Drakes Estero Panel Member's Report
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7 June 2010

1) For context, what short- and long-term effects might disturbance in Drake's Estero have on individual harbor seals, the Drake's Estero harbor seal population, the broader regional population, and harbor seal habitat? Please address the potential for disturbance from human presence and activity, as well as the potential for disturbance of habitat from the presence of oyster bags and other materials related to mariculture.

Individual harbor seals: Short-term effects of disturbance on individual harbor seals from human presence and activity in Drake's Estero should be limited to minor increases in energetic expenditure and stress responses due to increased vigilance and evasive behaviors, and increased time in the water. There seem to be sufficient choices for alternative haul-out sites in the estero, allowing displaced seals to haul out elsewhere if the need is great enough during that tide cycle. Whether these short-term effects can accumulate into long-term effects on survival and reproduction, should depend upon the individual's long-term foraging success and nutritional status; unless conditions are relatively poor such that the individual has no margin to recoup small energetic losses from disturbance, there should be no significant long-term effects on probabilities of survival or reproduction. These opinions are based on the assumption that the disturbance regime is not one of frequent (i.e., daily or multiple times per day) chronic disturbance. Under chronic and frequent disturbance, which is apparently not occurring under the current management regime, there would be strong potential for individuals to relocate to other sites in the region. The implications for a seal's energy budget, survival, and reproduction from such a change in preferred haul-out locale are unknown.

Drake's Estero harbor seal population: Population effects result from aggregated effects on individuals. If the assessment above is correct about effects on individuals being minor under the current disturbance regime, both short-term and long-term population effects should also be minor. It is worth being clear, however, about what is meant by the "Drake's Estero population." Harbor seal demography and spatial distribution should be viewed in a seasonal context. If harbor seals in central California follow similar patterns to those described elsewhere, it is likely that relatively discrete populations exist primarily during the reproductive period of May-June, perhaps extending into the summer pelage molt period. Harbor seals tend to have a high degree of fidelity to their breeding sites and, to a lesser extent, their molting sites. Outside of those periods, when seals are not constrained by reproduction and molting, seals range more widely and use more sites, presumably in response to patterns in prey availability. From late summer to early spring, therefore, haul-out groups are likely to comprise mixtures of individuals associated with different breeding groups from around the region. Thus, any population effects due to disturbance in Drakes Estero might be expected to be stronger if they occur in May-July than if they occur at other times of year because a larger portion of the disturbed seals would be from the Drakes Estero breeding population. By the same token, impacts of disturbance in the estero outside of the breeding & molting period might be expected to accrue partly to other populations in the region.

Broader regional harbor seal population: A prolonged period of intensive disturbance in Drakes Estero alone, sufficient to significantly reduce harbor seal survival and reproduction, would probably result in a strong divergence of the Drakes Estero population trend from the regional population trend. Disturbance of that magnitude would likely increase emigration to, and decrease immigration from, nearby sites. The combination of all these changes to vital rates would decrease seal numbers in Drakes Estero and increase numbers at nearby sites, creating a strong divergence in trends. However, the current disturbance regime does not appear to be intense enough to elicit these regional effects.

Modification or degradation of harbor seal habitat: Oyster bags and other mariculture materials should not be placed on currently or recently used haul-out sites. Assuming that is not done, there should be no significant direct effects on individuals from the presence of mariculture materials in the areas currently being used. The dynamic shore and bottom processes in the Estero can be expected to continue modifying the spatial arrangement of sites preferred by harbor seals. As the bathymetry and shorelines change in the future, it will be difficult to assess whether areas in current use for mariculture would become preferred sites for seals in the absence of the mariculture materials. A progressive and adaptive management approach would include some effort to detect or predict where mariculture activities and materials might preclude seals from establishing new preferred haul-out sites. Potential indicators might include seals frequently milling over a mariculture site during falling tides, or new channel scouring and deepening near mariculture sites that previously have been along channels that are too shallow for seals at low tides.

Based on a review of the background materials, I believe that the existence of second-order effects of mariculture on harbor seal habitat—such as modification of community structure that could impact seal prey—is equivocal. In any case, I wouldn't expect such effects to be particularly strong, given the history of coexistence of the seals with the oyster farm, and the likelihood that a substantial portion of seal foraging takes place outside the estero.

Summary: The population of harbor seals in Drakes Estero is currently healthy and likely to be resilient to moderate variations in disturbance regimes along the lines of what has been experienced under the current protective measures. There is sufficient evidence to suggest that the potential for population effects from disturbance, especially mariculture disturbance, is real. Under an active program of monitoring the scenario, and a willingness of the parties to adjust practices in response to seal declines that are out of step with regional trends, I would expect the seal population to recover easily from modest periods (say, up to 5 years) in which the level of disturbance impacts rise to significance. I don't think the mariculture operation is incompatible with an objective of having a healthy population of harbor seals in Drakes Estero. Obviously, if there are more stringent objectives for the seal population, such as the absence or near absence of human-caused disturbance, then the oyster farm and perhaps other forms of human presence in the estero may not be compatible uses. These scenarios were outside the sphere of consideration by this panel.

2) The National Park Service has used two sources of information to characterize disturbance.

a) The first pertains to disturbance data collected by volunteers and Park scientists from the observation point overlooking the estero. The data were collected as an adjunct to population monitoring conducted according to the National Park Service Pinniped Monitoring Protocol. The disturbance data were collected to "Determine the long-term trends in sources, frequency and level of effects of natural and anthropogenic disturbances on harbor seal haul out use and productivity" (Adams et al. 2009, p. 31). The data were used in Becker et al. (2009) to test for a relationship between mariculture productivity and harbor seal disturbance rate. Is this disturbance dataset suitable for assessing human/harbor seal interactions? That is, is it sufficient to characterize the rate and degree of disturbance by all sources and to determine the effects of that disturbance over time?

The disturbance data set is likely to be suitable for assessing human and harbor seal interactions, but only over the very long term and perhaps only for disturbance in the aggregate, not for the rate, degree, and effect of disturbance by particular sources. The mode of collecting disturbance observations incidentally to the seal surveys seems rather susceptible to bias from confounding of patterns in the timing of the surveys, with patterns in timing of the various sources of disturbance (i.e., the surveys are non-random samples). There is also reasonable doubt about whether the relation between harvest productivity and disturbance by mariculture activities has been similar under the two operators (Johnson and Lunny) of the oyster farm. As discussed during the panel meeting, the rate of disturbance relative to oyster production, measured as equivalent weight of shucked oysters, is likely to include variation in the fraction of shucked versus whole oysters that are sold, because there is more potential for seal disturbance in the production of whole oysters, which are tended in bags near important seal haul-out sites. The fraction of whole versus shucked oysters produced has varied substantially, at least during the period that Lunny has operated the farm. Over a sufficiently long period, say several decades, these kinds of variability may eventually be overwhelmed by 'signal', but the time series available now seems too short for conclusive comparisons.

In Becker et al. (2009), the disturbance data were compared with oyster harvest data by Spearman rank correlation, and a modest positive correlation (0.55) was found. The authors demonstrated that the correlation was robust to exclusion of several data points, including some that have been disputed, and reported that the observed rank correlation was statistically significant. However, the significance was based on a one-tailed test, which admits only a positive correlation as the alternative to the null. I don't see an *a priori* reason for restricting this test to the upper tail. Usually this is done when there is some structural characteristic of the data process that would lead only to one of the two possible alternative hypotheses, and this doesn't seem to describe the present case. The correlation would not be significant in a two-tailed test

at the 0.05 level, though that is not necessarily the appropriate level for testing in this situation (a larger value may help to balance risks of over- versus under-protection errors). As a side note, it seems to me that the relationship between oyster production and disturbance rate could have been more fully explored in a logistic regression framework than in the non-parametric correlation analysis. This would allow a test for whether the disturbance rate is itself a function of numbers of seals present. Perhaps this was tested somewhere in the bewildering array of models that were fit in the two Becker papers but, if so, I've lost track of it.

In summary, the existing data are insufficient to determine the effects of the disturbances at the *de facto* standard for confidence in statistical tests (e.g. 95% probability of avoiding an error of falsely concluding that there is an impact). The potential is too great for failures of assumptions and influence of variables that are unidentified and not included in the models. However, this is not the appropriate standard and the burden of proof should not fall too heavily on the managers of a protected resource.

In Becker et al. (2009) and Becker et al. (2010), the relevant data were used to assess the relative explanatory power of a broad range of models based on plausible hypotheses about events and activities that might impact harbor seals. While it is easy enough to point out imperfections in some of the data, and inconsistencies between some of the hypotheses and the actual history of events, it is more difficult to pose other credible hypotheses to explain the patterns in abundance and distribution of seals in the area. To my knowledge, no credible and superior alternatives have been proposed. Using statistical models to account for patterns in numbers of harbor seals on shore is always challenging because there always seems to be a great deal of random or unexplained variation. The present case is no exception, but I think the two papers by Becker et al. are *suggestive* of impacts from mariculture on at least the distribution of harbor seals within the estero. There have been several suggestions for ways to further refine the analyses; if the resources are readily available to do so, refinement of the analyses should probably continue. However, if resources available for addressing the harbor seal issue are scarce, it may be more productive to focus on collaborative and creative efforts to monitor and manage the situation rather than honing the analyses to the finest point possible (given the inherent variability of the data).

If not, how might you improve the Park Service's ability to collect data for the stated purpose?

As a general strategy, methods for collecting useful data on the relationship between mariculture activities and harbor seals in Drakes Estero should be developed and implemented in a collaborative spirit by a team that includes both NPS and DBOC. The sentiments expressed by Kevin Lunny during the panel meeting and site visit indicated to me that he has a sincere interest in operating with little or no impact on harbor seals. If true, that could be the basis for a very productive co-management relationship if it can be done in

such a way that Lunny can trust that the data will be collected and used constructively. [I leave it to others to determine whether there is scope for this kind of relationship within the mandates for management of PRNS and Drakes Estero]. There must be restraint about drawing conclusions prematurely and there must be flexibility and patience on both sides to allow for some adaptive management. This may require some courage, sacrifice, and patience from both sides to let results of different mariculture regimes play out for long enough to ascertain any effects.

More specifically, I think it might be reasonable to ask DBOC to carry passive GPS loggers on their vessels (e.g., http://www.skytrx.com/compare.html model 3100-INT) and to give NPS staff permission to provide/retrieve/replace the devices at suitable intervals for downloading the data. These devices are small and self-contained, and their use should require very little effort, or inconvenience to DBOC. A continuation of the volunteer survey effort, perhaps with a little strengthening of protocols for reliable and consistent documentation of the presence of vessels in DE, would provide incentive for DBOC to help maintain the continuity and integrity of the vessel tracking data. One relatively simple way to document observer presence at a site is to take a photo of a hand-held GPS screen displaying date, time, & lat/lon. Or, take a photo of the site with a camera that logs the GPS data into the photo header. I suspect, though, that the incidence of further disputed data points will decline or vanish on its own if the parties can manage to begin working together, rather than against each other.

If the validity of any single data point is questionable, should it be removed from the dataset, modified to remove/identify only those aspects in question, or retained as is?

Overall, my approach to this topic is guided by a belief that the people involved in this issue are, like everyone, capable of mistakes in observation and recording but they do not fabricate data. The general strategy should be to consider each disputed observation on a case-by-case basis, with the objective of preserving as much of the record as possible while assuring that the disputed aspects of the data will not get included improperly in analyses or database queries. In many cases, this assurance may be obtained by adding new codes to existing database fields, identifying an observation as "disputed". For example, a field for disturbance source that includes levels such as "kayak", "mariculture", "coyote", and "unknown", could be augmented by adding "disputed". A disputed record that formerly had the value "mariculture" would be changed to the value "disputed". Associated comments or notes fields could address the nature of the dispute. This way, other fields containing undisputed aspects of the record, potentially useful for other purposes, can be preserved while ensuring that the record will not be included in an analysis or query of mariculture disturbance.

A hierarchical approach to consideration of disputed data may be helpful: Is there a dispute about whether an observation took place at the stated time & location? If there is evidence that no observation was conducted at that time

and place (as opposed to simple unsubstantiated doubt), then the entire record should be discarded. If not, shift the focus to which aspect(s) of the observation is in dispute? If feasible, address the disputed aspect(s) by recoding as suggested above. Drill down in this way to the minimum chunk of information that must be discarded from each disputed record.

b) The second pertains to implied disturbance by mariculture activities as estimated by annual oyster production and is central to the Becker et al. (2009, 2010) manuscripts that we reviewed for the meeting at Point Reyes National Seashore. Is annual oyster production a reliable proxy for mariculture effort in the estero? Why or why not?

Annual oyster production, measured as equivalent pounds of shucked oysters, is a crude measure of mariculture effort because it does not include potentially significant variations in the portions of effort allocated to racks and to bagged oysters. The placement of bags near seal haul-outs and the activities of tending the bags, are likely to have a higher rate of disturbance than the activities of culturing oysters on the racks, which are mostly farther away from haul-out sites. Becker et al. (2010) attempted to account for this by forming a new (binary) index of disturbance based partly on the presence of bags near haul-out sites. This may just be substituting one form of imprecision in the proxy relationship (lack of detail about shucked/whole) for another (binary representation of a large range of values). In either case, I believe the index will eventually be useful and reliable, but a longer period of time is needed before the signal overwhelms the noise.

Also, is effort data alone a reliable measure of actual or potential disturbance, whether by human activities or habitat alteration (e.g., presence of oyster bags)?

Effort data is an index of actual or potential disturbance, subject to biases and imprecision from variation in disturbance rates that stem from variation in mariculture practices. Whether the effort data is sufficiently reliable depends on the question to be answered and factors such as the length of the time series and the extent of the variations in practices. The numbers and distribution of bags relative to seal haul-out sites should contain useful signal, but there could also to be substantial variation from behavior of the workers during bag placement and tending. Eventually, effort indexes like those used in the two Becker papers are likely to be quite useful. I think it is questionable whether they are yet reliable for detailed quantitative conclusions about mariculture impacts in general or impacts of the Lunny operation in particular.

If not, how might you develop a better measure of mariculture effort and its relationship to the disturbance or displacement of seals in the estero? What factors would you include in such a measure?

c) Volunteers and National Park Service scientists identify disturbances on the basis of head alerts, flushing, and flushing into the water. Are each of these measures suitable for characterizing disturbance? Why or why not?

Actually, none of these measures are very suitable for characterizing disturbance, without reference to the rate at which these behaviors occur in the absence of identifiable disturbance agents. Even in very pristine settings, harbor seals frequently disturb each other in haul-out groups and it is well documented that there are many "natural" sources of disturbance, such as birds, shadows from clouds, etc. Therefore, behaviors such as head alerts and flushing toward but not into the water are part of life in a harbor seal haul-out group; great care should be taken before ascribing significance to these responses in impact studies.

I recommend focusing solely on flushing into the water. This is an unequivocal sign of disturbance (though the source of the disturbance cannot always be determined unequivocally). The other behaviors are more easily missed by observers who have several tasks to which they must devote their attention, and therefore I don't expect that those behaviors get recorded as consistently. Moreover, flushing into the water has clear potential for energetic consequences that could be significant; the other behaviors seem to me to be much less likely to rise to the level of energetic and demographic significance (Jansen et al. 2010. Reaction of harbor seals to cruise ships. Journal of Wildlife Management 74(6):000–000; 2010; DOI: 10.2193/2008-192).

3) Management measures for Drake's Estero are based on a suite of laws and agreements that establish pertinent authorities and identify purposes deemed suitable for the estero. The existing management measures are composed largely of temporal and spatial measures that are based primarily on areas where the seals haul out and that dictate when and where certain activities can occur. For example, management measures prohibit powerboats in the estero year-round, except boats used for mariculture. They also prohibit non-powerboats (e.g., kayaks, canoes) in the estero from 1 March through 30 June. The 1992 Record of Agreement Regarding Drake's Estero Oyster Farming and Harbor Seal Protection has provided an important supplement to those management measures pertaining to mariculture[1]. The agreement prohibits mariculture workers from using the main channel from 15 March through 30 June, except for weekly collection of water quality samples. It also prohibits mariculture workers from using the lateral channel between beds #1-2 (presumably now labeled beds 15 and 17) and bed #3 (presumably bed 20) from 15 March to 1 June. In addition, it indicates that mariculture workers should plan, and make every effort, to begin seeding beds #1-3 after 1 June, and the lateral channel should be used as little as possible between 1 and 30 June. Oyster beds #2-3 should be approached from the north at low speed and the beds planted north to south so that "disturbance near the lateral channel will more likely be limited to the end of the pupping season" (language from the agreement). As a temporary matter pending further review, the California Coastal Commission imposed, and

[1] The agreement was signed by the Point Reyes National Seashore, National Marine Fisheries Service, California Department of Fish and Game, California Department of Health Services, and the Johnson Oyster Company. It was not signed by the Drake's Bay Oyster Company or the California Coastal Commission.

the National Park Service Special Use Permit incorporated, a year-round restriction on use of the eastern two-thirds of the lateral channel and specific sand bars where seals haul out. Under current conditions, mariculture workers may use the western one-third of the lateral channel during the period from 1 June through 14 March.

a) Recognizing that the estero is a dynamic environment (although less so away from the mouth of the estero) and that harbor seals may shift their hauling patterns over time, are the temporal and spatial restrictions from the 1992 agreement, the California Coastal Commission, and National Park Service individually or collectively sufficient to avoid disturbance and displacement of harbor seals?

I believe those restrictions are sufficient for the time being. The parties should be alert for changes in channel morphology or seal distribution and behavior that might cause conflicts.

Is the available information sufficient to evaluate the utility of the measures? Is it sufficient to evaluate the utility of the restriction added by the California Coastal Commission? If you consider it to be sufficient, please describe the basis for your conclusion. If you do not consider it to be sufficient, please describe why not and what additional information would be helpful.

Evaluating the utility of a specific measure is subject to many of the same difficulties as evaluating the impact of a specific type of disturbance. It appears that seal numbers in the estero have generally increased under these measures, and to that extent the measures seem effective, or at least not woefully ineffective. It certainly makes intuitive sense to minimize or eliminate disturbance during the whelping and nursing periods. I don't see any means of conclusively assessing the effectiveness of the Coastal Commission restriction on its own.

b) The primary spatial limitations pertain to use of the main and lateral channels. Much of the debate regarding use of the lateral channel pertains to the question of whether the existing measures ensure suitable separation between mariculture activities near the western end of the lateral channel and areas along the lateral channel that harbor seals might use, absent any human activity. The debate implicitly involves a null hypothesis that the distance between the two locations is sufficient to avoid disturbance of harbor seals and that the seals do not use the rest of the channel because of other natural factors (e.g., shallowness). The alternative hypothesis is that the distance is not sufficient and is displacing the seals from potential haulout areas along the lateral channel. Is the existing evidence sufficient to discriminate between these two hypotheses? If so, what conclusion(s) can be drawn and what supporting data are available?

I don't think the existing evidence is sufficient to discriminate between these hypotheses. I would note, however, that even if the alternative is true, I doubt that the "displaced" seals are unable to find sufficient habitat within the estero.

Also, what is your best estimate of the separation distance required to avoid harbor seal disturbance on land and in the water? If you don't feel you can answer that question with existing information, how would you go about determining the distance?

It is well known that the distance at which harbor seals are disturbed on land depends on many context-specific factors. The response distance in the region of mariculture-seal interaction in Drakes Estero could probably be determined incidental to daily mariculture activities Something similar to the method used by Jansen et al. (2010) could be adapted; observers would record seal behavior while oyster operations take place at varying distances and the results would be analyzed in a Cox regression type model. I'm not sure, however, of the utility of obtaining a specific number. It might be more productive for NPS to work with DBOC workers to foster a culture of awareness of incidental impacts and motivation to change procedures when disturbances are observed. Work zones where activities are prone to causing disturbance should be closed or replaced in areas farther from the seals.

4) Harbor seals recently shifted their habitat use patterns in the estero. Site A became connected to land, which allowed access by human visitors and coyotes. The seals abandoned site A, presumably because of the threat posed by disturbance or harassment. They likely moved either to other sites in the estero or to neighboring colonies. Their shift in habitat suggests that they prefer isolated sandbars. However, based on the timing of the reconnection of site A to land and the presumed corresponding increase in exposure to disturbance and harassment, it is reasonable to infer that disturbance, or the threat of it, may affect the behavior or habitat use patterns of seals in the estero. In contrast, Becker et al. (2010) did not find that spring (March through May) disturbances (that they referred to as short-term and were relatively infrequent) caused a shift in habitat use by seals using haulout sites isolated from land. How can those apparent differences in response to disturbance be explained?

This difference may simply be due to one or a few disturbance agents that are associated with connection to land but are not present or not strong at isolated sites. Coyotes, of course, are the most obvious possibility, already implicated as a main cause of abandonment of site A after it became attached to land (e.g., Becker et al. 2009). The resulting redistribution of site A seals to other sites in the estero may cause failures of assumptions or masking of effects in regression models for the effects of disturbance; sites receiving the displaced seals will have increased regardless of their disturbance regimes.

5) Based on data that were being collected in late April and early May 2007, the National Park Service concluded that increasing oyster activities, including the placement of additional oyster bags near the OB haulout site, had caused a substantial reduction in the number of seals using that site. The Service originally estimated an 82 percent decline for pups and 77 percent for all seals. It later revised that estimate to 65 percent for pups and 56 percent for

all seals. In hindsight, are the available data on haulout patterns on OB sufficient to form or support the final conclusion? Why or why not?

The data are not sufficient to support the conclusion that a decline was caused by the oyster activities. The period of comparison is too short, and the bulk of the decline seems to have preceded the increase of oyster activities on the sand bars. Nonetheless, the data do demonstrate that there was a decline at OB and there certainly is a reasonable possibility that some or all of it was due to oyster farming. This is the kind of information that should be used to shape an adaptive approach to managing the oyster farm. DBOC should acknowledge that they *may* have had such an impact; NPS should acknowledge that the decline at one site is not a catastrophe for harbor seals in Drakes Estero given typical patterns of variability in numbers. From that position, the two parties should move on to a plan for keeping an eye on the situation and preparing for adjustments in practices if declines become significant (e.g., Drakes Estero declining while regional numbers are stable or increasing). The thresholds for significance of declines may not be easy to determine, but a common-sense and perhaps even somewhat informal approach in which both parties are engaged is probably preferable to a rigid quantitative approach that fails to engender buy-in from DBOC and other stakeholders.

6) At the meeting the panel described the need for a review of Becker et al. (2009) and especially, Becker et al. (2010) by one or more statisticians. The review would start with the available data and then work through the analyses. The primary focus would be on the suitability of the statistical analyses presented in these two papers.

My thinking about the need for an additional statistical review has changed somewhat since the meeting. It may be necessary only if the dialog on this issue continues to focus on formal quantitative assessment of impacts. The statistical challenges are great, the data are marginal for that purpose, and as everyone now knows the stakes are very high (or at least perceived to be very high by many parties). Consequently, if the numbers continue to be used in an adversarial manner rather than to inform a collaborative approach, there should be yet another review, starting with a diagnostic exploration of the data (i.e., sampling properties, any inherent structure that could compromise analysis, evidence of insufficient QA/QC, etc).

In addition to a statistical review, do you have any suggestions for improving the data and analyses included in Becker et al. (2009) and Becker et al. (2010)? For example, should they include other measures or sources of disturbance?

I don't have any suggestions along these lines, except for the possibility that we discussed, of deriving a measure of oyster production based on whole oysters that might better reflect effort in the areas where bags are used and tended.

Would you like to see other alternative hypotheses tested to assess the potential threats to harbor seals in Drake's Estero?

I don't think the data have much power for discriminating between many alternative hypotheses. The current models don't explain enough of the variation to be confident that we have the main covariates in mind or even that the underlying processes are stationary enough to bother trying to model them. Nevertheless, no superior alternatives have been presented, so the results should be taken as suggestive of some impacts on harbor seals, and this should guide the monitoring and management approach going forward.

7) Do you see a need for changes to existing management measures or additional measures to avoid disturbance of harbor seals by all sources (i.e., including kayaking, hiking, etc.)? If so, what new measures or adjustments to old measures do you suggest?

I would recommend a longer period under the present measures, with continued monitoring. I think more time is needed to ascertain whether the present measures and practices are truly impacting the seals. A working group should set some thresholds and agreed measures for adapting to various scenarios of change (possibly including both negative and positive changes from the perspective of seal numbers and distributions). These don't have to be forbiddingly formal.

Do you think an adaptive management approach could be used here to address remaining questions about the effects of disturbance? If so, what high-priority questions would you attempt to address?

Yes, definitely. As indicated above, I think that a collaborative and adaptive approach will be the most productive, and vastly preferable to an adversarial or enforcement approach. One guiding objective might be to ensure that the trend for numbers of seals in Drakes Estero tracks the overall trend for the other sites in the region within some specified bounds, keeping in mind potential confounding factors such as sandbar dynamics in the estero and significant events such as major disturbances at nearby regional sites. This may be too simplistic, but it could be used as a starting point for choice of a suitable management target.

8) What additional scientific questions do you consider important to the assessment of human/harbor seal interactions at Drake's Estero?

It would certainly be nice to know more about dispersal rates among the regional breeding sites, but I don't see any obvious way to get this information without substantial disturbance and cost.

Report to the Marine Mammal Commission's review of harbor seal and human interactions in Drake's Estero, California.

By Sean A. Hayes, PhD
May 17, 2010

1. For context, what short- and long-term effects might disturbance in Drake's Estero have on individual harbor seals, the Drake's Estero harbor seal population, the broader regional population, and harbor seal habitat?

For the purposes of this response and the questions below the concept of disturbance needs to be defined. There are 3 potential definitions by which one might interpret a disturbance. These are:

1. A statistically significant and measureable disturbance in response to an identifiable stimulus.
2. A biologically meaningful level of disturbance that has a negative impact.
3. A culturally and legally acceptable level of disturbance.

For the purposes of this report, I believe it is the preference of the MMC (and my own) to avoid identifying disturbance according to the definition of #3 above, as this definition is likely to have little relationship with that of #1 and #2, and my responses to the questions below will relate primarily to definition #2 above. I also acknowledge that it is difficult to completely separate my scientific opinion from personal values on what is culturally acceptable. Regardless, the thresholds for these are likely to vary between definitions and species and likely even within species across populations. For example, based upon professional experience observing a range of phocid species, Elephant seals (*Mirounga* sp) are the least likely to respond to a potential disturbance from almost any visual or noise stimulus, short of aggressive behavior from an animal of sufficient size/agility to cause physical harm (e.g., human proximity of less than a couple meters or attack by a canine), and any measureable response, short of physical trauma, or separation of mothers and pups (low probability in most harem situations) is unlikely to have biological significance. In contrast, Hawaiian monk seals (*Monachus schauinslandi*) show quantifiable responses to identifiable stimuli at fairly low thresholds, e.g., close approach by human (10s to 100s of meters). Such disturbances, if repeated, may cause animals to abandon haulout sites in favor of less-suitable habitat, place stress on the mother-pup bond, or expose pups to aquatic predation risks (Gerrodette and Gilmartin 1990, Kenyon and Rice 1959). In contrast, harbor seals (*Phoca vitulina*) are hyper vigilant and exhibit disturbance behaviors on a regular basis, often without identifiable stimuli. Where stimuli are identifiable, such disturbances can be statistically quantified quite satisfactorily, however, often at thresholds that have little biological significance. Relative to the other species above, the mother-pup pair bond is quite strong, and the pups are extremely precocial in their development and ability to enter the water on a regular basis. As a result, any disturbance from a new stimulus that has no real threat to the animal will probably be realized by individuals in a population. After the novelty wears off, the animals will ultimately desensitize to the given source. In

the short term, animals may relocate to alternative haulout sites not associated with the disturbance site, but if there is a behavioral preference for the site where disturbance is occurring, they will likely desensitize over a period of months to years. Such events have been observed in places like Elkhorn Slough, Moss Landing, CA, where seal haulouts are often exposed to repeated stimuli from hundreds of kayaks per day, dozens of motor boats and crop dusting helicopters, and at Children's Pool, La Jolla, CA, which has an overhead walkway above the seal haulout with as many as 100,000 visitors per month (http://www.beachcalifornia.com/chilrens-pool-la-jolla.html)

The impacts of human related stimuli in the short term and within the specific region of Drakes Estero are likely to have statistically measurable disturbance responses, ranging from head alerts to flushing into the water to relocating to new haulout habitats. The biological significance of this is very hard to quantify. The general understanding about why harbor seals haul out in given regions is understood, but there are unknown variables in how a group makes its decision to haul out in a particular spot and not 100 m to the left or 1000m to the right on a given beach or sand bar where all variables measureable to scientists appear constant. In either case, a list potential impacts to harbor seals from disturbance could include:

1. Energetic cost to animals for entering cold water during a preferred resting period
2. Potential break in the mother-pup bond if separated
3. Potential for trauma to occur to an animal while running into the water
4. Boat strike if a moving boat is the disturbance source
5. An increase in the possibility of predation by aquatic predators
6. Interference with breeding behaviors

From my own knowledge of the system, most of the items on this list are not likely to occur at a frequency which could have impacts at the broader regional population level. There is some risk of disturbance causing relocation to different sites and potentially more severe impacts to individuals. But in general, they are normal risks and regular components of harbor seal behaviors in almost all populations to which they are well adapted, and the likelihood of items 3-5 occurring is probably very low in the upper Estero. While conjecture on my part, I suspect the risk of shark attack in the upper Estero is quite low. NPS potentially has some data on this? Regarding number 2, I believe there is a fair bit of literature on mother-pup interactions in harbor seals, which I won't review, but the pair bond is quite strong, the pups are very precocious and capable of swimming at birth, so again concerns about occasional disturbances (less than 1 per day perhaps) are not likely to be a biological problem for the species, or they would not be so willing to exhibit disturbance behaviors. This last is a somewhat subjective opinion and others might take a more conservative view on the subject which I would be hard pressed to argue who is more correct. Regarding item 6, harbor seal breeding behaviors are mostly aquatic, and appear to peak during dawn and dusk periods when mariculture activities are at a low level and seals tend to be just returning or departing from the haulout site. In general, it is my opinion that these behaviors are very resilient to disturbance and unlikely to be impacted even by boat noise (Hayes 2002, Hayes et al. 2004a).

2. The National Park Service has used two sources of information to characterize disturbance.

> **a) The first pertains to disturbance data collected by volunteers and Park scientists from the observation point overlooking the Estero. …... Is this disturbance dataset suitable for assessing human/harbor seal interactions? That is, is it sufficient to characterize the rate and degree of disturbance by all sources and to determine the effects of that disturbance over time? If not, how might you improve the Park Service's ability to collect data for the stated purpose? If the validity of any single data point is questionable, should it be removed from the dataset, modified to remove/identify only those aspects in question, or retained as is?**

I have a few concerns and comments about these observational data. The first is that these observations are hard work, require a great deal of effort and NPS has made a tremendous effort to build a rigorous QA/QC'd data base. I have published papers (Hayes et al. 2004b) on similar limited observational data sets so I can sympathize with the authors for wanting to maximize the value of the data. However, I do have concerns with the data collection, or more specifically who collected the data. In theory the data should be collected by someone who is completely indifferent to the fate of harbor seals or the success of the oyster farm so as to avoid any interpretational biases in the observations. This is by no means an implication that data were falsified, but the ability to actually determine the cause of a harbor seal disturbance is very subjective, since often there are multiple potential stimuli present, or worse, none, and it's possible to guess wrong as to the cause. This is compounded by the distance between the upper Estero and the observation site and the narrow field of view available through spotting scopes. It is very likely for even a trained observer to miss a potential cause, and if there are boats in the area, there could be a natural bias to assume that is the source when perhaps the individual seal that started the disturbance simply didn't know there was a pelican standing next to it while it was sleeping and startled when it opened its eyes, ran into the water and the whole group followed. I would presume that most observers likely have a "pro-harbor seal bias" for lack of a more diplomatic term. NPS staff are mandated to protect and conserve natural resources and I can't imagine a volunteer who would stand out in the challenging weather conditions than can occur on that ridge and not care about harbor seals. Since it is unlikely a group of "indifferent" volunteers are likely to appear, or funds to be available to contract unbiased observers, it would seem a reasonable compromise to improve the program would be to try and recruit volunteers who either work for the oyster farm, or are at least favorable to its presence, to partner with current staff.

Regarding the validity of single data points, it is hard to make a solid statement. The arguments regarding these data points and their validity are really more in the area of sociology and I am unfamiliar with what criteria are used for keeping/discarding data in those circumstances. It does seem that some of the issues could be resolved by refining the hypothesis and surrounding assumptions. If NPS is working on testing if boats disturb harbor seals, it may not be possible to assume all boats are oyster mariculture craft.

Drakes Estero, while difficult to access, is not impossible to access- on calm days, boats can cross in from the ocean, and it is even theoretically possible to launch a boat from the oyster farm, having done it twice myself. If NPS wants to specifically test the impacts of mariculture craft, and records show the boat was broken that day, or the observed boat was a different color, than perhaps these data points can not be used. However the scientific process is not a democratic process, so in my mind, the validity of the science can not be maintained if people have a discussion and vote on each data point. Ideally there would be an *a priori* set of rules for utilizing a given dataset that all parties agreed to and then go forward, but the *a priori* issue is lost in this particular situation and I do not have advice on how to reconcile that.

b) The second pertains to implied disturbance by mariculture activities as estimated by annual oyster production and is central to the Becker et al. (2009, 2010) manuscripts that we reviewed for the meeting at Point Reyes National Seashore. Is annual oyster production a reliable proxy for mariculture effort in the Estero? Why or why not? Also, is effort data alone a reliable measure of actual or potential disturbance, whether by human activities or habitat alteration (e.g., presence of oyster bags)? If not, how might you develop a better measure of mariculture effort and its relationship to the disturbance or displacement of seals in the Estero? What factors would you include in such a measure?

I address this to some extent in my answer to question 6 below, but in general I feel others on the panel are more qualified to comment than myself.

c) Volunteers and National Park Service scientists identify disturbances on the basis of head alerts, flushing, and flushing into the water. Are each of these measures suitable for characterizing disturbance? Why or why not?

These behaviors are standard metrics for assessing disturbance. For a reevaluation of the protocols, and insight into the validity of these behaviors I would recommend contacting staff in the NMFS Hawaiian Monk Seal program which have vast amounts of data using similar criteria and extensive experience analyzing it. As above, my greater concern with this is accurately identifying the source of the disturbance.

3. Are current management measures in place for harbor seals in Drakes Estero appropriate?

Until the issues of concern I raised for Becker et al. (2010) in question 6 below are addressed, I am hesitant to suggest that current protections are inadequate for limiting disturbance by mariculture activities at a significant biological level for harbor seals in Drakes Estero. As the Estero currently supports a large population of harbor seals, the management measures currently in place are potentially sufficient. It is not clear at this time if the pending year round restriction to the use of the eastern 2/3's of the lateral

channel will have a significant benefit, beyond protections during the pupping season, and I would again recommend waiting to institute this restriction pending reanalysis of Becker et al. (2010).

It was apparent during the panel meeting that part of the current controversy over the current boundaries recently established by the Coastal Commission was due to lack of understanding about where and when those boundaries were effective. In an effort to address the issue raised in 3a to deal with the dynamic situation of both harbor seal behavior and physical habitat, I would recommend the formation of a technical oversight committee for mariculture operations. Such a group would help clarify communications and have the ability to respond to physical and behavioral changes through adaptive management. Several recommendations for a technical oversight committee would be:

1. There should be representatives from Drakes Bay Oyster Company, DFG, Coastal Commission, and NPS. Although I suspect this would be a fairly balanced group, it might be good to find a neutral moderator whom all parties trust for the initial meetings. I see no value in having representatives from the NGO's present at the meeting as they hold no regulatory authority and the agency representatives are sufficiently educated in the current ecology of the system to make sound scientific judgments.
2. Agencies should instill authority in their representatives to negotiate minor changes to agreements at the meeting, e.g., the ability to change the timing of access to a seasonally restricted area by a couple weeks, or move a boundary line a couple hundred meters, etc. It's my experience these negotiations fail when an agency representative says one thing at a meeting, then goes back to their supervisor and it is overruled or never approved, thus invalidating the purpose of the meeting.
3. This group should meet at least twice a year, possibly quarterly if necessary
4. Any significant conclusions/changes made during the meeting should be written down and reviewed by all parties at the close.
5. Having consistent membership on the committee allows for a small group to exist that can communicate freely by email/phone to respond to unforeseen changes in the Estero between meetings.

Regarding 3b, and the question of whether there is sufficient evidence to address whether the separation between haulout usage by harbor seals on the eastern channel and mariculture activities on the western channel is sufficient, I would say several variables are still in play here. It is likely that the increasing shallowness of the western channel does reduce the preference for use of this habitat by harbor seals. However it is hard to put a number on recommended distance for separation. Harbor seals in Elkhorn Slough will haul out and pup, with regular exposure to motor boats and kayakers, sometimes within 30m, but would not tolerate humans on land that close. Harbor seals in Children's Pool will tolerate standing humans on an overlook, potentially within 30m, although for full disclosure, I have not visited the site and only have seen video footage, so this is a rough estimate. In either case, harbor seals in Drakes Estero, while having some population overlap with Elkhorn Slough (based on anecdotal observations of tagged

animals moving between populations- Allen, S, D. Greig, J. Harvey, S. Hayes, S. Oates) are likely to be more sensitive to disturbance. Experiments could potentially be developed to measure the „disturbance sensitivity threshold' of this population; however there are several unavoidable issues. The first is that the experiments themselves will likely serve to either sensitize or desensitize the seals. The second is that the current sensitivity threshold for this population is itself dynamic and likely to change in response to changes in population size and various sources and rates of disturbance in the Estero. The only solid estimate that can be stated is that some seals in the population are tolerating the mariculture activities at the current level of separation. If reanalysis of Becker et al.(2010) suggests that harbor seal pupping success at this region is in decline in a way that is significantly correlated with mariculture activities, then this distance may not be adequate; conversely, if there is no relationship, this distance may be more than sufficient.

4. Why did harbor seals abandon site A if anthropogenic short term disturbance is not an issue (Becker et al 2010)?

Without exaggeration, this issue truly made my head hurt. My interpretation of Becker et al. (2010) was that they included mariculture activities in their list of anthropogenic disturbances used for the analysis described on pp 10-11, 18-20, and Fig. 3 a,b,c, therefore my understanding is this issue is not one of separating non-mariculture disturbances from mariculture related disturbances. I am not qualified to evaluate their AIC model results. Regardless, their results and the description of this question point to perhaps an overly simplistic explanation, but it's the only possibility that occurs to me. The unaccounted-for-variable is that disturbance/displacement occurs primarily in response to REAL threats like terrestrial predators. Again, I lack statistical expertise, but it may be worth rerunning the model to assess the impact of terrestrial predation potential- in a binary state of yes/no, or perhaps like the oyster production harvest variable as it was done with high/low for risk probabilities. I imagine there is concern about using this variable, since the only place where the state changed was site A, when it reconnected to the mainland and all other haulouts are islands and one might argue there is no comparison. On the other hand if terrestrial predator threat is the primary driver of distributions in the Estero, it explains why peninsulas and other beach habitat connected to the mainland are not being used when all other features are similar to island habitat.

5. Validity of the spring 2007 decline at OB?

This question is a difficult issue with limited data to address the concerns. An observation of the National Park Service's actions on this issue suggests they were in a difficult situation. As an agency with a joint scientific and resource conservation/management agenda, there is a natural conflict placed upon the personnel in regards to their ability to interpret data with undo bias as scientists and their need to take a conservative approach and action as managers. Regardless, after reviewing the data and its various interpretations by NPS personnel and others, it does appear that there was a decline in harbor seal pups at the OB site based on the trend between 2004 and 2007, and from interpretation provided by the Jarvis letter (2008) the best estimate of this

decline was probably 65% for pups and 56% for seals in general. I have two points of concern regarding this issue. The first is that the NPS estimate uses a single year- 2004 - as their baseline estimate from which this decline began. I would not be comfortable using the single 2004 data point as a representative baseline from which to assess this decline. As stated by Becker et al. (2009, 2010), there was a significant shift in breeding/pupping activity into the Estero in 2003, likely driven by displacement from aggressive male elephant seal attacks at Double Point, producing a peak in pupping rates in the Estero that year (Fig. 6a, Becker et al. 2010). This shift of animals to Drakes Estero could have continued into 2004, only one year later, as evidenced by 2004 having the highest count of any year for pups at the OB site since 1997 (Fig. 2a, Becker et al. 2009). With that said, it would seem that 2004 is not an ideal baseline for this comparison, and rather if the objective is to correlate with low versus high periods of oyster culture activity, a more appropriate baseline might be the mean of the combined years of 2000-2004. One could argue that pre-2004, was a recovery period for harbor seals in the Estero following years of mariculture disturbance, and time needs to be allowed for lag effects. However, the counter argument then applies to the lag in potentially artificially high numbers in 2004, as a function of the 2003 Double Point displacement disturbances. My second concern pertains to the simple correlational relationship between mariculture and adult/pup seal counts. I am concerned that there were other unaccounted for variables in the population such as changing oceanographic conditions, and the larger California harbor seal population dynamic itself which I address in question 6 below.

6. In addition to a statistical review, do you have any suggestions for improving the data and analyses included in Becker et al. (2009) and Becker et al. (2010)?

I have four concerns about the Becker et al. 2010 manuscript/report that if addressed may improve the document. The first is a disagreement with the opening statements/predictions of the abstract and introduction, that harbor seals are not expected to habituate to disturbances that prove non-threatening and both examples provided to question 1 above, and those provided by panel members during discussion suggest that harbor seals are quite capable of habituating to non-threatening disturbances. I can understand the NPS having a management directive of wanting to provide an environment that is free of unnecessary disturbances for harbor seals, but this is very different from the science of testing whether a given disturbance is having an effect, which appears to be the intent of Becker et al. 2010. Given that, there are additional reasons for this potential bias in the preparation of the manuscript. The first is the obvious cultural sensitivity to marine mammals that exists. The second builds on this, in that studies tend to be conducted where concerns about disturbance have arisen, whereas I suspect that studies documenting where seals habituate are lacking in the literature, potentially do to less concern about the given population that successfully habituated to harmless disturbances (but I am not current with the literature). While I am not qualified to critique the analysis used in Becker et al. 2010, it does appear that the data used infer that disturbance is occurring. However, the introduction and changes to several of the variables used may influence this conclusion, and in that light, it might be better to have a

more two-sided statistical approach to the hypothesis, that habituation as well as sensitization could occur. My other concerns relate to three variables used or not used in the manuscript. The first is the use of shellfish harvest for Drakes Estero as a proxy for disturbance. In truth, I thought it was a very creative variable to use, but given further discussions with panel members I am concerned about its relevance as a correlative variable. I suspect other panel members will address this more and so I will spend little time on it except to say that one of my concerns with the variable is that it is only correlative in the year of harvest, and may not account for the level of mariculture activity that took place in the preceding year(s?) to achieve that harvest value and that due to changes in production practices that occurred during the study, these activity levels may not be well tied to ultimate harvest. The second variable that I would like to see addressed is that harbor seal stocks, like many marine mammal stocks since the passing of the MMPA in 1972 have been recovering. The current stock assessment acknowledges the potential that the California stock may be reaching carrying capacity, but states trends are still uncertain (Carretta et al. 2009). Therefore harbor seal population dynamics may not be stable at this time. While there is extensive literature on terrestrial systems population dynamics, my concern is we don't know how populations of a top level predator in the marine environment with larger foraging areas will respond to hitting carrying capacity. Given the size of the Drakes Estero population (Becker et al. 2010) it is likely to respond to whatever large scale dynamics influence the California stock. Frankly, I have no idea how the authors can address this variable, but at the bare minimum, it needs to be acknowledged in the manuscript, especially since there were some results suggesting Drakes Estero population dynamic correlated with the regional population dynamic and all were declining somewhat during the period of increased mariculture activity. My final concern relates to an oceanographic variable that, like an ENSO, could be affecting harbor seal stocks in that Pt. Reyes area. The variable is called "curl" and in layman's term is the relative strength of onshore versus offshore winds. If winds are stronger offshore, curl increases and nutrients that are pulled from the ocean bottom as a function of upwelling can be subsequently advected off the shelf, resulting in a nutrient poor environment for coastal foraging species. Oceanographically, strong curl effects are the opposite extreme to an ENSO event, but may result in similar productivity problems on the shelf and has been determined to be one of the major influences causing the stock failures of central CA coastal coho salmon and Chinook salmon leaving the Sacramento River as juveniles during 2005-2008 (Lindley et al. 2009, MacFarlane et al. 2008, Wells et al. in review, Wells et al. 2008). The initial ocean foraging area for Sacramento Chinook salmon stocks is the Gulf of the Farallones (MacFarlane et al. 2008), which is the identical foraging area for Pt. Reyes harbor seal stocks. It is very likely that any oceanographic effect reducing productivity sufficiently to impact salmon and other stocks (e.g., birds and rockfish) will have an impact on harbor seals. As such if the authors are evaluating the impact of ENSO in seal dynamics, they also need to evaluate curl. This variable could have significant implications for the conclusions of the paper as this period of peak curl intensity occurred during the same time as decreased pupping in Drakes Estero and other rookeries in the Pt. Reyes area (Figs. 5 & 6 Becker et al. 2010).

7. Do you see a need for changes to existing management measures or additional measures to avoid disturbance of harbor seals by all sources (i.e., including kayaking, hiking, etc.)? If so, what new measures or adjustments to old measures do you suggest? Do you think an adaptive management approach could be used here to address remaining questions about the effects of disturbance? If so, what high-priority questions would you attempt to address?

Pending further analysis recommended above in question 6, I do not have recommendations for changes in existing management measures. I do think an adaptive management approach in the form of a technical oversight committee as recommended in my response to question 3 above would be valuable for continued assessment of mariculture related issues.

8. What additional scientific questions do you consider important to the assessment of human/harbor seal interactions at Drake's Estero?

The assessment of human/harbor seal interactions needs to be considered in the larger context of an ecosystem in balance. At first this might seem to go beyond the scope of the panel, however there needs to be several long-term considerations that may have repercussions for harbor seal populations within Drake's Estero. The first is the issue of what constitutes baseline/natural population levels. Unfortunately there is no way to truly answer this question. It is possible that prior to the introduction of "Europeans" into the ecosystem, the existing predators in the area, bears, and indigenous humans kept harbor seal populations in the Estero quite low. Population numbers likely dropped with increasing European influence at first. However, seal populations certainly benefited from the elimination of bears and ultimately from the 1972 MMPA. That said, it is entirely possible that the harbor seal population in Drakes Estero is near historical highs. As a top predator in the environment, harbor seals can have dramatic top down impacts on the ecosystem both in terms of their prey requirements (Estes et al. 1998) and the sheer energy turn over and nutrient flux associated with so many predators in one spot. Presumably NPS has equal concerns for other fauna in the Drakes Estero. Given that, it is impossible for them to manage for a maximum harbor seal population and „natural' levels of everything else if the predator is out of balance with other resources. While harbor seals are likely deriving most of their nutrient requirements from the local marine environment, this can have cascading effects at several levels. There are dozens of potential issues that could develop from changes in management protocols to harbor seal disturbance and oyster culture, but there are two areas of concern that come to mind immediately.

A. The impact of the ecosystem services provided by the oyster culture is completely undefined at this point. My concern is that if oyster farming is removed it could impact nutrient loading in the Estero as it currently exists, with a specific source being harbor seal feces. This may have repercussions on water quality, which in turn could have negative impacts on seals (not my areas of expertise- consider asking Francis Gulland- TMMC) as well as impacts to the eel grass beds which are reported to be flourishing. There appears to be some controversy about the historical presence of native oysters in the area and therefore controversy about

what ecosystem services were historically provided. However given that harbor seals numbers are probably well above natural/historical levels, the historical shellfish population is essentially irrelevant and attention needs to be placed on whether current mariculture is providing an ecosystem service to the Drakes Estero ecosystem today.

B. The NPS has invested a great deal in restoring a native steelhead stream at the north end of the Estero. This population of steelhead is threatened under the federal Endangered Species Act and is part of the Central California Coast Distinct Population Segment (http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Maps/upload/Steelhead%20Central%20CA%20Coast%20map.pdf). In addition, coho salmon also spawn in the streams of the Pt. Reyes area. I do not know if there is historical evidence of them spawning in the Estero streams, but the population is critically endangered as part of the Central California Coast Coho Salmon Evolutionarily Significant Unit (http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Coho/COCCA.cfm). Both fish species are likely suffering primarily from poor land use practices by humans, but having very large harbor seal populations will not help with their recovery.

Finally, this may seem ironic to say, but from a purely ecosystem-based management perspective, the day may come when the ideal management practice may be to cap or limit harbor seal use and population size; disturbance could be a tool for this. This is beyond the scope of current legislation and cultural values, but considerations may become necessary in the near future.

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Jeffries-Drake's Estero Harbor Seals and Oyster Farming: Questions and Answers-

Before I try to address the Marine Mammal Commission questions, l want to start by saying I have been to Drake's Estero before as have panel members Peter Boveng and Sean Hayes, to help catch seals as part of earlier studies of harbor seals in the estero,. From my first visit to Point Reyes to help Sarah Allen tag seals for her early work on harbor seal to this most recent visit as part of the MMC review, Drake's Esteros continues to strike me as being very similar to many other estuaries along the west coast where I have been fortunate enough to work on harbor seals.

Drake's Estero has a substantial amount of intertidal sandbars that are exposed during low tide and selectively used by harbor seals as haulout sites. Other similar west coast estuaries include Willapa Bay, Grays Harbor and Samish Bay in Washington, as well as Tillamook Bay, Netarts Bay, Alsea Bay and Coos Bay in Oregon. All of these estuaries have at least two things in common: lots of harbor seals and oysters farming.

Harbor seals are protected by provisions of the federal Marine Mammal Protection Act which under Section 101 established a moratorium on taking any marine mammal. For oyster farming activities like those being conducted by DBOC, the Marine Mammal Protection Act also provides a regulatory mechanism under Section 118 for taking marine mammals incidental to mariculture/aquaculture activities in U.S. waters. Takes of any marine mammals including harbor seals by DBOC or any other oyster farming operation are covered by this exemption and as such are designated under NOAA's regulatory process and 2010 List of Fisheries as a Category III Fishery.

Each of these estuaries has numerous harbor seal haulout locations. Some are used year-round and others are used as nursery areas only during the pupping season. Year-round sites are just that, used year-round. Nursery sites on the other hand are used only during the pupping season and provide important areas where females give birth and nurse their pups and can get away from other seals using year-round haulout sites.

A nursery area provides critical habitat used only during the pupping season for giving birth, establishing mother-pup bonds and suckling pups. Additionally, near the time of birth, a pregnant female may also seek out an isolated location that is not associated with any particular haulout location where she can come ashore and pup. Following parturition, mother- pup pairs will typically move back to a nursery area and use this site for 4-6 weeks until the pup is weaned. Once weaned, a pup is on its own and gradually gets integrated into the local seal population usually hanging out with other weaner pups on the periphery of year-round haulout sites.

Throughout their range, harbor seals consistently use the same haulout sites from year to year but not all haulout sites are used in the same manner. Substrate on a haulout site may vary from mud to sand to cobble to rock to log booms to docks to ice and even on top of oyster and mussel growing racks in some areas. Haulout cycles can be timed when a low tide (or a high tide in some locations) allows seals access to a preferred haulout area. In some

areas like on docks, log booms or oyster racks where tidal access is not an issue, time of day rather than tide is important.

Why seals pick one area over another to haulout is really a seal's choice but in general I think most harbor seal researchers would agree that the main attributes that a haulout site provides to seals and share in common is that it needs to provide 1) protection and isolation from an approaching threat by land or sea (in the case of transient killer whales), and 2) provides easy access to deep water routes where seals can readily come and go to meet their biological needs. By their nature, most haulout areas in an estuary are on intertidal shoals along main or side channels exposed at low tide. Typically, estuarine haulout areas are along channels that do not de-water at low tides and are free of vegetation and other obstructions.

That being said, as a long-time harbor seal researcher, I still scratch my head and am puzzled when flying over an area like Willapa Bay and Grays Harbor (which are large ocean facing estuaries on the southwest Washington coast), why harbor seals always use certain locations even though there is seemingly unlimited and unused haulout space available in other areas. In the case of estuaries like Drake's Estero (or Willapa Bay or Grays Harbor or other similar estuaries on the west coast), there are specific areas that have been used as a haulout site year after year and will most likely continue to be used in the future unless altered by natural processes i.e. siltation, reshaping or channel filling or repeated detrimental disturbance. It is also highly unlikely that other areas that look "good" from a human's perspective will ever be used even if we think they should be.

1) For context, what short- and long-term effects might disturbance in Drake's Estero have on individual harbor seals, the Drake's Estero harbor seal population, the broader regional population, and harbor seal habitat? Please address the potential for disturbance from human presence and activity, as well as the potential for disturbance of habitat from the presence of oyster bags and other materials related to mariculture.

How harbor seal respond to environmental stimuli that can potentially trigger a disturbance event will depend on whether they are in the water or hauled out. For seal in water, they are in their element and can generally swim or dive and move away to avoid whatever the source of disturbance or stimuli.

For disturbances or activities that potentially impact harbor seals on a haulout site, I will try and address how short- and long-term disturbance sources potentially impact harbor seals which are on land. A haulout is a location where harbor seals congregate out of water in groups to rest, socialize, digest the meal they consumed at sea, give birth, suckle their pups, molt, and just be a seal. As such, there are a number of documented cases where certain types of disturbance can change how seals use of a haulout site and if continual and detrimental in nature, cause abandonment of a site.

Estuaries like Drake's Estero provide lots of haulout space on sandbars adjacent to deep water channels that wind through exposed shoals and are used by seals, as well as boats operated by DBOC, PRNS/NPS, CDF&G and on occasion others, to travel to various locations throughout the area. Channels are used by seals as a highway to their haulout sites; DBOC uses them to work oyster lease areas and check water quality; PRNS/NPS and

CDG&G uses them to access research stations and enforcement; and other boats and kayaks use them for recreation.

All of these non-seal users contribute, at one time or another to short-term disturbance of seals using haulout sites in Drake's and Limintour Esteros. I would note that most of the haulout sites in Drake's Estero are down bay and most of DBOC lease areas are up bay. Some of the lease sites require operation of DBOC boats to within 100 yards of seals that may be disturbed by an approaching boat or work on the beach. I would also point out that the mainland areas at the entrance to the esteros from Drake's Bay including Limintour Spit are the only areas used by harbor seals with direct land access to hikers, horse back riders and coyotes. If a predator like a coyote (or wolf in British Columbia and Alaska) has access, they are capable of killing a pup but rarely if ever kill adults.

Based on PRNS/NPS studies, the most sensitive time period for harbor seals in Drake's and Limintour Esteros occurs annually during the pupping window March 15 to June 1. At this time of year, because harbor seal pups are typically born on a beach, pregnant females are seeking a location where they can go to give birth and form a strong mother-pup bond. Access to these nursery areas is especially critical during the first 1-3 days when the mother-pup bond is formed and is so important for pup survival.

As far as effects of disturbance on harbor seals in general, we need to remember that harbor seals are marine mammals that spend the majority of their lives in the water where they forage and hunt the prey they need to catch to make a living and survive, so seals fleeing into the water in response to some type of environmental stimuli is not necessarily bad. Being in the water is actually a seal's "safe" place where the source of a disturbance can be "evaluated" for its level of threat or risk.

Although Drake's and Limintour Esteros provide haulout sites, they likely provide only limited foraging opportunities for the abundant local and regional harbor seal populations. These areas do provide excellent, relatively protected habitat that is ideal areas for pupping. Once a pup is weaned, it can search around in the shallows for something to eat like shrimp, flatfish, sculpin and shiner perch. These estuaries are were weaned pups learn how to hunt before heading out in search of more challenging prey outside in the ocean.

To answer to the question of what will short- and long-term effects of disturbance in Drake's Estero have on individual harbor seals, the Drake's Estero harbor seal population, the broader regional population and harbor seal habitat, one also needs to know what type of disturbance you are talking about and how harbor seals perceive the disturbance. We also need to remember that if we have difficulty identifying what natural processes or attributes seals use to select one area over another as a haulout site, we will have difficulty answering the question of how disturbance will influence the use of a haulout area by a seal.

A seal's interpretation of what an approaching or passing boat means is interesting and depends on the context. Seals seem to be able to tell the difference between a boater focused on them versus another boater that is passing by and could care less about seals. In the first situation, seals will usually enter the water at fair distances. In the later case, seals will just sit there on a haulout site and unaffected.

I know a lot of this because my job for the last 30 years with WDFW has been working with harbor seal researcher on the west coast, trying to catch seals for different research efforts in a variety of locations from Alaska to California to tag, mark, deploy instruments and track movements to answer questions about basic harbor seal biology, population status and foraging ecology. This is what brought me to Drake's Estero in the past to help Sarah Allen with her earlier harbor seal research. My expertise with capturing seals is what also brought me to San Francisco Bay in the past to assist Jim Harvey with harbor seal studies requiring captures at Corde Madero, Mowry Slough and Castro Rocks near the Richmond Bridge.

In some cases where we have attempted captures in areas where seals are continually harassed, haulout sites around Bristol Bay in Alaska come to mind; seals generally will not allow close approach by a boat for setting capture nets and flee off a haulout beach before we can get within several hundred yards. These are typically locations where seals have interactions and conflicts with fishermen. Seals on a haulout site in these locations know that an approaching boat is a threat.

In other areas where, for whatever reason, boats or humans are perceived as not being a threat, seals tend to not be disturbed by an approaching boat and can be easily captured because they do not readily flee into the water and can be either grabbed or netted by a capture crew.

Regular use of haulout sites by harbor seals in a variety of locations where they are exposed to repeated exposure to boaters in Oregon and Washington support this view. Examples include seals in Oregon's Alsea Bay which tolerate recreational crabbers in boats to set pots and rings within a couple dozen yards of where they are resting on their intertidal haulout sites.

Harbor seals in Washington routinely haul out on docks and booms at marinas in Poulsbo and Semiahmoo where passing power and sailboat traffic comes within yards of where seals are resting. Other areas in Washington like Westcott Bay and Penn Cove have harbor seals routinely using haulout areas on oyster and mussel growing rafts that are in production. Harbor seals also regularly haulout on log rafting areas in Everett Harbor and tolerate workers operating boats and walking around on the same booms where they are resting and pupping.

Another example is from Quilcene Bay, where more than a dozen oyster and mussel growing rafts being actively operated by the Coast Seafood Co., are anchored sub-tidally, floating and used by harbor seals as haulout sites. Because they are anchored and floating these harvest production rafts provide year-round haulout areas used by +300 seals almost daily. Even with oyster and mussel growing operations going on nearby, seals tolerate this activity and remain hauled out. Coincidentally, this location produces more pups than almost any of the other haulout area used in Hood Canal because oyster and mussel rafts have a low profile and provide easy access for females to nurse their pups.

In Grays Harbor and Willapa Bay, there are certain areas where haulout sites are on channels with oysters being either cultivated directly on the substrate or on racks. I often look for the oyster growing areas to guide me to the haulout areas for counting and photos.

These are all observations from working on harbor seals for the last 30 years. I hope these examples show how seals can tolerate potential sources of disturbance particularly from boats if it is perceived as benign. I would therefore conclude that there is really no reason why oyster farming and harbor seals cannot coexist in a healthy and productive Drake's Estero ecosystem.

From background document provided to us by the MMC, protection of harbor seals in Drake's Estero has always been a management priority. From the initial 1982 management plan between JOC and PRNS in 1982 with their FONSI on oyster farming activities and harbor seals to the 1992 management plan between JOC, NPS/PRNS, and CDF&G that was in force when JOC was purchased by DBOC, harbor seal haulout areas, critical pupping windows and detrimental human activities from motor boats, kayakers, oyster boats and over-flying aircraft have been identified, regulated or restricted to minimize disturbance.

At some point there was a breakdown in meaningful discussions of everyone's respective mandates, regulations, issues and needs. To address these concerns what is needed is for the parties to work on a reasonable and comprehensive management plan to protect resources of Drake's Bay from harbor seals to DBOC oyster growing operations.

All we need is for DBOC, NPS/PRNS, NMFS, CDF&G, California Coastal Commission and other stakeholders (and maybe some more help from the MMC) to get together and have meaningful discussions to get mutual agreement about what is good for harbor seals and the Drake's Estero/Point Reyes ecosystem. With the proper guidelines and protocols in place to identify potentially detrimental oyster farming activities (and other on-water activities like kayaking tours) that should be avoided, there is no reason why harbor seals and DBOC operations cannot coexist in a healthy and productive Drake's Estero ecosystem. Communication and adaptive management have worked to resolve issues like this in the past and there is no reason it cannot work today to resolve this divisive issue.

I would be glad to help.

Finally, as a little aside while we continue to ponder the question of how disturbance by DBOC boat operations impact harbor seals in Drake's Estero, please take a look at this YouTube video link: http://www.youtube.com/watch?v=MbJVghgi7DE. Some of you may have already seen this but if you have not, it was taken on May 15, 2010 at Children's Cove in La Jolla. I know this is another one of the MMC's favorite issues, but for those unfamiliar with the ongoing Children's Cove harbor seal conflict, it does shows how adaptive and tolerant harbor seals are to what most of us consider a pretty extreme disturbance stimulus and these seals seem to care less about. It also clearly demonstrates how, over time, harbor seals adapt to the presence of humans they no longer fear.

2) The National Park Service has used two sources of information to characterize disturbance.

a) The first pertains to disturbance data collected by volunteers and Park scientists from the observation point overlooking the estero. The data were collected as an adjunct to population monitoring conducted according to the National Park Service Pinniped Monitoring Protocol. The disturbance data were collected to

> "Determine the long-term trends in sources, frequency and level of effects of natural and anthropogenic disturbances on harbor seal haul out use and productivity" (Adams et al. 2009, p. 31). The data were used in Becker et al. (2009) to test for a relationship between mariculture productivity and harbor seal disturbance rate. Is this disturbance dataset suitable for assessing human/harbor seal interactions? That is, is it sufficient to characterize the rate and degree of disturbance by all sources and to determine the effects of that disturbance over time? If not, how might you improve the Park Service's ability to collect data for the stated purpose? If the validity of any single data point is questionable, should it be removed from the dataset, modified to remove/identify only those aspects in question, or retained as is?

As a researcher who collects field data, my first inclination is that if these data sets were collected with the same protocols over the timeframe being used in an analysis, they should be comparable, so I would not to change or remove data points but be cautious in how they are being used.

In the case of the Drake's Estero observation data set, I believe the objectives and protocols have changed over time. Looking at some of the older data collection forms and maps that were used in the 1980's compared to the data collection forms being used today, it looks like data elements, data fields, observation questions and mapping protocols have changed and evolved between the late 1980's and today.

If the questions originally being asked in the 1980's were different than today, these changes likely have a significant influence on how the data sets can be used and any subsequent interpretation of the data. For example, if in the early data was being collected to answer the question of how many seals use the esteros and what are sources of disturbance that have an effect on count variability, that is essentially a population assessment and census correction factor issue. This appears to be the original intent for using of the data and is largely population assessment question and issue.

CDF&G counts of harbor seals using Drake's and Limintour Esteros between 1982-2003 show an average about 700-800 seals hauled out during aerial surveys with 350 to 400 seals using haulout sites in each indicating both esteros provide important haulout areas for local harbor seals. Because of the size of the regional harbor seal population around Pt. Reyes (reported at +6,000 seals), there is certainly not a sufficient prey base inside these esteros to meet the metabolic needs for seals that prefer prey such as squid, herring, sardines, salmon and other more marine fish. Studies of seals in these esteros show they move outside and move into San Francisco Bay to take advantage seasonally abundant prey like spawning herring or offshore to forage in adjacent ocean waters. For Drake's and Limintour Estero harbor seals, having an abundant prey base in the ocean is essential for a healthy harbor seal population.

Density dependent factors outside of the esteros where harbor seals forage such as prey availability and competition with other pinnipeds (harbor seals, California sea lions and elephant seals) that share common prey, many of which are known to be depleted fish stocks, may be playing a significant role in limiting harbor seal growth for the local harbor seal population around Pt. Reyes including seals in Drake's and Limintour Esteros. As the

harbor seal population has grown, Drake's Estero likely has "filled up" with seals, local prey inside the estero declined and emigration to other areas away from Pt. Reyes would not be unexpected.

At a time when harbor seal numbers in Drake's Estero were stabilizing, populations in adjacent areas inside San Francisco Bay and along the rocky ocean coast north and south of Pt. Reyes were growing. This is evident from trends in overall harbor seal stock abundances in California, Oregon and Washington which have all exhibited substantial population growth since the 1970's and based on population trend analysis for these stocks are at or near carrying capacity levels. The changing population dynamics that have occurred as regional harbor seal numbers have grown will contribute to why harbor seal use haulout sites in these esteros and adjacent areas and is influenced by natural density dependent factors affecting the overall harbor seal population.

At some point we were still collecting harbor seal count and disturbance data but started to ask a new and more complex question, "Has disturbance for DBOC operations caused declines in Drake's Estero harbor seal populations and displacement from haulout sites?". This is a much more complicated question and use of data sets that was collected with changing or revised protocols to answer these two very different questions may not be valid. Although the data may be perfectly fine to answer the 1980's question, it may be a stretch to use this entire time series to answer a different question about a cause and effect relationship between haulout site use and DBOC operations. As noted in the NAS review noted, the data collection is not in question, it is how potentially different data sets are being summarized, analyzed and interpreted.

Also, remember we have come a long way with how we are doing field research. Few if any of us working on harbor seals in the early 1980's had any of the gadgets and electronic tools we have today. Biologists were out in the sun and rain collecting field data. We just did not have all the sophisticated radiotags, satellite tags, time depth recorders, digital cameras, video recorders, laptops, cell phones or analysis programs we have today, and the questions being asked were simpler.

The disturbance question we are currently trying to be answer with the observation data set is way more complex, complicated by unknowns, subject to interpretation and contentious than the original question. If all the parties agree to what we need to know about harbor seals in Drake's Estero, we can go forward with answering the harder questions being asked using all the high tech gadgets, much improved GIS mapping software and analysis tools we have today.

Working together and communicating is essential. Biologists will still be out there in the sun and rain collecting data on harbor seals and disturbance in the esteros and hopefully, the respective resource managers, DBOC and the local community can move forward and stand together to resolve issues needed to continue to protect this amazing Point Reyes ecosystem.

b) The second pertains to implied disturbance by mariculture activities as estimated by annual oyster production and is central to the Becker et al. (2009, 2010) manuscripts that we reviewed for the meeting at Point Reyes National Seashore.

> Is annual oyster production a reliable proxy for mariculture effort in the estero? Why or why not? Also, is effort data alone a reliable measure of actual or potential disturbance, whether by human activities or habitat alteration (e.g., presence of oyster bags)? If not, how might you develop a better measure of mariculture effort and its relationship to the disturbance or displacement of seals in the estero? What factors would you include in such a measure?

My first concern is that using annual oyster production levels by DBOC is not a reasonable proxy for boat activity and disturbances of seals on haulout sites adjacent to oyster growing lease areas. Based on oyster lease and harbor seal haulout site maps presented at the review, it appears that a relatively small number of lease tracks are actually near haulout sites. This is essentially a spatial component that is not reflected in annual oyster production levels data and is important to understanding how much oyster production activities are actually close enough to harbor seal haulout areas to cause disturbance.

Another factor I would want to be considered in using DBOC annual oyster production levels is the timing of oyster harvests over the calendar year since the harbor seal data is only collected during a portion of the year focused around pupping season.

At a minimum, oyster harvest records should be stratified spatially by lease area, temporally by date and weighted accordingly for any analysis of how DBOC operations affect Drake's Estero harbor seals.

In addition, I would also want additional co-variants be added to the analysis of potential causes for changes in harbor seal uses of sites associated with DBOC including: 1) use of a combined data set for Drake's and Limintour Estero harbor seal counts; 2) overall population trends for California harbor seal, California sea lion and elephants seal stocks; 3) additional long-term trends in other ocean productivity indices in addition to El Nino events; 4) extent of eel grass coverage in Drake's Estero particularly in channels with haulout sites i.e. Sites UEF, OB and UEN; 5) a measure of PRNS annual visitation levels that correlate with use by hikers and horse back riders on Drake's and Limintour Estero beaches used as haulout sites; and 6) some measure of kayak use of the esteros over time.

I would also note that the marine mammal management plan for harbor seals adopted in 1992 between by JOC, NPS/PRNS, CDF&G and NMFS (and transferred to DBOC) established protocols for boats used for oyster farming activities to minimize seal disturbance. If violations or situations with DBOC activities were impacting seals and being recorded by the PRNS/NPS harbor seal observer program and a panel was in place as part of a management plan where affected parties could hold periodic forums or meetings to discuss these issues and come up with reasonable mitigation measures to resolve concerns, the debate going on right now might have been prevented.

> c) Volunteers and National Park Service scientists identify disturbances on the basis of head alerts, flushing, and flushing into the water. Are each of these measures suitable for characterizing disturbance? Why or why not?

Head alerts, flushing and flushing into the water are likely the only behavioral response parameters you can use to measure response of hauled out seals to a disturbance. Interpreting how these responses impact harbor seals in the short- and long-term is the most complex and difficult questions to evaluate.

Harbor seals (along with most other critters) have an instinctive tendency to flee perceived threats or changes in their environment. Head alerts occur as seals on land are always vigilant of what is going on in their environment. Flushing, where seals move closer to the water, can occur periodically every tidal cycle as seals which initially haulout out on the first exposed shoal move closer to the waters edge or in response to perceived threat or unknown change in a seal's surroundings. Flushing into the water occurs when seals perceive a significant threat and they all enter the water. Pups may be injured or killed if caught off guard by an uncontrolled stampede of seals into the water.

If you take the time to watch seals long enough on a haulout site, you will find that when they encounter many things in their environment ranging from a coyote to a circling eagle, vulture or gull to an approaching boat to repeated flashes of a kayakers paddle to low flying or loud aircraft, and sometime even just rain and wind, seals enter the water. It is not uncommon when watching seals on a haulout to see at least one rambunctious seal frolicking at the water's edge that scares all the other seals into the water just by its antics.

Head alerts and flushing occur all the time as seals respond to a changing environment. Flushing into the water is a rapid response to a disturbance and can be detrimental. However, we need to remember that harbor seals use all of these behaviors in response to various stimuli in their environmental and although seals may respond to a stimulus with one of these behaviors, and with the exception of an uncontrolled stampeding of seals into the water when nursing pups are present, none of them are necessarily bad for seals entering the water where they feel safe.

I agree with the NAS report findings that found that because the existing data set was not originally collected to address the effects of disturbance on haulout site use is likely not suitable to use this data set to try and answer this cause and effect relationship between haulout site use and sources of disturbance.

For PRNS/NPS observations looking at seals at haulout sites at Sites A and A1, detecting the cause of a disturbance should be relatively straight forward due to the proximity of seals to the vantage point over looking the haulout sites.

Due to extreme distances involved and potential disturbance categories ranging from a DBOC boat (large and visible) to a over-flying gull (small, in the air, casting a show), I would think there was a considerable amount of observer bias associated with accurately identifying the proximate source of disturbance at these distances. You can count seals at these distances but recording information on a behavior associated with a specific stimulus would be challenging even on a good visibility day.

I would recommend locating an additional observation station for Sites UEN, OB and UEF, at distances comparable to those at Sites A and A1. I would also recommend PRNS/NPS and DBOC work out a more collaborative monitoring arrangement and work together as

much as possible to communicate and deal with issues of concern. If the seals researchers share what activities disturb seals, I believe DBOC made a commitment to PRNS/NPS at the review meeting to modify and stop any detrimental activities. Healthy harbor seal populations and oyster growing operation co-exist elsewhere on the west coast so why not in Drake's Estero?

3) Management measures for Drake's Estero are based on a suite of laws and agreements that establish pertinent authorities and identify purposes deemed suitable for the estero. The existing management measures are composed largely of temporal and spatial measures that are based primarily on areas where the seals haul out and that dictate when and where certain activities can occur. For example, management measures prohibit powerboats in the estero year-round, except boats used for mariculture. They also prohibit non-powerboats (e.g., kayaks, canoes) in the estero from 1 March through 30 June. The 1992 Record of Agreement Regarding Drake's Estero Oyster Farming and Harbor Seal Protection has provided an important supplement to those management measures pertaining to mariculture[1]. The agreement prohibits mariculture workers from using the main channel from 15 March through 30 June, except for weekly collection of water quality samples. It also prohibits mariculture workers from using the lateral channel between beds #1-2 (presumably now labeled beds 15 and 17) and bed #3 (presumably bed 20) from 15 March to 1 June. In addition, it indicates that mariculture workers should plan, and make every effort, to begin seeding beds #1-3 after 1 June, and the lateral channel should be used as little as possible between 1 and 30 June. Oyster beds #2-3 should be approached from the north at low speed and the beds planted north to south so that "disturbance near the lateral channel will more likely be limited to the end of the pupping season" (language from the agreement). As a temporary matter pending further review, the California Coastal Commission imposed, and the National Park Service Special Use Permit incorporated, a year-round restriction on use of the eastern two-thirds of the lateral channel and specific sand bars where seals haul out. Under current conditions, mariculture workers may use the western one-third of the lateral channel during the period from 1 June through 14 March.

a) Recognizing that the estero is a dynamic environment (although less so away from the mouth of the estero) and that harbor seals may shift their hauling patterns over time, are the temporal and spatial restrictions from the 1992 agreement, the California Coastal Commission, and National Park Service individually or collectively sufficient to avoid disturbance and displacement of harbor seals? Is the available information sufficient to evaluate the utility of the measures? Is it sufficient to evaluate the utility of the restriction added by the California Coastal Commission? If you consider it to be sufficient, please describe the basis for your conclusion. If you do not consider it to be sufficient, please describe why not and what additional information would be helpful.

The 1992 marine mammal management plan is a reasonable starting point but is obviously not enough since we are having this review of DBOC operations. It should be revisited with

[1] The agreement was signed by the Point Reyes National Seashore, National Marine Fisheries Service, California Department of Fish and Game, California Department of Health Services, and the Johnson Oyster Company. It was not signed by the Drake's Bay Oyster Company or the California Coastal Commission.

today's issues on the table for discussion and resolution, and a revised management plan developed. DBOC, NPS/PRNS, CDF&G, NMFS and the California Coastal Commission should all be represented to develop a mutually agreeable management plan.

As I stated above, with appropriate guidelines and protocols in place that identify and address potentially detrimental oyster farming and other activities by kayakers, hikers, horse back riders that should be avoided, there is no reason why harbor seals, DBOC oyster growing activities and other uses cannot coexist in a healthy and productive Drake's Estero ecosystem.

It was obvious during the review that all the players involved in this debate share a passion and concern that Drake's Estero ecosystem remains healthy and productive. However, it was also apparent that the resource managers and oyster growers, while sharing common goals, have different points of reference and maybe speak a different language when describing the issues. They we will need to develop shared points of reference. As efforts continue to resolve the biological and political issues, lines of communication need to remain open and used. Communication is needed between all of the players so everyone knows what is going on.

> b) The primary spatial limitations pertain to use of the main and lateral channels. Much of the debate regarding use of the lateral channel pertains to the question of whether the existing measures ensure suitable separation between mariculture activities near the western end of the lateral channel and areas along the lateral channel that harbor seals might use, absent any human activity. The debate implicitly involves a null hypothesis that the distance between the two locations is sufficient to avoid disturbance of harbor seals and that the seals do not use the rest of the channel because of other natural factors (e.g., shallowness). The alternative hypothesis is that the distance is not sufficient and is displacing the seals from potential haulout areas along the lateral channel. Is the existing evidence sufficient to discriminate between these two hypotheses? If so, what conclusion(s) can be drawn and what supporting data are available? Also, what is your best estimate of the separation distance required to avoid harbor seal disturbance on land and in the water? If you don't feel you can answer that question with existing information, how would you go about determining the distance?

Based on my experience in other areas where seals and oyster farming co-exist plus knowing how harbor seals have learned to ignore non-threatening sources of disturbance, the separation distances in place can work. DBOC will need to revisit how they work on their leases near sensitive harbor seal areas but we know seals are not being disturbed if actions are controlled and non-threatening.

If DBOC lease agreements allow them to place oyster bags at sites adjacent to a haulout, place them on the upper beach areas and not along the channel edges which are potential haulout space. DBOC may have to walk a little further but by doing so will be avoiding any areas along channels harbor seals may try haulout.

I also suggest that since we are most concerned about disturbance of hauled out seals which occur during low tides particularly during the pupping seaon, why not let DBOC try using a buoying system for harvesting oyster bags at high tides when all the issues associated with seals being disturbed while hauled out at low tide are non-existent?

As stated above, if detailed data on sources of disturbance associated with DBOC oyster lease sites are going to be collected, an observation site needs to also be established that is closer to the sites being monitored for behavioral responses that are subtle and may not be evident from long distances.

4) Harbor seals recently shifted their habitat use patterns in the estero. Site A became connected to land, which allowed access by human visitors and coyotes. The seals abandoned site A, presumably because of the threat posed by disturbance or harassment. They likely moved either to other sites in the estero or to neighboring colonies. Their shift in habitat suggests that they prefer isolated sandbars. However, based on the timing of the reconnection of site A to land and the presumed corresponding increase in exposure to disturbance and harassment, it is reasonable to infer that disturbance, or the threat of it, may affect the behavior or habitat use patterns of seals in the estero. In contrast, Becker et al. (2010) did not find that spring (March through May) disturbances (that they referred to as short-term and were relatively infrequent) caused a shift in habitat use by seals using haulout sites isolated from land. How can those apparent differences in response to disturbance be explained?

We are really only talking about abandonment of Site A. PRNS/NPS reported decreases in numbers of seals at Site OB but it was not abandoned.

Both Site A and A1 are essentially shoals at the entrance to Drake's Estero which is the most dynamic area of the estero and is constantly being exposed directly to the ocean, tidal currents and extreme weather. Presumably these shoals are similar to other entrance shoals that are exposed to a high energy environment and are continually changing shape due to sediment transport and siltation. This causes some channels to fill in and others to be formed. Changing shoals and channels mean changing haulout sites. Have the shoals and channels near Sites A and A1 changed over time to explain use by harbor seals?

Regarding haulout site abandonment, I would note that when panel members went on the field trip in February and were at the harbor seal observation overlook above Sites A and A1 at about 1 pm, which was about 1 hour after an 11:52 +0.3 ft. low tide prediction at Pt. Reyes. There were several dozen seals hauled out near the water's edge at Site A1 (as well as +100 seals using Site OB on the lateral channel) that had been there for some time based on the haulout marks on the sand farther up the beach. They had obviously hauled out earlier and had moved down the beach as the tide receded.

No seals now use Site A which was assumed to be abandoned because a backside channel had disappeared allowing potential access by coyotes and hikers. Interestingly, at the 1 pm tide height when we visited during our field trip, there was still water on the back side of the shoal where Site A is located and the shoals was still separated from the mainland. Substantial shoal was exposed but coyotes (or hikers) would still need to wade or swim to get to seals at Site A.

My initial interpretation of this is that tides need to be lower than 0.0 ft. for the water to dry up in the backside channel. On any tides higher than 0.0 ft., seals at Site A would not be accessible to coyotes and hikers because it is still separated from the mainland by a shallow channel filled with water to get to seals hauled out at Site A. Bottom-line is that even though Site A was not available to coyotes and hiker at +1.0 ft. tides it still was abandoned so the cause was likely not regular access by coyotes or hikers.

In regards to the assumption that if coyotes had access to Site A, seals would abandon the site, I would point out that even if coyotes have access to seals on the beach at Site A, they can really only attack and kill pups but likely not adults. That means that predation by coyotes is really only an issue during the pupping season.

In Washington, there are a fair number of haulout areas where we have records of coyotes killing pups such as haulout sites on the entrance shoals in Willapa Bay, along Hood Canal, at Gertrude Island in south Puget Sound and on shoals in Boundary Bay that even though they are accessible to coyotes and we have documented pups being killed, have never been abandoned. This may be due in part to the fact coyotes cannot kill an adult and females with pups use nursery areas or even more isolated areas to give birth, making them pups are less vulnerable.

I would suggest a more likely explanation for harbor seal abandoning the Site A haulout is that due to shoaling and sedimentation the water depth along the edge of Site A no longer provides a deep water access for seals. If the access channels near a shoal get too shallow or obstructed by vegetation like eel grass seals will likely move to a new location which could be inside an esturary or potential outside.

As I said in earlier comments, Drake's Estero is very similar to other ocean facing estuaries like Grays Harbor and Willapa Bay in Washington. Entrance shoals in these estuaries are very dynamic and are continuously changing shape and location. Some shoals used by seals in these estuaries in 1980's no longer exist today. Other shoals have built up and if a channel is available provide new haulout areas.

5) Based on data that were being collected in late April and early May 2007, the National Park Service concluded that increasing oyster activities, including the placement of additional oyster bags near the OB haulout site, had caused a substantial reduction in the number of seals using that site. The Service originally estimated an 82 percent decline for pups and 77 percent for all seals. It later revised that estimate to 65 percent for pups and 56 percent for all seals. In hindsight, are the available data on haulout patterns on OB sufficient to form or support the final conclusion? Why or why not?

I suspect that placement of oyster bags near the Site OB haulout site could have had a short-term effect on seals reflected in the changes in numbers hauled out. In the long-term, unless bag placement was right on a haulout site making it inaccessible for seals to use or resulted in increased oyster activities at a haulout site, I doubt seals would care. In hindsight, I would also add that it seems as if the interpretation of the initial data set by NPS/PRNRS was a

little premature given inherent variability in counts we see in other areas where we count harbor seals.

One data set we did not see were counts at Site OB and other Drake's Estero haulout sites for 2008 and 2009 to see if seal numbers rebounded to expected levels at OB. These counts would be useful to see if numbers have returned to normal and what ever happened in 2007 was an anomaly not a pattern. I also think that looking at changes in counts at Site OB which is close to DBOC lease areas is biased and counts at all haulout sites in Drake's and Limintour Esteros need to be examined for changes in use and potential correlations with DBOC use and other co-variants as well.

There were essentially no disturbance incidents by DBOC associated with total abandonment of Site A although access by coyotes and hikers was suggested as the reason. That is a 100% decline and seals have not come back to Site A but began using Site A1 on an adjacent shoal. As described above, I would want to know more about how estuary processes have changed shoals and channels over time to see how shoal dynamics influence use by seals. Shoals that were present and regularly used by harbor seals in Willapa Bay and Grays Harbor 30 years ago no longer exist today. Low lying shoals and islands have come and gone but harbor seals found new haulout sites that were not there before. All because of natural shoal building processes and not disturbance.

6) At the meeting the panel described the need for a review of Becker et al. (2009) and especially, Becker et al. (2010) by one or more statisticians. The review would start with the available data and then work through the analyses. The primary focus would be on the suitability of the statistical analyses presented in these two papers. In addition to a statistical review, do you have any suggestions for improving the data and analyses included in Becker et al. (2009) and Becker et al. (2010)? For example, should they include other measures or sources of disturbance? Would you like to see other alternative hypotheses tested to assess the potential threats to harbor seals in Drake's Estero?

First I am not a statistician or biometrician, but based on my understanding of the basic statistics used in the Becker et al. papers, their analysis are fine but suffer from using data sets collected for other purposes and not using additional co-variants in the analysis that potentially could have more influence on harbor seal use than disturbances attributed to DBOC activities.

Rather than continue to look for flaws and critique the conclusions in the Becker et al. papers, I would like to see a new analysis by an applied biometrician with additional co-variants used including: 1) a combined data set for Drake's and Limintour Estero harbor seal counts; 2) overall population trends for the California harbor seal stock, California sea lions and elephants seals; 3) additional long-term trends in other ocean productivity indices; 4) extent of eel grass coverage in Drake's Estero; 5) PRNS annual visitation levels; and 6) some measure of kayak use of the estero over time.

7) Do you see a need for changes to existing management measures or additional measures to avoid disturbance of harbor seals by all sources (i.e., including kayaking, hiking, etc.)? If so, what new measures or adjustments to old measures do you suggest? Do you think an

adaptive management approach could be used here to address remaining questions about the effects of disturbance? If so, what high-priority questions would you attempt to address?

As stated above, earlier management plans recognized the need to minimize harbor seal disturbance and can serve as the starting point to address and minimize oyster growing disturbances to harbor seals in Drake's Estero. These earlier plans that were developed and agreed to by JOC, PRNS/NPS, CDF&G and NMFS, were inherited when DBOC purchased the oyster leases from JOC. Although DBOC was aware of conditions in the 1992 plan, apparently little discussion of issues followed and since we are having this review and debate over impacts of oyster growing activities on harbor seals in the estero, these plans are obviously not enough.

A revised, adaptive management plan, negotiated with all the management agencies and DBOC would provide for the long-term benefits for harbor seals and allow compatible operation of oyster leases in Drake's Estero. As with past plans, identification of critical spatial and temporal requirements for harbor seals will be needed and appropriate studies conducted to address those issues. A mechanism for communication of issues and concerns needs to be included to allow adaptive management in the future.

8) What additional scientific questions do you consider important to the assessment of human/harbor seal interactions at Drake's Estero?

At the review, there were discussions about which areas were being used by DBOC that might be potential harbor seal habitat. I would like to see a joint study by PRNS/NPS and DBOC that examines various parameters associated with the dynamics of the intertidal shoals and channels in Drake's and Limintour Esteros. At a minimum, parameters to examine should include mapping of haulout sites, mapping of oyster lease areas, mapping of of substrate type and eelgrass beds, tide levels for shoal exposure, length of time shoal is exposure (and available as a haulout site or oyster lease area), and depth of adjacent channels. Some of these parameters are already available; others will require additional work.

This will help answer the question about what are the characteristics of estero shoals being used by harbor seals versus shoals not used as well as provide a predictor of how much haulout space is really available in these esteros for harbor seals to use. There also seems to be PRNS/NPS maps for some of their resources and DBOC maps for their oyster leases. At a minimum, a GIS mapping component would produce one set of maps that all parties could use in common for ongoing adaptive management needs. If I am optimistic, this effort might even help answer the question of why seals prefer some locations and not others.

Submitted to the Marine Mammal Commission on June 14, 2010 by Steven Jeffries, Washington Department of Fish and Wildlife.

Centre for Shellfish Research

Creating Wealth from Knowledge

June 8, 2010

Tim Ragen
Executive Director
U.S. Marine Mammal Commission
4340 East-West Highway, Room 700
Bethesda, MD 20814 USA

Via email

Dear Tim,

Re: Comments on Drakes Estero Marine Mammal Commission Review

Thank-you for the opportunity to serve on the Drakes Estero Panel. The following memo outlines my observations in relation to the panel guidance that was provided by the commission. Any opinions included are my own and do not necessarily reflect the position of Vancouver Island University.

Please do not hesitate to contract myself should your have further questions or require clarification.

Sincerely

Brian

Brian Kingzett
Deep Bay Field Station Manager

Cc:

attach

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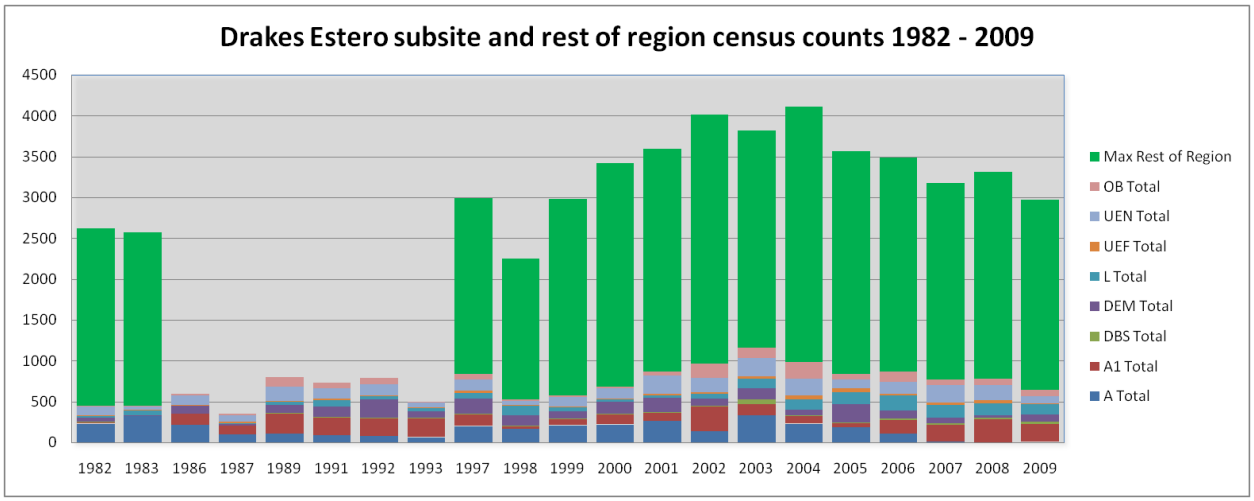
Responses to Questions posed by MMC

1) For context, what short- and long-term effects might disturbance in Drake's Estero have on individual harbor seals, the Drake's Estero harbor seal population, the broader regional population, and harbor seal habitat? Please address the potential for disturbance from human presence and activity, as well as the potential for disturbance of habitat from the presence of oyster bags and other materials related to mariculture.

Regional population of Harbour Seals and influence on Drakes Estero Population

During the commission hearings there was a discussion that the Estero population was part of a larger regional population and although there is a trend toward site fidelity by pupping females animals move thought out the region. This is observed in radio telemetry data collected by Green et al 1996[1]. Don Neubacher in addressing the panel indicated that during the non breeding season that local seals may disperse as far as the Klamath River or Monterey Bay.

Summary data on estero subsite mean and regional census data and was subsequently requested and provided by Peter Becker on March 31st, 2010, and is presented below in figure generated by the authour.



In the above figure stacked bars represent the sum of mean observations by year for pooled pups and adults. Each bar consists of observations for each subarea haulout within the estero and the green component of the bars indicates the estimate of regional population outside the estero. Note that regional data is missing for years 1986-1993.

The graph is oversimplified as confidence limits on estimates are not shown. Only standard deviation was provided in the data set. Confidence intervals about this data set are expected to be high as the reported Standard Deviation for each mean observation with the estero ranged from 0.7 – 338.2% of the estimate with a mean Standard Deviation of 97.2%.

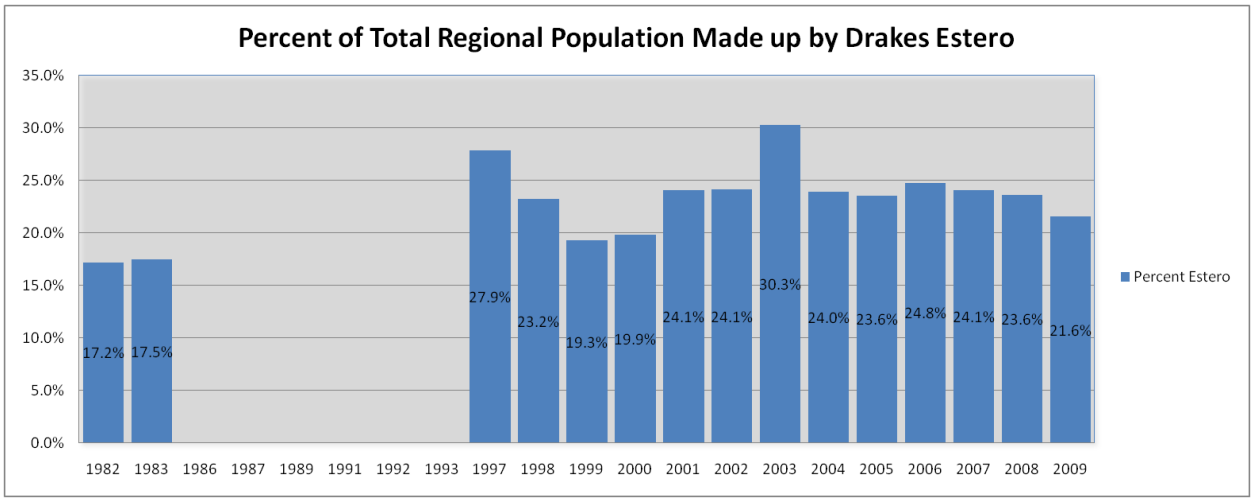
[1] Green, D., E. Grigg, S. Allen and H. Markowitz. 2006. Monitoring the potential impact of the seismic retrofit construction activities and the Richmond San Rafael Bridge on Harbour Seals (*Phoca vitulina*): May 1, 1998 – September 15, 2005. Final report to the California Department of Transportation January 2006. Contract 04A0628. 99p

The data set shows that there is significant variability within subareas within the estero and that the regional population estimate ranged from 2251 to 4109 (almost double) seals during the census period. An estimate of standard sampling error during census was not provided.

Population Range observations 2002 - 2009

	Drakes Estero Total	Rest of Region	Total Region
min	348	1728	2251
max	1157	3125	4109
mean	721	2523	3360

During the observational period the estimates of Drakes Estero populations as a percentage of total population estimates ranged from 17.2% (1982) to 30.3% (2003).



Overall Disturbance Data

Noted sources of disturbance include both anthropogenic and natural sources. The following table is derived from slide 30 of the presentation by Sarah Allen presented on February 21st, 2010. This lists all the types of disturbances noted during 7 years of surveys during the breeding season ordered by magnitude of disturbance.

Source	Total	Percent
Human (assume hikers?)	79	31.98%
Unknown	53	21.46%
Birds	38	15.38%
Aircraft	26	10.53%
Clammer	13	5.26%
Motorboat (assume proxy for aquaculture?)	10	4.05%
Researcher	7	2.83%
Coyote	7	2.83%
Non motorboat	6	2.43%
Other	5	2.02%
Fisherman	3	1.21%
Total	247	100.00%

Of these, anthropogenic sources of disturbance account for a total of 58.3% of all noted disturbances and 10 disturbances by motor vessels (which may be assumed here to be a proxy for aquaculture) make up 4% of the total (I believe this does not account for disputed data points?). Park representatives indicated that the Park receives 2.4 million visitors per year and this data suggest that these have a greater influence on overall disturbances than the presence of motor vessels within the estuary.

Summary of Sources	Total	Percent
Motor vessel	10	4.05%
Other Anthropogenic	134	54.25%
Natural/ unknown	103	41.70%

2) The National Park Service has used two sources of information to characterize disturbance.

a) The first pertains to disturbance data collected by volunteers and Park scientists from the observation point overlooking the estero. The data were collected as an adjunct to population monitoring conducted according to the National Park Service Pinniped Monitoring Protocol. The disturbance data were collected to "Determine the long-term trends in sources, frequency and level of effects of natural and anthropogenic disturbances on harbor seal haul out use and productivity" (Adams et al. 2009, p. 31). The data were used in Becker et al. (2009) to test for a relationship between mariculture productivity and harbor seal disturbance rate. Is this disturbance dataset suitable for assessing human/harbor seal interactions? That is, is it sufficient to characterize the rate and degree of disturbance by all sources and to determine the effects of that disturbance over time? If

not, how might you improve the Park Service's ability to collect data for the stated purpose? If the validity of any single data point is questionable, should it be removed from the dataset, modified to remove/identify only those aspects in question, or retained as is?

b) The second pertains to implied disturbance by mariculture activities as estimated by annual oyster production and is central to the Becker et al. (2009, 2010) manuscripts that we reviewed for the meeting at Point Reyes National Seashore. Is annual oyster production a reliable proxy for mariculture effort in the estero? Why or why not? Also, is effort data alone a reliable measure of actual or potential disturbance, whether by human activities or habitat alteration (e.g., presence of oyster bags)? If not, how might you develop a better measure of mariculture effort and its relationship to the disturbance or displacement of seals in the estero? What factors would you include in such a measure?

After review, it is my personal opinion that any discussion of individual data points is irrelevant given the larger issues within the study design, data analyses and proxies used for effort. As the total number of disturbances attributed to aquaculture activities is relatively small, each has a potentially significant effect on the outcome of the statistical analyses and it is tempting to want to exclude or include them from a discussion of causality. To do so loses site of the larger issue.

I agree with Paul Thompson as stated in National Academy of Sciences Report[2] that the seal data disturbance data, because of the study design cannot be used to assess causation of population trends or the severity of impacts. Thompson was clear and insufficient argument has been provided to contest Thompson's statements that a) none of the studies were designed to assess effects; b) the studies suffer from weaknesses of high observer variability and *disturbance data collected cannot be used to infer cause and effect* (National Academy report page 5). As a result, this data set cannot be used to either directly or indirectly demonstrate any effects of the oyster farm on harbour seals or to demonstrate the absence of potential threat as restated by Thompson in his presentation to the panel.

The hypotheses tested by Becker et al are correlational at best and causality cannot be derived due to the limitations of the data as stated above.

Three other factors significantly affect the basic premise of the data analyses:

a) the *a priori* hypothesis that aquaculture activities have a significant disturbance that result in the influence of population behavior;

b) that the population within the estero and its behavior can be considered as distinct subgroups based on haul out sites and separate of the regional population (see comments above) and;

c) that oyster production based on biomass in a year may be used as a proxy for aquaculture activity.

A priori Hypothesis: The use of *a priori* hypothesis to test for correlation between aquaculture activities and seal population without also incorporating alternate hypotheses seems

[2] National Academy of Sciences. 2009. Shellfish Mariculture in Drakes Estero, Point Reyes National Seashore, California.. National Academies Press. 138pp.

irresponsible. Especially in light of other potential factors such as the much larger number of observed anthropogenic disturbances listed by Sarah Allen in her presentation and the influence of larger oceanographic factors in the California nearshore environment such as those described by Sean Hayes during panel discussion.

Additionally causality from natural effects within the estero were stated as fact and not factored into the overall hypotheses. For example, the connection to sand bar A which exposed mothers and pups to coyotes and hikers is assumed to have causality in use trends within the estero. In summary, it seems apparent that the population within the estero cannot be considered distinct within individual haul out use or regional trends and those individuals are routinely subject to a variety of natural and anthropogenic disturbances as well as short and long term environmental trends.

Annual oyster production as a proxy for activity: It is unreasonable to model oyster harvest as an accurate proxy for operational activity. Various points can be made in this regard:

- The oyster farm currently operates at a approximately 50% of maximum historic levels (see Kirtsen chart).
- All data collected by the California State for statistical records uses a conversion method that may further blur the accuracy of the production.
- During the Lunny operation of the farm there have been significant changes in operational activity primarily increasing the volume of single oysters grown in plastic mesh pouches, the addition of Manila clams in addition to the historic technique of growing oysters from wooden racks. These techniques have different labor and operational requirements as well the techniques are employed in different parts of the estero with rack oyster culture concentrated in the upper and central reaches of the estero and single oysters concentrated in the lower reaches of the estero on the south shore of the "lateral channel". It can be generally assumed that most businesses will be seeking to improve efficiency whenever possible.
- Increased harvest in one year will be preceded by more seeding and maintenance in previous years . Some crops such as single oysters may be on a single year cycle while other crops (Shucking oysters) will be on a multi-year cycle.
- Activity related to production will not increase in a linear fashion as significant economies of scale will be observed. To use a simple hypothetical example – if an oyster farm harvest 500 lbs of oysters a week, typically delivered to market once a week - the firm might send a crew and vessel out for typically one day to assemble and transport the order. If the order is increased fourfold to 2000 lbs a week, the farm would most likely still make one vessel trip out to assemble and collect the order depending on the capacity of its vessels and barges. The converse of the relationship is also true; in order to maintain a market during periods of low demand the farmer will most likely still have to send a crew and vessels out for a very small order.
- This lack of clear relationship between activity and harvest data was exhibited during interview with the Lunnys and their manager during the site visit.

In summary, the testing of an *a prior* hypothesis to show correlation between a proxy for a single anthropogenic activity without also examining alternate hypothesis is only of minor statistical interest. To extend this correlation to state causality does not appear valid. Furthermore when combined with the inaccurate use of oyster production within any one year as a proxy for activity it is irresponsible at best to make the statement (Becker) that for every 100,000 lbs of oysters harvested there will be 19 less pups and 71 less adults implying that the observed correlation is causal or linear.

c) Volunteers and National Park Service scientists identify disturbances on the basis of head alerts, flushing, and flushing into the water. Are each of these measures suitable for characterizing disturbance? Why or why not?

I agree with the statement by Thompson: *Explore alternative predictive modeling framework that does not rely on any of the disputed data set*. There is a need to provide guidance on what is the effect of cumulative, long term and short term disturbances. In disturbance data set, aquaculture activities accounted for a smaller percentage of disturbances in the total anthropogenic data set. It does not make sense that varying sources of disturbances should be handled differently or that analyses of data sets should pick and choose which ones should be assessed as critical (aquaculture versus kayaks for example.

My specific expertise does not allow me to make comment on the relationship to various disturbances related responses (head alert, flushing etc.).

3) Management measures for Drake's Estero are based on a suite of laws and agreements that establish pertinent authorities and identify purposes deemed suitable for the estero. The existing management measures are composed largely of temporal and spatial measures that are based primarily on areas where the seals haul out and that dictate when and where certain activities can occur. For example, management measures prohibit powerboats in the estero year-round, except boats used for mariculture. They also prohibit non-powerboats (e.g., kayaks, canoes) in the estero from 1 March through 30 June. The 1992 Record of Agreement Regarding Drake's Estero Oyster Farming and Harbor Seal Protection has provided an important supplement to those management measures pertaining to mariculture[3]*. The agreement prohibits mariculture workers from using the main channel from 15 March through 30 June, except for weekly collection of water quality samples. It also prohibits mariculture workers from using the lateral channel between beds #1-2 (presumably now labeled beds 15 and 17) and bed #3 (presumably bed 20) from 15 March to 1 June. In addition, it indicates that mariculture workers should plan, and make every effort, to begin seeding beds #1-3 after 1 June, and the lateral channel should be used as little as possible between 1 and 30 June. Oyster beds #2-3 should be approached from the north at low speed and the beds planted north to south so that "disturbance near the lateral channel will more likely be limited to the end of the pupping season" (language from the agreement). As a temporary matter pending further review, the California Coastal Commission imposed, and the National Park Service Special Use Permit incorporated, a year-round restriction on use of the eastern two-thirds of the lateral channel and specific sand bars where seals haul out. Under current conditions, mariculture workers may use the western one-third of the lateral channel during the period from 1 June through 14 March.*

[3] The agreement was signed by the Point Reyes National Seashore, National Marine Fisheries Service, California Department of Fish and Game, California Department of Health Services, and the Johnson Oyster Company. It was not signed by the Drake's Bay Oyster Company or the California Coastal Commission.

a) Recognizing that the estero is a dynamic environment (although less so away from the mouth of the estero) and that harbor seals may shift their hauling patterns over time, are the temporal and spatial restrictions from the 1992 agreement, the California Coastal Commission, and National Park Service individually or collectively sufficient to avoid disturbance and displacement of harbor seals? Is the available information sufficient to evaluate the utility of the measures? Is it sufficient to evaluate the utility of the restriction added by the California Coastal Commission? If you consider it to be sufficient, please describe the basis for your conclusion. If you do not consider it to be sufficient, please describe why not and what additional information would be helpful.

The measures being exercised by the Drakes Bay Oyster Company appear to be more than sufficient in my experience with other aquaculture areas where Harbour Seals are commonly habituated and coexist with aquaculture activities. Further comment on the utility of the measures in relation to Seal biology is outside of my expertise.

b) The primary spatial limitations pertain to use of the main and lateral channels. Much of the debate regarding use of the lateral channel pertains to the question of whether the existing measures ensure suitable separation between mariculture activities near the western end of the lateral channel and areas along the lateral channel that harbor seals might use, absent any human activity. The debate implicitly involves a null hypothesis that the distance between the two locations is sufficient to avoid disturbance of harbor seals and that the seals do not use the rest of the channel because of other natural factors (e.g., shallowness). The alternative hypothesis is that the distance is not sufficient and is displacing the seals from potential haulout areas along the lateral channel. Is the existing evidence sufficient to discriminate between these two hypotheses? If so, what conclusion(s) can be drawn and what supporting data are available? Also, what is your best estimate of the separation distance required to avoid harbor seal disturbance on land and in the water? If you don't feel you can answer that question with existing information, how would you go about determining the distance?

I did not observe any data presented in the Drakes Estero studies that specifically supported either hypothesis. I found it interesting that seals showed relatively strong behavioral changes in relation to significant disturbances As example, the complete abandonment of site A due to access of coyote predation and hiker/clam fisher disturbance followed by the increase of seal use at site OB closer to the mariculture operations. Further comment on the effectiveness of avoidance buffers in relation to Seal biology is outside of my expertise.

4) Harbor seals recently shifted their habitat use patterns in the estero. Site A became connected to land, which allowed access by human visitors and coyotes. The seals abandoned site A, presumably because of the threat posed by disturbance or harassment. They likely moved either to other sites in the estero or to neighboring colonies. Their shift in habitat suggests that they prefer isolated sandbars. However, based on the timing of the reconnection of site A to land and the presumed corresponding increase in exposure to disturbance and harassment, it is reasonable to infer that disturbance, or the threat of it, may affect the behavior or habitat use patterns of seals in the estero. In contrast, Becker et al. (2010) did not find that spring (March through May) disturbances (that they referred to as short-term and were relatively infrequent) caused a shift in habitat use by seals using haulout sites isolated from land. How can those apparent differences in response to disturbance be explained?

This is outside of my area of expertise.

5) Based on data that were being collected in late April and early May 2007, the National Park Service concluded that increasing oyster activities, including the placement of additional oyster bags near the OB haulout site, had caused a substantial reduction in the number of seals using that site. The Service originally estimated an 82 percent decline for pups and 77 percent for all seals. It later revised that estimate to 65 percent for pups and 56 percent for all seals. In hindsight, are the available data on haulout patterns on OB sufficient to form or support the final conclusion? Why or why not?

As was shown in the panel meeting this 82% decline was a) not correct as data was not collected not the peak of pupping season as evidenced by Park Staff later and b) not taken in context of either Drakes Estero sub population or regional population. Although I am not an expert in wildlife biology I do not believe that the data supports the causality that was inferred from the observations.

6) At the meeting the panel described the need for a review of Becker et al. (2009) and especially, Becker et al. (2010) by one or more statisticians. The review would start with the available data and then work through the analyses. The primary focus would be on the suitability of the statistical analyses presented in these two papers. In addition to a statistical review, do you have any suggestions for improving the data and analyses included in Becker et al. (2009) and Becker et al. (2010)? For example, should they include other measures or sources of disturbance? Would you like to see other alternative hypotheses tested to assess the potential threats to harbor seals in Drake's Estero?

See previous comments on limitations of testing a priori hypothesis, inadequacy of data set to evaluate causality, and lack of testing of alternate hypotheses. During discussion it was stated by panelists and others that the regional seal population, has been expanding over the long term and may have hit carrying capacity. This population is exposed to a variety of anthropogenic and natural phenomena that could affect behavior, survival and reproductive success. It would not be unlikely for this population to undergo trends both positive and negative and all possible factors should be assessed when looking for potential reasons to explain year to year variability.

7) Do you see a need for changes to existing management measures or additional measures to avoid disturbance of harbor seals by all sources (i.e., including kayaking, hiking, etc.)? If so, what new measures or adjustments to old measures do you suggest? Do you think an adaptive management approach could be used here to address remaining questions about the effects of disturbance? If so, what high-priority questions would you attempt to address?

I believe that adaptive and improved manage mane subject is key in going forward. The intersection of a motivated user within the estero (Drakes Bay Oyster Company), concerned Parks Staff and volunteers represents a unique opportunity to provide management and research that supports the intent of the Park Service in protecting wildlife populations and sustainable coastal marine uses. Partnerships between all parties and adaptive management are the solution. Discussions during the panel meeting illustrated how this has factored in the unique success of the Pt Reyes Seashore since its inception and the potential for this to continue to provide leadership is significant.

The following recommendations are presented:

- Conduct direct studies in partnership with DBOC to observe farm activities in relation to seal behavior, this would also allow experimental observations such as response to various thresholds of activities, ranges, sounds etc.
- Potential for partnerships: DBOC is only point of embarkation for kayakers, should be used point of education for kayakers and as locale for enumerating kayak departures.
- Recommendation – clearly mark vessels used by DBOC so that they may be clearly identified by observers.
- Include site visit to DBOC during annual observer training so that observers understand the nature of mariculture activities and can differentiate between mariculture and other activities within the estero.
- Create feedback loop with observers (ie cell phone numbers) so that anomalous events or incidents of disturbance relating to crews is immediately reported back to DBOC and Parks Staff for follow-up.
- Investigate any information on how to mitigate seal response to activities – use this data to train DBOC staff – ie operate vessels on certain paths, do not make erratic course changes or throttle changes that would cause head or startle responses.

8) What additional scientific questions do you consider important to the assessment of human/harbor seal interactions at Drake's Estero?

See previous comments regarding hypothesis testing

Investigate the linkages between seal population and environmental carrying capacity – do Drakes Estero resident seals primarily forage within the estuary? If so what is the linkage between prey species (fish/invertebrates) and seal populations? What is the limiting factor on seal use on seasonal or annual use? How do prey populations change in relationship to environmental and ecosystem shifts and how does that affect local seal populations.

1) *For context, what short- and long-term effects might disturbance in Drake's Estero have on individual harbor seals, the Drake's Estero harbor seal population, the broader regional population, and harbor seal habitat? Please address the potential for disturbance from human presence and activity, as well as the potential for disturbance of habitat from the presence of oyster bags and other materials related to mariculture.*

The potential effects of disturbance on harbor seals will depend on several factors associated with the disturbance; e.g., spatial and temporal extent, severity, cumulative impact, and interactions with other potential effects. As such, the effects that disturbance, including human presence and activity, in Drake's Estero might have on individual seals, the Drake's Estero population, the broader regional population, and seal habitat will depend on the nature of the disturbance, and could range from no effects to substantial short- and long-term effects. Specific effects could include the following: head alert, flush into water, mother-pup separation, shift in use among haul out sites, decrease in pup production, and decrease in pup survival. Similarly, a range of potential disturbance, or impact, of habitat exists from the presence of oyster bags and other materials related to mariculture.

2) The National Park Service has used two sources of information to characterize disturbance.

> *a) The first pertains to disturbance data collected by volunteers and Park scientists from the observation point overlooking the estero. The data were collected as an adjunct to population monitoring conducted according to the National Park Service Pinniped Monitoring Protocol. The disturbance data were collected to "Determine the long-term trends in sources, frequency and level of effects of natural and anthropogenic disturbances on harbor seal haul out use and productivity" (Adams et al. 2009, p. 31). The data were used in Becker et al. (2009) to test for a relationship between mariculture productivity and harbor seal disturbance rate. Is this disturbance dataset suitable for assessing human/harbor seal interactions? That is, is it sufficient to characterize the rate and degree of disturbance by all sources and to determine the effects of that disturbance over time? If not, how might you improve the Park Service's ability to collect data for the stated purpose? If the validity of any single data point is questionable, should it be removed from the dataset, modified to remove/identify only those aspects in question, or retained as is?*
>
> The disturbance dataset has been used appropriately to provide a descriptive understanding of the relative frequency of different sources of disturbance within and across years, and to examine general emerging or changing issues of disturbance. The disturbance data were not collected in a manner that permits a

sufficient quantitative comparison of the effects of different sources of disturbance over time and space.

The collection of a much more extensive dataset would be required, based on a robust experimental design, to meet the objective of determining the effects of both natural and anthropogenic disturbance (and distinguishing between those two types of disturbance) on harbor seal haul out use and productivity over time. Specifically, the following improvements should be considered:

1. include multiple sites for observing the seals and sources of disturbance.
2. dedicated observations for monitoring and recording disturbance, rather than adjunct to population monitoring.
3. record disturbance at the sub-site level.
4. increase observations during the week days when the majority of the mariculture activity occurs.
5. based on previously collected data, determine the sample sizes required to have sufficient statistical power to distinguish between effects of numerous sources of disturbance and known variability in harbor seal haul out use patterns across seasons, years, and seal age, gender, reproductive status, etc.
6. at the level of individual seals and the local and regional population level, clearly define the spatial and temporal 'effects' from disturbance that are of interest; i.e., head alert, flush into water, decrease in amount of time suckling, mother-pup separation, shift in use among haul out sites, decrease in pup production, decrease in pup survival, etc.

A questionable data point should be accepted only if a thorough review of the questionable aspects results in an unequivocal modification; otherwise, the data point should be removed.

b) The second pertains to implied disturbance by mariculture activities as estimated by annual oyster production and is central to the Becker et al. (2009, 2010) manuscripts that we reviewed for the meeting at Point Reyes National Seashore. Is annual oyster production a reliable proxy for mariculture effort in the estero? Why or why not? Also, is effort data alone a reliable measure of actual or potential disturbance, whether by human activities or habitat alteration (e.g., presence of oyster bags)? If not, how might you develop a better measure of mariculture effort and its relationship to the disturbance or displacement of seals in the estero? What factors would you include in such a measure?

Based on the available data and information provided during the meeting at Point Reyes National Seashore, factors exist that could decrease the reliability of annual oyster production as a proxy for mariculture effort. Examples include the following:

1. The level of effort associated with different types of oyster farming practices (clusters on racks vs. bags) may result in different levels of production.
2. Use of a consistent metric of productivity; i.e., index to # of oysters harvested (100 oysters per gallon) vs. count of oysters produced.
3. The effort to double the number of bags at a site (and hence production) may not necessarily require a doubling of effort.

Further, factors exist that could decrease the strength of using effort data alone as a reliable measure of actual or potential disturbance. Examples include the following:

1. Spatial distribution of effort - both the level and type of effort may not be equal in all areas, such that the probability of disturbance is not equal at all areas.
2. Temporal distribution of effort - variability in the vulnerability of seals to disturbance and the level and type of effort across periods/seasons.

To develop a better measure of the relationship between mariculture effort and disturbance or displacement of seals, well defined categories of mariculture activities/efforts need to be agreed upon by DBOC and NPS staff. Subsequently, the spatial and temporal distribution of those activities would be recorded by the DBOC, and, when disturbance or displacement of seals is observed by NPS (and possibly DBOC) staff these categories of activities are utilized in the data recording protocol.

c) Volunteers and National Park Service scientists identify disturbances on the basis of head alerts, flushing, and flushing into the water. Are each of these measures suitable for characterizing disturbance? Why or why not?

These measures are suitable characterizations of specific seal behaviors. However, these behaviors are not necessarily a response to disturbance; i.e., in the absence of disturbance they may occur due to vigilance, social interactions among seals, and other factors.

3) Management measures for Drake's Estero are based on a suite of laws and agreements that establish pertinent authorities and identify purposes deemed suitable for the estero. The existing management measures are composed largely of temporal and spatial measures that are based primarily on areas where the seals haul out and that dictate when and where certain activities can occur. For example, management measures prohibit powerboats in the estero year-round, except boats used for mariculture. They also prohibit non-powerboats (e.g., kayaks, canoes) in the estero from 1 March through 30 June. The 1992 Record of Agreement Regarding Drake's Estero Oyster Farming and Harbor Seal Protection has provided an important supplement to those management measures pertaining to mariculture[1]. The agreement prohibits mariculture workers from using the main channel from 15 March through 30 June, except for weekly collection of water quality samples. It also prohibits mariculture workers from using the lateral channel between beds #1-2 (presumably now labeled beds 15 and 17) and bed #3 (presumably bed 20) from 15 March to 1 June. In addition, it indicates that mariculture workers should plan, and make every effort, to begin seeding beds #1-3 after 1 June, and the lateral channel should be used as little as possible between 1 and 30 June. Oyster beds #2-3 should be approached from the north at low speed and the beds planted north to south so that "disturbance near the lateral channel will more likely be limited to the end of the pupping season" (language from the agreement). As a temporary matter pending further review, the California Coastal Commission imposed, and the National Park Service Special Use Permit incorporated, a year-round restriction on use of the eastern two-thirds of the lateral channel and specific sand bars where seals haul out. Under current conditions, mariculture workers may use the western one-third of the lateral channel during the period from 1 June through 14 March.

> *a) Recognizing that the estero is a dynamic environment (although less so away from the mouth of the estero) and that harbor seals may shift their hauling patterns over time, are the temporal and spatial restrictions from the 1992 agreement, the California Coastal Commission, and National Park Service individually or collectively sufficient to avoid disturbance and displacement of harbor seals? Is the available information sufficient to evaluate the utility of the measures? Is it sufficient to evaluate the utility of the restriction added by the California Coastal Commission? If you consider it to be sufficient, please describe the basis for your conclusion. If you do not consider it to be sufficient, please describe why not and what additional information would be helpful.*

The available data indicate that the peak pup count for the estero, and the broader region, is between the last week of April and the first week of May;

[1] The agreement was signed by the Point Reyes National Seashore, National Marine Fisheries Service, California Department of Fish and Game, California Department of Health Services, and the Johnson Oyster Company. It was not signed by the Drake's Bay Oyster Company or the California Coastal Commission.

subsite data on peak pup counts is presumably not available. Mariculture activity is not permitted in (1) the main channel from 15 March - 30 June (except for weekly collection of water quality samples), (2) the eastern two-thirds of the lateral channel year round, and (3) the western one-third of the lateral channel from 15 March - 31 May. Collectively, these restrictions likely greatly reduce disturbance and displacement of seals in those areas, especially during the pupping period. However, some disturbance and displacement may occur near the borders of the areas and when weekly water samples are taken.

The available information is not sufficient to evaluate the utility of the measures (including the restriction added by the California Coastal Commission) because of inadequate information on seal use and mariculture activity prior to implementation of the measures to establish a baseline, and subsequent to implementation, to evaluate a possible effect. The additional information that would be helpful are included in responses to questions 2a and 2b, above.

b) The primary spatial limitations pertain to use of the main and lateral channels. Much of the debate regarding use of the lateral channel pertains to the question of whether the existing measures ensure suitable separation between mariculture activities near the western end of the lateral channel and areas along the lateral channel that harbor seals might use, absent any human activity. The debate implicitly involves a null hypothesis that the distance between the two locations is sufficient to avoid disturbance of harbor seals and that the seals do not use the rest of the channel because of other natural factors (e.g., shallowness). The alternative hypothesis is that the distance is not sufficient and is displacing the seals from potential haulout areas along the lateral channel. Is the existing evidence sufficient to discriminate between these two hypotheses? If so, what conclusion (s) can be drawn and what supporting data are available? Also, what is your best estimate of the separation distance required to avoid harbor seal disturbance on land and in the water? If you don't feel you can answer that question with existing information, how would you go about determining the distance?

The existing evidence is not sufficient to discriminate between the two hypotheses, for similar reasons described in 3a, above. Specifically, inadequate information on seal use and mariculture activity prior to implementation of the measures to establish a baseline, and, subsequent to implementation to evaluate a possible effect.

Specific to existing information available from the lateral channel, estimating the separation distance required to avoid harbor seal disturbance on land and in the water with sufficient accuracy is not currently possible. Restricting use of the

entire lateral channel year round (i.e., adding the western third) would allow an initial assessment of whether the mariculture activities are precluding harbor seal use further west along the channel. Experiments designed to determine seal responses to specific mariculture activities at specific distances would help determine the distance.

4) Harbor seals recently shifted their habitat use patterns in the estero. Site A became connected to land, which allowed access by human visitors and coyotes. The seals abandoned site A, presumably because of the threat posed by disturbance or harassment. They likely moved either to other sites in the estero or to neighboring colonies. Their shift in habitat suggests that they prefer isolated sandbars. However, based on the timing of the reconnection of site A to land and the presumed corresponding increase in exposure to disturbance and harassment, it is reasonable to infer that disturbance, or the threat of it, may affect the behavior or habitat use patterns of seals in the estero. In contrast, Becker et al. (2010) did not find that spring (March through May) disturbances (that they referred to as short-term and were relatively infrequent) caused a shift in habitat use by seals using haulout sites isolated from land. How can those apparent differences in response to disturbance be explained?

The apparent differences could potentially be explained by the following:

1. Access to deep water channels may be better at seal haul out sites isolated from land compared to haul out sites connected to land, and the proximity to such deep water channels likely influences how seals respond to disturbance or harassment. Specifically, deep water channels represent good 'escape habitat', and seals without access to it likely respond by flushing into the water more readily, and eventually use such sites less resulting in a shift to sites isolated from land.
2. Differences in the type and frequency of disturbance at isolated vs. connected haul out sites. Disturbance by coyotes, which represents a potential for increased mortality, is likely higher at sites connected to land, and seals would likely shift to sites isolated from land.

5) Based on data that were being collected in late April and early May 2007, the National Park Service concluded that increasing oyster activities, including the placement of additional oyster bags near the OB haulout site, had caused a substantial reduction in the number of seals using that site. The Service originally estimated an 82 percent decline for pups and 77 percent for all seals. It later revised that estimate to 65 percent for pups and 56 percent for all seals. In hindsight, are the available data on haulout patterns on OB sufficient to form or support the final conclusion? Why or why not?

Maximum counts (adult and pup) at one haul out subsite from the one day in which peak counts are obtained during the pupping period from 2004 and then 2007 can be compared to estimate a difference; in this case a decrease in numbers. However, attributing that decrease, at least in part, to the placement of additional oyster bags near the subsite is not supported, based on the available information, for the following reasons:

1. The use of a haul out by seals varies substantially within a year, as the 2007 data for subsite OB shows, as well as across years and among haul outs.
2. A more robust estimate of changes in numbers at one site should include the variability at that site across the years of interest.
3. In addition to data from 2004 and 2007, data from 2005 and 2006 should be utilized, both the count data and associated variability.
4. Because of the relatively large fluctuation in numbers at a site across years, including additional years of data would provide a more robust estimate.
5. 2004 is considered the baseline year for the comparison with 2007 because of an increase in oyster production observed after DBOC took over the lease in 2005. This increase in production is assumed to be a result of increased effort (more oyster bags near the lateral channel), which resulted in increased disturbance. However, see 2b above for problems associated with this assumption.
6. Lastly, the decrease in numbers should be qualified relative to a possible shift to other haul out sites as opposed to an actual decrease in pup production.

6) At the meeting the panel described the need for a review of Becker et al. (2009) and especially, Becker et al. (2010) by one or more statisticians. The review would start with the available data and then work through the analyses. The primary focus would be on the suitability of the statistical analyses presented in these two papers. In addition to a statistical review, do you have any suggestions for improving the data and analyses included in Becker et al. (2009) and Becker et al. (2010)? For example, should they include other measures or sources of disturbance? Would you like to see other alternative hypotheses tested to assess the potential threats to harbor seals in Drake's Estero?

1. A review of the Becker et al. papers should begin with a critical assessment of whether the available data are sufficient to test the primary hypothesis. Specifically, are the available data on oyster productivity a

reliable proxy to the mariculture activities that may result in disturbance to harbor seals, on the spatial and temporal scales of interest?

2. The use of a binary value to classify oyster harvest levels as either high or low appears appropriate, and the authors note it eliminates the assumption of a linear relationship between harvest and the activity associated with that harvest. In deciding which years were high vs. low, the authors state "*... we did this based on the inferences in Table 1 regarding increased presence of oyster equipment at sites near seal haul out sites and an apparent break point of around 138,000 lbs of oysters.*" However, the largest break in the distribution of the annual harvest data is 152,580 lbs, which is between 138,958 (2005) and 291,538 (2006). The highest harvest below 138,958 is 125,749 which is a break of 13,209, and the first harvest higher than 291,538 is 292,188 which is a break of 650. As such, harvest levels 138,958 and lower could arguably be considered low, and thus the period of low harvest would be the 7 years between 1999-2005. The analysis of the data should consider this revised classification for this important covariate. Further, available information on the increase in production in 2005 should be examined in more detail; e.g., what proportion may be due from a possible increase from cluster production on racks away from seal haulouts.
3. The seal count data are from the months associated with the pup/breeding season. Oyster harvest data are available on a monthly basis, and the subset of harvest data from the pup/breeding season should be considered as a covariate.
4. Oyster harvest rate is used as a proxy for mariculture activities that may result in disturbance. The analysis assessing the relationship between the available data on disturbance and harvest rate should be reviewed, noting the proportion of disturbance due to mariculture activities. Further, the relationship should be examined using only the harvest data from the months during the pupping/breeding season.

7) Do you see a need for changes to existing management measures or additional measures to avoid disturbance of harbor seals by all sources (i.e., including kayaking, hiking, etc.)? If so, what new measures or adjustments to old measures do you suggest? Do you think an adaptive management approach could be used here to address remaining questions about the effects of disturbance? If so, what high-priority questions would you attempt to address?

The level of compliance with the existing measures should be assessed.

Management measures and restrictions should be considered for the molting period as well as the pupping/breeding period. An adaptive management approach could be used to assess the effectiveness of existing measures and determine if modifications are warranted. High priority questions could include the following:

1. Would harbor seals haul out and use the western third of the lateral channel for pupping in the absence of oyster bags and associated mariculture activities?
2. Can harbor seals habituate to mariculture activities in Drake's Estero? If so, to what type of activities and at what distance?
3. Is the effect of disturbance on harbor seals the same for mariculture activities compared to other sources of disturbance?

8) What additional scientific questions do you consider important to the assessment of human/ harbor seal interactions at Drake's Estero?

Based on the existing policies and management restrictions, what is the standard by which the potential effects of human related is considered ecologically significant?

Report for the Marine Mammal Commission Regarding Drakes Estero Review 7-31-10

From: Michael T. Walsh DVM

To: Tim Ragen

Dear Tim,

First let me whole heartedly apologize for my lack of professionalism in not responding in a timely manner to the needs of the panel and the commission. I will not offend you, the group, or the parties with excuses but will attempt to give this the effort it so deserves.

In regards to the guidelines you out lined in April, they were very helpful in avoiding focus and responsibility drift in purpose and opinion. Please see my responses to your questions in the guideline copy included.

This situation is a very difficult one when taking into account the historic length of time involved with the mariculture activity, the desire of many to preserve as much of our rapidly dwindling pristine environments as possible, and our tendency to make decisions based on limited information at hand. Listening to the numerous people from both sides of the issues it seemed like it was more important for both to defend their current positions based on their opposing desires than to move toward a cooperative approach. As I have been exposed to more and more medical issues with varying degrees of knowledge I have realized that the first and most important consideration to remember is that we all will make decisions based on what we know at that time not on all of the potential information.

The methodology used to determine associations in the publications is complicated by the narrow approach in observations that were meant to crudely determine population numbers not numerous variables inherently involved in behavioral evaluation. Distance from subjects, level of time involved, level of training of observers, and numerous other factors limit the application of the information in many contexts. While there is some solid data available it may not provide an accurate picture of the interactions between harbor seals and mariculture activity.

In thinking about the short and long term reactions of harbor seals to human intrusion there have obviously been health assessments in other seal populations that have resulted in direct human interaction for restraint and handling. Have these efforts resulted in groups no longer able to return to their choice habitat because the intrusion is temporary or has this secondary effect not been examined?

The desire to determine the reasons for apparent decreases in the numbers of animals hauling out in the Drakes Estero area or the decline in pup numbers has been focused on what has been visually observed in the population counts with a secondary goal of documenting animal interaction. While mariculture activity is a logical strong and potentially direct influence there are many other factors that, while hard to prove with the available level of observation or the lack or other data that should still be considered. As in the case of human interactions the investigation into the influence of natural shifts and disease has been minimal. These efforts should include known pinniped mortality causes, unusual mortality events, temporary regional shifts in population, unknown fisheries changes other than current theories and our general inability to understand all aspects of harbor seal behavior in response to human interaction.

For my part as the medical contributor there has been limited information available from necropsy specimens that would clarify disease or toxic processes that may influence population fluctuations

An evaluation of 46 Unusual Mortality Events showed the last recorded UME for harbor seal in California waters occurred in 2000. These events are but a glimpse into animal die offs and are not inclusive of all die offs that are occurring. Details were not available on the UME web site but the 2005 Stock report for California harbor seals gave some information on the UME for 2000 and mentioned a mortality event from 1997 at http://www.nmfs.noaa.gov/pr/pdfs/sars/po2005sehr-ca.pdf. This excerpt is taken from that report. "Two unexplained harbor seal mortality events occurred in Point Reyes National Park involving at least 90 seals in 1997 and 16 seals in 2000. Necropsy of three seals in 2000 showed severe pneumonia; tests for morbillivirus were negative, but attempts are being made to identify another virus isolated from one of the three (F. Gulland, pers. comm.).
All west-coast harbor seals that have been tested for morbilliviruses were found to be seronegative, indicating that this disease is not endemic in the population and that this population is extremely susceptible to an epidemic of this disease (Ham-Lammé et al. 1999)."

Though there was no indication of disease as a cause of the decrease in pup numbers in 2007 and there were no reports of large numbers of dead pups or adults locally, the involvement of other undetermined disease influences on animal haul out numbers has not been ruled out. Available mortality records were requested for the region in question and 11 reports from 2008 were submitted. I appreciated the effort in acquiring necropsy data for the review. These were mainly focused on an increase in mortality of pups on Drakes beach, of which the majority were attributable to trauma. While this is not an uncommon issue in newborns it could also be related to an increase in new inexperienced females or secondary to other issues such as aggressive individuals present or an increase in flight response associated with newborns present, beach crowding, or even weak pups unable to fend for themselves. Apparently one animal was tested for herpes though further workups on most were not available. These reports are included in an attachment. The investigations did not cover causes that may be associated with areas of concern such as water runoff or disease etiologies associated with cattle that have been on the surrounding land for many years. Often this information is not pursued unless there is a notable die off and substantial efforts are made to determine a cause.

There is also no easily available data base on biotoxin levels or contaminants for this region. This does not mean they are not being investigated but that there is nothing in print at this time. This is an area that should be pursued as part of good science and stock management to set a baseline for future investigations regarding the animals and their adaptability to the decisions made regarding their environment.

My recommendations regarding the current techniques of data collection and the issues at hand are contained in my point by point response to your report guidelines. In general I feel very strongly that new observational studies should be performed with a design heavily contributed by third party behaviorists and ethologists to get to the bottom of specific questions. This should include new points of observation much closer to the sites, video documentation of interactions and on the ground cooperation with observers placed above and at the activity for accurate accounting of the animals' responses.

Medically there should be a baseline study for contaminants, PCR for disease categorization and biotoxin when appropriate carcasses are available. The usual rationalization of it is expensive and budgets are lean

should be balanced with the need to better understand what impacts this population. This could involve a health assessment of the population or one of those in close proximity. Alternate sources of analysis and funding should be pursued if needed.

Please let me know if the responses to the guidelines should be pulled out as a separate document but I felt that they are better suited in close association with the questions so as to avoid the appearance of repetition of shared responses. Again I apologize to the panel, the agencies and the industry for my over committing myself these last few months and hampering progress.

Sincerely,

Michael T. Walsh DVM

Guidance
Report with Responses to
Questions

16 April 2010

To: Members of the Marine Mammal Commission's Drake's Estero Panel

From: Tim Ragen

Regarding: Guidance for your reports to the Commission

In preparing your reports on human interactions with harbor seals in Drake's Estero, please focus on the scientific matters identified in the background materials and discussed at the meeting at Point Reyes National Seashore. Please avoid imposing your personal views regarding wilderness designation and future (post-2012) use of the estero for mariculture. Those are matters of policy that Congress and the National Park Service must decide. Instead, please consider the following questions based on your professional judgment as scientists knowledgeable about harbor seals and/or the potential effects of human disturbance. For each question, please provide a detailed explanation of your answer. If you choose not to address a question (e.g., you do not feel it relevant to the scientific issues at hand or you feel it falls outside your area of expertise), please provide an explanation to that effect.

The background material and, especially, the discussion at the meeting focused on the issue of avoiding disturbance and displacement of harbor seals. Information provided by the National Park Service identifies a number of sources of harbor seal disturbance, including kayaking, hiking, horseback riding, clam digging, low-flying aircraft, oyster farm operations, and people using nearby beaches.

1) For context, what short- and long-term effects might disturbance in Drake's Estero have on individual harbor seals, the Drake's Estero harbor seal population, the broader regional population, and harbor seal habitat?

While not a pinniped biologist my background in marine mammal medicine with 21 years of working with captive pinnipeds in reproductive and non reproductive groups reinforces the commonality of most behavioral characteristics exhibited in wild and captive individuals. The predicted outcomes of behavioral disturbance whether in controlled or wild environments would be based on the level of effort given to observations of interaction with disturbances and their length of involvement possibly covering many breeding seasons and the need for individual identification. Individual harbor seals short and long term effects will be related to the degree of the noxious or threatening stimuli, it tendency to be repeated, the proximity to the animal which would raise the reaction level and a decision to rate the stimuli as non threatening or worthy of response. Short term effects of insignificant stimuli would most likely trend toward a level of adaption. Noxious stimuli might result in change of posture, movement toward water and abandonment of the location. Since most

harbor seals will haul out in multiples the individual will be influenced to react by another individual in proximity that reacts. So while stimuli may be non threatening the response from a cohort may influence the rest of the group to a mob like reaction which may decrease in severity if others do not continue to perceive a threat. If perceived threats are repetitive or constant the group may seek other options for haul out that are deemed more secure. Prediction of consequence at this point is based on the shared flight or fright responses seen in many species. If the population seeks more secure haul out and relocates this may cause disruption in other costal populations and include competition for dry area for haul out and pup support, increased marginalization of individuals and groups and food competition.

Please address the potential for disturbance from human presence and activity, as well as the potential for disturbance of habitat from the presence of oyster bags and other materials related to mariculture.

Any human activity that mimics wild predator activity such as approach on land or water may result in behavioral change of the group or the individual. The severity of disturbance from human activity covers a very wide range from an accidental approach to injury which is construed as predator activity so the population or individual may have memory of recent past incidents if they occurred. A population not exposed to injury or death may have no historic memory of the level of human take. What I am not sure of is what the historic levels of disturbance have been in regards to human take of animals for food and how this initially may have affected distribution, haul out sites preference or return of animals in following years.

The presence of oyster bags and the resultant human activity for placement, maintenance and harvest can negatively affect the harbor seals if this activity is too close in proximity to the animal or groups comfort zones, too loud or perceived as threatening (rapid decreases in distance indicating an increased likelihood of harm). The level of activity needed to make a negative impact may decrease during pupping or nursing with the females more likely to move away or abandon areas to keep the pups from harm.

2) The National Park Service has used two sources of information to characterize disturbance.

> a) The first pertains to disturbance data collected by volunteers and Park scientists from the observation point overlooking the estero. The data were collected as an adjunct to population monitoring conducted according to the National Park Service Pinniped Monitoring Protocol. The disturbance data were collected to "Determine the long-term trends in sources, frequency and level of effects of natural and anthropogenic disturbances on harbor seal haul out use and productivity" (Adams et al. 2009, p. 31). The data were used in Becker et al. (2009) to test for a relationship between mariculture productivity and harbor seal disturbance rate. Is this disturbance dataset suitable for assessing human/harbor seal interactions?
>
> **After touring the observation site I am concerned that the location is not close enough to see details that may influence the behavior of the animals at the**

sites. The larger variables that are visible from the distance such as people and boats will be obvious and the cause and effect appear distinct but the distance and sole source monitor site could suggest an element of poor data mining based on the limitations of observation. In Becker's conclusions there are a few statements acknowledging the potential limits of the observation data based on time of year and length of observation times.

That is, is it sufficient to characterize the rate and degree of disturbance by all sources and to determine the effects of that disturbance over time?

Becker's study does not characterize the rate and degree of disturbance by other sources nor the relationship of these other disturbances over time. Modeling of the harbor seals activity is based on a very limited number of factors that have been most easily documented and counted but the original goal for the observations was to count animals and not to design an observational or detection system to study disturbance as a goal. I have no doubt that human disturbance is a major factor in loss of desirable habitat for rest, birth and nursing but should the decision be based on historic data not originally taken for the purpose of determining factors of disturbance or now with the potential importance of this issue instead design new studies to better characterize the questions and issues.

If not, how might you improve the Park Service's ability to collect data for the stated purpose?

An ethogram or series of ethograms should be designed by a reputable behaviorist to examine the question of, and the potential connection between, oyster activity and the disturbance of harbor seals. This would best be implemented by utilizing a third party from a university background who would interview both parties involved, study past observation data and add additional observation points to allow closer viewing in tandem with the west observation point historically used. This could be done from blinds if needed. Observations should be recorded with video to alleviate personal bias and incorporate wide angle lens capability to decrease scope bias. This study should also involve other times of the year to better compare numbers of seals throughout their use of the locations. Some discussion of this issue took place in side bars at the meeting but there was the issue of financial support given as an excuse to place the idea aside. If this is so important to tie up the discussion and future use of the DE area then the two groups can work together to fund or write grants to fund the needed studies. Contacting with an animal behaviorist may also result in other sources of funding or manpower to achieve the goals such as from a university.

If the validity of any single data point is questionable, should it be removed from the dataset, modified to remove/identify only those aspects in question, or retained as is?

I think less time should be spent in arguing or posturing on data points taken so far from a retroactive data management approach but instead take a step

back and recognize the lack of detail and potential weakness of both sides arguments and redesign a prospective study with input from both views as to the study design.

b) The second pertains to implied disturbance by mariculture activities as estimated by annual oyster production and is central to the Becker et al. (2009, 2010) manuscripts that we reviewed for the meeting at Point Reyes National Seashore. Is annual oyster production a reliable proxy for mariculture effort in the estero? Why or why not?

Oyster production is used as a proxy because the actual observation data regarding the disturbance-population relationship is not available in a form to make it useful in the discussion. Too many points of contention exist and weaknesses in data point to the need to redo a study during the remaining portion of their lease before the opportunity is lost.

Also, is effort data alone a reliable measure of actual or potential disturbance, whether by human activities or habitat alteration (e.g., presence of oyster bags)?

Effort data should be considered as a part of the evaluation since that information potentially impinges on normal harbor seal activity. Again it is important at this juncture to potentially accept that the data is inadequate to be used as a justification for either the Park Service or the mariculture industry to claim the high upper hand in the debate in its current form.

If not, how might you develop a better measure of mariculture effort and its relationship to the disturbance or displacement of seals in the estero? What factors would you include in such a measure?

The use of well designed ethograms should not only utilize the areas above the bay for more detailed pertinent observation but can be used in on the ground measurements as well. Observers can also deploy with oyster work crews focusing on seal interaction and better qualifying the direction of attention of seals to the harvest crews.

c) Volunteers and National Park Service scientists identify disturbances on the basis of head alerts, flushing, and flushing into the water. Are each of these measures suitable for characterizing disturbance?

These measures can be suitable for use as indicators of disturbance when taken in proper context.

Why or why not?

Behavioral evaluation is the basis of all scientific and medical approaches. While marine mammal medicine is thought to be based on the application of the understanding of disease and injury, the principles of therapy and ultimately prevention, it is also fundamentally based on the understanding of

an animal's behavior in health and illness. These responses of the harbor seal are different levels of their response to threats and prevention of injury. They each represent a level of the individual or groups response to different stimuli based on their placement in the food chain as prey for a number of species.

3) Management measures for Drake's Estero are based on a suite of laws and agreements that establish pertinent authorities and identify purposes deemed suitable for the estero. The existing management measures are composed largely of temporal and spatial measures that are based primarily on areas where the seals haul out and that dictate when and where certain activities can occur. For example, management measures prohibit powerboats in the estero year-round, except boats used for mariculture. They also prohibit non-powerboats (e.g., kayaks, canoes) in the estero from 1 March through 30 June. The 1992 Record of Agreement Regarding Drake's Estero Oyster Farming and Harbor Seal Protection has provided an important supplement to those management measures pertaining to mariculture[1]. The agreement prohibits mariculture workers from using the main channel from 15 March through 30 June, except for weekly collection of water quality samples. It also prohibits mariculture workers from using the lateral channel between beds #1-2 (presumably now labeled beds 15 and 17) and bed #3 (presumably bed 20) from 15 March to 1 June. In addition, it indicates that mariculture workers should plan, and make every effort, to begin seeding beds #1-3 after 1 June, and the lateral channel should be used as little as possible between 1 and 30 June. Oyster beds #2-3 should be approached from the north at low speed and the beds planted north to south so that "disturbance near the lateral channel will more likely be limited to the end of the pupping season" (language from the agreement). As a temporary matter pending further review, the California Coastal Commission imposed, and the National Park Service Special Use Permit incorporated, a year-round restriction on use of the eastern two-thirds of the lateral channel and specific sand bars where seals haul out. Under current conditions, mariculture workers may use the western one-third of the lateral channel during the period from 1 June through 14 March.

a) Recognizing that the estero is a dynamic environment (although less so away from the mouth of the estero) and that harbor seals may shift their hauling patterns over time, are the temporal and spatial restrictions from the 1992 agreement, the California Coastal Commission, and National Park Service individually or collectively sufficient to avoid disturbance and displacement of harbor seals? Is the available information sufficient to evaluate the utility of the measures? Is it sufficient to evaluate the utility of the restriction added by the California Coastal Commission? If you consider it to be sufficient, please describe the basis for your conclusion. If you do not consider it to be sufficient, please describe why not and what additional information would be helpful.

One of many difficulties in deciding whether these measures have been useful is basing their utility on past assumptions and past reports of harbor seal spatial relationships to disturbance. While these approaches are based on the best assumptions and information available there are few situations with

[1] The agreement was signed by the Point Reyes National Seashore, National Marine Fisheries Service, California Department of Fish and Game, California Department of Health Services, and the Johnson Oyster Company. It was not signed by the Drake's Bay Oyster Company or the California Coastal Commission.

these specific parameters involved. It would be better to design observational studies to examine the behavior of the animals prior to disturbance that is delaying harvest activity for the purposes of a study during the first half of low tide until the animals are hauled out. Baseline behavior can be determined then introduce the normal harvest or disturbance activities as determined by the above agreement. Observers should be present above the activity (not just on the West historic site) and with the harvest group to record and characterize movement and sound on the ground. Both areas should be visually and sound recorded for further review.

b) The primary spatial limitations pertain to use of the main and lateral channels. Much of the debate regarding use of the lateral channel pertains to the question of whether the existing measures ensure suitable separation between mariculture activities near the western end of the lateral channel and areas along the lateral channel that harbor seals might use, absent any human activity. The debate implicitly involves a null hypothesis that the distance between the two locations is sufficient to avoid disturbance of harbor seals and that the seals do not use the rest of the channel because of other natural factors (e.g., shallowness). The alternative hypothesis is that the distance is not sufficient and is displacing the seals from potential haul out areas along the lateral channel. Is the existing evidence sufficient to discriminate between these two hypotheses? If so, what conclusion(s) can be drawn and what supporting data are available? Also, what is your best estimate of the separation distance required to avoid harbor seal disturbance on land and in the water? If you don't feel you can answer that question with existing information, how would you go about determining the distance?

I personally do not feel there is adequate data at this site to determine the spatial distance needed. While there has been some mention of historic distances such as 300 or so feet the long term use of some areas of the bay by the mariculture industry may have modified these distances if the encounters have not resulted in substantial disturbance of individuals or larger groups. Closer observational platforms or blinds near the channels could give more detailed observations at different periods of the day including but not limited to low tide. Animals might be observed in water exploring these areas during non maintenance or non use times as well as during harvest activity.

4) Harbor seals recently shifted their habitat use patterns in the estero. Site A became connected to land, which allowed access by human visitors and coyotes. The seals abandoned site A, presumably because of the threat posed by disturbance or harassment. They likely moved either to other sites in the estero or to neighboring colonies. Their shift in habitat suggests that they prefer isolated sandbars. However, based on the timing of the reconnection of site A to land and the presumed corresponding increase in exposure to disturbance and harassment, it is reasonable to infer that disturbance, or the threat of it, may affect the behavior or habitat use patterns of seals in the estero. In contrast, Becker et al. (2010) did not find that spring (March through May) disturbances (that they referred to as short-term and were relatively infrequent) caused a shift in habitat use by seals using haul out sites isolated from land. How can those apparent differences in response to disturbance be explained?

There may be a number of explanations or factors for this discrepancy including inadequate observations, poor characterization of disturbance activity for comparison of different time points, locations, an increase in disturbance response when pups are present due to increased vigilance, utilization of observation data not designed for the purpose used. It points out the weakness of retrospective information rather than prospective data collection.

5) Based on data that were being collected in late April and early May 2007, the National Park Service concluded that increasing oyster activities, including the placement of additional oyster bags near the OB haul out site, had caused a substantial reduction in the number of seals using that site. The Service originally estimated an 82 percent decline for pups and 77 percent for all seals. It later revised that estimate to 65 percent for pups and 56 percent for all seals. In hindsight, are the available data on haul out patterns on OB sufficient to form or support the final conclusion? Why or why not?

It is logical to assume that the presence of new bags may present a visual deterrence when hauling out or the increased activity in placing and maintaining the bags deter the seals use of the site. The term used in the paper was that the increased activity <u>suggested</u> an explanation for decreased counts, not cause and effect. Again there are strong weaknesses in the use of distant observations for short periods of time to be considered the sole source of decreased numbers of pups in a given year. The papers to date and data collection methods may best be used to indicate a notable relationship between the mariculture industry and the harbor seals use of the Estero area but the parties involved may be missing a unique opportunity to effectively study the interactions between two competing uses of a controlled environment. Data from properly designed behavioral studies can be a substantial contribution to how we view interactions that will likely become more common. We base too much on partial data which while the facts are woefully lacking in providing a true understanding of the interactions of nature and commerce. This is a unique opportunity to better characterize interactions that will continue to play a future political and environmental role in the use of shared habitat in this country.

6) At the meeting the panel described the need for a review of Becker et al. (2009) and especially, Becker et al. (2010) by one or more statisticians. The review would start with the available data and then work through the analyses. The primary focus would be on the suitability of the statistical analyses presented in these two papers. In addition to a statistical review, do you have any suggestions for improving the data and analyses included in Becker et al. (2009) and Becker et al. (2010)? For example, should they include other measures or sources of disturbance?

All methods of disturbance should be included and where the observations do not support a full accounting of these activities then the authors must note these shortcomings in full.

Would you like to see other alternative hypotheses tested to assess the potential threats to harbor seals in Drake's Estero?

Utilizing better and more complete observations of mariculture activity I would like to see the actual distances noted as to proximity of activity to signs of disturbance such as flushing. Also the association of head movement to flushing. The association of tidal timing to flushing in that it is more likely that a mother pup pair will vacate if nursing is over or if the disturbance is associated with the period of incoming tide. There is too little detail available from the current observations and what appear to be rationalizations that follow because no additional detailed information can be gleaned from such a distance.

7) Do you see a need for changes to existing management measures or additional measures to avoid disturbance of harbor seals by all sources (i.e., including kayaking, hiking, etc.)?

It appears that the contributions from other sources of disturbance are not well documented. If all determinations of the contributors to disturbance are based on only low tide relationships from one vantage point a substantial distance away through a scope then a great deal of information is not being evaluated as to its existence or importance.

Evaluation of the presence of hikers on beach areas should be incorporated into a study design. All non mariculture use should be examined in a controlled study to see where these activities may contribute to disturbance.

If so, what new measures or adjustments to old measures do you suggest?

The response to this question is similar to previous ones regarding how you would change the approach to the questions facing the Estero area. A list of questions regarding the issues should be compiled and studies incorporating behaviorists and ethologists invited to share in the design.

Do you think an adaptive management approach could be used here to address remaining questions about the effects of disturbance? If so, what high-priority questions would you attempt to address?

At what distance does mariculture activity result in flushing of animals? Place measuring markers for determination.
What level of disturbance is needed to affect seal behavior other than distance, noise from workers, boat noise?

Is there a level of activity that is acceptable to seals, fewer people, and quieter people?

Does the presence of boats in the lateral channel cause flushing and at what distance?

Is there a quieter method of boat propulsion that results in decreased flushing?
Can harvesting activity be patterned around low tide to allow nursing behavior to partially separate from harvesting activity?

Can bag harvesting methods be modified to allow activity in deeper water and allow low tide more for pup activity? A different modified rack system in the flats?

8) What additional scientific questions do you consider important to the assessment of human/harbor seal interactions at Drake's Estero?

Can a limited well managed mariculture activity coexist with wild populations of marine mammals in close proximity in the absence of any lethal take by humans?

Can opposing views held strongly by wildlife managers and business interest accepts a limited well managed mariculture activity?

How do National Park managers decide the level of acceptable disturbance by the public when marine mammals are involved?
Can harbor seals adapt to consistent, predictable, non threatening human presence?