Agenda Item H.2.a
Attachment 1
November 2011

PACIFIC COAST FISHERY ECOSYSTEM PLAN

FOR THE U.S. PORTION OF THE CALIFORNIA CURRENT LARGE MARINE ECOSYSTEM

DRAFT

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OCTOBER 13, 2011: NOTE TO REVIEWERS

This Fishery Ecosystem Plan (FEP) outline is intended as a discussion document to help the Pacific Council, its advisory bodies, and the public think about and comment upon the structure and content of an advisory FEP for the California Current Ecosystem (CCE). This document has been developed in response to Council direction from its June 2011 meeting and includes work developed by the EPDT and commented upon by the Council's other advisory bodies for the Council's September 2010, March 2011, and June 2011 meetings.

LIST OF ACRONYMS AND ABBREVIATIONS

CalCOFI	California Cooperative Oceanic Fisheries Investigations
CCE	California Current Ecosystem, or California Current Large Marine Ecosystem
Council	Pacific Fishery Management Council
CPS	Coastal Pelagic Species
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EPDT	Ecosystem Plan Development Team
ESA	Endangered Species Act
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
HMS	Highly Migratory Species
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act

1.0 Introduction

1.1 Purpose and Need

At its June 2011 meeting, the Pacific Fishery Management Council (Council or Pacific Council) adopted the following Purpose and Need Statement for a Fishery Ecosystem Plan (FEP):

The purpose of the FEP is to enhance the Council's species-specific management programs with more ecosystem science, broader ecosystem considerations and management policies that coordinate Council management across its Fishery Management Plans (FMPs) and the California Current Ecosystem (CCE). An FEP should provide a framework for considering policy choices and trade-offs as they affect FMP species and the broader CCE.

The needs for ecosystem-based fishery management within the Council process are:

1. *Improve management decisions and the administrative process by providing biophysical and socio-economic information on CCE climate conditions, climate change, habitat conditions and ecosystem interactions.*
2. *Provide adequate buffers against the uncertainties of environmental and human-induced impacts to the marine environment by developing safeguards in fisheries management measures.*
3. *Develop new and inform existing fishery management measures that take into account the ecosystem effects of those measures on CCE species and habitat, and that take into account the effects of the CCE on fishery management.*
4. *Coordinate information across FMPs for decision-making within the Council process and for consultations with other regional, national, or international entities on actions affecting the CCE or FMP species.*
5. *Identify and prioritize research needs and provide recommendations to address gaps in ecosystem knowledge and FMP policies, particularly with respect to the cumulative effects of fisheries management on marine ecosystems and fishing communities.*

1.2 How this Document is Organized

This FEP takes its organization from the Council's Purpose and Need statement (Section 1.1). Chapter 2 provides the FEP's Goals and Objectives, a more detailed exploration of what the FEP would do to meet its Purpose and Need. Chapter 3 provides biophysical and socio-economic information on the CCE, including its climate conditions, climate change and shift conditions, habitat conditions, and ecosystem interactions. Chapter 3 also includes information on the cumulative effects of fisheries management on marine ecosystem and fishing communities. Chapter 4 discusses the uncertainties of environmental and human-induced impacts to the marine environment and potential cross-FMP fishery management measures that could be used to buffer against those uncertainties. Chapter 5 discusses Council CCE policy priorities across its FMPs, so that ocean resource management and policy processes external to the Council (e.g. West Coast Governors' Agreement on Ocean Health, National Ocean Council, international fishery and ocean resource management bodies) may be made aware of and may better take into account those priorities. Chapter 6 identifies and prioritizes research needs and provides recommendations to address gaps in ecosystem knowledge and FMP policies.

1.3 Schedule and Process for Developing the FEP

At its June 2011 meeting, the Council tasked its EPDT with drafting a schedule and process for developing the FEP. This FEP is a living document, which means that the Council anticipates regularly amending and updating the FEP. The following proposed process and schedule is intended to allow the Council to swiftly finalize an initial FEP, with the understanding that the Council will annually assess and update the FEP.

June 2011: Council decides to develop an advisory FEP, adopts Purpose and Need Statement. Advisory FEP is to be structured so that, if the Council wishes, it could be later converted to an Ecosystem FMP with regulatory authority.

November 2011: Council reviews EPDT's draft FEP outline, makes recommendations on additions to or subtractions from proposed FEP contents, makes recommendations on prioritizing issues to be considered within the FEP. [Prioritized issues to be listed here.]

June 2012: Council reviews and initially comments on draft FEP containing chapters on highest-priority issues; Council sends FEP out for public comments.

November 2012: Council receives comments on draft FEP from its advisory bodies and the public, directs EPDT to revise FEP as appropriate, and adopts 2013 FEP workload priorities. [Prioritized issues and chapters to be listed here.]

March 2013: EPDT provides draft initial FEP, as modified in response to Council direction from November 2012; Council adopts final initial FEP.

June 2013: Council reviews and initially comments on 2013 FEP priority issues and chapters.

November 2013: Council receives comments on 2013 draft FEP sections from its advisory bodies and the public, directs EPDT to revise as appropriate, adopts 2014 FEP workload priorities. [Prioritized issues and chapters to be listed here.]

2014 and beyond: Council continues to add issues and chapters to FEP in priority order, with draft additions available each June and Council final decisions each November.

1.4 Schedule and Process for Annual State-of-the-Ecosystem Reporting

In addition to an FEP, the Council and its advisory bodies have discussed an annual process for bringing state-of-the-ecosystem information into the Council process. In its June 2011 report to the Council, the SSC's Ecosystem Subcommittee noted that much of the available information on ecosystem dynamics is highly technical and "not developed specifically for fisheries management applications." The Subcommittee also noted that NMFS's annual Ecosystem Considerations Report to the North Pacific Fishery Management Council is over 200 pages long, although its authors also provide summary information for that report. Bearing these and other comments in mind, the EPDT proposes that the Council consider both an annual ecosystem report and brief species-group ecosystem hotsheets. Ecosystem hotsheets would distill relevant annual report information for Council use during meetings when harvest-setting decisions are needed for particular species or species groups.

November 2011: Council receives sample discussion document on developing an annual report on conditions in the CCE, highlighting processes and results from the California Current Integrated Ecosystem Assessment.

June 2012: Draft list of potential indicators and information to be included in an annual ecosystem considerations report provided for Council and public review and comment.

November2012 (and each subsequent November): First annual ecosystem considerations report and ecosystem hotsheet for sardines and other coastal pelagic species (CPS) under Council management consideration at that meeting.

March 2013 (and each subsequent March): Ecosystem hotsheets for salmon and Pacific whiting.

June 2013 (and each subsequent June): Ecosystem hotsheet for mackerel.

September 2013 (and September in other odd-numbered years): Ecosystem hotsheet for groundfish. ***The EPDT is aware that the Council is considering revising its groundfish harvest specifications and management measures process. September odd-year hotsheet reporting is proposed as a placeholder until and unless groundfish process revisions occur.***

September 2014 (and September in other even-numbered years): Ecosystem hotsheet for highly migratory species.

2.0 Goals and Objectives

[Unlike the Purpose and Need Statement in Chapter 1.0, the Council has not yet adopted FEP Goals and Objectives. The EPDT first provided the draft Goals and Objectives in its September 2010 report to the Council (Agendas Item H.1.b., Attachment 1). For this draft FEP, the EPDT has modified its September 2010 draft Goals and Objectives, taking into account comments received from the Council and its advisory bodies].

The overarching goal of this FEP is to bring a greater understanding of the CCE to the Council participants and the public, so as to provide broad consideration and analysis of social, economic, and ecological policy options across the Council's areas of responsibility. The FEP and its associated scientific products are intended to support Council decision-making by more fully addressing the goals and objectives shared by all FMPs for a healthy ecosystem with productive and sustainable fisheries.

The Council's four existing FMPs each have suites of goals and objectives that differ in their precise language, but have four common themes that are consistent with an ecosystem approach to fishery management: avoid overfishing, maintain stability in landings, minimize impacts to habitat, and accommodate existing fisheries sectors. The CPS FMP also explicitly recognizes the role of the target species in the food web; this is the only FMP that specifies a need to "provide adequate forage for dependent species." These FEP objectives are intended to help integrate management across all the FMPs:

- Provide a vehicle to better inform Council decision-making by improving and integrating information that may affect species from multiple FMPs, such as trends in climate conditions or indicator species.

- Identify and address gaps in ecosystem knowledge, particularly with respect to the cumulative effects of fishing on marine ecosystems, and provide recommendations to address such gaps.

- Provide an ecosystem context for Council decisions that may involve common management concerns or trade-offs among species-specific FMPs.

- Provide administrative structure and procedures for coordinating conservation and management measures that address inter-species relationships across FMPs and with species external to the FMPs.

- Provide a nexus to regional and national ecosystem-related endeavors, particularly with respect to the consequences of non-fishing activities.

- Provide a framework for the consideration of cooperative management strategies that might facilitate management actions at appropriate spatial scales.

3.0 The FEP's Geographic Area and the California Current Ecosystem

[The Council adopted an initial geographic area for this FEP at its September 2010 meeting. Descriptions of the CCE are excerpted from the EPDT's March 2011.]

3.1 Geographic Area

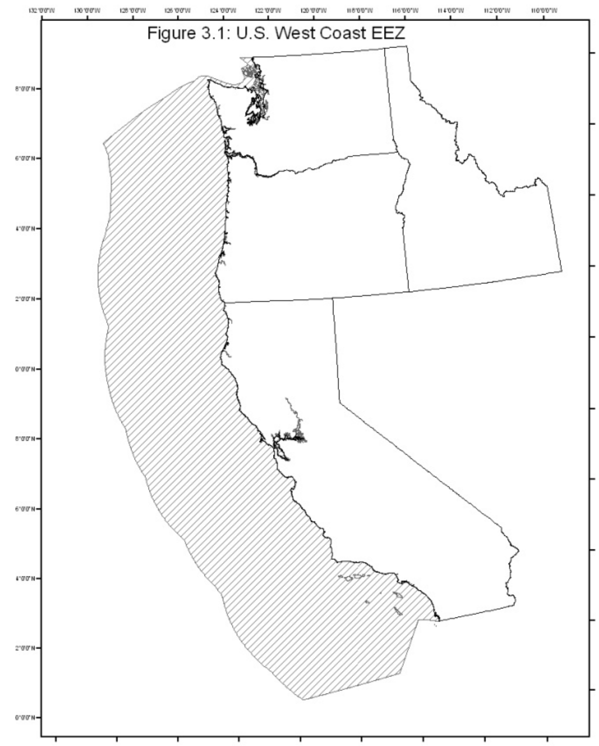

Figure 3.1: U.S. West Coast EEZ

The geographic range for this FEP is the entire U.S. West Coast Exclusive Economic Zone (EEZ.) The Council recognizes that the EEZ does not encompass all of the CCE, nor does it include all of the waters and habitat used by many of the Council's more far-ranging species. However, the Council also does not believe that designating the EEZ as the FEP's geographic range in any way prevents it from receiving or considering information on areas of the CCE or other ecosystems beyond the EEZ.

3.2 Oceanographic Features of the CCE

The California Current is an "Eastern Boundary Current," an upwelling-dominated ecosystem characterized by fluctuations in physical conditions and productivity over multiple time scales (Parrish et al. 1981, Mann and Lazier 1996). Food webs in these types of ecosystems tend to be structured around coastal pelagic species that exhibit boom-bust cycles over decadal time scales (Bakun 1996, Checkley et al. 2009). By contrast, the top trophic levels of such ecosystems are often dominated by highly migratory species such as salmon, tuna, billfish and marine mammals, whose dynamics may be partially or wholly driven by processes in entirely different ecosystems, even different hemispheres.

The CCE essentially begins where the west wind drift (or the North Pacific Current) reaches the North American continent. The North Pacific Current typically encounters land along the northern end of Vancouver Island, although this location varies latitudinally from year to year. This current then splits into the southward-flowing California Current heading south and the northward-flowing Alaska Current. The "current" part of the California Current is a massive southward flow of water ranging from 50 to 500 kilometers offshore (Mann and Lazier, 1996). Beneath this surface current, lies the California Undercurrent in the summer, which surfaces and is known as the Davidson current in winter. This current moves water poleward from the south in a deep yet more narrow band of water typically close to (but offshore of) the continental shelf break (Hickey 1998, Checkley and Barth 2009). The southward-flowing California Current is typically considered distinct from the wind-driven coastal upwelling jet that develops over the continental shelf during the spring and summer, which tends to be driven by localized forcing and to vary on smaller spatial and temporal scales than offshore processes (Hickey, 1998). Jets result from intensive wind-driven coastal upwelling, and lead to higher nutrient input and productivity; they in turn are influenced by the coastal topography (capes, canyons and offshore banks), particularly the large capes such as Cape Blanco, Cape Mendocino and Point Conception. The flow from the coastal upwelling jets can be diverted offshore, creating eddies, fronts and other mesoscale changes in physical and biological conditions, and even often linking up to the offshore California Current (Hickey, 1998). One example is south of Point Conception, where part of the California Current swirls eastward and then northward to form the Southern California Eddy.

Superimposed on the effects of these shifting water masses that drive much of the interannual variability of the California Current, are substantive changes in productivity that often take place at slower rates, during multi-year and decadal periods of altering ocean condition and productivity regimes. Climatologists and oceanographers have identified and quantified both the high and low frequency variability in numerous ways. The El Niño/Southern Oscillation (ENSO) is the dominant mode of interannual variability in the equatorial Pacific, with impacts throughout the rest of the Pacific basin (including the California Current) and the globe (Mann and Lazier 1996). During the negative (El Niño) phase of the ENSO cycle, jet stream winds are typically diverted northward, often resulting in increased exposure of the West Coast of the U.S. to subtropical weather systems (Cayan and Peterson 1989). Concurrently in the coastal ocean, the effects of these events include reduced upwelling winds, a deepening of the thermocline, intrusion of offshore (subtropical) waters, dramatic declines in primary and secondary production, poor recruitment, growth and survival of many resident species (particularly salmon and groundfish), and northward extensions in the range of many tropical species.

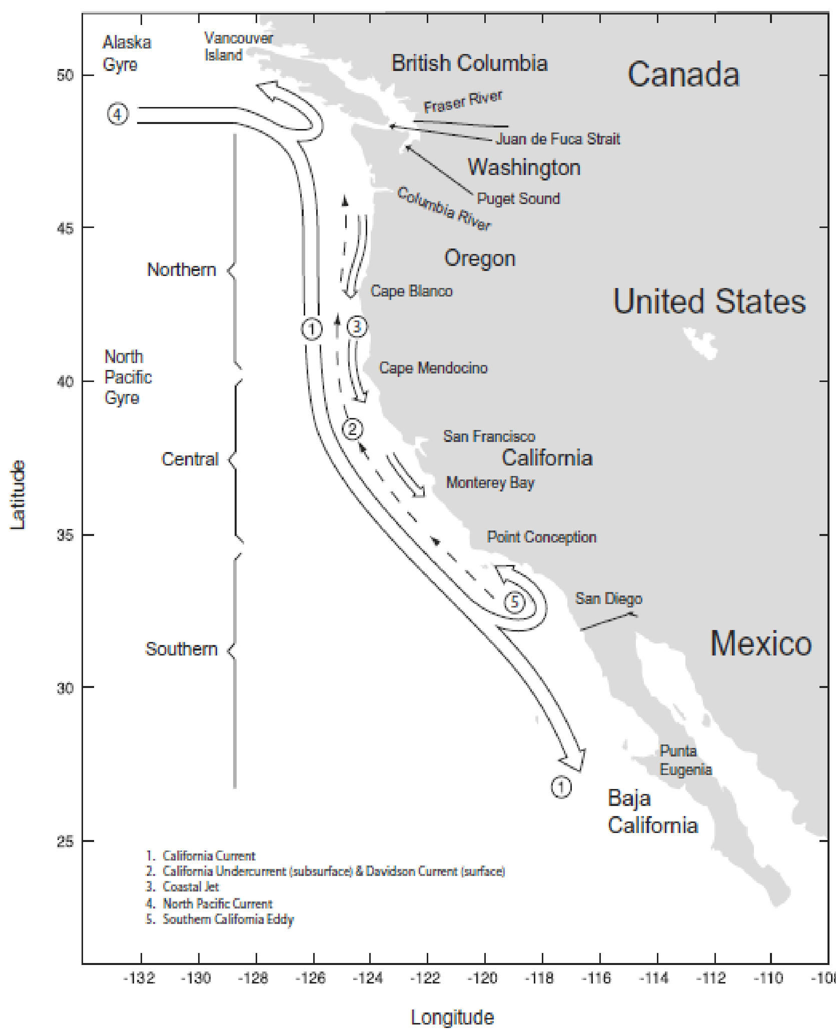

Figure 3.2: Dominant current systems off the U.S. West Coast

While the ENSO cycle is generally a high-frequency event (taking on the order of three to seven years to complete a cycle), lower frequency variability has been associated with what is now commonly referred to as the Pacific (inter)Decadal Oscillation, or PDO (Mantua et al. 1997). The PDO is the leading principal component of North Pacific sea surface temperatures (above 20° N. lat.), and superficially resembles ENSO over a decadal time scale. During positive regimes, coastal sea surface temperatures in both the Gulf of Alaska and the California Current tend to be higher, while those in the North Pacific Gyre tend to be lower; the converse is true in negative regimes. The effects of the PDO have been associated with low frequency variability in over 100 physical and biological time series throughout the Northeast Pacific, including time series of recruitment and abundance for commercially important coastal pelagics, groundfish and invertebrates (Mantua and Hare 2002).

Three major aspects of climate change that will have direct effects on the CCE are: ocean temperature, pH (acidity versus alkalinity) of ocean surface waters, and deep-water oxygen. Globally by 2050, ocean temperatures *on average* are expected to rise at least 1°C (by the most conservative estimates, ref: climate IPCC report), while at the same time, ocean pH in the upper 500m has steadily been decreasing (becoming more acidic, aka "ocean acidification") at a rate of approximately -0.0017 pH per year (Byrne et al., 2010). On a more regional basis within the CCE, deep-water oxygen levels have shown a steady and relatively rapid decrease since the mid 1980's (Bograd et al., 2008, McClatchie et al., 2010). There is linkage between these three factors: ocean temperature affects ocean pH, ocean temperature and deep water oxygen levels both can be controlled by large scale circulation patterns, primary production can affect both oxygen and pH, all three factors show long term trends and decadal scale variance similar to changes in the PDO (Mantua et al., 1997) and North Pacific Gyre Oscillation (DiLorenzo et al., 2008) climate signals.

Temperature

Increasing temperature will have both direct and indirect effects on all managed species within the CCE. For cold-blooded species, vital rates will change as a function of temperature, specifically growth and development rates, which could lead to changes in size-at-age relationships, and/or changes in egg production rates (Houde, 1989; Blaxter, 1992). Certain species with upper thermal limit tolerances, may become locally extirpated in some areas, or conversely expand into new territories that were once too cold. Other, more mobile species, may change their depth/and or spatial range in response to increasing temperature, typically through a northward shifting of population boundaries. Indirect effects on managed species include changes in both basic primary and secondary production rates, and/or community composition of the lower trophic levels which provide the food base for managed species. It is also likely that along with increased warming, there has been an increase in thermal stratification within the CCE (Palacios et al., 2004), which may lead to a decrease in overall primary production, through a reduction in the effectiveness of upwelling bringing nutrients to the surface layers. Thus we may expect system-wide changes in productivity or changes in the centers of productivity over the next 50 years. Related to changes in temperature, there may also be associated changes in the timing of the onset of spring's seasonal upwelling, which could have widespread effects on total production, the match-mismatch of certain trophic interactions, and possible community shifts (Loggerwell et al., 2003; Holt and Mantua, 2009).

Ocean pH

Decreasing ocean pH ("ocean acidification") will have direct effects on certain species within the CCE. Primarily, decreasing pH makes it more difficult for shell-bearing species (such as corals, bivalves, gastropods, and crustaceans) to make their shells (Kleypas et al., 1999; Riebesell et al., 2000; Fabry et al., 2008). Decreased pH may possibly impact the larvae and young stages of fish, although studies documenting such effects on fish are sparse (see Fabry et al. 2008, and references therein). The most significant impact likely for the managed species within the CCE would be if decreasing pH caused changes in plankton productivity or community composition. Currently, the likeliness and extent of such effects are poorly known, but could be considerable. As changes in ocean pH roughly track changes in atmospheric pCO2 levels, it is expected that as pCO2 continues to rise, ocean pH will continue to steadily decrease, making changes in ocean plankton production and community structure more likely in the future. It is important to note that there is considerable daily, seasonal, and decadal scale variability in ocean pH, overlain on the overall long-term trend (reviewed in Fabry et al., 2008). Thus many oceanic species are already exposed to considerable variability in ocean pH compared to the rate of long-term change, and thus have some natural resilience to such changes.

Oxygen

Within the CCE, there has been a notable decrease in deep-water oxygen levels since the mid 1980's (Bograd et al., 2008, Chan et al., 2008). Effects of low oxygen levels on marine organisms are fairly well known: death in most cases if the organisms cannot avoid the area, or reduced growth for those species with some tolerance. Overlaid on this steady decrease, occasional periods of heightened primary production without concomitant surface grazing, have sometimes led to large hypoxic or even anoxic zones in deeper waters, resulting in mass fish kills (e.g. recent events off Oregon coast; Chan et al., 2008). The decrease in deep water oxygen levels is most likely a result of changes in oxygen content of the source waters of deeper parts of the CCE, more of a basin-wide phenomenon affecting large regions of the CCE (Bograd et al., 2008). On top of the long term, system-wide changes in deeper water oxygen are regional-scale events that may further decrease oxygen levels. Particularly, strong surface primary production may sink out before being remineralized in surface layers, leading to a higher respiratory demand in deeper waters. Coupling such events with the already depleted deeper waters, may thus lead to fish kills, the likelihood of which will probably increase as the deep water oxygen continues to decrease under the current trend.

3.3 Biological Components and Relationships of the CCE

This section would describe the living components of the CCE, not individually, but by trophic level and ecological guild, as they interact with each other at the ecosystem scale. Sub-ecosystem, or regional, ecological interactions may also be described, as deemed necessary or useful by the Council and its advisory bodies. This section would also assess the cumulative effects of Council-managed fisheries on ecological interactions within the CCE. See Appendix A for a sample discussion of CCE lower trophic level species.

3.4 Socio-Economic Components and Relationships of the CCE

This section would describe the U.S. West Coast fisheries managed under the Council's authority, without duplicating descriptions from the Council's FMPs. This section assesses West Coast fisheries capacity and the cumulative socio-economic effects of Council-generated fishery management measures on fishing communities and summarizes safety-of-human-life-at-sea issues for West Coast fisheries.

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4.0 Uncertainties of Environmental and Human-Induced Impacts to the Marine Environment

Chapter 4 would consider the potential effects to the CCE from environmental processes and human activities, and could inform risk choices and recommend safeguards in fisheries management measures to buffer against uncertainties induced by those effects.

5.0 PFMC Policy Priorities for Ocean Resource Management

Chapter 5 would discuss Council CCE policy priorities across its FMPs, as they may apply to ocean resource management and policy processes external to the Council (e.g. West Coast Governors' Agreement on Ocean Health, National Ocean Council, international fishery and ocean resource management bodies). Unlike Chapter 2, Goals and Objectives, the purpose of Chapter 5 would not be to guide future Council work, but to better ensure that external entities are better aware of, and may better take into account, Council priorities for the CCE's health and function.

6.0 Bringing Cross-FMP and Ecosystem Science into the Council Process

[This Chapter is based on Chapter 4 of the EPDT's March 2011 report to the Council, Agenda Item J.1.c., Attachment 1, updated and modified by comments received from the Council and its advisory bodies through June 2011.]

6.1 Bringing Ecosystem Science into the Council Process

Based in part on advice received from the SSC in September 2010, the EPDT views the incorporation of ecosystem science into the Council process as a two-part process. The first part is to identify and act on opportunities to improve the quantity and quality of ecosystem information used in the science that supports Council decision-making, particularly stock assessments. The second part is to bring a new whole-picture assessment of the CCE into the Council process.

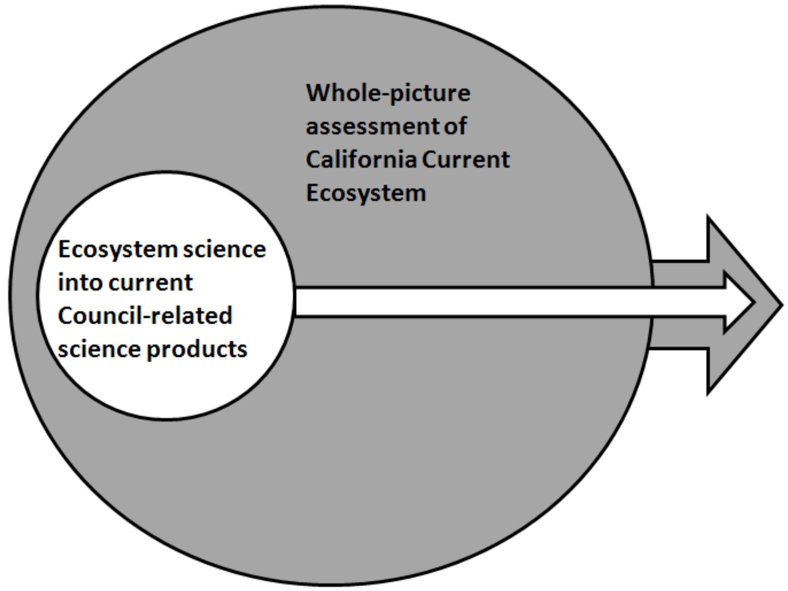

Figure 6.1: Two-part process to bring ecosystem science to the Council

6.1.1 Bringing More Ecosystem Information into Stock Assessments

While Council management decisions address a host of issues requiring wide-ranging science support and analysis, stock assessments and other harvest-level support science are the largest category of science products directly used in the Council process. Simultaneous to the FEP development process, the Council's SSC has been considering a process to bring ecosystem considerations into stock assessments. Recognizing the status of stock assessments as both frequently conducted and heavily used Council-related science, the SSC recommended in September 2010:

> "*. . . that a subset of stock assessments be expanded to include ecosystem considerations. This would likely require the addition of an ecologist or ecosystem scientist to the Stock Assessment Teams (STATs) developing those assessments. The SSC's Ecosystem-Based Management subcommittee should develop guidelines for how ecosystem considerations can be included in stock assessments."* (H.1.c., Supplemental SSC Report)

In its June 2011 statement, the SSC further outlined the process it had discussed in prior statements:

> *"A section on ecosystem considerations should be added to all stock assessments, starting with the 2013 assessment cycle. The detail and length of the section will*

vary and evolve over time. Stock assessment teams should include expertise in ecosystem processes to assist with this section development and stock assessment review.

The SSC will need to modify Terms of Reference for stock assessment reviews to include reviews of ecosystem consideration sections of assessments and application of ecosystem processes in assessments and harvest control rules. Consideration of resources needed will be important to insure that STATs are not overcommitted." (H.1.b., Supplemental SSC Report)

6.1.2 Bringing Ecosystem Information and Science into the Larger Council Process

In June 2011, the SSC and its Ecosystem SubCommittee also commented on an annual state of the CCE reporting process. The SSC wrote:

> *"A report on the state of California Current Ecosystem is available now to provide information on physical processes, habitat, and food web dynamics that are affecting Council-managed stocks. However, this information needs to be distilled into a useful product for Council review and discussion."* (H.1.b., Supplemental SSC Report)

And from the June 2011 SSC Ecosystem SubCommittee report at H.1.b:

> *The purpose of [an] annual update is to provide information about the physical and biological conditions of the system in the previous year that have the potential to affect recruitment, distribution, or vital rates of managed stocks. Possible information to include would be El Niño/La Niña conditions, environmental indices such as the Pacific Decadal Oscillation, upwelling start and end time, extent of the hypoxic zone off the central coast, krill, copepod or crab larvae abundance, and marine mammal and seabird trends. Information in the report should be put in the context of Council management. This report should be developed specifically for fisheries management applications; as such, it would need to be distilled and summarized to provide an update on the available science and ways it should be considered by the Council. The NPFMC has produced an annual Ecosystem Report (http://www.afsc.noaa.gov/refm/docs/2009/ecosystem.pdf) but the document is over 200 pages; any comparable report for the California Current would need to be summarized according to implications for each FMP to be useful for consideration in setting optimum yields (OYs) or prioritizing research needs.*

This draft FEP outline provides a proposed process for annual state of the ecosystem reporting in Section 1.4, above. The contents and format of an annual ecosystem considerations report would need to be developed through collaborative discussions between report contributors and Council advisory bodies.

6.2 Science Questions for Future Consideration

Ecosystem science can be useful both in its application to FMP species-group management, and to aid in long-term Council planning on ecosystem-wide concerns. In this section, we review the science questions common across all four FMPs, follow with FMP-specific research issues, and conclude with a discussion of some broad-scale and long-term issues that could affect fisheries management, such as climate shifts and ocean acidification. Francis et al. (2007) recommend making scientific progress towards ecosystem based fisheries management with these principles: 1. Keep a perspective that is holistic, risk-averse, and adaptive. 2. Question key assumptions, no matter how basic. 3. Maintain old-growth age structure in fish populations. 4. Characterize and maintain the natural spatial structure of fish stocks. 5. Characterize and maintain viable fish habitats. 6. Characterize and maintain ecosystem resilience. 7. Identify and maintain critical food web connections. 8. Account for ecosystem change through time. 9. Account for evolutionary change caused by fishing. 10. Implement an approach that is integrated, interdisciplinary, and inclusive (Francis et al. 2007). Given those recommendations, here are areas where ecosystem science might better inform Council decisions:

6.2.1 Cross-FMP – Needed Future Ecosystem Considerations

1. Evaluate the influence of climatic/oceanographic conditions on the population dynamics of FMP species. Develop IEA indicators to track that influence, such as for upwelling, sea surface temperatures, Pacific Decadal Oscillation, chl-a, and zooplankton index. Evaluate the efficacy of incorporating environmental factors within the current stock assessment modeling framework (Stock Synthesis 3). Model effects of climate forcing on productivity and assess utility of simulated estimates of the unexploited biomass over time (a "dynamic B0") rather than the static estimate of long-term, mean, unfished abundance (Sibert et al. 2006). This is now done for many assessments in order to represent relative depletion from both a static and dynamic perspective (Maunder and Aires-da-Silva 2010).
2. Assess high and low frequency changes in the availability of target stocks, and the vulnerability of bycatch species, in response to dynamic changes in climate and oceanographic conditions (such as seasonal changes in water masses, changes in temperature fronts or other boundary conditions, and changes in prey abundance). Link with socio-economic data and modeling to assess effects of changes in availability on West Coast fisheries. For example, during periods of low HMS availability, recreational fishermen who might prefer to harvest HMS species may increase harvest rates and activity for alternative species, such as rockfish and other groundfish.
3. Examine ecological interactions for influence on managed and non-managed species, including predator-prey relationships, competition, and disease. Investigate the role of FMP species in the food web, including analysis of behavioral interactions (e.g. functional response) between predators and prey.
4. Evaluate effectiveness of standardized bycatch reporting methodologies in all FMP fisheries and develop quantitative information on the extent of the cumulative bycatch of all FMP fisheries.
5. Spatially-explicit management: What is the effect of marine spatial planning on FMP species and fisheries? To address this question, a review of marine spatial planning would include both fisheries and non-fisheries closures, traditional fishing grounds, the effects of potential future non-fishing ocean areas uses, and asking about the types of activities tend to generate EFH/ESA consultations.

6. Investigate how viability and resilience of coastal communities are affected by changes in ecosystem structure and function, including short- and long-term climate shifts.
7. Investigate how fishing activity affects ecosystem structure and function, particularly spatial and temporal fishing patterns and their relation to changing patterns in the ecosystem (cumulative impacts of all FMP fisheries).
8. Identify key indicators for recruitment, growth, spatial availability, and overall CCE productivity.
9. Review management reference points, including rebuilding reference points, in light of ecosystem interactions. For example, do reference points like Bzero account for ecosystem interactions of a given species, or do they just reference the life history information about that particular stock? (Brand et al, 2007)
10. Investigate how different habitat types contribute to species productivity rates (habitat-specific demographic rates). Determine whether Habitat Assessment Improvement Plan (NMFS 2010) can be used to incorporate habitat data into stock assessment models.
11. Better understand spatial structure and geographic range (meta-population structure) of managed stocks and investigate what are the most appropriate spatial scales for management.
12. Assess the effects of different types of fishing gear on ecosystem structure and function, and investigate the effects of the ecosystem structure and function on gear performance.
13. Assess near-shore distribution of FMP species for habitat needs and fishery vulnerability during nursery and pre-reproductive life stages. Characterize the influence of nearshore marine, estuarine and freshwater water quality on survival, growth, and productivity.
14. Assess the evolutionary impacts of fishery management measures and fishing practices, and investigate whether those impacts affect yield or sustainability.
15. Develop an analytical framework to compile the information and evaluate the tradeoffs society is willing to make across the alternative ecological benefits fishery resources provide.

6.2.2 CPS FMP – Needed Future Ecosystem Considerations

1. Climate or ecosystem indicators are not included in the annual stock assessments for Pacific sardine and Pacific mackerel, the FMP's actively managed species. If significant climate-productivity relationships could be developed for Pacific sardine and Pacific mackerel, as well as for other CPS, assessments would benefit since CPS are known to be quite sensitive to long and short-term climate change in the CCLME.
2. Review and revise the climate-based factor in the harvest control rule for Pacific sardine. While not included directly in the assessment process, a climate-based factor is included in the process for determining the annual harvest level for Pacific sardine. For sardine, the FRACTION term in the harvest control rule formula is a function of a three-year average of sea surface temperatures (SST) taken at the Scripps Institute of Oceanography pier located in La Jolla, California. Including this term reflects the positive relationship between sardine reproductive success and water temperature; at higher SSTs a greater fraction of the available biomass can be harvested. Recent work by McClatchie et al. (2010) finds that the Scripps Institute of Oceanography SST is no longer valid in terms of predicting sardine reproductive success. The Council has long identified the review of harvest control rules as a high priority research need and has tasked the CPSMT and the SSC with reviewing these findings. It is anticipated that the Council, the SWFSC, and the States will work toward the development of improved environmental indicators.

3. A management concern of the Council under EBFM will be the evaluating trade-offs between increasing/decreasing the yield of CPS and the potential yield loss/gain of a predator that may be in another Council FMP or be of concern in terms of its ecological importance. In order to come up with a comprehensive optimum yield in this situation, ecological and economic considerations come to the fore, since its resolution depends crucially on the relative net benefits provided society through these interactions (Hannesson et al. 2009; Hannesson and Herrick 2010).
4. NMFS's Southwest Region initiated a pilot observer program for California-based coastal purse seine fishing vessels targeting CPS in 2004 to augment and confirm bycatch rates derived from CDFG dockside sampling. The pilot observer program's primary intent was to gather data on total catch and bycatch, and on interactions between their fishing gear and protected species such as salmon, marine mammals, sea turtles, and sea birds. This program needs to be reviewed to determine whether it should be revived and fully implemented to include standardization of data fields, development of a fishery-specific Observer Field Manual, construction of a relational database for the observer data, and creation of a statistically reliable sampling plan.

6.2.3 Groundfish FMP – Needed Future Ecosystem Considerations

1. Many species show low frequency variability in recruitment due to lower biomass and/or a low productivity environmental regime. For example, the biomass of widow rockfish has decreased steadily since the early 1980s, and recruitment during the early 1990s is estimated to have been considerably smaller than before the mid 1970s (He et al. 2007). However, there is evidence that recruitment of many rockfish species since 1999 has been higher than the average of the 1990s (He et al. 2007). Additionally, several data sources in the cabezon assessment indicate that there was potentially good recruitment after 1999 and before 1977, whereas these same sources indicate that recruitment was poor prior to 1999 in the Southern California Stock (Cope and Punt, 2006). The cabezon recruitment patterns of the California sub-stocks suggest a possible link between environmental forcing and population dynamics (Cope and Key 2009). Specifically, strong ENSO conditions (especially in southern California) may be a pre-cursor to significant recruitment events and should be explored further to help increase the understanding of spatially-explicit recruitment responses and inform future recruitment events (Cope and Key 2009). For example, declines in kelp habitat caused by increasing ocean temperatures in southern California since the 1990s led assessors to suspect that the decline of blue rockfish in this area was in part due to environmental factors affecting habitat, rather than entirely a function of fishing (Key et al. 2008). Finally, correlations between spring sea surface height (Schirripa 2005), zooplankton indices (Schirripa 2007) and sablefish age-0 survival suggest environmental forcing of recruitment. Hamel et al. (2009) recommend investigating effects of PDO, ENSO and other climatic variables on recruitment. A better understanding of the relationship between the population dynamics and climate for such species could reduce the uncertainty of future assessments (Cope and Punt, 2006; He et al. 2007).
2. Provide research on relative density of rockfish in trawlable and untrawlable areas and differences in age and length compositions between these areas (e.g. shortspine thornyhead (Hamel 2005); darkblocked rockfish (Hamel 2008)).
3. Investigate predation impacts likely to affect abundance of assessed species (e.g. lingcod on gopher rockfish (Key et al. 2005); sablefish and shortspine thornyhead on longspine

thornyhead (Fay 2005, Field et al. 2006); Humboldt squid on Pacific hake (Field et al. 2007, Homes et al. 2008).

4. Investigate hake spatial distributions across all years and between bottom trawl and acoustic surveys to estimate changes in catchability/availability across years (Helser et al. 2006; Helser et al. 2008). Two primary issues are related to the changing spatial distribution of the survey as well as the environmental factors that may be responsible for changes in the spatial distribution of hake and their influences on survey catchability and selectivity (Agostini et al. 2006, Helser et al. 2006; Helser et al. 2008). Hamel et al (2009) also recommend investigating time-varying availability inshore for lingcod.
5. Review acoustic hake data to assess whether there are spatial trends in the acoustic survey indices that are not being captured by the model (Helser et al. 2006; Helser et al. 2008). Analysis should include investigation of stock migration (expansion/contraction) in relation to variation in environmental factors (Helser et al. 2006; Helser et al. 2008).
6. Investigate time-varying growth rates and maturity schedules as influenced by environmental factors because of apparent low frequency variability (e.g. Pacific hake (Hamel and Stewart 2009), bocaccio (MacCall 2008); chillipepper rockfish (Field 2007); english sole (Stewart 2008); lingcod (Hamel et al. 2009); splitnose rockfish (Gertseva et al. 2009), chilipepper (Harvey et al., 2011).
7. Research consequences of poor environmental conditions on bioenergetic allocation patterns (bocaccio (Field et al. 2009)).

6.2.4 HMS FMP – Needed Future Ecosystem Considerations

1. Assess nearshore distribution of juvenile sharks for habitat needs and fishery vulnerability during nursery and pre-reproductive life stages (Hanan 1993, Cartamil 2010).
2. Research and modeling needed on the links between climate and the migration patterns of protected bycatch species to allow us to refine our closed area management programs, such as for leatherback and loggerhead sea turtles.
3. Evaluate utility of Pacific pelagic ecosystem models (e.g., Kitchell et al. 1999, Kitchell et al. 2002, Cox et al. 2002, Olson and Watters 2003, Watters et al. 2003, Hinke et al. 2004, Lehodey et al. 2008) for informing Council decisions. Polovina et al. (2009) recently found that with increasing fishing pressure, the catch rates of top predators such as marlin, spearfish, sharks, and large tunas (bigeye and yellowfin) declined, while the catch rates of mid-trophic level species such as mahimahi, pomfret and escolar increased – consistent with earlier models for this same area (Kitchell et al. 1999, Kitchell et al. 2002). Conversely, some later models did not predict as strong effects of fishing through the food web (e.g., Cox et al. 2002) or did not predict long term changes (e.g., Watters et al. 2003), the resulting release of predation mortality from mid-trophic level populations from declines in top trophic-level predators is consistent with the empirical results described in Sibert et al. (2006) and Polovina (2009).

6.2.5 Salmon FMP – Needed Future Ecosystem Considerations

1. Develop tools that describe the environmental state and potential habitat utilization for near-shore anadromous fish, including coastwide sampling of juvenile distributions, monitoring and characterization of the forage based for juvenile and adult salmon, and fine-scale mapping of stock-specific ocean catch distributions.

2. Characterize and map the ocean habitats for anadromous species using data from satellites and electronic tags.
3. Characterize trends in hatchery salmon production and assess the potential for density-dependent effects in freshwater streams, estuaries, and coastal ocean environments. Assess the potential for increasing hatchery production throughout the Pacific Rim to impact body size, age-at-maturity and productivity of salmon in offshore ocean environments.
4. Examine temporal trends in regional salmon harvest rates and measure their covariation with temporal and spatial patterns of environmental variability. Characterize temporal changes in size, age and migration timing of heavily exploited salmon stocks to evaluate correlations with harvest and environmental patterns.
5. Research is needed on the effects of ecological interactions such as disease, predation and competition on the population dynamics of adult and juvenile salmon. In particular, research is needed on the unique impact of cultured salmon, both hatchery smolts and marine net pen reared fish, on disease and competition.
6. Characterize the influence of nearshore marine, estuarine and freshwater water quality on survival, growth, and reproduction of salmon.
7. Evaluate potential impact to wild salmon populations of interbreeding with genetically-modified hatchery salmon.
8. Determine influence of sea surface temperature anomalies to smolt-to-adult return predictions.
9. Evaluate apparent increasing percentage of one-ocean jacks in salmon returns to fresh water.

6.2.6 Oceanographic Conditions, Broad-Scale and Long-Term Ecosystem Conditions

Temperature within the CCE is monitored reliably via several methods. Surface temperatures are sampled via satellite on relatively high temporal (daily) and spatial (several km) scales. In situ and some sub-surface temperatures are less frequently monitored by buoys and ship-based measurements. Gliders and shore-stations provide additional measurements at lower spatial coverage. CCE water temperature measurements have been taken for a longer span of time than any other measurements, providing excellent background data to evaluate current and historic trends (e.g. the CALCOFI program).

Measurement of ocean pH requires in situ water sampling, and cannot currently be conducted via remote means. However, because of the relatively tight coupling of ocean pH with atmospheric forcing, biogeochemical models may be used in some cases to determine ocean pH at higher temporal and spatial frequency than in situ sampling would allow. In fact, historic ocean pH levels used for calculating long term trends have mostly been calculated used biogeochemical-atmospheric models (Fabry et al., 2008). There is much less data available, both temporally and spatially concerning ocean pH than nearly all other physical-chemical measurements, partly because up until recently, it was believed that the ocean was relatively “self-buffering” and would not undergo significant changes in pH. With the recent recognition that pH is indeed decreasing, and that this may be detrimental to many marine organisms, monitoring of pH has increased, particularly in coastal regions.

Oxygen levels have been measured for many decades throughout the CCE (e.g.CALCOFI), traditionally via in situ sampling, followed by ship-board analysis. Oxygen cannot be measured remotely via satellites or other means. However, recent technological advances have enabled the development of in situ oxygen sensors that can provide fairly rapid subsurface measurements of oxygen (Tengberg et al., 2006). Modeling in situ oxygen levels is problematic in most cases, since it requires complex atmospheric-physical-biological coupled models with accurate mixing schemes, although such models do exist and can be applied in some areas with decent success (Najjar and Keeling, 2000). Thus, modeling may provide a limited ability to fill in data gaps, and make limited predictions of water oxygen content.

Future research considerations that would improve the Council's ability to incorporate temperature, pH, and Oxygen research and information into ecosystem-based fishery management are:

1. Direct physiological effects of temperature, pH, and O changes on managed and non-FMP forage species, including, but not limited to: tolerance limits, growth rate, reproductive rate
2. Current spatial and depth boundaries of all FMP, and non-FMP forage species in regards to Temperature, pH, and O.
3. Spatially-specific trend analysis of temperature, pH, and O changes specific to the EFH of all FMP and non-FMP forage species
4. Spatially-specific forecasts of temperature, pH, and O changes specific to the EFH of all FMP and non-FMP forage species
5. Spatially-specific trend and forecast of temperature, pH, and O effects on food chain base (1° and 2° production) for all FMP and non-FMP forage species

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Appendix A – List of Species

At its June 2011 meeting, the Council directed the EPDT to develop "a list of species that are not currently included in any FMP, not the subject of state management, and not managed under ESA regulations. Also, identify the subset of this species list that could be subject to future target fishing."

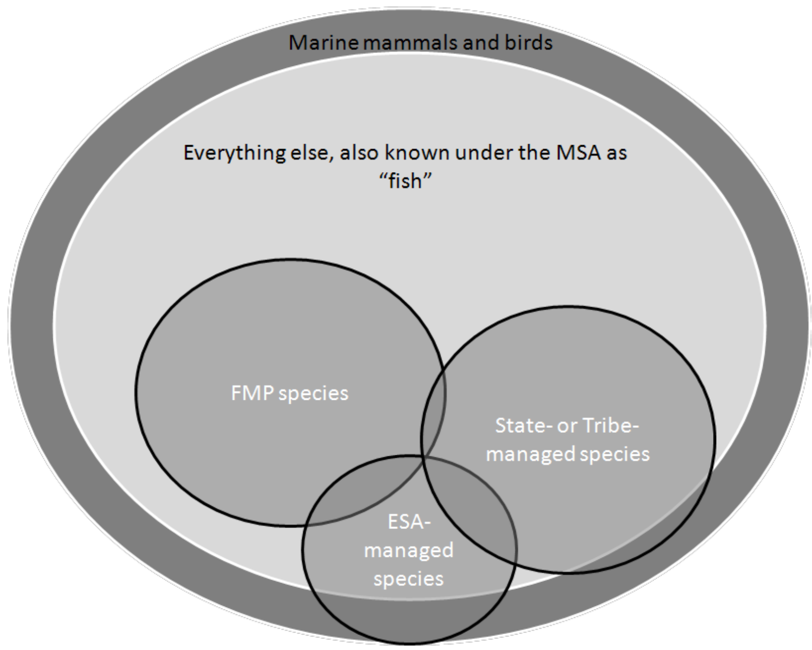


Figure A1: Separating Organisms of the West Coast Exclusive Economic Zone by Jurisdiction

Figure 1 represents the separate management jurisdictions for the organisms of the U.S. West Coast EEZ, as envisioned by the Magnuson-Stevens Fishery Conservation and Management Act (MSA.) Federal management of marine mammals is shared between NOAA and the US Fish and Wildlife Service (USFWS,) under the Marine Mammal Protection Act (MMPA) and, where applicable, the Endangered Species Act (ESA). Federal management of seabirds is primarily the responsibility of the USFWS, under the Migratory Bird Treaty Act. Of the organisms of the West Coast EEZ, the Council has potential jurisdiction over "fish," which the MSA defines as: "finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds." Within the subset of organisms the MSA calls "fish" lie FMP species, state- or tribe-managed species (which may also be FMP species,) and species managed under the Endangered Species Act (which may also be FMP or state- or tribe-managed species.)

In thinking about how best to address the Council's list-of-species assignment, the EPDT tried to develop an ecosystem-based approach to the assignment that was guided by the FEP's Purpose and Need statement. The Council's direction came out of a discussion about the desire of some stakeholders to protect "forage species," and counter-concern by other stakeholders that the term "forage species" is overly broad, and can refer to any animals that are preyed upon by other animals. The EPDT reviewed the scientific literature for a more definitive term for these organisms that are themselves generally plankton-eating and eaten by higher-order predators and suggests initially tackling the Council's assignment by:

1. Providing a draft definition to bound the term "low trophic level (LTL) species," which would include those species commonly thought of as "forage fish," accompanied by a list

of those CCE species that currently meet that definition, with information on those species' relative abundance, fisheries potential, and role in the ecosystem;

2. Assessing worldwide fisheries landings (marketability) for low trophic level (LTL) species that are unfished or little-fished within the CCE, yet are similar to species that are moderately- or heavily-fished elsewhere in the world;
3. Reviewing the range of fisheries permissible within the West Coast EEZ under the MSA and current Federal regulations.

If the Council finds this approach to its list-of-species assignment acceptable for LTL species, the EPDT would be interested in reporting back to the Council at a future meeting, using this same approach for mid- and higher trophic level species. Many of the lowest trophic order organisms, such as phyto- and zooplankton smaller than krill, are likely to be too small to be of interest as fisheries targets. The Council may, however, be interested in the status of those species, either as potential predictors of available harvest levels of FMP species, or as indicators of health and status of the ecosystem at large. The EPDT does not yet have suggestions for how best to review the lowest trophic order organisms within the CCE, but can work at that level, should the Council so desire. Depending on Council guidance on FEP contents, some or most of the information from these discussions could be used in Chapter 3, above.

Defining Low Trophic Level (LTL) Species

The EPDT found a helpful working definition for LTL species developed by Smith et al. (2011,) which they defined as species that are often present in high abundance, forming dense schools or aggregations, and which are generally plankton feeders for a large part of their life cycle. They characterize such species as including small pelagic "forage" fish such as anchovy, sardine, herring, mackerel and capelin, as well as invertebrate species such as krill. Such species are often the principal means of transferring production from primary and secondary tropic levels (typically phytoplankton and zooplankton) to larger predator fish, marine mammals and seabirds.

Many researchers have noted that in coastal upwelling ecosystems, like the CCE, the vast majority of trophic transfer often takes place through a small number of key LTL species. Coastal upwelling systems have been described as 'wasp-waist' ecosystems , where the abundance of a few key low-to-mid-trophic level species (such as sardines, anchovies or krill) exerts both top-down control on a much more species rich assemblage of zooplankton prey, as well as bottom-up control on a diversity of higher trophic level predators. Consequently, we focus this preliminary analysis on LTL species that may be very abundant in a given habitat (e.g., nearshore, shelf, pelagic, mesopelagic) in any of the major biogeographical regions of the CCE, rather than on providing a comprehensive list of each and every species within the CCE. Table A-1, below, focuses on a handful of select or key species or taxonomic groups: providing: some approximations of their known typical habitat and relative abundance,

The term "wasp-waist"and the species assemblages it refers to have been described by Bakun (1996), Cury (2000) and Freon et al. (2009). These authors suggest that ecosystems for which this seem to be especially true are Eastern Boundary Current upwelling systems, which are subject to dynamic interannual and interdecadal changes in physical conditions. Ecosystems analogous to the CCE include other shelf and coastal systems, such as the confluence of the Kuroshio and Oyashia currents off of the east coast of Japan.

briefly noting their fisheries history or potential, current level of management, and, qualitatively evaluating their role in the ecosystem. For this report, the EPDT focused most strongly on pelagic zone LTL species. The EPDT believes that, should the Council find it of interest, further analysis focused on benthic zone LTL species could provide additional information on LTL species that primarily feed on small benthic invertebrates.

For the purpose of Table A-1, the term "managed" refers to whether there is active management under state, tribal or federal actions (including both FMP species and ESA listed species,) noting that some species for which management is listed as "none" may have some gear restrictions or other regulatory actions. The EPDT considered that if the ultimate objective is truly an ecosystem-wide perspective, information on state-managed species is or will be relevant for evaluating trade-offs and making decisions. For simplification, the EPDT also did not include juveniles of species that would otherwise be considered higher trophic level predators, although we recognize that the role of younger life history stages of all species as forage is critical and that the vast majority of predation mortality typically takes place in the larval or juvenile life history stages of most marine species. While the list in Table A-1 is incomplete, it captures a majority of the significant species and assemblages that could be considered LTL species under the suggested Smith et al (2011) definition, based on a documented review of existing literature.

In the diet of Pacific whiting, Euphausiids (krill), herring and anchovy represented over half of the prey, with predation on younger groundfish and other species (including cannibalism) representing the bulk of the remainder (Osmerids accounted for approximately 2% of all prey). Similarly, in a combined study and literature review of food habits of North Pacific albacore, Glaser (2010) found that northern anchovy consistently represented the most important prey species across multiple decades and regions. Finally, in a study of sea lion food habits in the southern California Bight, Lowry (1999) found that the CPS FMP species (market squid, northern anchovy, Pacific sardine, Pacific mackerel and jack mackerel), as well as Pacific hake, shortbelly rockfish and pelagic red crabs, were the most important prey species over a two decade period. Smelts (Osmerids) and to a lesser extent silversides (Atherinospsidae,) among others, are present in some food habits studies, but rarely to the magnitude of managed species.

Ichthyoplankton, which includes planktonic eggs and larvae, typically reflect relative spawning biomass for their species. A summary of over nearly 50 years of the ichthyoplankton community gives some sense of the relative abundance of various ecologically important species in the CCE (Moser et al. 2001). Six of the top 10 most abundant species throughout this long time period are northern anchovy, Pacific hake, Pacific sardine, jack mackerel, and rockfish (shortbelly rockfish and unidentified *Sebastes*, as most species are not identifiable to the species level). This indicates that the relative abundance and importance, at least in the southern part of the CCE, of these key species is far greater than most other LTL species. Notably, the remaining four species in the top 10 are mesopelagic species that further account for 12 of the top 20 most abundant species. There is considerably less comparable ichthyoplankton data for central and northern California, although survey data suggest that anchovy, herring, sardine and whitebait smelt have been the most abundant and important forage species in this region over the past 13 years (Orsi et al. 2007, Bjorkstedt et al. 2010). Ichthyoplankton data are more limited for the CCE north of Cape Mendocino, but existing studies suggest that off Washington and Oregon, *Osmeridae* (smelts, typically not identified to the species level) are often very abundant in the nearshore shelf waters, and tomcod and sandlance are often fairly abundant (see Richardson and Pearcy 1977, Kendall and Clark 1982 and Brodeur et al. 2008).

Although a comprehensive review of every food habits study and result was also beyond the scope of this exercise, and despite the observation that virtually all of the species listed in Table A-1 are encountered in predator food habits studies at times, the literature suggests that the greatest proportion of energy flow in the CCE appears to be through krill, market squid, northern anchovy, Pacific sardine and Pacific herring. There are few other species (excluding juveniles of non LTL species) that occur with high frequency and with a comparable significance to the above core group of species, suggesting that the conceptual wasp-waist model described earlier is reasonable for the CCE. Thus, despite real or potential historical or future conservation problems for some of these species, there is not a high level of unmanaged standing biomass for LTL species that could become subject to fisheries targeting over the short term and which are critical to large scale CCE functioning, energy flow, or integrity.

Table A-1: Preliminary summary of select LTL species in the CCE

Common and species name	Relative abundance	Fisheries potential	Role in ecosystem	Managed
Vertebrates				
Northern anchovy (*Engraulis mordax*)	Low frequency (regime scale) variability over time and space, but typically abundant from nearshore to offshore habitats throughout the CCE	Formerly a major fisheries target (100,000s tons), currently a small scale (largely bait) and incidental catch	Key forage species for wide range of HMS, salmon, groundfish, seabird and marine mammals	CPS FMP
Pacific sardine (*Sardinops sagax*)	Low frequency (regime scale) variability over time and space, but often abundant from nearshore to offshore habitats throughout the CCE	Historically, largest fishery in California Current (100,000s tons), currently a major fisheries target	When abundant, a key forage species for wide range of HMS, salmon, groundfish, seabird and marine mammals	CPS FMP
Pacific mackerel (*Scomber japonicus*)	Low frequency (regime scale) variability over time and space, but often abundant from nearshore to offshore habitats throughout the CCE	Historically and currently an important fisheries target (10,000s tons)	When abundant, a moderately important forage species for many HMS and some marine mammals	CPS FMP
Jack mackerel (*Trachurus symetricus*)	Low frequency (regime scale) variability over time and space, but often abundant in offshore habitats (rarely close to shore) throughout the CCE	Occasionally important fisheries target (10,000s tons)	When abundant, a moderately important forage species for many HMS and some marine mammals	CPS FMP
Pacific herring (*Clupea pallasi*)	Abundant to very abundant in nearshore and many estuaries	Fairly high commercial importance (up to 10,000s tons)	Among the more frequently encountered prey in predators such as salmon, hake, rockfish, marine mammals, seabirds	States
Round and thread herrings (*Etrumeus teres* and *Opisthonema libertate*)	Subtropical species that are "reasonably abundant" in the southern part of the CCS. Range likely to expand with global climate change	Unknown in CCS, but in 100,000s tons throughout Eastern Tropical Pacific	Currently key LTL species in core range, could potentially be in CCS with global change	none
American shad (*Alosa sapidissima*)	Anadromous, moderately abundant in rivers, estuaries	CCS landings in 100s tons, com./rec. important elsewhere	An introduced species (Bzero=0!), moderately important prey for some predators	none
Mesopelagic fishes (Myctophidae, Bathylagidae, Paralepididae, Gonosomatidae; 100s of species in CCS)	Likely the most abundant fish assemblage on the planet. Uncommon inshore but tremendously abundant in mesopelagic (offshore, midwater) waters	Currently limited fisheries potential; despite tremendous abundance, technology is historically infeasible	Important prey for entire mesopelagic food web, many large squids, many tunas and HMS, some rockfish (esp. blackgill, bank), rare in mammal or seabird diets	none
Pacific sandlance (*Ammodytes hexapterus*)	Common, but not abundant, in coastal waters of Pacific Northwest	Important fishery target in other regions (particularly North Atlantic)	Moderately important prey for some fishes, seabirds and marine mammals in the Pacific Northwest	none
Pacific saury (*Cololabis saira*)	Low frequency (regime scale) variability over time and space, primarily an offshore (pelagic) species, often very abundant in offshore waters during cool regimes/periods	Very important fishery off of Japan, elsewhere in North Pacific; presumably a potential large-scale target	Relatively important prey to albacore, sablefish, sharks, other HMS species (rarely found in predators shoreward of shelf break)	none

Common and species name	Relative abundance	Fisheries potential	Role in ecosystem	Managed
Silversides (Atherinospsidae; includes grunion, jacksmelt, topsmelt, perhaps 3-5 other rare spp.)	Moderately abundant in nearshore (but considerably less so than osmerids based on larval abundance data)	Historically commercial and recreational targets (up to ~ 1000 tons in 1940s), recent catches relatively modest. Fisheries typically nearshore	Very abundant in some nearshore areas, presumably important forage species in such areas, but rarely encountered in food habits data for key commercial species	none
Eulachon (*Thaleichthys pacificus*)	Anadromous, coastal, formerly fairly abundant, currently rare	Formerly of fairly high commercial/recreational importance (CCS landings in 1000s tons)	Common but not abundant prey item for wide range of predators	ESA
Other Osmerid smelts (Osmeridae; includes capelin, surf smelt, whitebait smelt, perhaps 3-5 other spp)	After the clupeids (and exclusive of mesopelagics), among the most abundant family of forage fish species in nearshore; typically less abundant offshore	Some species are of minor to modest commercial significance (surf smelt), or have been the target of major fisheries elsewhere (e.g., Atlantic capelin)	Preyed on by wide range of piscivores (seabirds, marine mammals, Pacific hake, sablefish, rockfish, salmon), but rarely comprise a large fraction of total prey.	none
Shortbelly rockfish (*Sebastes jordani*)	Likely the most abundant Sebastes spp. in Central and Southern California, exhibits low frequency (regime like) variability	Minor incidental landings, potential future fisheries target	Juvenile and adult life history stages are very important to salmon, many groundfish, seabirds and marine mammals.	Groundfish FMP
Sanddabs (*Citharichthys* spp), particularly Pacific (*C. sordidus*) and speckled (*C. stigmaeus*)	One of the more abundant soft-bottom groundfish, also found in water column, typically over shelf.	Substantial commercial and recreational catches (100s to 1000s tons)	Juvenile and adult life history stages are very important to many groundfish, particularly piscivorous flatfish; some seabirds and marine mammals.	Groundfish FMP
Pacific tomcod (*Microgadus proximus*)	Locally abundant in some nearshore habitats	Trace historical landings, little current fishery interest or potential	Relatively minor importance in most food habits studies.	none
Small croakers (*Sciaenidae*) e.g. white croaker and queenfish **	Fairly abundant, particularly in nearshore waters of the southern CCE	Some commercial and recreational landings (perhaps to 1000s tons)	Somewhat important for some nearshore species; larvae are very abundant in ichthyoplankton, suggesting relatively high abundance in some areas.	none
Invertebrates				
Euphausiids (krill), primarily *Euphausia pacifica* and *Thysanoessa spinifera*	Tremendously abundant throughout coastal and offshore waters, a hugely important component of the food web	Commercial targets in Antarctica, Japan, small fisheries off British Columbia and other locations; increasing commercial potential.	Key forage species for wide range of both juvenile and adult salmon, groundfish, squid, seabird and marine mammals	Fishing prohibited in CPS FMP
Market squid (*Doryteuthis opalescens*)	Nearshore and shelf distribution (adults relatively rare offshore)	Very important commercial target in CCS (up to, rarely over, 100,000 tons)	Key forage species for wide range of HMS, salmon, groundfish, seabird and marine mammals	CPS FMP (CA state)
Pelagic squids (such as boreal clubhook squid, neon flying squid and Humboldt squid)	Offshore distribution (most spp. rare inshore)	Important commercial target elsewhere in range	These and other squid are key prey for HMS species and marine mammals.	none

** Sciaenidae, excluding white sea bass (*Atractoscion nobilis*) and corbina (*Menticurrhus undulates*) but including small, schooling species such as queenfish (*Seriphus politus*), spotfin croaker (*Roncador stearnsii*), white croaker and potentially others (the latter three are probably the most abundant; note that white seabass is clearly a higher trophic level predator).

Potential for Developing LTL Fisheries in the CCE

In addition to assigning the EPDT to review unmanaged species, the Council requested that we identify species that could be subject to future target fishing within the CCE. Under this criterion, several of the select LTL species in the CCE could potentially be the subject of future fisheries targeting, based on their importance in global commodity markets. Although these species are not presently targeted by large-scale U.S. commercial fisheries, they are an incidental catch in a number of fisheries and occasionally show up in the West Coast commercial fisheries landings (Figure A2). Globally, some of these species constitute significant landings outside of the CCE (Figure A3).

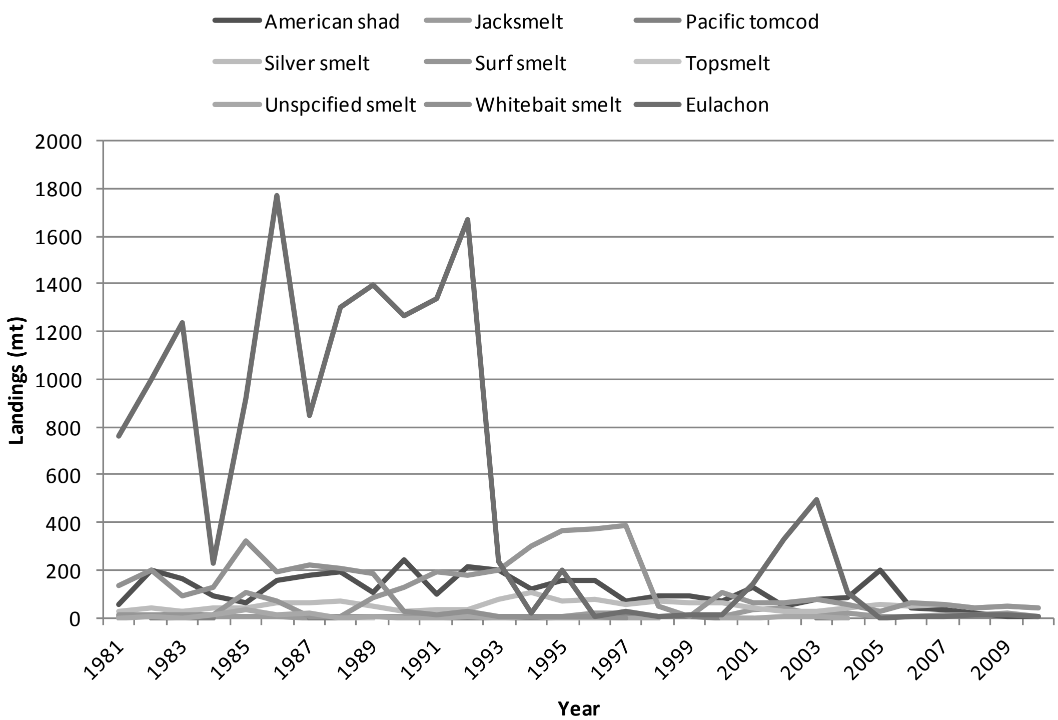
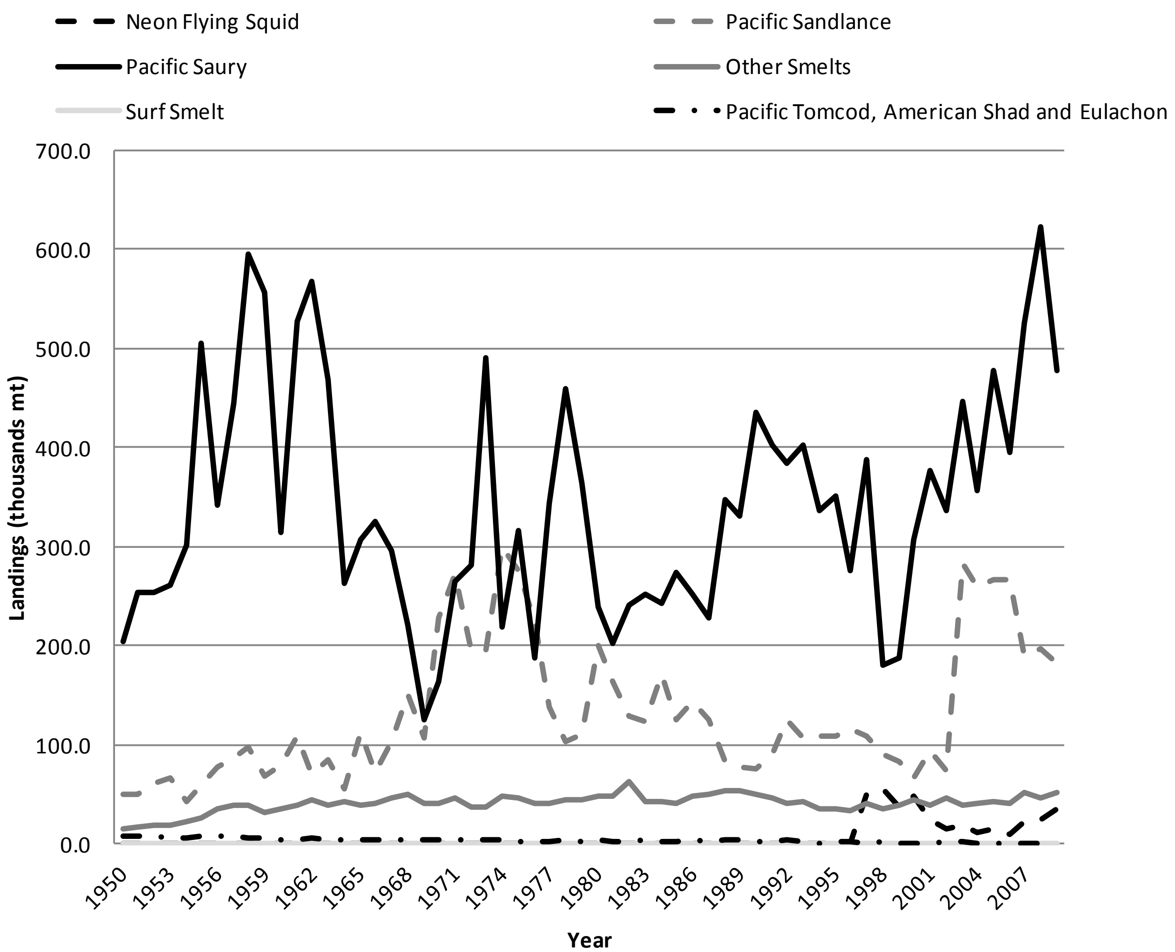


Figure A2. West Coast landings (mt) of select California Current Ecosystem LTL species, 1981-2010.

Figure A3. Global landings of select California Current Ecosystem LTL species, 1950-2009.



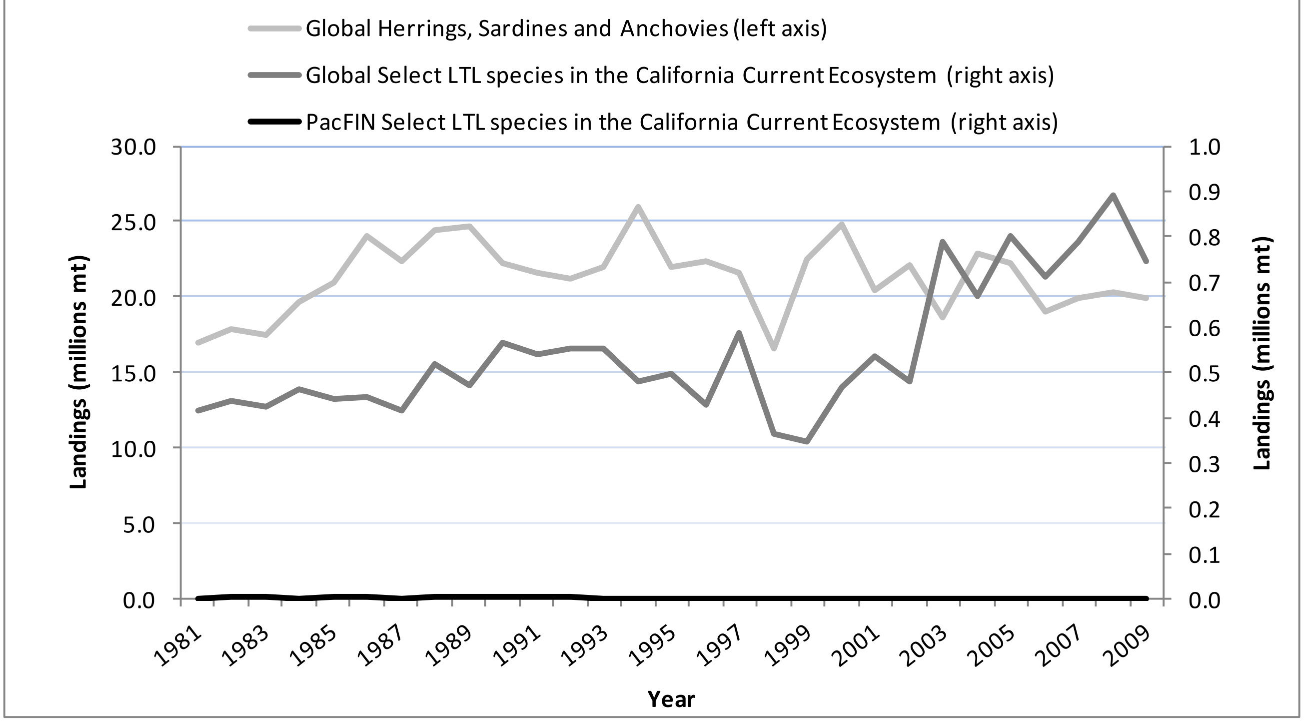
Sources: FAO Statistics and Information Service of the Fisheries and Aquaculture Department. 2011. Capture production 1950-2009. FISHSTAT Plus - Universal software for fishery statistical time series [online or CD-ROM]. Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/fishery/statistics/software/fishstat/en; PacFIN Management Database.

Harvests of LTL species are converted into various commodities through value added production processes (Herrick et al. 2009). Based on Food and Agriculture Organization (FAO) fisheries commodities, production and trade data from1976-2009, most of the reported LTL species commodities production was in the fishmeal and fish oil category. During that period, commodities in the fishmeal and fish oil category increased to well over 50% of total annual LTL species commodities production. With the fisheries for traditionally popular LTL species appearing to be at or exceeding MSY levels, the growing importance of these minor LTL species in the global landings largely reflects their increasing use as ready substitutes in the production of fishmeal and fish oils (Figure A3).

Demand for LTL species in the production of fishmeal has mainly been driven by the spectacular growth of global aquaculture, which is expected to continue into the foreseeable future (Tacon and Metian 2008, Shamshak and Anderson 2008, Herrick et al. 2009). The production of many aquaculture species depends on LTL species fisheries to supply the raw ingredients in today's aquafeeds. In the recent boom in capture-based aquaculture, demand has increased for whole live/fresh/frozen LTL species for pen fattening aquaculture operations (Zertuche-Gonzales et al. 2008). All these feed requirements pose a potential sustainability problem for the aquaculture industry, because at present, unlike fishmeal use in livestock production, there are limited opportunities to replace LTL species, either in fresh or in fishmeal form, with cost effective protein substitutes. Given limited potential for increased fishmeal production from traditional LTL species prices for fishmeal and fish oil will continue to rise (Figure A5). This makes the prospect for fisheries developing on the minor LTL species all that more attractive, as higher fishmeal prices are sure to translate into higher exvessel prices for the raw ingredients.

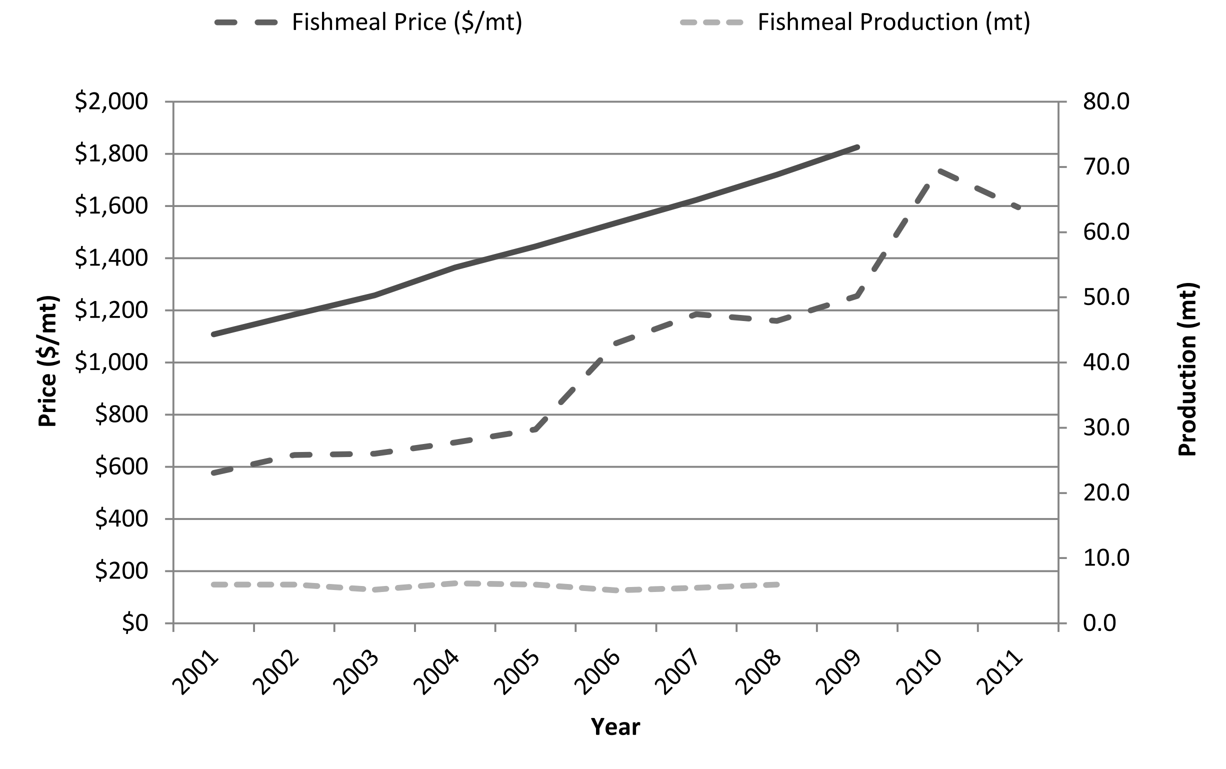
From an ecosystem prospective, the benefits resulting from commercial exploitation of LTL species will have to be balanced against the full range of benefits these resources provide when considering their total economic value (Hannesson et al. 2009). In terms of ecosystem impacts, more intense use of LTL species for fishmeal and fish oil will incur economic costs associated with the role LTL species play as prey for numerous finfish species targeted by higher trophic level fisheries, as well as economically valuable seabirds and marine mammals.

Figure A4. Landings of herrings, sardines, anchovies and selected California Current Ecosystem low trophic level (LTL) species, 1981-2009.



Sources: FAO Statistics and Information Service of the Fisheries and Aquaculture Department. 2011. Capture production 1950-2009. FISHSTAT Plus - Universal software for fishery statistical time series [online or CD-ROM]. Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/fishery/statistics/software/fishstat/en; PacFIN Management Database.

Figure A5. Global aquaculture production, fishmeal production and fishmeal price, 2001-2011.



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Allowable CCE Fisheries

At its June 2011 meeting, the Council had requested a list of those species outside of FMP, state- or ESA-management that "could be subject to future target fishing." In addition to the question of which species might be subject to future targeting by virtue of their marketability is the question of what fisheries are currently allowed within the West Coast EEZ. Under the MSA at §305(a), the Secretary of Commerce (via NMFS) is required to maintain a list of all fisheries and fishing gear under the authority of each Council. No person or vessel is permitted to "employ fishing gear or engage in a fishery not included on such list without giving 90 days advance written notice to the appropriate Council…" With these provisions, the list of fisheries essentially prohibits new fisheries from developing without some sort of alert to the appropriate Council. Fisheries not on the list are not prohibited altogether, but Councils may use the 90-day period to comment on, develop a regulatory plan for, or prohibit the proposed fishery as appropriate.

The MSA requirement for a federal list of allowable fisheries is found in Federal regulations at 50 CFR 600.725(v). This list was implemented in 1999 and, at least for the West Coast EEZ, has not been amended since. The list of fisheries within the Pacific Council's jurisdiction is fairly liberal, naming not only those fisheries that were in place at the list's creation, but also providing generally for unspecified recreational fisheries (spear, trap, handline, pot, hook and line, rod and reel, hand harvest gears) and unspecified commercial fisheries (trawl, gillnet, hook and line, longline, handline, rod and reel, bandit gear, cast net, spear). The list does not supersede any other federal, state, or tribal regulations that otherwise prohibit or constrain participation in any of the fisheries on the list.

The list of authorized fisheries and gears for the West Coast EEZ is clearly in need of updating, since it does not reflect the changes from the Northern Anchovy FMP to the CPS FMP, nor the development of the HMS FMP. If the Council ultimately seeks to protect unfished species from becoming the subject of as-yet-unformed fisheries, it could do so by more actively managing its federal list of allowable fisheries, requesting that the Secretary update the list so that it is less open-ended in the types of fisheries permitted.

For this report, the EPDT focused on the federal list of fisheries. For future iterations of this report, if the Council so desires, the EPDT could also provide information on laws and processes for emerging fisheries within the state waters of Washington, Oregon, and California. These fisheries and gear are currently authorized under 50 CFR 600.725(v) for the U.S. West Coast EEZ (3-200 nm off the coasts of Washington, Oregon, and California).

Table A2: Authorized West Coast EEZ Fisheries and Gear	
Fishery	**Authorized gear types**
1. Washington, Oregon, and California Salmon Fisheries (FMP):	
A. Salmon set gillnet fishery	A. Gillnet
B. Salmon hook and line fishery	B. Hook and line
C. Trawl fishery	C. Trawl
D. Recreational fishery	D. Rod and reel
2. West Coast Groundfish Fisheries (FMP):	
A. Pacific coast groundfish trawl fishery	A. Trawl
B. Set gillnet fishery	B. Gillnet
C. Groundfish longline and setline fishery	C. Longline
D. Groundfish handline and hook-and-line fishery	D. Handline, hook-and-line
E. Groundfish pot and trap fishery	E. Pot, trap
F. Recreational fishery	F. Rod and reel, handline, spear, hook-and-line
3. Northern Anchovy Fishery (FMP)	**Purse seine, lampara net**
4. Angel Shark, White Croaker, California Halibut, White Sea Bass, Pacific Mackerel Large-Mesh Set Net Fishery (Non-FMP)	**Gillnet**
5. Thresher Shark and Swordfish Drift Gillnet Fishery (Non-FMP)	**Gillnet**
6. Pacific Shrimp and Prawn Fishery (Non-FMP):	
A. Pot and trap fishery	A. Pot, trap
B. Trawl fishery	B. Trawl
7. Lobster and Rock Crab Pot and Trap Fishery (Non-FMP)	**Pot, trap**
8. Pacific Halibut Fishery (Non-FMP):	
A. Longline and setline fishery	Longline
B. Hook-and-line fishery	Hook-and-line
9. California Halibut Trawl and Trammel Net Fishery	**Trawl, trammel net**
10. Shark and Bonito Longline and Setline Fishery (Non-FMP)	**Longline**
11. Dungeness Crab Pot and Trap Fishery (Non-FMP)	**Pot, trap**
12. Hagfish Pot and Trap Fishery (Non-FMP)	**Pot, trap**
13. Pacific Albacore and Other Tuna Hook-and-line Fishery (Non-FMP)	**Hook and line**
14. Pacific Swordfish Harpoon Fishery (Non-FMP)	**Harpoon**
15. Pacific Scallop Dredge Fishery (Non-FMP)	**Dredge**
16. Pacific Yellowfin, Skipjack Tuna, Purse	**Purse seine**

Table A2: Authorized West Coast EEZ Fisheries and Gear	
Fishery	**Authorized gear types**
Seine Fishery (Non-FMP)	
17. Market Squid Fishery (Non-FMP)	**Purse seine, dip net**
18. Pacific Sardine, Pacific Mackerel, Pacific Saury, Pacific Bonito, and Jack Mackerel Purse Seine Fishery (Non-FMP)	**Purse seine**
19. Finfish and Shellfish Live Trap, Hook-and-line, and Handline Fishery (Non-FMP)	**Trap, handline, hook and line**
20. Recreational Fishery (Non-FMP)	**Spear, trap, handline, pot, hook and line, rod and reel, hand harvest**
21. Commercial Fishery (Non-FMP)	**Trawl, gillnet, hook and line, longline, handline, rod and reel, bandit gear, cast net, spear**

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