Mr. Phil Anderson, Chair
And Members of the Pacific Fishery Management Council

Dear Mr. Anderson and Council Members,

Please consider the following comments and recommendations on:

NOAA Fisheries Ecosystem-Based Fishery Management Western Road Map Implementation Plan (WRIP) PUBLIC REVIEW DRAFT

Richard H. Parrish
August 7, 2018

Overview:

The Western Road Map Implementation Plan (WRIP) for ecosystem-based management contains very little information on the population biology, species interactions or environmental forcing associated with variations in the California Current Ecosystem. For example, the only environmental relationship mentioned in the WRIP is the unreferenced comment on the "particular sensitivity of California sea lions to changing temperatures".

The Draft contains no references to the several ecosystem models that have been developed for the California Current or to comparison of ecosystem model results between ecosystem models for different ecosystems. Essentially there are no ecosystem model results applicable to the management of fisheries in the WRIP. The present plan is like a Google map with the road function turned off.

In this regard, Olsen et al (2018[1]), published a very recent evaluation of the effects of fishing on ocean ecosystems, using a number of Atlantis ecosystem models from around the world. Their analysis, which includes the California Current Atlantis Model, suggests that doubling the fisheries on small pelagic fishes will have minimal direct impacts on ecosystems; "negative effects were primarily limited to a few predator groups rather than extending throughout the food web". "Losers within the pelagic-fish guild (lower quartile) declined by 6%, and declines in this lower quartile for mammals, birds, sharks and demersal fish were also only 1–4%."

The draft WRIP states "*Living marine resource management should consider best available ecosystem science in decision-making processes (within our legal and policy frameworks)*"
The authors apparently understand that there may be extensive legal and policy limitations that will prevent the use of the "best available ecosystem science". Therefore, it is important that the WRIP process should include a section that documents what can and cannot be done within the present legal framework as distinguished from what can and

[1] *Ocean Futures Under Ocean Acidification, Marine Protection, and Changing Fishing Pressures Explored Using a Worldwide Suite of Ecosystem Models*. Frontiers in Marine Science Volume 5 | Article 64 www.frontiersin.org 1 March 2018 |

cannot be done within the present policy framework. Clearly it is easier to modify policy decisions than legal requirements.

Summary of Recommendations:

A review of the legal and policy measures that limit possible ecosystem-based management of protected species should be made early in the planning process.

A review of the current management regulations that could be considered ecosystem-based management should be made early in the planning process.

Current ecosystem-based management regulations should be examined to see if they are based on the best available science before any further ecosystem-based management regulations are enacted.

If current ecosystem-based regulations are found not to be based on the best available science, work on correcting these regulations should have higher priority than new ecosystem-based regulations.

Ecosystem-based management differs from most previous management in that it will require input from multiple advisory committees. Ground rules for cooperative work between the advisory committees need to be established.

It is likely that protected species regulations and policies will severely limit the types of ecosystem-based management that are possible. If this is in fact the case, the development of an analysis of the types of ecosystem-based management that are both legal and desirable would be an efficient use of the Ad Hoc Ecosystem Workgroup.

There is essentially no ecosystem information in the WRIP. An analysis of the available California Current ecosystem models and comparisons between ecosystem models for different marine ecosystems needs to be undertaken.

Natural climatic variability at ENSO and decadal time scales as well as global climate change should be an important part of ecosystem-based management. For example, the expansion of the tropical anchovies and herrings into Southern California is one of the most likely early indications of major changes in the California Current ecosystem due to global warming. (It should be noted that current management policy prohibits new target fisheries on these stocks, which also stifles adaptation to mitigate the impacts of climate change on fisheries.)

***Ecosystem-based Management vs. Ecosystem Management*:**

It appears that there is a consensus that we do not yet know how to do ecosystem management of the California Current or other large marine ecosystems. This is why there is an attempt to do ecosystem-based management. The distinctions between these two types of management are not well documented or described in the WRIP draft. Simply stated, ecosystem management involves management by trophic level, habitat and/or species groups.

Managing small epi-pelagic nekton with a total annual quota for the entire group of species, with or without individual species quotas, would be an example of ecosystem management. The establishment of a network of marine protected areas that contains a significant proportion of the nearshore, hard bottom habitat, as accomplished in California, is another example of ecosystem management. Curtailing the anchovy fishery because it was thought that California sea lion pups were undernourished, or that such reduction would increase the landings in the salmon fishery, are examples of ecosystem-based management.

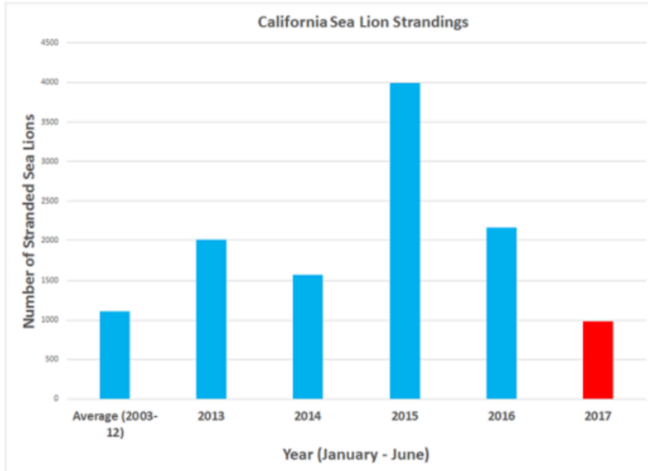
Fishery management to achieve an optimum ecosystem state could be considered ecosystem management. Fishery management to achieve an optimum state of an individual species or species group would be considered ecosystem-based management.

Everyone will not agree with the above definition, thus it is important that the Council explain what ecosystem-based management policies are being considered. In my opinion, the WRIP Draft does an excellent job of showing the types of information and analyses that will be necessary before ecosystem-based management should be attempted.

***Examples of potential ecosystem-based management*:**

The Council has been repeatedly asked to alter the management of the central stock of northern anchovy and the northern stock of the California sardine in response to the greatly increased strandings of California sea lion pups that occurred in 2015. In hindsight, this extreme event clearly shows the futility of attempting to manage a complex ecosystem based on extreme events, no matter how politically charged! The strandings in 2015 were about four times that of the 2003-12 average, but by 2017 the strandings had declined to below the 2003-12 average strandings [2] (Figure 1). If the Council had acted to alter management of the anchovy fishery, it is likely that the change would not have occurred until 2017, when strandings fell below the long-term average.

2 https://www.fisheries.noaa.gov/national/marine-life-distress/2013-2017-california-sea-lion-unusual-mortality-event-california



Comparison of monthly strandings for California sea lion pups and yearlings in 2013-2017 versus the average stranding rate (2003-2012).

Figure 1. Strandings of California sea lion pups in Southern California[1].

California Sardine:

The original California sardine fishery occurred in association with a population outbreak of the northern stock that occurred in the late 1920s, and the age 2+ biomass peaked at just over 3.6 MMT in 1934 (Figure 53). The second observed population increase occurred in the 1990s (Figures 53 and 34) and the age 1+ biomass exceeded 1.7 MMT in 1999 and 2006, based on the maximum model estimates; minimum estimates were about half the maximum estimates.

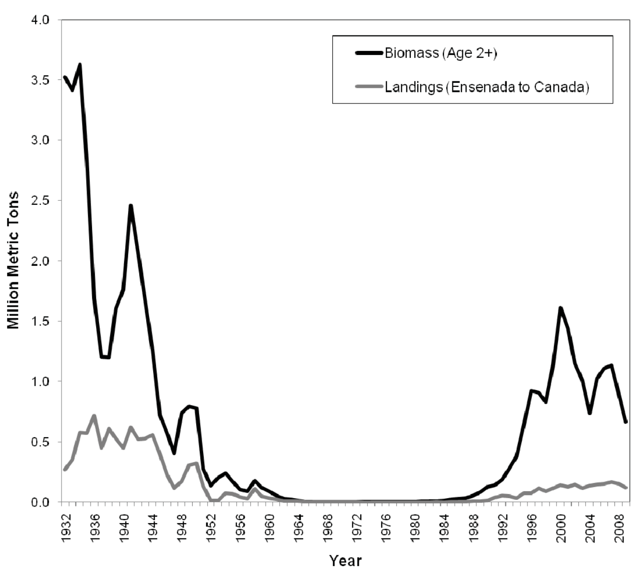


Figure 53. Historic sardine biomass (age 2+) from Murphy and the base model (from 2009 sardine stock assessment, October 14, 2009).

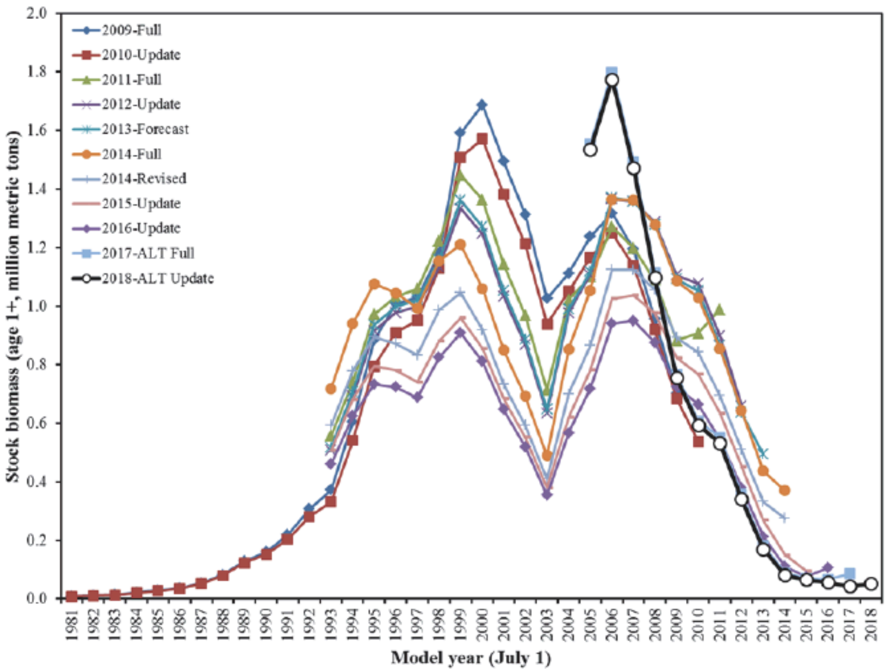


Figure 34. Estimated stock biomass (age 1+ fish), time series for ALT and past assessment model used for management. (From 2018 draft sardine stock assessment, March 6, 2018).

California Sea Lion:

The population size of the California sea lion in the Southern California breeding colonies (Table 1) during the 1920s sardine outbreak was only one percent of that at the 2006 peak of the second sardine outbreak (Parrish, 2018)[3]. Presently there are an estimated additional 105,000 California sea lions that breed on the Pacific side of Baja California; many of them spend most of the year feeding in US waters. There are also breeding colonies in the Gulf of California. The Southern California breeding colonies rebounded to their carrying capacity of about 280,000 in 2008 and reached a maximum of about 306,000 in 2012 before declining as ocean conditions changed (NOAA Fisheries, 2018[4]), which adds an additional twist to potential management actions.

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[3] Parrish, R.H. Management of the Northern Anchovy in US Waters. PFMC Agenda Item C.4.b, Public Comment, April 2018.

[4] NOAA Fisheries. https://www.fisheries.noaa.gov/feature-story/california-sea-lion-population-rebounded-new-highs

Table 1. California Sea Lion Population Trends. Pup counts multiplied by 4.317, CDF&G survey counts multiplied by 1.935 (Carretta et al 2013) and forage based on 4.563 mt per sea lion. (Survey and pup counts from Bonnot 1928, Cass 1946, Carretta et al. 2013. Baja estimates from Lowry and Maravilla-Chavez 2005. US carrying capacity from press releases)

	Pup counts	Survey counts	Population estimates	Forage Consumption mt	Annual Growth
USA					
1928	-	1,429	2,800	13,000	9.3%
1938	-	3,882	7,500	34,000	8.6%
1946	-	7,338	14,000	64,000	6.8%
1975	12,000	-	52,000	237,000	5.8%
2000	49,000	-	212,000	967,000	4.3%
2008	68,740	-	297,000	1,355,000	2.3%
Carrying Capacity			275,000	1,255,000	
Baja California (Pacific Coast)					
2000			81,000	369,000	
2018 Projection					
US Carrying Capacity			275,000	1,255,000	
Baja California [a]			105,000	479,000	
TOTAL in 2018			**380,000**	**1,734,000**	

[a] 2018 Baja Estimate = 2000 Baja estimate * US carrying capacity / US 2000 population estimate.

California sea lions consume a huge amount of forage in the California Current, presently about 1.7 MMT (Table 1). This is essentially equal to the maximum northern stock biomass estimated since the end of WWII (Table 1, Figure 53 and 34). In contrast, 2017 landings [5] of anchovy in California were 5,408.8 mt and US landings of sardine were 524.3 mt (2018 Stock Assessment). (The directed Pacific sardine fishery was closed coastwide according to provisions of the harvest control rule.)

Clearly both ecosystem and ecosystem-based management must progress beyond using management models based on steady-state or average population levels. Population parameters and mean virgin biomass levels determined by stock-recruitment models derived in these models will be biased if used as the basis of environmental-dependent models. For example, tuning an ecosystem model to have an unfished sardine biomass based on that observed in the peak of the original fishery in the 1930s will result in an overly-optimistic estimate of unfished biomass due to the near absence of many marine mammal species and low abundance of many marine birds at that time.

Equally clearly, the legal and policy limitations involved in management of the large number of protected species that have populations ranging from carrying capacity to threatened levels need to be evaluated to determine possible management of the high trophic level animals that dominate the fauna that have protected status.

Discussion:

[5] CDFW Table 15 - Poundage And Value Of Landings Of Commercial Fish Into California By Area - 2017

This brings us to the subject that has been largely missing from the forage fish vs. protected species ecosystem-based management controversy. Should management treat protected species that are near carrying capacity the same as it does protected species that have large healthy populations and are well below carrying capacity? How should management of threatened species differ from protected species that have healthy populations? Should guidelines be established to classify the status of protected species and should management of protected species be based on their population status?

For example:
Class A – threatened and endangered species.
Class B – species with populations needing rebuilding (biomass < 40% of carrying capacity)
Class C - species below carrying capacity (biomass < 75% and >40% of carrying capacity)
Class D - species at or near carrying capacity (biomass >75% of carrying capacity)

The expected symptoms of a population of animals near carrying capacity include reduced reproductive output, decreased growth and survival of young animals, delayed sexual maturity, increases in disease or parasites and decreased size and survival of adults. There have been recent increases in California sea lion pup mortality and reduced pup growth rates, as well as increased incidence of leptospirosis observed in central California and Oregon, leading to the suggestion that the population is approaching carrying capacity (McClatchie et al. 2016). Is a population under stress from being close to or above present carrying capacity as "healthy" as a population at 66% of carrying capacity and not under density-dependent stress?

Certainly anyone familiar with the California Current Ecosystem and its fisheries is aware of the detrimental effects of El Niño events on short lived animals, as well as the regime-scale, climatic-dependence of sardine and anchovy populations. Clearly environmental variation causes large inter-annual and decadal changes in the carrying capacity of the California Current for market squid, sardine and anchovy, as well as other key forage species and the animals that prey on them. Optimum ecosystem-based management policies should include variation in management designed with the observed climatic variations in mind, and they should also allow for both detrimental and favorable effects of global climatic change. The Magnuson Act actually mandates achieving a balance:
National Standard 1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the U.S. fishing industry.

Considering the example of management of small pelagic "forage" fisheries in an ecosystem-based context presents a conundrum:

1. Apparently, it was OK to allow fisheries for small pelagic fishes while populations of protected species were rebuilding; but now that some of them are at or approaching carrying capacity, should we curtail the commercial fisheries in hopes of preventing the undesirable features of a population at carrying capacity?
2. What causes a greater problem for struggling protected species such as the threatened marbled murrelet: an anchovy fishery with average annual landings of

less than 10,000 mt or a California sea lion population that annually consumes 1-2 million tons of forage species?

3. Will future resource management involve limiting the size of the populations of abundant protected species or will it create a number of sacred cow populations limited only by starvation?

The concluding issue is one that has had very little analysis; that is, the forlorn hope that closing fisheries for key forage fishes will significantly benefit protected species with very low population levels. For example, the marbled murrelet is listed as a threatened species and northern anchovy is one of its important prey, comprising 18.4% of its total diet (Koehn et al 2016).

If the U.S. fishery for anchovy were closed, how much additional forage would be eaten by the threatened marbled murrelet?

The Koehn et al. (2016) ecosystem analyses provide information that allows this to be calculated. The 2000-14 average U.S. anchovy fishery landings were 8,095 mt and the average 2000-14 take of northern anchovy by fishes, mammals and birds was 1,318,094 mt. These values include both the northern and central stocks of northern anchovy (Table 1). The average marbled murrelet take of forage was 7,653 mt; of which 5,394 mt was key forage fishes and 1,307 mt was anchovy. The natural mortality rate of anchovy during its high abundance regime was estimated to be M=0.8 (Jacobson et al. 1994), giving an annual mortality rate of 55% in the absence of a fishery. Thus, with no fishery an additional 4,452 mt (i.e. 8095*0.55) would have been consumed by fishes, mammals and birds. The marbled murrelet would have increased its consumption of anchovies by 4.4 mt (i.e. 4,452*1,307/1,318,094) and its total consumption of forage would have gone from 7,653 mt to 7657.4 mt.

Closing the U.S. anchovy fishery would have increased the forage taken by marbled murrelet by 0.06% in the year the fishery was closed; and the percentage would be slightly higher in following years.

In conclusion, it is apparent that during the present environmental regime, competition between protected species is far more important than competition between protected species and the U.S. fishery for forage fishes. The present management regulations have resulted in minimal landings. According to the 2018 assessment, west coast sardine landings were 524.3 mt and the California landings[5] of northern anchovy were 5,408.8 mt in 2017. These landings are only 0.07% of the total annual take of the key forage fishes by fishes, mammals and birds (8,596, 606 mt : Table 1 in Parrish [7])

[6] Koehn et al 2016, Developing a high taxonomic resolution food web model to assess the functional role of forage fish in the California Current Ecosystem. Ecological Modelling, 335: 87–100.

[7] Parrish, R.H. Perspectives on Forage Fishes and Protected Species Ecosystem-based Management (Agenda Item G.2.b, September 2018, Public Comment)