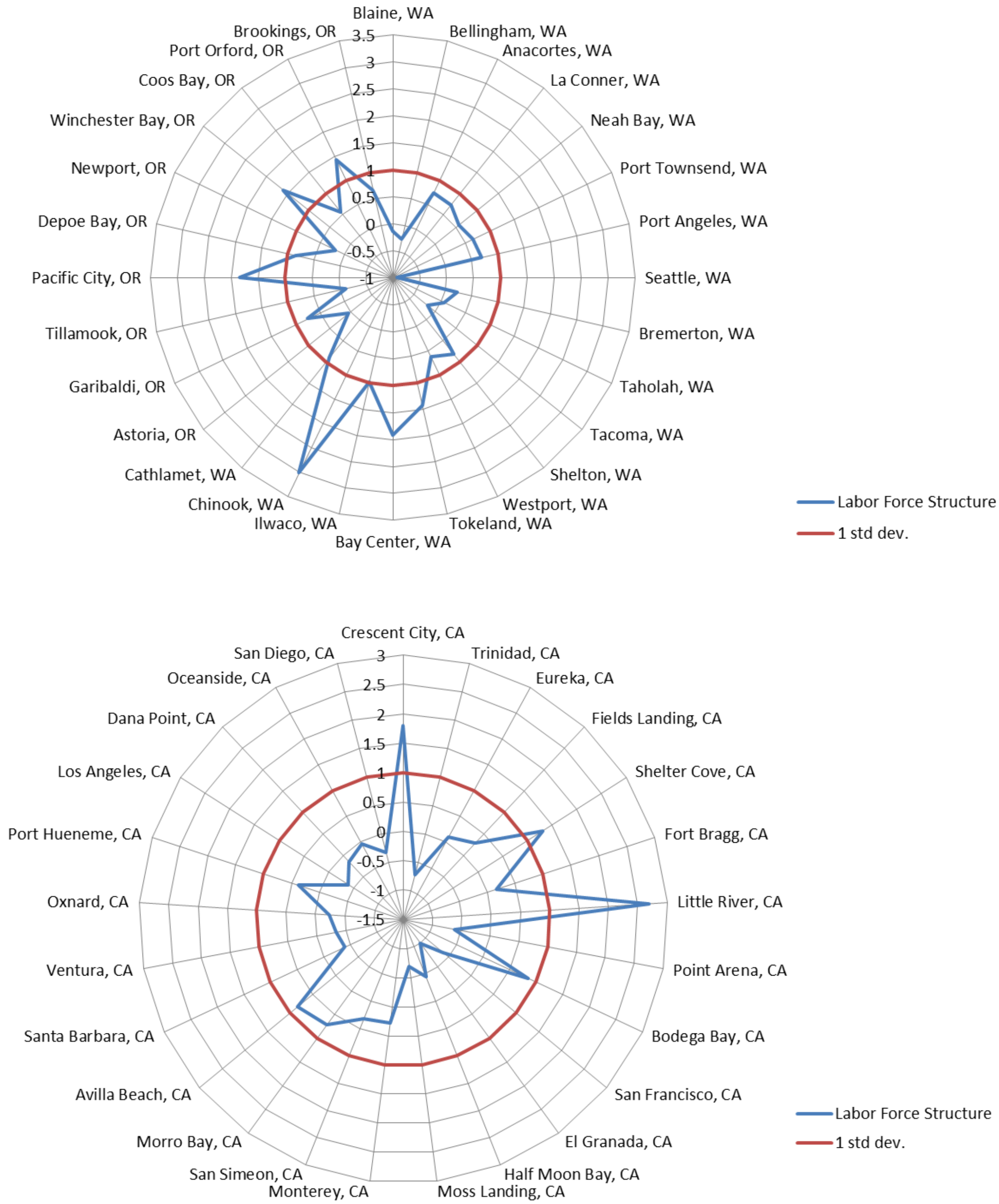
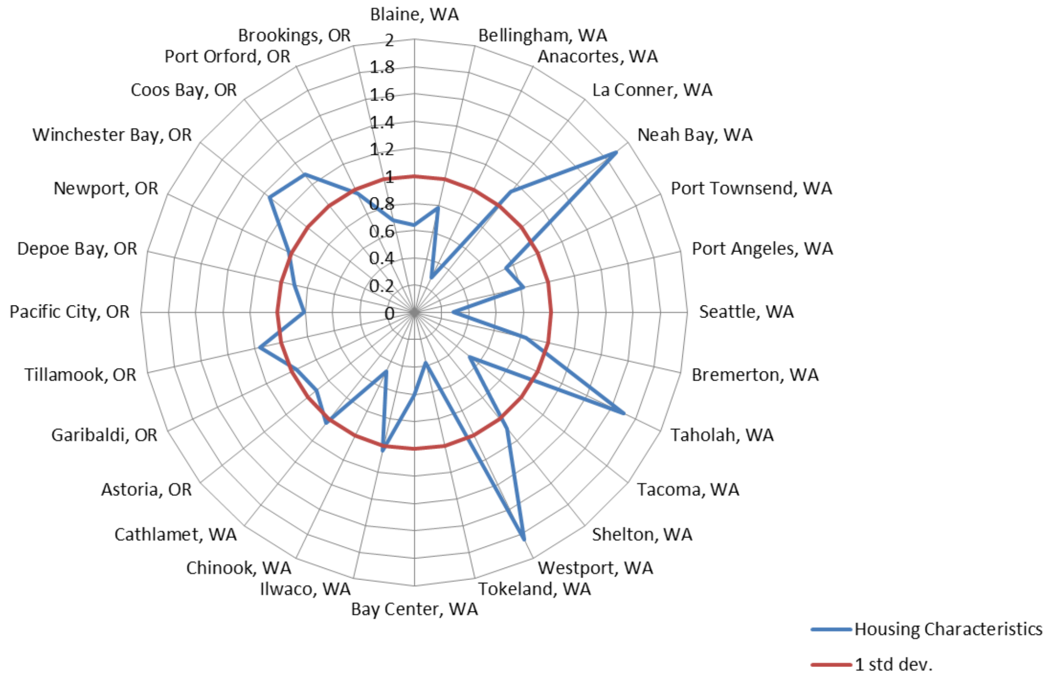


Figure G5. Relative comparisons for the labor force structure index among (top) Washington and Oregon communities and (bottom) California communities. For the Labor Force Structure and Housing Characteristics indices, the cardinality was reversed (higher employment and greater participation of females in the labor force is indicative of lower vulnerability in the Labor index and the higher housing characteristics are similarly associated with decreased vulnerability in the Housing index).



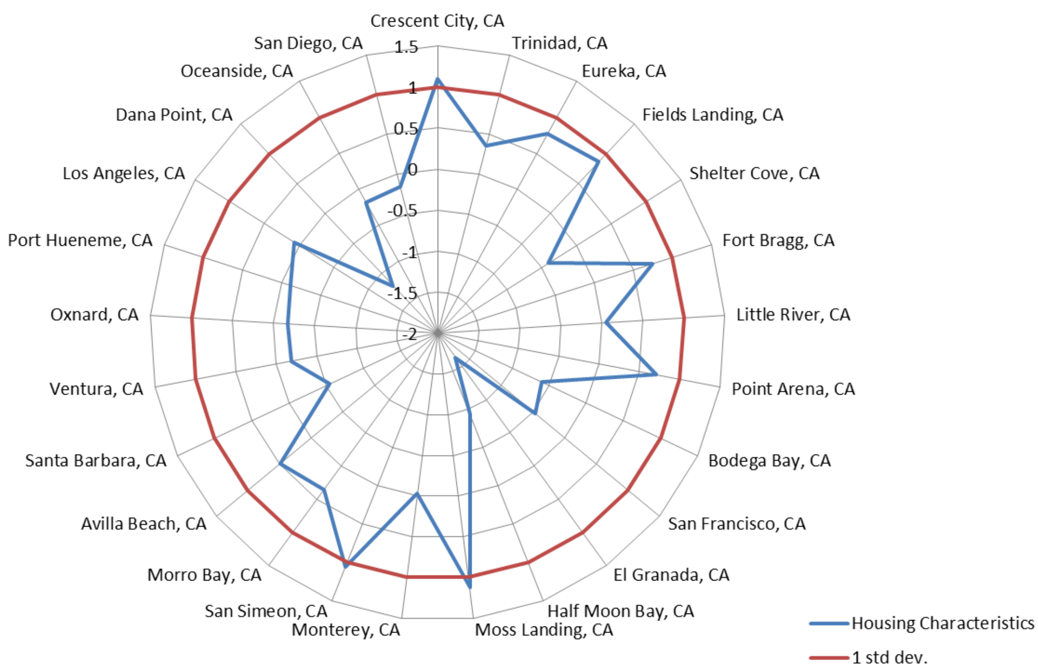
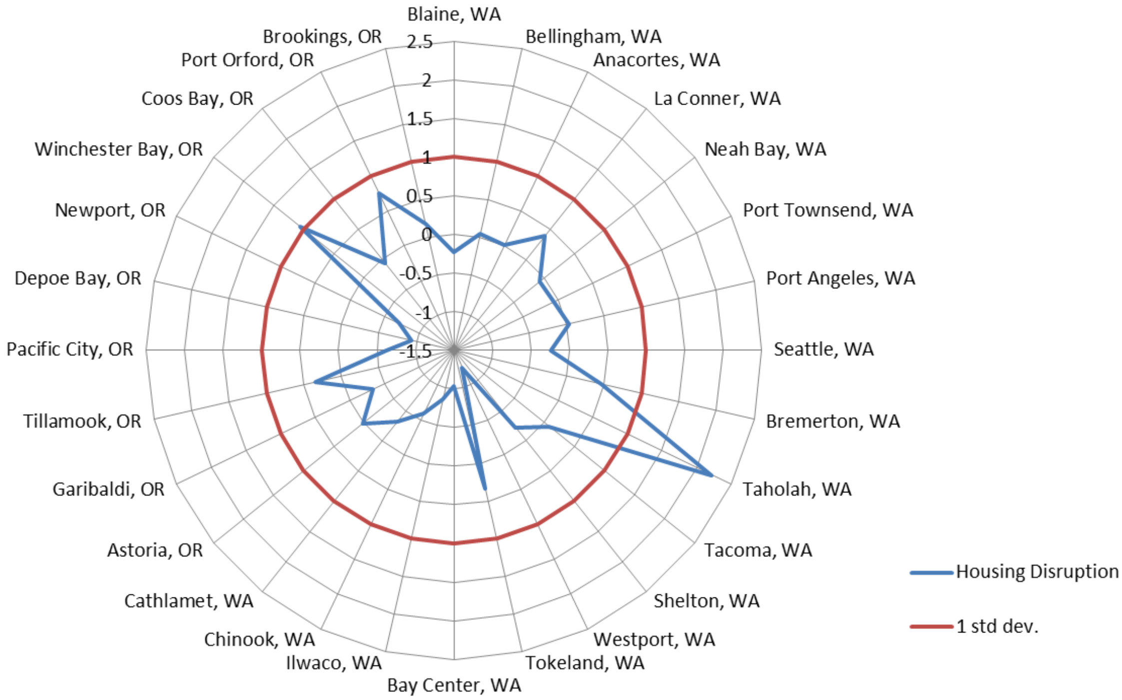


Figure G6. Relative comparisons for the housing characteristics index among (top) Washington and Oregon communities and (bottom) California communities. For the Labor Force Structure and Housing Characteristics indices, the cardinality was reversed (higher employment and greater participation of females in the labor force is indicative of lower vulnerability in the Labor index and the higher housing characteristics are similarly associated with decreased vulnerability in the Housing index).



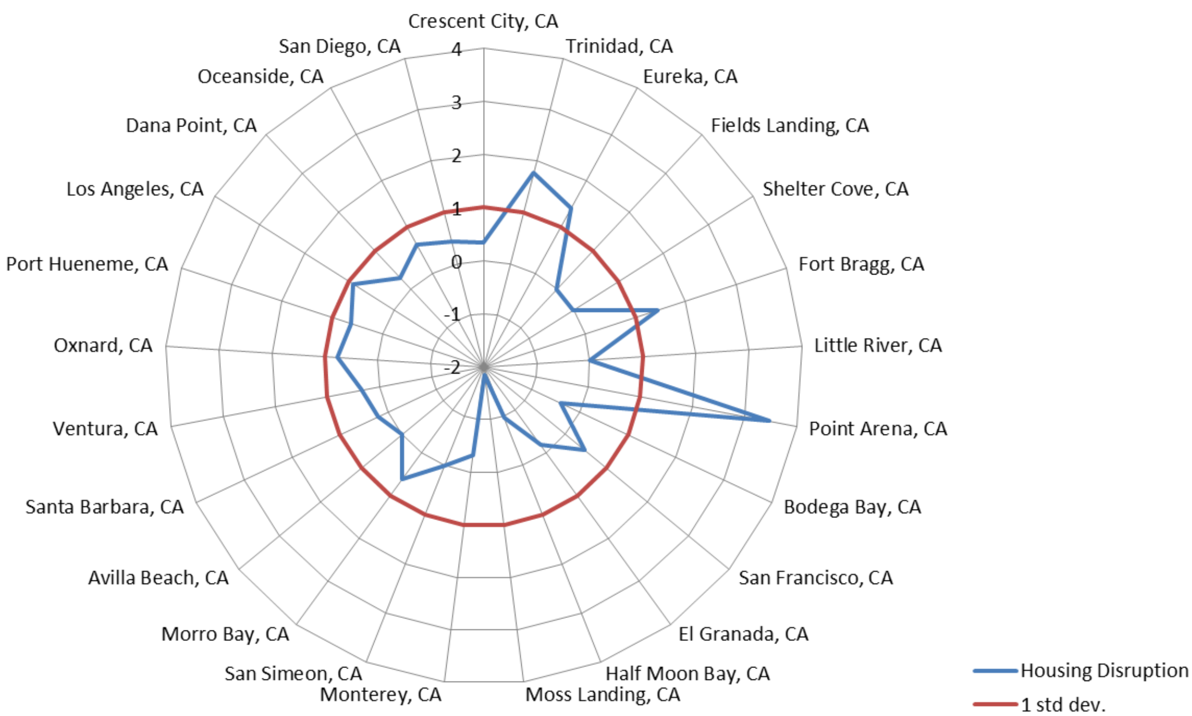
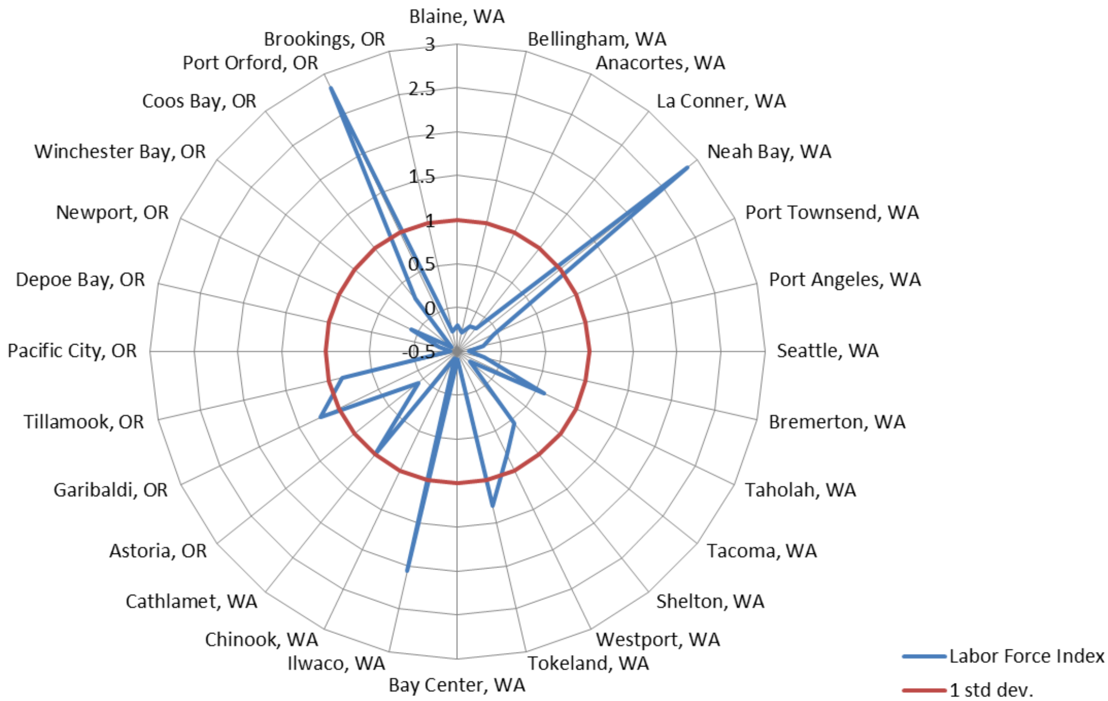


Figure G7. Relative comparisons for the housing disruption index among (top) Washington and Oregon communities and (bottom) California communities.



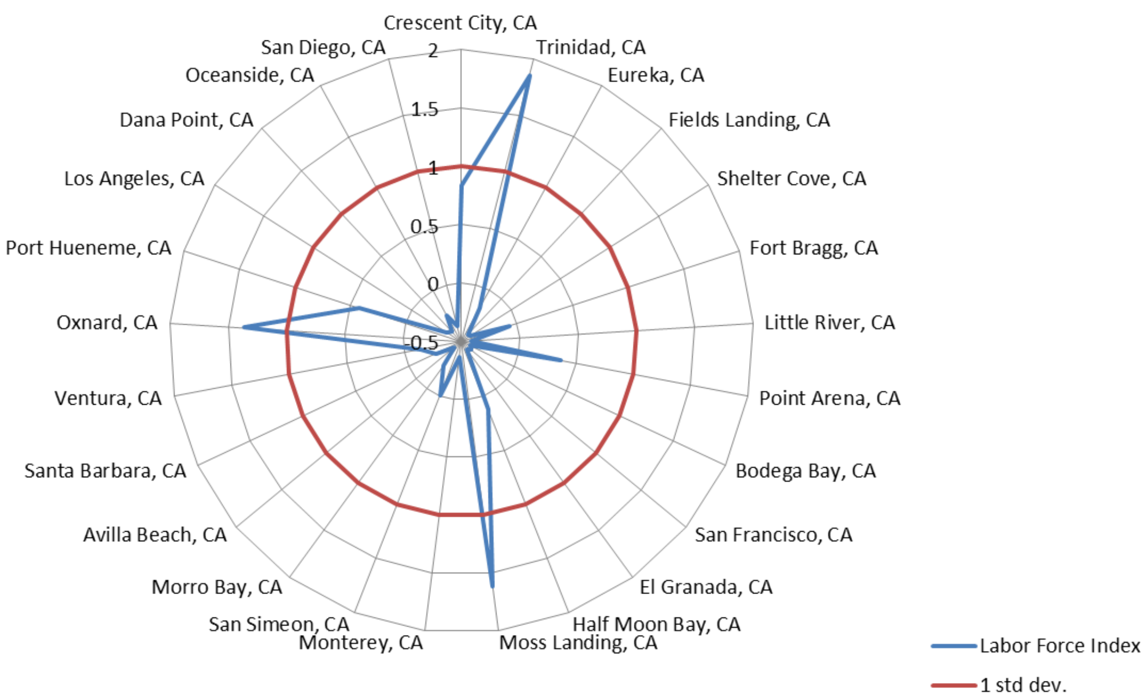
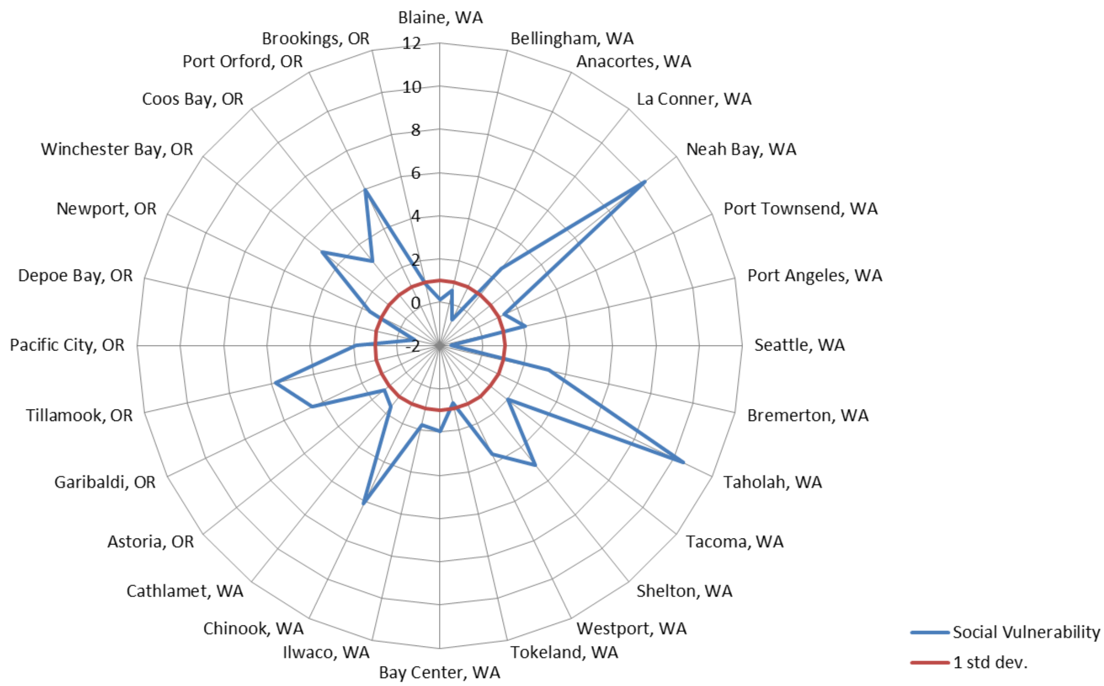


Figure G8. Relative comparisons for the labor force index among (top) Washington and Oregon communities and (bottom) California communities.



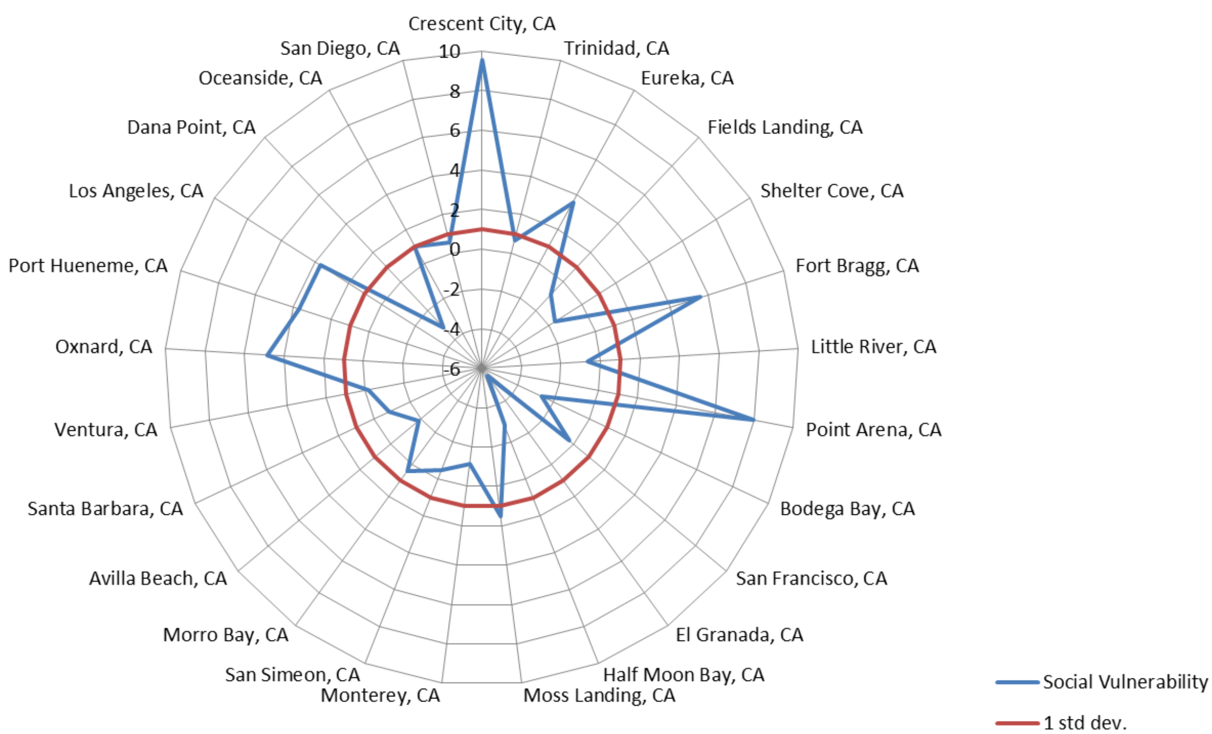


Figure G9. Relative comparisons among (top) Washington and Oregon communities and (bottom) California communities according to an overall composite score for social vulnerability.

Literature cited in Coastal Community Vulnerability analysis:

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