November 28, 2011

From: Dr. Corey Goodman, elected member, National Academy of Sciences, and
David Lewis, Director, U.C. Cooperative Extension Marin County

To: Steve Kinsey, Supervisor, Marin County Board of Supervisors

Re: II. Marine Mammal Commission Drakes Estero Report rejection of Goodman's models in response to NPS correlation in Becker 2011 paper

Dear Supervisor Kinsey,

You asked us to examine the NPS science concerning the oyster farm in Drakes Estero, with particular reference to the potential impact of the oyster farm on the harbor seals. In April of this year, NPS scientists published a new paper (Becker, Press, and Allen, 2011; herein called Becker 2011) using statistical analysis to provide evidence for long-term spatial displacement of harbor seals and their pups caused by the oyster farm.

Over the past few months, we worked to understand and analyze the NPS Becker 2011 paper. As reported earlier, we concluded that the NPS assertion of long-term spatial displacement of harbor seals out of Drakes Estero attributed to oyster farm activity was incorrect. Our review of NPS data indicated that a short-term spatial displacement of harbor seals *into* Drakes Estero had occurred, caused by a rogue elephant seal at Double Point in 2003 (documented by NPS). Superimposed on this stochastic (random) event was a second influence – the ebb and flow of the total regional seal population, peaking in the 2002-2004 period. We showed that NPS incorrectly ascribed to the oyster farm the movement of harbor seals – movements that were *into* Drakes Estero -- caused by natural forces along the coast.

In Goodman and Lewis Report I, *Marin Mammal Commission Drakes Estero Report acceptance of NPS correlation of harbor seals with oyster activity in Becker 2011 paper*, we reported that the Marine Mammal Commission made a series of errors in accepting the NPS correlation of harbors seals with oyster activity.

In brief, the NPS data are so thin (as acknowledged by MMC), and so highly leveraged (i.e., unduly influenced) by a stochastic (random) event in 2003, that they cannot possibly be used to conclude any correlation with oyster farm activity.

In this second analysis of the MMC Report – Goodman and Lewis Report II -- we focus on a second key conclusion: <u>the MMC rejected Dr. Goodman's models that led to better correlations with the harbor seals in Drakes Estero than do the NPS models</u>.

How did the MMC and we come to such different conclusions? Here we describe that the MMC failed to discuss this issue with either Dr. Goodman or Mr. Lewis, failed to make or recommend minor modifications to Goodman's models, and failed to consider the biological significance of Goodman's models.

In brief, the MMC mistakenly rejected a class of models based upon the harbor seals at Double Point and the total regional harbor seal population, even though graphs of the NPS data strongly suggest the validity of these models. In fact, three of the MMC panel members (Drs. Sean Hayes, Steven Jeffries, and Brian Kingzett; see Appendix F to MMC Report) recommended just such models involving the total regional population dynamics in their individual panel member reports.

Dr. Sean Hayes (National Marine Fisheries Service, Southwest Fisheries Science Center) wrote (Appendix F, MMC Report):

> *"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. … 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."*

Dr. Steven Jeffries (Washington Department of Fisheries and Wildlife) wrote (Appendix F, MMC Report):

> *"I would like to see a new analysis by an applied biometrician with additional covariants used including: … overall population trends for the California harbor seal stock, California sea lions and elephants seals …"*

This issue of the impact of the overall population trend pre-dates the MMC panel meeting in February 2010 and goes back to the National Academy of Sciences panel meeting in September 2008. The importance of this analysis was suggested by NAS panel member Dr. Francis O'Beirn (Trinity College Dublin and leader at the Marine Institute in Galway) at the September 4, 2008 NAS meeting. After Dr. Becker's presentation, Dr. O'Beirn noted that seals increased in 2002-2004 and then decreased in 2005 throughout the region, and was thus unlikely to be due to the oyster farm.

> Dr. Francis O'Beirn: *My point is that during the period that you're apportioning it to aquaculture, which is the latter years, 2005, 2006, and 07, a similar decrease has been observed* [at other regional sites]
>
> Dr. Ben Becker: *I did not mean to imply that there is any relationship to the total population size in the estero declining in relation to mariculture … The paper was talking about subsites in the upper estero related to mariculture.*

Dr. Becker agreed with Dr. O'Beirn. That was a key exchange. But in his 2011 paper, Becker failed to properly examine the relationship of the proportion of pups in DE vs. the total regional seal population. Rather, he examined the total regional seal population minus the Drakes Estero seals, which was a different analysis (especially given the stochastic event at Double Point in 2003 that drove hundreds of seals away from Double Point and into Drakes Estero).

Based upon these observations of regional vs. Drakes Estero population dynamics, Goodman thought it important – as did three MMC panel members -- to examine the influence of the total regional population on Drakes Estero. Ragen had the recommendations of the panel members for sixteen months prior to issuing his report, but he apparently did not ask Becker to consider models that included the total regional seal population (see below for how this can be done without a built-in dependency).

The logic was as follows. Goodman hypothesized that as the total regional seal population increased, one might find a disproportionate increase in the mothers and pups entering Drakes Estero. In others words, seal counts in Drakes Estero would go up with an increase in regional seal population, but they might do so disproportionately, and thus lead to an increase in the proportion of seals in Drakes Estero. The reason behind this hypothesis is that the haul-out sites along the coast appear to be space limited (i.e., beaches with cliffs to protect the pups from predation, and competition with aggressive elephant seals), whereas there is considerable available haul-out space in Drakes Estero, and no elephant seals with which to compete.

This is the variable (i.e., total regional seals) for which Goodman got most heavily criticized, and yet it is the variable that three panel members suggested. Nevertheless, as shown below, the variable can be easily modified (consistent with the MMC concerns) to answer the criticism, and the modified models retain their overall statistical significance and conclusions.

The November 22, 2011 MMC Drakes Estero Report stated:

> *"The scientist chosen by Drakes Bay Oyster Company completed a set of analyses that he believed countered the results of Becker et al. (2011). He pointed toward the elephant seal event at Double Point in 2003 and the total number of seals in the area as the dominant factors explaining harbor seal haulout patterns both regionally and within Drakes Estero. However, his analyses are difficult to evaluate because his statistical models are confounded by built-in dependencies that are inconsistent with the statistical procedures he used."*
>
> *"However, it is difficult to compare Dr. Goodman's results with those of the Park Service for two reasons. The purpose of this type of statistical analysis is to determine if a relationship exists between a dependent variable (in the above cases the proportion of Point Reyes pups found in Drakes Estero), and the various combinations of independent or explanatory variables listed above. First, the dependent and "independent" variables he used in numerous models, including his top models, have a built-in dependency—that is, the dependent variable also occurs as part of one of the explanatory variables. This means the regression results are artificially linked and inflated, and much more likely to appear "significant" using superficial statistical tests that do not account for this built-in dependency. The "adjusted R-squared" procedure used by Dr. Goodman does not account for this built-in dependency. Figure 20 illustrates that dependence by expanding the explanatory variables in Dr. Goodman's top six regression models. Second, he used explanatory variables that also are linked. For example, his top two models include the explanatory variables Double Point (i.e., DP) pups and total regional seals. However, the number of Double Point pups also is used in calculating the total regional seals."*

According to the MMC Report, Goodman's models were rejected because (i) his dependent and independent variables in his top models had a built-in dependency, and (ii) his top two models used independent variables that were linked (i.e., shared the same term when the independent variables were expanded).

These technical criticisms imply that major errors were made in our analysis, and thus that the outcome of our analysis was similarly in error. Was our analysis fatally flawed? The answer is no (see below). Goodman's top model can be easily modified to meet the technical criticisms, and the modified version leads to the same conclusions.

The MMC Report stated that Goodman's models "*are difficult to evaluate*." There was no indication, however, that the MMC or NPS (i) requested clarifications or revisions to Goodman's August 29 report or our October 23 report, or (ii) tried to modify Goodman's models on their own to make them easier to evaluate. For example, either the MMC or NPS could have tested the models by eliminating the built-in dependencies, or independently tested the dominant biological factors that Goodman was exploring: "*… the elephant seal event at Double Point in 2003 and the total number of seals in the area ...*" Or at the very least, the MMC could have brought this issue up with Goodman and Lewis and asked them to modify their models, but it did not do so.

Both by their actions and inaction, MMC established a double standard for these statistical reviews. Goodman's review was criticized for perceived limitations in its models, while the NPS models in several instances did the same thing, for which the MMC elected to be silent in their report. There is no indication that either the MMC or NPS applied the same "built-in dependency" or "double-linked" logic to the original NPS models (in Becker 2011) or to the new NPS models (in Becker's November 4 document and the MMC Report itself). Some of Becker's models contain these same issues, but MMC neither commented on nor dismissed them.

While the MMC criticism of built-in dependency is fair, Goodman's models were easily modified, tested, and validated (in a matter of a few minutes). In the end, however, it was a technical criticism with little consequence. Removal of the built-in dependency made no difference to Goodman's overall statistics and conclusions.

The MMC lack of collaboration since submission of the reviews, and failure to ask a single substantive question, led to a misinformed conclusion. The resulting MMC rejection of this class of models, and acceptance of the NPS models, displayed a statistical double standard and an unwillingness to consider the importance of the biology underlying these models: "… *the elephant seal event at Double Point in 2003 and the total number of seals in the area ...*"

Dr. Goodman had two weeks to examine the data, repeat Becker 2011, do further analysis, devise and test new models, and write his report. Dr. Ragen and Dr. Becker and others had over two months to analyze Goodman's models. All that was required was one email or phone conversation, and five minutes of statistical analysis, to correct the apparent built-in dependencies and show that the modified models retain the same degree of statistical significance as Goodman's original models.

After NPS rejected the MMC plan on August 30 to conduct an open process with a public meeting to review the critiques of Becker 2011, Ragen informed Goodman that the same review would occur, albeit informally, and that Goodman would be asked questions when they arose, asked for clarifications when appropriate, and asked for additional analysis when needed. Between August 29 and November 22, neither Goodman nor Lewis were asked by the MMC a single statistical question, asked for a single clarification, or asked for additional information. The process became closed.

It is troubling that Ragen chose not to raise this issue with either Goodman or Lewis, especially in light of Ragen's commitment to conduct an open review. All he had to do was bring his criticisms to our attention and we would have modified it. This highlights why instead of turning to a closed insular process, the MMC should have adhered to its initial plan for an open process with open discussion and exchange. <u>In brief, the variable dependencies in Dr. Goodman's original models were not fatal, were easily modified, and when evaluated, led to the same overall statistics and conclusions</u>.

Goodman's top models vs. Becker's top models

In his detailed analysis submitted to the MMC on August 29, Goodman developed his reasoning in two steps. First he analyzed Becker's top models, all of which included the OYST Hi/Low categorical designation for oyster activity at sandbars OB and UEN during pupping season (March-May). Goodman's analysis showed that the OYST Hi/Low variable was highly leveraged (i.e., unduly influenced) by a stochastic (random) event at Double Point in 2003 (documented in NPS reports and cited in Becker

2011). In brief, a rogue elephant seal killed ~ 40 seals and chased ~ 600 seals away from Double Point, with ~ 300 of them entering Drakes Estero and transiently increasing the proportion of adults and pups in Drakes Estero.

Below are a series of figures that show the impact of the random event at Double Point that coincided with the "low" oyster activity designation in the OYST Hi/Low model, and thus provided misleading statistical support for the NPS model. If one compares Figure 5 in the MMC Report (below) with the May 2007 figure from Koenen and Allen NPS Research Project Summary Report, it is clear that a stochastic event at Double Point in 2003 had a major influence on seals and pups in Drakes Estero in 2003 & 2004.

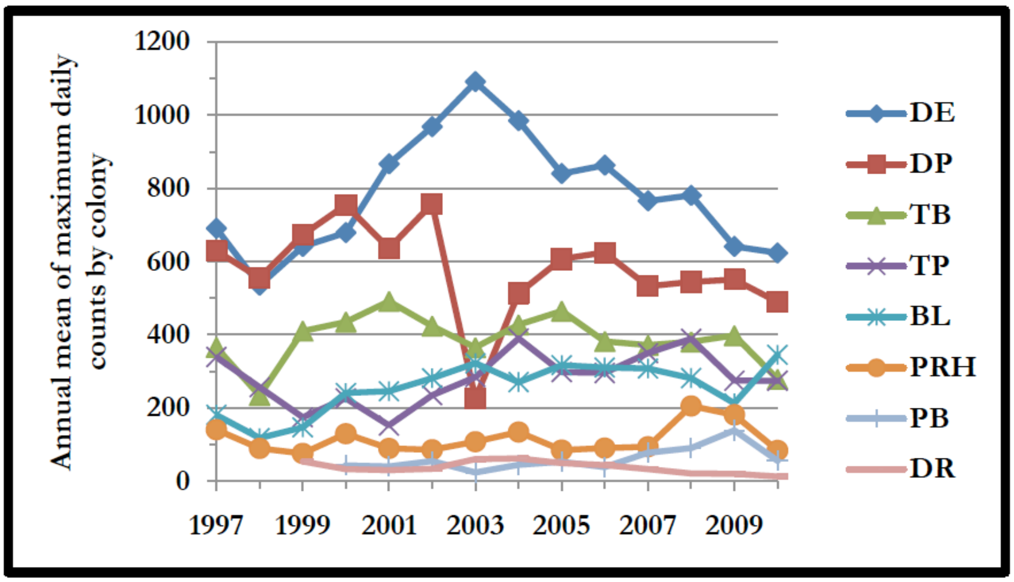
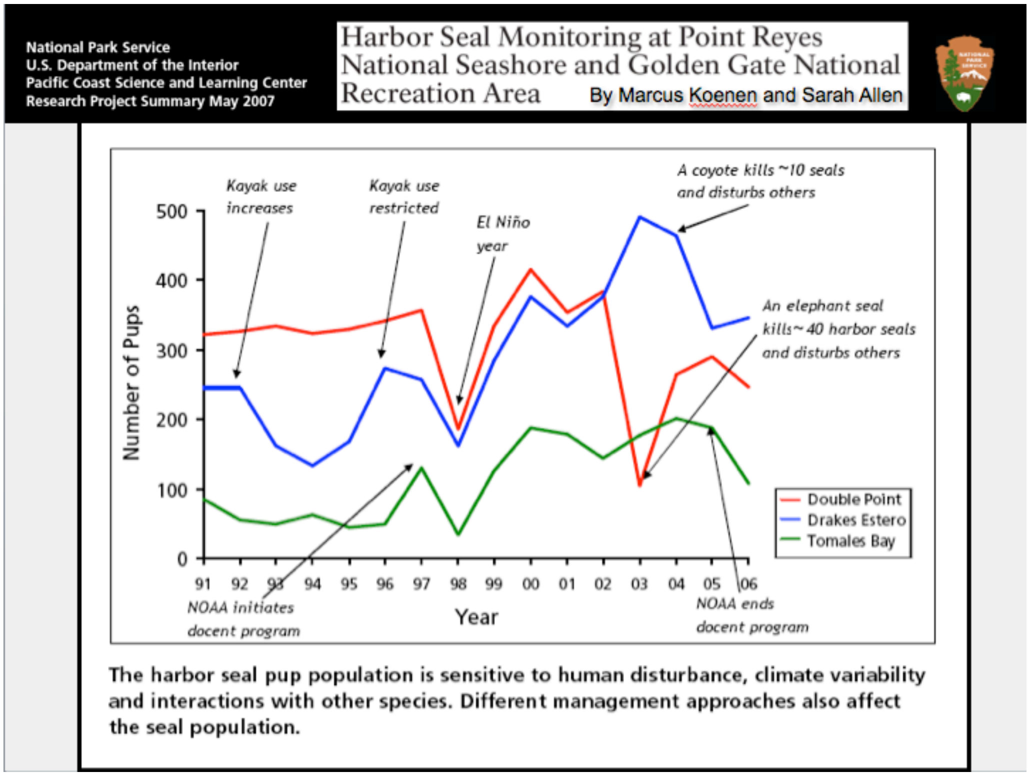


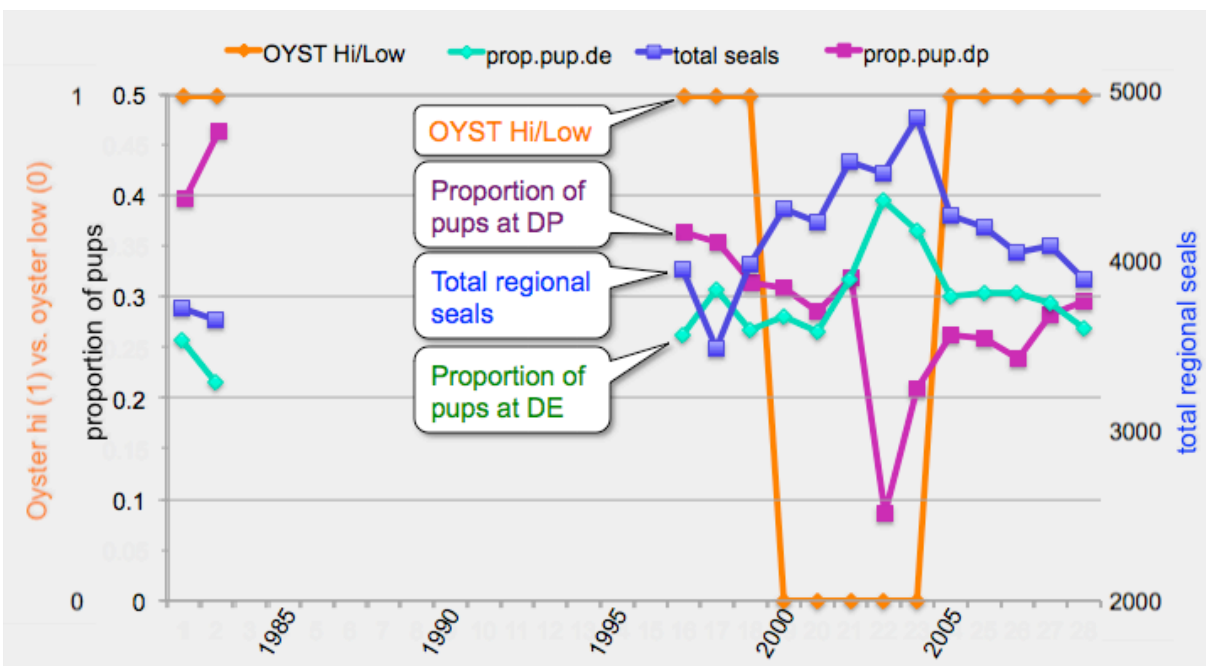
Figure 5. Annual mean of maximum daily counts (adults and pups) by colony and during the full year (left axis), and total of those counts (right axis). Colonies are Drake's Estero (DE), Double Point (DP), Tomales Bay (TB), Tomales Point (TP), Bolinas Lagoon (BL), Point Reyes Headland (PRH), Point Bonita (PB), and Duxbury Reef (DR) (data from National Park Service)

Goodman concluded, based upon NPS data, that the NPS assertion of long-term spatial displacement of harbor seals out of Drakes Estero attributed to oyster farm activity was incorrect. His review of NPS data indicated that a short-term spatial displacement of harbor seals into Drakes Estero had occurred, caused by a rogue elephant seal at Double Point in 2003 (documented by NPS; see above). Superimposed on this stochastic (random) event was a second influence – the ebb and flow of the total regional seal population. We showed that NPS incorrectly ascribed to the oyster farm the movement of harbor seals – movements that were *into* Drakes Estero -- caused by natural forces along the coast, external to and independent of the oyster farm.

These two natural forces – the stochastic event at Double Point in 2003, and the peak of the total regional seal population between 2002-2004 – coincided with the "low" oyster activity in the NPS OYST Hi/Low model, and thus likely highly influenced the models in Becker 2011. Such a hypothesis is consistent with Goodman's graph of NPS data below.

The event in 2003 led to a dramatic increase in the proportion of pups in Drakes Estero in 2003, with a residual decay in 2004. The proportion returned to baseline in 2005.

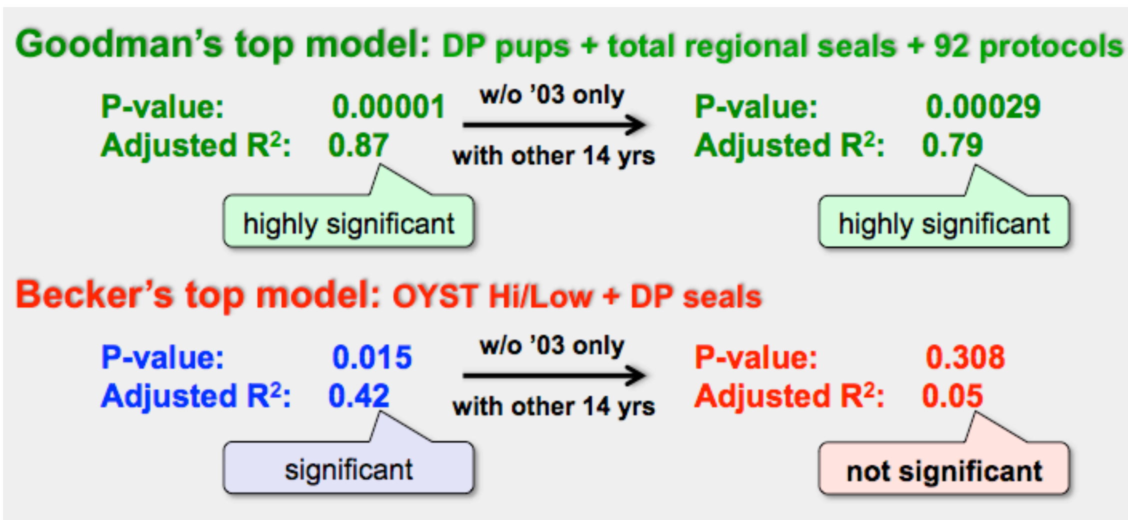




Statistics textbooks (see Goodman and Lewis *Analysis to MMC Report part I* for further details) recommend checking for influential points (or influential outliers), particularly points that are so unduly influential that they support the entirety of a supposed relationship. In a case such as this in which the outlier point is caused by an unrelated stochastic event (i.e., the cause is known), it is appropriate to diagnose whether that stochastic event unduly influences the correlation by eliminating the highly leveraged data point and then testing the significance and coefficient of the remaining data.

Goodman used this recommended diagnostic outlier test to ask if the OYST Hi/Low model, and Becker's best models that included this variable (OYST Hi/Low + DP seals), were unduly influenced by the 2003 event. Goodman eliminated both 2003 and 2004 from the analysis, and statistically analyzed the remaining thirteen data points. Goodman and Lewis (October 23 report to MMC) took this analysis one step further. They eliminated 2003 alone and analyzed the remaining fourteen data points. The MMC Report, as published, included Goodman's August 29 report in the appendix, but without explanation, does not include the Goodman and Lewis supplemental analysis from October 23.

Goodman and Lewis evaluated the NPS correlation by eliminating the influential outlier year (2003) and determined that this single data point leveraged the NPS correlation -- the correlation was no longer statistically significant (see figure below). <u>Goodman and Lewis concluded that the influential outlier year (2003) had a disproportionate influence on the NPS correlation, and that the main independent variable used by the NPS (oyster farm activity) did not correlate with the dependent variable (number of harbor seals) when the stochastic event was removed.</u>



Goodman then went on to ask: if not oyster activity, then what independent variables correlated with harbor seal counts in Drakes Estero? As shown in the figure on the previous page, the natural hypothesis was a combination of the event at Double Point (as modeled by either the DP pups or proportion of pups at DP) and the total regional seal population (as modeled by total regional seals). Goodman also included a variable for the 1992 protocols, since Becker had included data from 1982 and 1983 prior to this major management change, and it seemed reasonable to test the correlation of this change with the response variable.

Goodman's top model was $Pups_{DP} + Seals_{Reg}$ + 92 protocols (using the nomenclature as in the MMC Report). He ran that model against the same dependent variable as used in Becker 2011: the proportion of pups in Drakes Estero ($Pups_{DE}/Pups_{Reg}$). He obtained the following result using multiple linear regression and adjusted R^2 analysis:

$Pups_{DP} + Seals_{Reg}$ + 92 protocols	adjusted $R^2 = 0.87$	P-value = 0.00001
OYST Hi/Low + $Seals_{DP}$	adjusted $R^2 = 0.42$	P-value = 0.015

Goodman's top model had an adjusted R^2 value that was twice Becker's top model (0.87 vs. 0.42), and a P-value that was three orders of magnitude more significant than Becker's top model (0.00001 vs. 0.015).

As shown in the figure on the previous page, when 2003 alone was eliminated as a diagnostic test, Goodman's top model retained statistical significance.

$Pups_{DP}$ + $Seals_{Reg}$ + 92 protocols (-2003)	adjusted R^2 = 0.79	P-value = 0.0003
OYST Hi/Low + $Seals_{DP}$ (-2003)	adjusted R^2 = 0.05	P-value = 0.3

Under the identical diagnostic test, Becker's top model was no longer statistically significant. In contrast, Goodman's top model retained statistical significance, and was three orders of magnitude (1000X) more significant than Becker's best model.

This analysis of NPS data led Goodman and Lewis to the following four conclusions:

- The same conclusions are derived regardless of statistical method: Goodman and Lewis provided head-to-head comparison of GLM using AIC vs. MLR using R squared analysis, and derived same conclusion.
- The Becker 2011 statistics are highly leveraged (i.e., unduly influenced) by a single data point – the rogue elephant seal at Double Point in 2003. When 2003 alone is eliminated, Becker's best models are no longer statistically significant whereas Goodman's best models are highly significant.
- What was called a long-term displacement OUT of Drakes Estero was actually a short-term displacement INTO Drakes Estero caused by events at Double Point.
- There is no evidence for long-term displacement of seals from Drakes Estero that can be related to shellfish aquaculture.

MMC rejection of Goodman's top models

As noted above, the MMC Report rejected Goodman's top models, stating that:

> "[Goodman's] *analyses are difficult to evaluate because his statistical models are confounded by built-in dependencies that are inconsistent with the statistical procedures he used."*

The MMC Report went on to explain this issue as follows:

> *"First, the dependent and "independent" variables he used in numerous models, including his top models, have a built-in dependency—that is, the dependent variable also occurs as part of one of the explanatory variables. This means the regression results are artificially linked and inflated, and much more likely to appear "significant" using superficial statistical tests that do not account for this built-in dependency. … Second, he used explanatory variables that also are linked. For example, his top two models include the explanatory variables Double Point (i.e., DP) pups and total regional seals. However, the number of Double Point pups also is used in calculating the total regional seals."*

Below is Figure 20 from the MMC Report that shows the expanded independent variables with the built-in dependency.

Models to explain the proportion of pups in DE

1) Explanatory variables: DP pups plus total regional seals plus '92 protocols

$Pups_{DE}/Pups_{Reg} = Pups_{DP} + Seals_{Reg} + 92$

$Pups_{DE}/Pups_{Reg} = Pups_{DP} + (Adults_{Reg} + Pups_{notDE} + Pups_{DE}) + 92$ (expand $Seals_{Reg}$)

2) Explanatory variables: DP pups plus total regional seals

$Pups_{DE}/Pups_{Reg} = Pups_{DP} + Seals_{Reg}$

$Pups_{DE}/Pups_{Reg} = Pups_{DP} + (Adults_{Reg} + Pups_{notDE} + Pups_{DE})$ (expand $Seals_{Reg}$)

3) Explanatory variables: DP proportional pups

$Pups_{DEprop} = Pups_{DPprop}$

$Pups_{DEprop} = Pups_{DE}/Pups_{Reg}$ and $Pups_{DPprop} = Pups_{DP}/Pups_{Reg}$ (note)

$Pups_{DP} = Pups_{Reg} - Pups_{notDP,\ notDE} - Pups_{DE}$ (note)

$Pups_{DE}/Pups_{Reg} = (Pups_{Reg} - Pups_{notDP,\ notDE} - Pups_{DE})/Pups_{Reg}$ (substitute)

$Pups_{DE}/Pups_{Reg} = 1 - (Pups_{notDP,\ notDE}/Pups_{Reg}) - (Pups_{DE}/Pups_{Reg})$ (simplify)

4) Explanatory variables: DP pups plus total regional pups

$Pups_{DE}/Pups_{Reg} = Pups_{DP} + Pups_{Reg}$

$Pups_{DE}/Pups_{Reg} = Pups_{DP} + (Pups_{notDE} + Pups_{DE})$

5) Explanatory variables: DP seals plus total regional seals

$Pups_{DE}/Pups_{Reg} = Seals_{DP} + Seals_{Reg}$

$Pups_{DE}/Pups_{Reg} = (Adults_{DP} + Pups_{DP}) + (Adults_{Reg} + Pups_{Reg})$

$Pups_{DE}/Pups_{Reg} = (Adults_{DP} + Pups_{DP}) + (Adults_{Reg} + (Pups_{notDE} + Pups_{DE}))$

6) Explanatory variables: DP proportional seals

$Pups_{DE}/Pups_{Reg} = Seals_{DP}/Seals_{Reg}$

$Pups_{DE}/Pups_{Reg} = Seals_{DP}/(Adults_{Reg} + Pups_{notDE} + Pups_{DE})$

Figure 20. Statistical models (single or combined explanatory variables used by Dr. Corey Goodman to explain the proportion of regional pups in Drakes Estero. The models are confounded because terms in the dependent variable are also part of the independent variable; thus, the models have a built-in dependency. (DE = Drakes Estero; DP = Double Point; Reg = Regional; notDE = not at DE; notDP = not at DP; notDP,notDP = not at DP or DE)

Thus, concerning Goodman's top model ($Pups_{DP} + Seals_{Reg} + 92$), the MMC Report expanded "$Seals_{Reg}$" to "$Adults_{Reg} + Pups_{notDE} + Pups_{DE}$" and concluded that both the dependent variable ($Pups_{DE}/Pups_{Reg}$) and one of the independent variables ($Seals_{Reg}$) contain the same term: $Pups_{DE}$. Moreover, $Pups_{DP}$ is contained within the broader term $Pups_{notDE}$. Thus, the MMC Report reasoned that Goodman's top model had artificially linked variables that could have inflated both the adjusted R2 value and the P value. As a result, the MMC Report rejected these models and proceeded instead to collaborate with NPS and Dr. Becker on further refinements of his original and new models.

Goodman's modified models reaffirm overall statistics and conclusions

It is regrettable that Dr. Ragen failed to communicate with either Dr. Goodman or Mr. Lewis about this issue. Both reached out to Ragen. For example, on September 12, Goodman wrote to Ragen and asked if any substantive issues with his report had arisen. Several days later, Ragen answered no, and provided no discussion of issues for the next two months leading up to the release of the MMC Report on November 22. In parallel, Mr. Lewis reached out to Dr. Ragen by email on multiple occasions, first on October 24 when they mutually agreed to postpone a discussion, and again on November 1, writing "*it would be beneficial to discuss the science and statistical issues*" with no reply from Ragen.

Only through release of the MMC Report on November 22, was it made known that Ragen had questions about Goodman's models (never raised with Goodman and Lewis), had preemptively rejected Goodman's models, and had done so because of the so-called built-in dependency in his variables and the concern that this might inflate his R^2 and P values. All of this could have been tested and modified. When comparing proportional numbers to absolute numbers, our consulting Stanford statistics professor does not believe modifications are required. But nevertheless, it is easy to do, and we have now modified Goodman's best models.

<u>The variable dependencies in Dr. Goodman's original models were not fatal, were easily modified, and when evaluated, led to the same overall statistics and conclusions</u>.

Goodman's top model was $Pups_{DP}$ + $Seals_{Reg}$ + 92. The $Seals_{Reg}$ term contains $Pups_{DE}$ that is shared with the dependent variable. This is likely only a very minor issue, since the majority of the harbor seals counted in the "$Seals_{Reg}$" term are adults throughout the region (the pups make up only a minority of the total animals). Thus, we modified the model to $Pups_{DP}$ + $Adults_{Reg}$ + 92. The two statistical values – the adjusted R^2 and the P value – remained essentially the same.

Goodman's modified top model – substituting adults for seals – led to the same overall statistics and conclusions. This modified model, either alone or when 2003 is eliminated, remains three orders of magnitude more significant than Becker's models.

DP pups + total regional seals + 92 prot. (original)	adj R^2 = 0.87	P-value = 0.00001
DP pups + total regional adults + 92 protocols (new)	adj R^2 = 0.86	P-value = 0.00001
DP pups + total regional adults + 92 protocols (-2003)	adj R^2 = 0.80	P-value = 0.0002

These values are virtually identical to the values generated in the original Goodman August 29 review and Goodman and Lewis October 23 review (and remain 1000X more significant than Becker 2011). Clearly, the built-in dependency in this model was trivial, easily modified, and gave rise to the same conclusions.

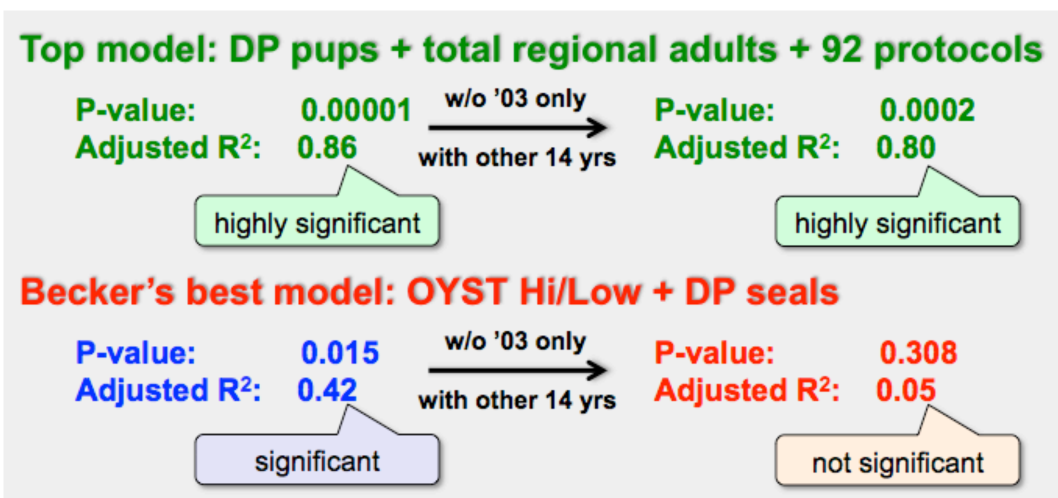
While considerable time and attention was given to criticizing Goodman's top models in the MMC Report, it appears this was done to identify a technical problem with the models and not to test them. Had Ragen done so on his own, or consulted with Goodman or Lewis, it could have led to a more productive discussion in the MMC Report about the ecology-based models that are superior to Becker 2011.

Dr. Goodman's top model (modified from seals to adults) is three orders of magnitude more statistically significant than Becker's best model (from Becker 2011). Moreover, it is robust and remains statistically significant when 2003 alone is removed (in the diagnostic outlier test), whereas Becker's best models fail that diagnostic test.

Below is a chart, much like that included in Goodman's August 29 analysis, showing the relative ranking of Goodman's modified models and the models in the Becker 2011 paper. Goodman's top models remain superior to the models from Becker 2011.

notes	In Becker 2011?	model	P-value	Adj R^2
Goodman model	no	DP pups + total regional adults + 92 protocols	0.00001	0.87
Goodman model	no	DP pups + total regional adults	0.00034	0.69
Goodman model	no	DP pups + OYST Hi/Low	0.00330	0.55
Goodman model	no	DP pups + 92 protocols	0.00375	0.54
Goodman model	no	Total regional adults	0.00225	0.49
Goodman model	no	DP proportional adults	0.00522	0.42
Goodman model	no	DP pups + OYST annual harvest	0.00854	0.47
Becker model	yes	OYST Hi/Low + DP seals	0.01474	0.42
Goodman model	no	92 protocols	0.04201	0.26
Becker model	yes	OYST Hi/Low	0.04680	0.21

In the chart below, much as previously submitted to MMC, we use Goodman's modified top model (substituting adults for seals) and compared it to Becker's top model, using the diagnostic outlier test to examine the impact of removing 2003 alone.



Some of Becker's models are subject to the same criticism

While Goodman's models were subjected to the criticism of built-in and linked dependencies, it appears as if Becker's models were not subjected to the same standard.

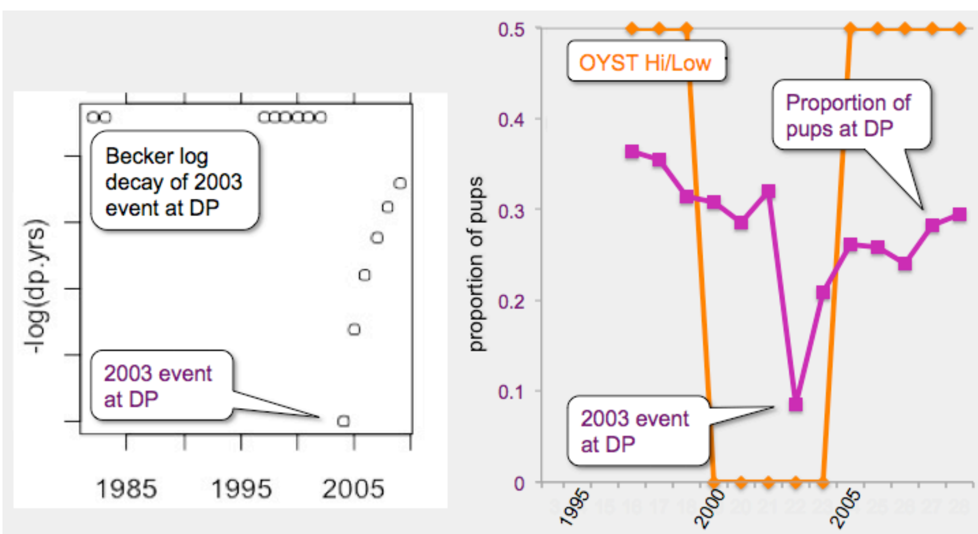
For example, in both Becker's colony scale and regional scale analyses, Becker's models involving the proportion of seals at subsite A, when expanded, also contain terms found in the dependent variable, such as $Seals_{DE}$ or $Pups_{DE}$ (using the same logic as applied in Figure 20 of the MMC Report). In the case of Becker's regional scale model, the dependent variable is either $Seals_{DE}/Seal_{Reg}$ or $Pups_{DE}/Pups_{Reg}$, and the independent variable is $Seals_A/Seals_{DE}$ can be expanded such that Seals includes Adults + Pups at each geography. In the case of Becker's colony scale model, the dependent variable is either $Seals_{up}/Seals_{DE}$ or $Pups_{up}/Pups_{DE}$, and the term $Seals_A$ in the independent variable can be expanded to include either $Seals_{up}$ or $Pups_{up}$ as part of the $Seals_{DEnotA}$, and $Seals_{DE}$ or $Pups_{DE}$ can be expanded to include $Seals_{up}$ or $Pups_{up}$ respectively.

Becker's models can probably be easily modified, just as were ours, by focusing the dependent variable on pups and the independent variable on adults.

Another example, in this case of a linked dependency, can be found in Becker's use in Table 5 of Becker 2001 of the model OYST + DP + Pup where DP = $Pups_{DP}$ and Pup = $Pups_{notDE}$ that can be expanded to include $Pups_{DP}$. All this points out is that in that such a narrowly defined biological system filled with co-dependencies, it is difficult to define independent variables that do not have either built-in or linked dependencies.

<u>We do have one major concern about this issue as applied to Becker's models. We are concerned about the new models developed by Becker and described in the MMC Report.</u> Those analyses, and those new models, were only shared with us for the first time on November 17, on the eve of the release of the MMC Report. We have reason to believe that additional materials were submitted to Ragen that were not shared with us. We were not given the opportunity to make the following evaluation and comment, and not provided with new data used in these models to which we do not have access.

At the suggestion of Dr. Harwood, Becker developed a mathematical model for the stochastic 2003 event at Double Point (see Goodman and Lewis *Analysis to MMC Report part I* for further details). Below on the left is shown Becker's logarithmic model for the 2003 event, a model that is a good best-fit curve for the proportion of pups at Double Point. On the right is our plot of the NPS data.



To add another independent variable with the 2003 event [as Becker did with *log(double point event.yrs)*] effectively doubled down on the 2003 event, creating a cryptic but very significant linked dependency – both were highly leveraged by the 2003 event.

The MMC Report, in writing about Goodman's top models, stated:

> "[Goodman] *used explanatory variables that also are linked.*"

The same could be said – even more so – about Becker's new top model: OYST Hi/Low + log(Double Point.yrs). Both independent variables are highly leveraged by the 2003 event, the OYST variable by its coincidental shift from high to low to high (as confirmed using the diagnostic outlier test) and the log Double Point variable by definition. In brief, if our analysis of the OYST Hi/Low variable is correct using the diagnostic outlier test, then these two terms are linked in that both are highly leveraged by the same explanatory variable – the 2003 event at Double Point – one cryptic and the other overt.

Becker used different parameters for the dependent variable than in Becker 2011 (see Goodman and Lewis *Analysis to MMC Report part I*) giving rise to a larger R^2 for OYST Hi/Low (0.42 vs. 0.26 in Becker 2011). Becker then showed the following R^2 values:

OYST Hi/Low + log(Double Point.yrs)	$R^2 = 0.83$
log(Double Point.yrs)	$R^2 = 0.72$
OYST Hi/Low	$R^2 = 0.42$

By doubling down on the 2003 event, the R^2 value essentially doubled. In Table 9 (below) in the MMC Report these numbers are not put side-by-side to show that log (Double Point) as a single variable is far superior to OYST Hi/Low, suggesting that the 2003 event at Double Point predicted 72% of the variability in the harbor seal counts. The Best-fit curve for the 2003 event (modeled with a log decay) was the best single model. <u>This R^2 value of 0.72 is telling us something very important, namely, that 72% of the variability in the Drakes Estero seal population over the fifteen years of data can be predicted by a single random event that occurred at Double Point in 2003</u>.

Table 9. QAICc ranking of models with exponentially decaying function for Double Point

Model	QAICc	ΔQAICc	r^2
Oyster (High/Low) + log(Double Point.yrs)	81.3	0.0	0.83
Oyster (continuous)+ log(Double Point.yrs)	84.1	2.8	0.78
Log(Double Point.yrs)	84.7	3.4	0.72
Exp(Double Point.yrs)	88.2	6.9	0.67

If OYST Hi/Low is leveraged by 2003, then adding another term leveraged by that same year is not appropriate. The Log (Double Point) variable on its own is a proper model, and has an R^2 of 0.72, showing that the event at Double Point is a large and major driver of the adult seals and pups in Drakes Estero, just as predicted by Goodman and Lewis. The 2003 event at Double Point was more significant than oyster activity.

In essence, what Becker did was to take his OYST Hi/Low variable, which was already leveraged by the 2003 event, and add to it another independent variable that was entirely leveraged by the 2003 event (by definition of the best-fit curve). Thus, it is not surprising that he got a larger R squared. In fact, given the notion of the importance of the 2003 event, it would have been surprising if he had not. His two independent variables were different manifestations of the same, both leveraged by the 2003 event at Double Point.

Becker did test his OYST Hi/Low model by eliminating 2003 and 2004 using the diagnostic outlier test (although to be accurate, he protested being asked to conduct this test). Becker did not provide the P-value, but we presume it was not significant given the low R^2 value. When the 2003 event was eliminated from the OYST Hi/Low analysis by deleting 2003 and 2004, the R^2 value is 0.13. When the 2003 event was essentially duplicated in the OYST Hi/Low analysis by adding another independent variable entirely leveraged by that event (by definition), the R^2 value is 0.83. The R^2 value of the 2003 event [log(Double Point)] independent variable on its own is 0.72 (compared to 0.42 for the OYST Hi/Low variable on its own).

OYST Hi/Low + log(Double Point.yrs)	$R^2 = 0.83$	
log(Double Point.yrs)	$R^2 = 0.72$	
OYST Hi/Low (with new parameters)	$R^2 = 0.42$	in Becker 2011, $R^2 = 0.26$
OYST Hi/Low - 2003	$R^2 = 0.13$	

We tested Becker's new mathematical models for the 2003 event (we tested the exponential model because we did not have access to the parameters of Becker's new log model) using the same parameters for the dependent variable as originally used in Becker 2011. Using proportion of pups in Drakes Estero as the dependent variable (as in Becker 2011), we obtain the following adjusted R^2 values:

Exp(Double Point.yrs) + 92 protocols	adjusted $R^2 = 0.76$
Exp(Double Point.yrs) + Tot reg. adults	adjusted $R^2 = 0.71$
Exp(Double Point.yrs) + OYST Hi/Low	adjusted $R^2 = 0.60$
Exp(Double Point.yrs)	adjusted $R^2 = 0.60$
Total regional adults	adjusted $R^2 = 0.49$
OYST Hi/Low + DP seals	adjusted $R^2 = 0.42$
92 protocols	adjusted $R^2 = 0.26$
OYST Hi/Low	adjusted $R^2 = 0.21$

The mathematical model for the 2003 event at Double Point had an adjusted R^2 value of 0.60 that was not improved by the addition of OYST Hi/Low, but that was improved significantly by the addition of either total regional adults or the 92 protocols. This suggests that when modeling the proportion of pups in Drakes Estero, the 2003 event dominated the variability of the harbor seals, and that the categorical measure of oyster activity added little of additional significance and thus was likely to be driven largely by the 2003 event.

We speculate that Becker found additional significance when adding oyster activity along with the mathematical models of the 2003 event because he switched the parameter of the dependent variable from the proportion of pups to the absolute mean number of seals. Whereas the proportion tended to normalize for the ebb and flow of the total regional population, the absolute count numbers allowed those increases and decreases in the regional population – which coincidentally correlate with the increase of oyster activity – to participate to a greater extent in the statistics.

In summary, we interpret these results from Becker's latest analysis, as published in the MMC Report, as confirming our conclusion that the stochastic event at Double Point in 2003, which randomly coincided with the "low" designation in the OYST Hi/Low variable, is the single most important independent variable in explaining the variability in the harbor seals in Drakes Estero over the study period. Partially subtracting the 2003 event by removing 2003 eliminated much of the R^2. Effectively doubling the 2003 event by adding another independent variable defined by a best-fit curve essentially doubled the R^2. The numbers tell the story. Our analysis leads to the hypothesis that much of the remaining variability can be explained by the ebb and flow of the total regional seal population, as defined by adult seals in our modified models. The 1992 protocols also may play a role (although we caution that the data are thin).

Conclusions and recommendations

1) The Becker 2011 statistics are leveraged (i.e., unduly influenced) by a single stochastic (random) event -- the rogue elephant seal at Double Point in 2003: when 2003 alone is eliminated (the diagnostic outlier test), Becker's best models are no longer significant.
2) In his August 29 report to the MMC, Goodman presented models relying on the seals at Double Point, the total regional seal population, and the 1992 protocols that were three orders of magnitude (1000X) more statistically significant than Becker's best models, and remained statistically significant when 2003 alone was removed (i.e., were robust to the diagnostic outlier test).
3) The MMC panel members in their reports in Appendix F of the MMC report sited the ecologic importance of both the total regional harbor seal population dynamic (peaking in 2002-2004) and the stochastic event at Double Point (in 2003 with residual impact in 2004) as potential major influences on the harbor seal population in Drakes Estero, and cautioned that both tended to artificially coincide with the NPS measure of oyster activity.
4) The MMC Report rejected Goodman's top models due to built-in and linked dependencies. It is troubling that Dr. Ragen failed to raise the issue with either Dr. Goodman or Mr. Lewis. It is equally troubling that neither MMC nor NPS modified the models themselves.
5) The variable dependencies in Goodman's original models were not fatal as stated by the MMC, were easily adjusted, and when modified, gave rise to the same overall statistics and conclusions. In other words, MMC dismissed the Goodman analysis based upon variable dependencies that in the end made no difference. At the same time, when NPS contained similar dependencies, MMC was silent.
6) Goodman's modified best model (DP pups + total regional adults + 92 protocols), substituting adults for seals, has an adjusted $R^2 = 0.86$ and a P-value = 0.00001. These values are virtually identical to those generated from the original model, and drive the same overall statistics and conclusions as in Goodman's August 29 report and the Goodman and Lewis October 23 report.
7) Dr. Goodman's top model (modified from seals to adults) is three orders of magnitude more statistically significant than Becker's best model (from Becker 2011). Moreover, it remains statistically significant when 2003 alone is removed (the diagnostic outlier test), whereas Becker's best models fail that test.
8) Becker's new models, including a mathematical model of the 2003 event at Double Point, may be guilty of the same linked dependency as Goodman's top models, but it appears as if they were not scrutinized in the MMC Report. By adding another independent variable entirely leveraged by the stochastic 2003 event, NPS essentially doubled down – they tested two variables that were both leveraged by the same event – and no surprise, found an increased R squared.
9) The NPS data are too thin, and too highly leveraged by a stochastic event in 2003, to be able to support the NPS correlation between harbor seals and oyster activity. Moreover, the NPS data are inadequate for MMC to affirm the NPS claim of a correlation between harbor seals and oyster activity.

10) What was called a long-term displacement OUT of Drakes Estero was actually a short-term displacement INTO Drakes Estero caused by events at Double Point. There is no evidence for long-term spatial displacement of seals and pups OUT of Drakes Estero that can be related to shellfish aquaculture.

11) The MMC mistakes could have been avoided had the MMC proceeded with their original open process rather than the insular closed process they conducted. Open dialogue, open discussion, and open exchange could have helped avoid these mistakes. Unfortunately, the closed process led to a flawed MMC Report.