An internal review of

Trites, A.W., R. Flinn, R. Joy, and B. Battaile. 2010. Was the decline of Steller sea lions in the Aleutian Islands from 2000 to 2009 related to the Atka mackerel fishery? University of British Columbia Fisheries Centre Working Paper 2010-10.

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General Comments:

Trites et al. (2010) report on a set of analyses that attempt to relate Steller sea lion counts (and annual changes in counts) to various metrics of Atka mackerel fishing activity and density in the Aleutians, with the ultimate goal of making inferences about whether observed declines in sea lions are related to Atka mackerel fishing. This analysis is complicated by a number of factors, including numerous 'no trawl' areas throughout the study area, as well as difficulties with calculating a reasonable mackerel relative abundance metric. Nevertheless, the authors attempt to use a generalized estimating equations modeling framework to relate sea lion counts (or changes in counts) to Atka mackerel fishing activity. Since none of the slope parameters in their models were negative, they suggest that causes other than Atka mackerel fishing (e.g., increased predation) are likely responsible Steller for sea lion declines.

To my mind, Trites et al.'s analyses are insufficient to make inferences about the importance of Atka mackerel fishing to Steller sea lion declines. There are several issues, including: (1) lack of randomization in allocating treatments to experimental units, (2) potentially inappropriate independent variables, and (3) an inappropriate dependent variable. I describe each of these issues in further detail below.

(1) Lack of randomization when allocating of 'experimental' treatments

Under a "prey depletion hypothesis," it should ultimately be mackerel biomass (or density) in a given area that is in some way related to Steller sea lion demography (e.g., survival, fecundity, carrying capacity). Thus, if one were able to measure and/or manipulate prey densities across the Steller sea lion range, it would potentially make for a good test of whether sea lion abundance is dependent on mackerel. The problem with the present study is that fishers will generally seek to maximize economic gain by going to places where there tend to be more fish (subject to other constraints such as distance from port, weather, etc.). Under such a scenario, treatments (fishing levels) are inextricably correlated with the values of prey density at different geographical areas. This can lead to serious problems in interpretation; for instance, one could just as easily point to Trites' et al.'s significantly positive slope parameters as providing evidence that Steller sea lion counts are positively related to mackerel abundance (the authors interpretation is reversed).

(2) Inappropriate independent variables
The lack of randomization seriously calls into question using the number of hauls or total amount of fish caught as dependent variables, at least in the ways they are being interpreted. If fishing vessels are targeting areas with more fish, a possible expectation is that fishing should be positively related to increases in sea lion abundance. This is not to suggest that fishing causes increases in abundance, but merely that "more mackerel" results in increased Steller sea lion numbers, and that fishing activity is correlated with "more mackerel."

Catch-per-unit-effort (CPUE) is a better proxy for fish abundance/density at different sites; however, the authors note problems with determining CPUE from available commercial fishery records because of "short-netting." Instead, they use catch-per-haul values as a proxy for mackerel relative abundance. I'm unfamiliar enough with Atka mackerel fishing to know if this is a reasonable assumption, but given that it's a trawl fishery I expect that the average catch-per-haul is hyperstable in relation to relative abundance (i.e., fishers will tend to only deploy nets when reasonably sure of catching fish, so that this metric does not scale linearly with true relative abundance/density). Fishery independent (research) trawl surveys would be much more useful in indexing relative mackerel abundance.

Although conducting a set of analyses in which the annual change in abundance at a rookery or haulout was the dependent variable made reasonable sense to me, I was perplexed about why the authors conducted such analyses with annual changes in fishing activity as dependent variables. The hypothesis that sea lion abundance may increase or decrease based on the underlying level of mackerel abundance is ostensibly the hypothesis we are trying to test; why would changes in sea lion abundance depend on whether fishing activity (or even relative abundance of mackerel) had increased or decreased? It seems the absolute level is more important. For example, under H_A, an increase from 'very low' to 'low' mackerel relative abundance would still likely result in negative sea lion abundance trends; a decrease in mackerel relative abundance from 'very high' to 'high' would still likely result in positive growth rates.

(3) An inappropriate dependent variable

Absolute abundance is typically a poor choice for dependent variable in these types of modeling exercises because it is inexorably linked to the history of the population in question. For instance, assuming minimal exchange between rookeries, Steller sea lion 'populations' that have historically had higher carrying capacities and/or high vital rates because of wide resource availability will tend to still have higher abundances regardless of present day resource depletion, because it takes time for depressed vital rates to change abundance substantially. Ideally, we would be able to model the vital rates themselves to test the effects of varying prey densities; however, in absence of such detailed data it makes the most sense to model annual changes in abundance at each rookery (as the authors have done in the second part of their modeling efforts, albeit with somewhat nonsensical independent variables).

Final thoughts

Whilst the present analyses of Trites et al. appear deficient for relating Steller sea lion decline to prey densities, this is not to suggest that it is not a legitimate hypothesis worth examining in further detail (e.g., with additional analyses or studies). For instance, recent stock assessments have indicated an overall increase in Atka mackerel biomass since 1977 (with several boom and bust cycles; see, e.g., http://www.afsc.noaa.gov/REFM/docs/2010/BSAIatka.pdf). At first glance, it would seem that there is no strong coupling between population trends of Steller sea lions and Atka mackerel. However, a general "prey depletion" hypothesis would better be cast in terms of total prey biomass/density rather than using that of a single species. Examination of stock assessment reports or fishery independent trawl data from research surveys may be useful in this regard. Studies relating sea lion vital rates (fecundity, survival) to underlying prey densities would provide even more information, albeit at higher cost.

Specific Comments:

- Use of an exchangeable correlation structure may make dealing with unbalanced data easier, but probably doesn't do a good job at capturing the empirical covariance structure. Given that we are dealing with a time series of counts, AR-type models would likely make more sense. I believe it is possible to construct customized working correlation matrices in SAS's PROC GENMOD so that one could handle missing/irregularly spaced data and a temporally dependent correlation structure at the same time. I'm not sure what effect (if any) using an exchangeable structure would have on estimators or their standard errors, but this may be worth looking into.
- Spatial dependence will not be accounted for when using a generalized estimating equations framework. The anticipated effect of this type of unmodeled overdispersion is that standard errors will be underestimated (i.e., p-values will tend to give 'significant' results more than they should).
- Lags in the effect of reduced prey densities on annual changes in sea lion counts should also be contemplated. It may take several years of consistently poor prey abundance to alter recruitment or survival. For instance, under the "prey depletion hypothesis" reduced prey density would most likely have the greatest effect on recruitment – namely fecundity and pup survival - and may require a lag to manifest itself.