NPFMC/IPHC Workshop on Halibut Bycatch Estimation, Halibut Growth and Migration, & Effects on Harvest Strategy

MEETING SUMMARY

APRIL 24-25, 2012

Facilitators: Dr. Jonathan Raab, Raab Associates, Ltd. and Stephanie Stern, CONCUR

The workshop was organized by the International Pacific Halibut Commission (Commission or IPHC) and the North Pacific Fishery Management Council (Council) to review the methodology and accuracy of the estimation of Pacific halibut bycatch in trawl/longline groundfish fisheries off Alaska, and the impacts of halibut bycatch on the halibut stock as a whole and by area, given the current understanding of halibut migration. The workshop also discussed general halibut ecology, including recent trends in exploitable biomass, spawning biomass, and size at age, and information concerning the causes and implications of declining size at age of halibut.

The two-day workshop was held in Seattle and was attended by 92 people with an additional 111 people participating via webcast (see Appendix 5 for full list of participants). The first day was spent reviewing the state of knowledge on halibut ecology and bycatch issues through 19 presentations followed by questions from the Panelists. Public testimony was provided on the morning of the second day with Panelists' discussion and summary presented in the afternoon. See Appendix 3 for a summary of ideas for future research that were raised during the workshop.

DAY 1: TUESDAY APRIL 24

Welcome: Dr. Jim Balsiger (National Marine Fisheries Service/North Pacific Fishery Management Council/International Pacific Halibut Commission) welcomed the panel and audience. He explained the purpose of the meeting, that there are more halibut in the ocean now than since Commission came into being, and that the current size limits coupled with reduced size at age of halibut were leading to a loss of commercial productivity. He thanked the Commission and Council staffs for their hard work to organize the workshop.

He also noted that while the Commission has been very successful, the Commission is revisiting its processes and ways of managing the halibut stock. The Commission hired CONCUR to conduct a Performance Review. Dr. Balsiger also explained that this meeting aimed to explore halibut ecology and the impact of management.

The remainder of the day comprised 19 presentations on halibut ecology, the impacts of halibut bycatch, and the management of halibut bycatch. See website for the presentation slides and audio recordings. See Appendix 1 for listing of the presentations plus any additional clarifications made by the presenters in response to questions from the Panel members.

DAY 2: WEDNESDAY, APRIL 25

Ms. Jane DiCosimo opened the day by noting that the Council has a decision pending in June 2012 to consider proposed reductions to limits on halibut bycatch in Gulf of Alaska trawl and hook-and-line groundfish fisheries, but that the scope of this workshop is broader and includes a review of the estimation methodology and impact of bycatch on the halibut stock. She noted that

the Council is also considering changes to bycatch management in the Bering Sea/Aleutian Islands in the near future.

The morning was then spent taking public comments from (non-Panel) attendees first on halibut ecology issues and then on halibut bycatch impacts and management. Nineteen people provided comments during the morning. Panel members were free to respond to the comments. For a summary of the public comments, and Panel responses, see Appendix 2.

During the afternoon Dr. Jonathan Raab facilitated a discussion among the Panelists on a pre-specified list of sub-topics and questions related to halibut ecology and halibut bycatch impacts and management, which were intended to initiate Panel discussions. Each sub-topic began with two panelists providing initial comments, followed by other panelists adding their views. Panelists used this opportunity to weave together not only their own expertise, but also their knowledge gained from the first-day presentations and the public comment from the morning. Dr. Raab, who facilitated the workshop, specifically asked the entire Panel whether they agreed with the observations and conclusions of the initial Panel commentators and whether they had differing or additional things to add. Below is a detailed summary of the Panel opening remarks and discussions.

Panel Discussion: Halibut Ecology

Size at Age – *How long has decline in halibut size (i.e., weight) at age been observed, and is it spatially isolated, or a coast-wide phenomenon? Has this been observed previously?*

Dr. John Neilson started the conversation with several observations, including that:

- The decline in size at age has been observed for about three decades and could be isolated or coastwide, though the assumption has been that it is a coastwide phenomenon, which he believes is accurate.
- The decline in size at age is apparent for all ages according to Dr. Hare's presentation yesterday, and is not particular to any specific age group.
- The time series is remarkably long, from 1926 to 2011, and no comparable period of declining weights at age have been noted, although comparable values were noted near the start of the series.
- There were episodic changes in size at age, which are not consistent with the gradual change that you would expect from changes in diet.
- Several speakers noted the potential for age determination to be an issue, given that the methods for age determination had changed, and the observation that changes in methods seemed concurrent with decreases in size at age.
- There seemed to be consensus that archived otoliths should be reexamined using the new break and bake technique; this is a priority for the IPHC and planning is underway.
- When size at age is plotted only for the years when a single method is used (i.e. from 2002 onward) a decline is still apparent.
- There may be more than one factor influencing our perception of changing halibut size at age.

Dr. Jim Ianelli followed up, agreeing with Dr. Neilson's summary and further noting that:

- From 1992 to 2002, the break and burn test method was gradually introduced and has been used exclusively since 2002.
- The beginning of the time series that is used in the assessment is 1996, the terminal age is taken as age 20, but once break and burn became the primary method, the terminal age moved to 25. It might require more evaluation to conclude that all age groups have changed their size at age.
- For future consideration by the Commission in considering CEY it should acknowledge difficulties in projected mean weights-at-age given past variability. What estimator of mean weight-at-age is used to determine next year's quotas?

Discussion on size at age included:

- Dr. Steven Hare responded to Dr. Ianelli's question, explaining that the current method uses the previous year's data, so it does not project a rate of decline into the analysis. He also noted Dr. Bill Clark's study showed that age 14 is where the big divergence begins between the two aging methods. He speculated that for ages 15 to 20 the magnitude of the decline is probably overstated.
- Dr. Hare also noted that any explanations for the decline in size at age must also explain the increase in size at age from the 1930s to 1950s.
- Dr. Gordon Kruse remarked on two graphs from yesterday; he noticed that trends indicate a decline since about 1960 for the younger ages and a decline since about 1970 for the older ages. When data during 1993-2011 are considered, size at age was relatively stable for ages 6-10 over 1993-2003 and then declined, whereas for the older ages, size at age generally declines steadily over 1993-2011. While there is overall decline, these subtle differences might give some insight on what is happening.
- Mr. Tom Jagielo agreed that it seems worth following up on these subtle points.
- Dr. Ianelli noted another area for investigation, the Bering Sea fishery data, where NMFS observers have measured more than 1.8 million halibut over the years, represents a wealth of annual length frequency measurements. These data, combined with NMFS survey-at-length data may help evaluate growth rates and relative year class strengths. He proposed also comparing data from the Gulf of Alaska and the Bering Sea to examine spatial differences.
- Dr. Steve Martell noticed empirical weights at age 6 are always 14 lbs for male halibut, but at age 7 is less than at age 14, implying that halibut are shrinking in weight, then increasing to 14 lbs again by age 16. He wondered how the fish lose weight during these ten years.
- Dr. Hare responded that this is an error in the code, the weights are determined with a bivariate smoother and because the fringes are quirky, they fixed the minimum weight at 14 lbs for an age-six male halibut, so that the smoother couldn't force the weight below that minimum; this minimum needs to be updated.
- Dr. Neilson inquired if there is a possibility to use conventional tagging data to compare to earlier time periods for older animals, to get an idea of growth rates independent of the otolith examination.
- Dr. Leaman responded that they haven't looked at this, but certainly could.

Causes of the Decline – *What are the contributing factors to the decline in size at age (e.g., expanded arrowtooth flounder biomass, changes in diet, spatial competition)? Are these natural phenomena or human-induced factors, and how well are these contributing factors understood? Can the decline in size at age be expected to continue?*

Dr. Gordon Kruse led the discussion with the following comments, first about natural phenomena:

- On density-dependence effects on growth, Clark and Hare (2002) wrote, "It appears that climate variability – both interdecadal and interannual – is responsible for most observed variation in Pacific halibut recruitment. The large changes in growth rates that occurred during the 20th Century appear to have been density-dependent responses to changes in stock size, with virtually no environmental influence."
- This implies that climate can have ecosystem effects with time lags; it seems that climate affects recruitment; strong/weak recruitment leads to increases/decreases in stock size, which then affects recruitment. He recommended that this analysis be updated to see if this finding still holds.
- In addition, are arrowtooth flounder causing an additional density dependent effect on growth? There are poor data in the 1920s on arrowtooth, but an update to Clark and Hare (2002) could evaluate the relative contributions of halibut stock size and/or arrowtooth flounder biomass on halibut growth rates.
- Further, inter-species competition may extend beyond arrowtooth flounder. A large increase in the biomass of other flatfishes (yellowfin sole, rock sole, flathead sole) occurred subsequent to the late 1970s regime shift. Could similarities in the timing and locations of larval and early juvenile stages, including their diets, have led to increased competition at early life history stages? Could reduced size at age be a manifestation of strong competition at very early life stages that cannot be subsequently made up?
- Diet data show a general trend for smaller/younger halibut to consume invertebrates (crabs, shrimps, and other crustaceans) and larger/older halibut to consume more fish. Dr. Kerim Aydin asked: "Do larger halibut have trouble finding adequate large prey." This remains an open question. Dr. Aydin showed a decline in the proportion of pollock in the diets of large halibut from the 1990s to the 2000s. Analyses of pollock prey per capita of large halibut may provide additional insights.
- Dr. Aydin's data also might suggest a reduced component of fish offal in large halibut. Offal was a relatively large component of the halibut diet in the Western Bering Sea. It is not clear that offal was distinguished in diet studies conducted by the IPHC. Dr. Kruse wondered if changes in fishing practices (e.g., full utilization) have reduced discards, at least in the Bering Sea. In Dr. Aydin's data, offal from the winter/spring pollock-cod fisheries may not be revealed in stomach samples collected in summer. So, groundfish stomachs may under-represent the historical importance of offal in the diets of halibut in the Eastern Bering Sea. He suggested a retrospective analysis that could investigate the potential role of discards in the decline in halibut size at age.
- Dr. Tim Loher proposed that size-selective mortality could also cause patterns in size at age. Type I mortality is higher mortality at smaller sizes, likely due to predation on early life stages. Type II mortality is higher mortality at larger sizes, due to fisheries owing to the nature of size limits and gear selectivity. However, this mechanism has yet to be

investigated. Studies have not been undertaken to formally evaluate this potential contributing mechanism.

Dr. Kruse made several comments about human-induced factors:

- There remains some possibility that the switch from surface to "break and bake" methods has led to an increase in estimated halibut age. He suggested that a re-evaluation of archived otoliths with contemporary methods would eliminate potential methodological impacts on the observed trends.
- The effects of fishing on size at age are speculative and more difficult to evaluate.
- The target harvest rate of ~20% roughly equates to $F_{35\%}$ that is the fishing mortality rate that reduces spawning stock biomass to 35% of the unfished level on average.
- For federal groundfish fisheries under the jurisdiction of the NPFMC, $F_{35\%}$ is used as a limit reference point (that defines overfishing) and $F_{40\%}$ is used as a target reference point.
- Also for a comparison, a 20% harvest rate is applied to fishery management in Alaskan herring, a species that lives to ~8 years old in the Gulf of Alaska and ~16 years old in the Eastern Bering Sea. As natural mortality rate decreases with increased longevity and appropriate fishing rate is tied to mortality, the current $F_{35\%}$ – type harvest strategy may not be sufficiently precautionary.
- An $F_{40\%}$ strategy would be more consistent with NPFMC procedures. The current retrospective pattern of the stock assessment model suggests that the current harvest policy may not be sufficiently precautionary.
- Apparent higher harvest rates, particularly in the eastern portions of the range, were higher than planned, which raises questions about fishing effects (e.g., localized depletion, other effects).
- Other effects are more speculative – do larger fish complete their counternatant migration sooner and are they subject to selectively higher harvest rates? Can this lead to fishing as a cause of evolution? Halibut have recovered from small size at age once before, which suggests a phenotypic (density-dependent) response. However, phenotypic plasticity is not necessary insurance against fishing as a cause of evolution.
- The probability is low that fishing has caused the current reduced sizes, however, the impact risk of being wrong on this is very high; he recommended that fishing as a cause of evolution should be a research priority so this potentially low chance, but high-risk, mechanism can be eliminated.
- For near-term expectations, to the extent that halibut density explains most of the variability in size at age and recent estimates of halibut recruitment are high (notwithstanding retrospective errors), it appears likely that the near-term expectation is for continued small size at age.
- If arrowtooth flounder also contribute to a density-dependent effect on halibut growth through prey competition, arrowtooth flounder abundance seems to be sustained at high levels. Thus, any negative effect of arrowtooth flounder biomass on halibut growth is expected to continue over at least the near term.

Mr. Tom Jagielo agreed with Dr. Kruse's analysis and added that:

- There might be some clues in onset timing of the phenomena, in growth slowing since the 1980s, he recommended that the could reexamine growth increments in the otolith time series and growth, in addition to size, at age.
- He also thought that density-dependence was the most likely driver of the decline.
- He recommended investigating density interaction with other species, especially those species with similar life phases.

Discussion on causes of size at age included:

- Dr. Robyn Forrest noted that there have been a number of hypotheses for the causes of the decline and it seemed that some of this has already been looked at by the IPHC and wondered when this work would be open for review. She also noted that there are several meetings coming up, including the Commission's Bycatch Working Group and Science Planning Workshop when it could be discussed.
- Dr. Leaman responded that there is a paper on the potential impacts of ageing methodology that will likely be available before the Commission's Interim meeting but that it is still undergoing internal review. The Science Planning Workshop is scheduled for May 8-9, 2012, following the performance review rollout, and meetings beyond that have not been scheduled.
- Dr. Leaman responded to Dr. Kruse's question and clarified that the western Pacific offal was distinguishable from fish remains.
- Ms. Tory O'Connell noted that the magnitude of removals has changed, particularly increasing in the Western areas where a lot of young fish are, which might affect growth or size at age.
- Dr. Leaman commented that we're seeing smaller halibut eating small pollock, which arrowtooth are also eating; this might lead to direct competition. This demonstrated overlap for this pollock size category was interesting when considering intra- vs. inter-species competition.
- Mr. Clark added that he was looking at the SAFE document for arrowtooth, which also shows some decrease in growth for arrowtooth. He recommended this for further research.
- Dr. Martell commented on Dr. Loher's presentation on Type II mortality; he noted that colleagues in Europe have looked at Atlantic cod, and it has a role in changes in size at age, especially with increasing mortality rates. As the fish recruit to the fisheries, we fish off the fast growing individuals. Given what we know about size in age, we could set up an equilibrium model with multiple growth-type groups to represent variation in growth and explore hard would the fishing mortality rate need to be to observe the changes in size at age that we see. Dr. Martell believes that the change in size cannot be fully explained by fishing.
- Dr. Leaman noted that we see two phases: a declining phase, but also a previously increasing phase, and mechanisms need to explain both aspects.
- Mr. Jagielo added that it is important to understand the biology of the fish, including density factors. There should be an explanation that holds for all time series of data. He also noted that we should look at spatial niches, and cited another study that looks at

possible spatial exclusion and population migration for rock sole, suggesting a similar type of study for halibut.

- Dr. Ianelli explained that the bottom trawl survey in the Gulf of Alaska for the whole time series is pretty flat for halibut biomass, and that there is three times the biomass of arrowtooth than halibut. He noted that, over time, the relative abundance between the species hasn't changed, though there could be competition, especially if there was a decrease in common prey.

Change in Minimum Size -- *What are the likely effects on ecology and halibut stocks if the commercial IFQ minimum size limit was changed from 32 inches to 26 inches*? (Note: This was not a pre-specified question but added at the request of a speaker during the public comments, and concurrence of the Panel.)

Dr. Steve Martell led the discussion with a quick summary of his presentation:

- Reducing the size limit would have a minor negative effect on landed value of the fishery because the smaller fish are assumed to have a lower price premium and therefore are less valuable per pound; however, there is a marked increase in efficiency in the catch rates of legal sized fish leading to lower operational costs and, fewer fish are discarded and wasted lowering the overall total mortality rate in the directed fishery.
- Current commercial selectivity barely catches the 26-32 inch halibut; currently the coastwide assessment model estimates that fish begin to recruit to the current gear around 29".
- Reducing the size limit would have a positive effect on the spawning stock biomass because of lower total mortality rates associated with the practice of hi-grading in the directed fishery.
- His joint-probability model includes the probability of catching a fish of a given size and keeping it, if it is greater than the minimum size limit. If the directed fishery were allowed to retain fish 26" or larger, the directed fishery would impose a lower mortality to land its quota. There are lower fuel costs and less wastage. The directed halibut longline fishery is currently throwing away $15 million in fish.
- Dr. Martell also suggested that managers find other ways to incentivize lower bycatch without giving the trawl fisherman a financial incentive, for example by allowing them to keep bycatch but with proceeds going to the IPHC to continue research.
- He summarized that lowering the size limit would improve the economic efficiency of the directed fishery, since there is no market for the smaller fish, fisherman would probably not change their fishing practices to catch smaller halibut, and spawning biomass would increase. Observer coverage or electronic monitoring is also a necessary to ensure compliance in efforts to lower wastage mortality rates.

Dr. Steven Hare contrasted Dr. Martell's analysis with the analysis that he and Dr. Valero completed, noting:

- A key difference was that Dr. Martell held selectivity constant, where he thinks that a change in the selectivity schedule would likely accompany a change to the minimum size limit.

- There is a potential beneficial effect on the female spawning biomass, but because the change in size limit would increase the total exploitable biomass, it would be hard to control total catch with a lower harvest rate.
- It might increase the number of halibut in the catch for a given removal since many are smaller fish. Dr. Hare concluded that there is not a clear-cut case for lowering the size limit once you get into the numbers, and that the benefits are modest.
- There should not be an expectation of an increased quota just because there would be an increase in exploitable biomass. There would be significant concerns about fishing selectivity.
- It would be interesting to try a different minimum size but not change the total allowable catch and see if there is a change in the commercial selectivity.

Discussion on this topic included:

- Ms. O'Connell thinks that selectivity will change, especially for smaller fish; she also wondered about downstream effects if the fishery starts catching smaller fish. She also mentioned that improvements to the directed IFQ fishery, while important, don't address bycatch reduction in other fisheries.
- Dr. Martell noted that corresponding to a decrease in size limit, it would also be necessary to calculate the appropriate target mortality rate to keep the target spawning biomass. He also pointed out that even if the size limit does not change, with declining size at age, the F_{35} reference points still need to be updated every year because halibut are growing slower and dying off faster than they are recruiting to the biomass. In a modeling exercise we may need to adjust mortality rates upward to get to the same depletion level.
- Dr. Martell suggested that the Commission should clarify its management objectives; if it is to keep the spawning biomass at B_{30}, this should be defined first, and then the harvest control rule can evolve around this.
- Dr. Ianelli pointed out that the management objectives are clear: to maintain a viable fishery. He noted that the three analyses on size limits seem to represent book-ends, with respect to selectivity assumptions and reality may likely fall somewhere in between. There may also be important spatial differences.

Future Research - *Suggestions for future research on halibut ecology?*

Note: These suggestions for future research are further summarized along with all the other research recommendations from the Workshop in Appendix 3.

Mr. Bob Clark opened the discussion with several comments:

- Looking at the time from the 1920s to 1980s when the size at age was increasing, there is an opportunity to learn about the mechanisms that lead to this; this may help us understand when and how populations of halibut responded in a positive way to help us see why we're seeing the current decline.
- Research should glean as much as possible from what was known about halibut ecology during the time period when size at age increased. For example, re-aging and calculating growth increments from otoliths (break and bake) from the time period of increasing size at age may help to understand when and how different sizes of halibut responded.

- Do we know anything about the relative abundance of the other flatfishes in the Gulf of Alaska during the 1950's from trawl surveys or commercial catches? What were the environmental conditions in the Gulf of Alaska during that time and what was the stock assessment telling us about halibut recruitments and the rate of fishing on halibut? Though this period is not as data rich, there is at least qualitative data about the kind of species that there were where should be considered.
- Can we say anything definitive about the possible shift in diet of halibut from the period of increased growth rate to the present (e.g., pollock abundance in the Gulf of Alaska then and now) and its effect on halibut growth?

Dr. Gordon Kruse listed the research approaches mentioned during the workshop so far:

- Methodological validation, a re-evaluation of archived otoliths with contemporary methods would eliminate potential methodological impacts on the observed trends. A sub-sampling approach may be an efficient means to quickly resolve this issue.
- Climate changes may alter timing of plankton bloom relative to larval period – affect larval growth and survival? Likewise, ocean temperatures may regulate physiology, affecting growth and survival. Research opportunity – examine growth increments on otoliths and compare to ocean conditions (mainly addresses second mechanism).
- Compare age-specific spatial distribution of potential halibut competitors – do they eat the same prey in the same areas? Is prey in limited supply?
- A detailed examination of spatial, temporal and age-specific patterns in size at age may help elucidate causal mechanisms. For instance, size at age was relatively stable for ages 6-10 over 1993-2003 and then declined. For the older ages, size at age generally declines steadily over 1993-2011. Are these changes associated with differences in diet among young/small and old/large halibut? Do such differences, when analyzed spatially, help elucidate ecological mechanisms behind the decline in size at age?
- Examine whether the decline in size at age has origins with competition during early life stages with other flatfishes (yellowfin sole, rock sole, flathead sole, arrowtooth, others).
- Changes in size at age for other species (e.g., GOA pollock, Pacific salmon) may offer insights into the mechanisms for reduced halibut size at age. Are there common ecological explanations (e.g., energy flow to pelagic vs. benthic) or biological explanations (e.g., stock density-dependent effects).
- Fishing as a cause of evolution – consider reaction-norm-based approach to disentangle evolutionary effects versus phenotypic plasticity. This approach was developed and applied to Atlantic cod. The method includes examination of growth and age and size at maturity. Density-dependence tends to lead to predictable changes in these growth and maturation. For instance, higher fish densities tend to lead to slower growth, which tends to delay maturation. When you find patterns that diverge from expectations owing to density-dependence, it may be indicative of an evolutionary genetic effect. Baseline genetic data could also be collected now against which future genetic samples could be compared.

Discussion on future research on halibut ecology included:

- Dr. Ianelli asked about the extent and status of maturity-at-age data.

- Dr. Hare responded that there was maturity data going back to the 1960s, tied to age, that shows that 50% are mature at 11 years, with little spatial variation. The mean length has dropped, so maturity is linked to age, not size.
- Dr. Leaman noted that age at first maturity is not well determined, though there have been some summer studies, but summer is not the best time to do studies on maturity since gonads are fully functional from September through February. He also noted that future diet research should be pursued.
- Dr. Hare added that there is an influence of climate on growth or size, which should be further studied; he mentioned one study (by Hagen and Quinn 1981) that demonstrated climate effect on early growth, but this issue hasn't been resolved and warrants further research.
- Dr. Ianelli also recommended investigating the use of length frequency data from the Bering Sea.

Accuracy of Halibut Bycatch Estimates – *How accurate are bycatch estimates (does it differ by region/jurisdiction), and how can the accuracy be improved upon? Can the accuracy be measured/reported?*

Dr. Bruce Leaman started the discussion with the following comments:

- There are two different regimes in the Gulf of Alaska and Bering Sea, respectively, with lower observer coverage in the Gulf.
- Alaskan fisheries that create bycatch mortality of halibut are distributed in the Bering Sea/Aleutian Islands and the Gulf of Alaska. The observer coverage, hence bycatch mortality estimation, in the Bering Sea/Aleutian Islands is reasonably (though not totally) comprehensive. However, the observer coverage in the Gulf of Alaska is inadequate for accurate estimation of halibut bycatch mortality.
- There are three major issues that may compromise the validity of halibut bycatch mortality estimates in the Gulf of Alaska groundfish fishery:
    - Non-random deployment of observers. Observer deployment is currently controlled by the vessel master and subject only to broad guidelines of necessary coverage for particular time intervals and fishery sector. This problem has been acknowledged by NMFS staff in publications and the workshop presentation by Mondragon and Cahalan, and creates both spatial and temporal biases in the data collection and subsequent estimation process (Benoit and Allard 2010, Faunce and Barbeaux 2011). Indeed, these sampling biases have been a dominant factor in the proposed restructuring of the NMFS Observer Program in Alaska.
    - Behavioral modifications of fishing activities by vessels/crews on observed vessels. NMFS, DFO, and harvesters have noted studies demonstrating that the presence of observers aboard vessels results in altered behavior and differences in fishing activities compared with similar characteristics for unobserved vessels. This form of modified behavior is also commonly reported *post facto* by harvesters, after mandatory 100% observer coverage programs have been instituted. Such alterations create non-representative data for observed vessels relative to unobserved vessels and have been analyzed by NMFS and DFO staffs,

as well as being reported in the workshop presentations by Ackerman and Turris and Caron (Faunce and Barbeaux 2011, Mawani 2009).

- Incomplete coverage of the fishing activity. The vessels that fall within the 60-125ft category have mandated 30% observer coverage (in each quarter of the year) and vessels in the growing < 60 ft category have zero coverage requirements. The estimation of total halibut bycatch mortality in the GOA therefore rests on the assumption that observations on observed vessels are representative of fishing activities and halibut bycatch estimates for unobserved vessels. There is ample evidence and analyses to deny the validity of this assumption. The biases in observer deployment and behavioral modifications noted above make it impossible to estimate the magnitude of bias embedded in current estimation procedures. The implementation of effective bycatch control measures in both IPHC Area 2B (Canada) and Area 2A (WA/OR/CA) have been a part of broader, comprehensive management programs which have stipulated mandatory 100% observer (or electronic monitoring) coverage on trawl vessels. These programs have not contemplated the form of incomplete coverage seen historically for the GOA groundfish fisheries. See Appendix 4 for References cited by Dr. Leaman.

Dr. Michelle Allen added a statistical perspective, noting that:

- Data issues, which need to be considered when deriving bycatch estimates are:
- **Multiple survey objectives**. When designing a survey, the survey objective should be clearly defined and quantifiable. If there are multiple objectives, a survey designed around one objective may not be adequate for another objective. After rationalizing the objectives to a core set, correlation analysis of the objectives is recommended. Significant positive correlation between multiple objectives generally results in a survey design adequate for the multiple objectives. When objectives are negatively correlated then generally a survey designed around one objective will not be adequate for another objective.
- **Underlying distribution of the data**. Marine fisheries data are typically non-normal and are usually positively skewed. Sample estimators are based on the assumption of normality. When data are not normally distributed this will inflate the variance estimator. A crude rule of thumb (Cochran, 1960) when assessing how large the sample should be for use of the normal approximation when deriving the variance estimator is $25G_1^2$, where G1 is an estimate of the population skewness (kurtosis). If the data are skewed the assumption of normality can be improved by analyzing the extreme values separately, that is post-stratify. Bycatch could be post-stratified into low and high bycatch.
- **Stratification**. Efficient stratification will group together similar units within a strata and maximize the mean difference between strata and will generally improve the precision of the estimator relative to simple random sampling the entire population. Deriving optimal sampling levels based on data from a previous survey, can be achieved by either fixing the cost/resource or fixing the precision. Comparison of the two approaches can show based on a fixed resource the level of precision that is realistically achievable, and then if wishing to achieve a target precision the level of resources required to meet the target

precision. A useful rule of thumb to note is when halving the precision the sample size will increase four-fold.

- **The use of auxiliary information**. If auxiliary or supplementary information, that is information which is easily accessible, cheap to measure and is available for the entire population, is significantly correlated with the variable of interest that the survey is attempting to estimate, where the variable of interest is difficult or expensive to measure, and is not available for the entire information then the supplementary information can be used to estimate the variable of interest for the population. The ratio and regression estimators are examples of estimators that use supplementary information. The ratio estimator is a special case of the regression estimator. If the intercept of the linear relationship between the variable of interest and the supplementary information is significantly different from zero then in theory the regression estimator will out-perform the ratio estimator (Cochran, 1960; Sukhatme and Sukhatme, 1970; Allen et al., 2001).
- **Multistage sampling design**. When sampling bycatch taking account of the hierarchical nature or levels when sampling can potentially improve precision, while informing at what level resources should be targeted when sampling. There are 6 nested levels when sampling bycatch – vessel, trip, haul, box if trawler or line if set, length and age – that can be completely enumerated or sampled. Decreasing variance components, when moving from one level to the next, would indicate that it would be more efficient to sample fewer sub-units and more units than vice versa (Cochran, 1960; Sukhatme and Sukhatme, 1970). When assessing the level of precision it is possible to achieve based on historic data, by apportioning out the variance over the levels, would be informative for those vessels that do not have 100% coverage at trip level.

Discussion on the accuracy of bycatch estimates included:

- Dr. Leaman questioned what the goal is for observer coverage and if we can achieve it with partial coverage.
- Dr. Ianelli noted that there is a distinction between sampling bias (e.g., from an estimator) as Dr. Allen discussed, and bias due to observer-effects (i.e., operations intentionally differing on observed vs. non-observed vessels).
- Dr. Allen explained that it isn't possible to quantify the observer effect, since it is not consistent from trip to trip, and that bootstrapping would just assess whether the estimator is biased, not quantify the observer bias.
- Dr. Leaman suggested that they take guidance from other geographic areas that use 100% observer coverage to deal with the issue of observer bias.
- Dr. Martell agreed that 100% observer coverage was a good way to improve accuracy.
- Dr. Neilson suggested that a gap analysis might be helpful to understand what data is missing since some fisheries are well covered, but some smaller fisheries have issues around bycatch that we don't understand.

Biological Impacts and Migration *–How well are biological impacts quantified, and how well are the effects of migration on biological impacts understood and quantified? Is coast-wide data and analysis sufficient or is a finer spatial scale possible? How reliable or accurate would a finer scale be?*

Mr. Bob Clark addressed each question for discussion:

- How well are biological impacts of bycatch quantified? Assuming our knowledge of the magnitude of bycatch is accurate we have a basic understanding and can reasonably quantify the direct and indirect impacts of bycatch on exploitable biomass and spawning potential of the halibut stock, as well as the effects on yields in directed fisheries. We know very well that in general the direct and immediate effect of O26 bycatch on directed fishery yields will be approximately 1 to 1. Although more assumptions are needed to assess the impacts of U26 bycatch, our current understanding of the delayed and prolonged effect on spawning biomass is consistent with what we know about the population dynamics of halibut and will occur in an approximately 2 to 1 ratio of pounds of spawning biomass accrued per pound of bycatch reduction.
- How well are the effects of migration on biological impacts of bycatch understood and quantified? Although there is generally less known quantitatively about halibut migration, we have come to understand that conceptually there is a general west to east migration of halibut that continues as the fish age past the age of recruitment. This migration would tend to redistribute the effects of bycatch from the area where much of the bycatch takes place in Areas 3 and 4, eastward. The quantitative extent of this biomass redistribution and how it might change over time and vary with where and on what ages/sizes of the population are bycaught is much less well understood and will require more analysis and research.
- Is coast-wide data and analysis of migration sufficient or is a finer spatial scale possible? How accurate would a finer scale analysis be? It is unclear whether a finer spatial scale analysis of the current migration data (PIT and external mark data primarily), if it were possible, would result in a better understanding of the effect of bycatch on the halibut stock. These types of mark-recapture data require fairly large sample sizes to provide estimates of migratory rate that could be used to inform the stock assessment model. That said, if possible, we should be looking more closely (spatially and temporally) at the current migration data to determine if size, sex, age, and/or growth rates influence the propensity to migrate and if the annual migration rates are density dependent.

Dr. Robyn Forrest added to the discussion with the following comments:

- How well biological impacts are quantified will largely depend upon assumptions in the model used for analysis, and we need to examine the effects of structural assumptions in models and the halibut stock assessment.
- With respect to migration, we might expect selectivity at length to be different in different areas, so the coastwide analysis might not be sufficient. Yet adding migration to an assessment adds a lot of complexity and additional parameters, which adds uncertainty. We may be able to take a hybrid approach, using different selectivity values in different areas, treating each area as a different fishery.
- Other assumptions that lead to an understanding of the impacts of bycatch include how we treat natural mortality, the variance used in estimates of length at age, and how we model selectivity (whether it's length-based or age-based). How we treat selectivity can affect our understanding of the population size.
- There is a peer review of the stock assessment coming up, so that will be an opportunity to review these assumptions.

- Dr Forrest noted concerns about the veracity of continued model predictions of large, increasing age 8+ total biomass, and the severe retrospective bias in these estimates, which predict a substantial increase in biomass. She questioned the degree that the predictions of large incoming biomass may be the result of model assumptions.

Discussion on the biological impacts included:

- Dr. Allen suggested that before committing to a finer scale, optimal sampling levels to support finer scale spatial data collection should be investigated, particularly to support 30% observer coverage. It is advisable not to have missing cells in a stratification.
- Dr. Leaman noted that the idea of size, sex, temporal change, growth and migration rates, and that a spatially explicit model would be an improvement over a coastwide model, especially with the migration issues that are arising. But when we look at the probability of movement, it comes out of the PIT tag data. We haven't looked at this by sex. One question he noted was what the residence period is for fish at different age and are they influenced by length at age; we don't know the answer now. It would be great if the data matrix was ten times the size, but the matrix gets sparse when looking at more variables although we haven't fully mined the data that they have from the PIT tags.
- Mr. Jagelio commented that on the issue of finer spatial scale, looking at the Bering Sea data, there seems to be an opportunity to look at it on a finer scale, especially in Area 4. It appears that there is some heterogeneity there, and suggests that this breakout should be considered, this seems to be workable with the existing data.
- Dr. Martell noted that the current coastwide assessment model represents the dispersal mechanism as a diagonal vector of 1s, with no movement. Can data from tagging be used to implement a dispersal kernel and account for migration in the model?
- Mr. Clark added a question, asking if migration models are being incorporated into management strategy evaluations? The answer was yes.
- Dr. Allen asked if raising factors is an issue for bycatch estimation. She noted that in the Northern Irish fishery, raising factors are based on the catch composition, the gear type used, and how the observer works, so they don't enumerate everything. But if the observer doesn't get it right, that is then compounded as data is expanded from haul to trip.
- Dr. Leaman asked if the species composition is aggregated over hauls? The answer was that they are not aggregated.
- Ms. O'Connell referred to Dr. Hare's Figure 21, which shows that one pound of under 26" bycatch has a bigger impact on biomass, up to five pounds depending on the area; she noted that she didn't want this point to get lost.
- Dr. Forrest responded to a comment from the floor that this could well be both a conservation issue and allocation issue, and that it also depends on how well we've estimated the amount of bycatch; if we've underestimated the bycatch, it could be more of a conservation issue.
- Dr. Martell followed up that if the bycatch isn't reported, then it really is a conservation issue.

Fishing Practices – *What changes in fishing practices have been made to reduce bycatch and how effective have they been?*

Ms. Jane DiCosimo started the discussion with several comments:

- Presentations from the different management agencies that have employed a variety of programs that uniquely fit their fisheries show a range of programs, including individual transferrable quota programs and cooperatives.
- Of fifteen US catch share programs, six are in the North Pacific and two are in the Pacific. Canada has one integrated program for its BC fisheries.
- The groundfish fisheries presentations included several examples of changes to fishing practices:
    - Regulatory limitations: closed area, seasonal and area apportionments of bycatch caps and result in mandated changes to fleet behavior (particularly when the fishery is closed as a result of hitting those caps). Careful release is required to minimize harm to released halibut.
    - Rationalization programs allocate catch shares of various types to individuals and allow for slower fishing and selective time and area decisions for fleet deployment. In the BSAI Amendment 80 program this was in order to meet increased retention/utilization requirements that were implemented under another Council management action.
    - John Gauvin presented on fish excluder devices that were tested under exempted fishing permits and slower, shorter fishing tows
    - Julie Bonney summarized the central GOA rockfish program and her concerns about paying a tax under reduced halibut bycatch apportionments, and subsequent reductions for any seasonal apportionment of halibut bycatch that is rolled over. She spoke about the effect such disincentives would create in that sector.
    - Kenny Down described the voluntary Bering Sea & Aleutian Islands Pacific Cod Hook & Line Cooperative, in which the freezer longline cod fleet began fishing as a voluntary cooperative in August 2010.
    - Sea State, Inc which allows the fleet to rapidly respond (both individually and collectively) to high bycatch rates by using real-time date from NMFS at-sea observers to stay under aggregate bycatch caps which close the fishery when a certain amount of bycatch occurs. Individual bycatch rate regulations attempt to create individual incentives for companies to minimize their bycatch by assessing violations when rates are above prescribed levels.
- Two presentations by Barry Ackerman and Chantelle Caron of DFO described two rationalized BC fisheries that have achieved great success in reducing halibut discards. Sarah Williams from the NMFS NWRO summarized the newest ITQ program for North West groundfish.
- These programs have resulted in:
    - 31% of cap in BC
    - 75% of cap under Amendment 80
    - 20% of cap in North West
- Across the range of halibut management areas (Area 2A, 2B, 2C/3, and Area 4), a variety of what we term “rationalization” or share-based catch limit systems have been developed from the top down (implemented by the government(s)) and bottom up (from

fishery stakeholders). Other programs have been framed together from both the government in consultation with stakeholders.

- Those programs have included a complementary component that placed lower caps on halibut bycatch, while awarding shares of the target groundfish fisheries.
- In many instances reduction goals were achieved more rapidly than expected when the fleet was provided with the management tools that defined the universe of participants and allowed them to develop strategies to achieve management goals.
- In Alaska halibut function as the grease in the wheel of harvesting approximately 2 million mt of groundfish target species in the North Pacific, which account for approximately $2 Billion in first wholesale value.
- US management is mandated to balance national standards: 1) to harvest optimal yield (as much as possible) of groundfish allocations with 2) to reduce bycatch.
- Comprehensive rationalization programs have been attempted for the GOA in the past and have encountered legal and management hurdles that were insurmountable.
- However managers on the Pacific coast have met with more success in creating and implementing rationalization programs that have identified smaller universes of participants and defined specific management objectives to address target and bycatch fishery issues that resulted in a number of distinct programs.

Dr. John Neilson added to the discussion with the following comments:

- We heard concerns that under current fishing practices, halibut are held for long periods of time before being released in some areas that Amendment 80 fleet operate due to regulatory requirements to allow those halibut to be sampled.
- He suggested that sampling of halibut take place on the deck rather than in the factory for the Amendment 80 fleet, which would decrease handling time, leading to substantial potential benefits particularly in the Gulf of Alaska. We understand that this measure will be piloted in the near future.
- Utility of individual bycatch caps was discussed, and appeared to be favorably viewed by fishery participants.
- We heard about many improvements, but there is still some way to go for other fleets.
- Such changes in their operations have resulted in significant declines in estimated discard mortality rates.
- However, it seems that an important deficiency remains the overall accounting of discard mortality. For example, Williams (2011) notes, "Observer coverage in the Gulf of Alaska groundfish fisheries remained at lower than necessary levels, continuing to raise questions about the accuracy of the estimates for that area."
- It is also a good idea to think about where there is not enough coverage. There are plans in place to augment observer coverage in important ways, but perhaps a "gap analysis" might also a good idea as a speaker this morning mentioned.

Discussion on fishing practices included:

- Ms. O'Connell added that careful release, i.e., rolling the fish off the hook on the waterside of the boat, was promising and that the Freezer Longline Association saw a decrease in mortality rate from 19 to 9%.

Management Programs/Approaches– *What management programs/approaches to reduce bycatch have been effective, and what have we learned from less successful efforts? What alternative or additional management programs/approaches could be considered for overcoming on-going halibut bycatch challenges (e.g., lowering the commercial size limit, set maximum size limits for sport charter harvests)?*

Ms. Tory O'Connell led discussion with the following comments:

- National Standard 8 requires reduction of bycatch and the terms of the IPHC agreement for both countries are to reduce bycatch in pounds, not just the rate, so we are looking at management programs and approaches that address this.
- All presentations show that halibut bycatch is reduced with individual vessel responsibility.
- Rates from the 2009 bycatch workshop are as follows:
    - British Columbia went from 40 lbs/metric ton in 1991 to 4.5 lbs/mt in 2008
    - Gulf of Alaska went from 1.95 lbs/mt in 1985 to 22 lbs/mt in 2008
    - Bering Sea went from 2.1 lb/mt in 1985 to 3.4 lb/mt in 2008
    - Couldn't get the rate for the North West

- In terms of the mandate from the convention, management action needs to reduce catch not just reduce rates (rates more similar to bag limits, only they do not reduce catch).
- Bycatch reduction management measures can decrease encounters, decrease retention and increase survival; they are most successful when they draw on knowledge of participants and have appropriate incentives, deterrents, and monitoring.
- The British Columbia program has worked to reduce their bycatch both in rate and absolute poundage by using 100% observer coverage in the BC trawl fishery with the allowance of a 4% maximum cap (8% annually, which allowed flexibility). Fishermen had to stop fishing once they reach their cap. All trawl caught halibut have to be released and they are generally in the water in 16 minutes. There overall mortality rate is on discards is significantly lower than Alaskan rates.
- Successful bycatch reduction occurs because fishermen have altered practices and redirected effort to species where bycatch of halibut is less, tow times have been shortened and they use short exploratory tows to identify catch composition. This has allowed trawl fleet a year round fishery and on average only 30% of halibut cap has been taken.
- In Hook and Line and Pot fisheries they hold Individual Fleet Quota for all fish (target and bycatch), and allow individual responsibility quotas to be traded. These bycatch are limited to prevent targeting by non-directed fishermen. They use electronic monitoring and a 10% audit rate to ensure compliance.
- In the Northwest, they have used individual trawl quotas and 100% observer coverage to achieve an 87% reduction compared to 2009 bycatch estimates. The cap represents 50% reduction. There is not much room for acquiring other IVQs, so it's not a market system, but there is a strong incentive to keep within cap.
- In Alaska, we heard that Amendment 80 vessels (with 200% observer coverage) were able to reduce their halibut bycatch 40% even when increasing retention of species and a 15% increase in target catch. They changed fishing patterns including using shorter tow lengths. Their bycatch is down to 13lbs halibut/mt groundfish.

- The rockfish program has also reduced their use of halibut by 80-90 mt. They were given 87% of their recent use, and 55% of the halibut saved can be rolled into the fall flatfish fishery. Their use is between 5 and 10 lbs of halibut/mt rockfish. Whether these fishing practices continue will depend on the incentives in place.
- What alternative or additional management programs/approaches could be considered for overcoming on-going halibut bycatch challenges?
    - Careful release (rolling the hook out of the mouth using a gaff outside the vessel) reduces release mortality 9 times more than if using hook strippers.
    - Depth release and halibut excluders and other gear configurations.
    - We heard the freezer longline fishery can reduce release mortality of halibut by slowing down their hauls and practicing careful release by carefully releasing halibut at the water line. They have reduced discard mortality rate from 19% to 9%– and can reduce further under coop fisheries (or 100 percent observers).
    - We heard that the trawl fishery has a potential of reducing release mortality nearly 40% by the practice of deck release of halibut with the goal to greatly reduce handling time instead of the current situation where the halibut have to go to a holding tank. This may be more effective in the Gulf than Bering Sea but the experiment has occurred in high bycatch areas in the Bering Sea so effects might be even greater in Gulf of Alaska.
- The most vulnerable portion of the stock, and the portion that is the most unknown, is U26.
- Increasing observer coverage (including electronic monitoring system) has been shown to decrease halibut bycatch and decrease release mortalities. What level is needed to estimate discard mortality and size selectivity may need a different level of monitoring groundfish catch accounting?
- The proposal of a floating cap that rises and falls with halibut is problematic at this time as to how/when it would be assigned (to Ebio or age 8+ fish). It does not address the potential increased impact on U26 halibut, the most uncertain and vulnerable portion of the stock. It also does not address the halibut convention agreement to reduce bycatch poundage (not just the rate).
- Time/area closures weren't discussed very much, but this can be by management or by voluntary. Fleets are good at avoiding bycatch when the target species is valuable or the incentives to reduce bycatch are strong (either punitive or positive).

Dr. Michelle Allen adding the following comments:

- In order to boost sampling levels, Northern Ireland uses fisher self-sampling for vessels under 10m. This approach could be used in conjunction with sampling with partial replacement. Sampling with partial replacement, within the bycatch context, would involve monitoring a core set of vessels on either all or some sampling occasions supplemented by those vessels not part of the core vessels on each sampling occasion, which would permit estimation of bycatch and also change over time.
- Usually the proportion of units to resample on future occasions is related to the correlation between sampling occasions. The number to resample decreases over time but will not fall below half of the number of units sampled on the first occasion. For bycatch the core set of vessels could be constant for each sampling occasion, which

would introduce some bias as sampling would no longer be random, but would establish strong working relationships with stakeholders.

- The sampling with partial replacement estimator is an extension of the regression estimator. The auxiliary information used would be bycatch on a previous occasion, where a previous occasion could be defined to be the previous quarter or the same quarter of the previous year. For sampling with partial replacement to give gains in precision there needs to exist significant correlation between sampling occasions of vessels' bycatch. The ratio and regression estimators use information based on a snapshot of the data, whereas the sampling with partial replacement estimator can be used for a time-series, such as bycatch. If significant correlation exists between sampling occasions, given the expense, difficulty and hazardous nature of gathering bycatch data, it is wasteful not to use historical data.
- The drawback of using bycatch as an auxiliary variable is that it is not known for the entire fleet. Hence, it is not possible to use bycatch as a raising factor when estimating for the entire fleet.
- Sampling with partial replacement has been successfully and extensively used within forestry (for example, Cunia, 1962; Cunia and Chevrou, 1969; Newton et al., 1974; Omule, 1982; Omule, 1984; Scott, 1984; Scott and Köhl, 1993; Scott and Köhl, 1994; Köhl et al., 1994). It can be combined with other sampling approaches such as multistage sampling where some or all of the levels are repeatedly sampled (for example, Tikkiwal, 1964; Singh, 1968; Singh and Kathuria, 1969; Kathuria and Singh 1971(a) and 1971(b); Kathuria, 1975; Chakrabarty and Rana, 1974 and 1977; Rana and Charkrabarty, 1976).
- William Warren (1993 and 1994) explored the use of sampling with partial replacement for marine fishery groundfish survey data. The variable of interest was an abundance index, which was log-transformed prior to analysis. The underlying distribution of the index was not stated but log-transforming data prior to analysis would indicate that the data were non-normal and skewed. While not discussed in the papers (Warren 1993 and 1994) it was assumed that the non-normality of the data was addressed, as it would inflate the variance estimator. Warren (1993 and 1994) advised restricting the number of sampling occasions to two for fishery surveys, as sudden shifts in the abundance or introduction of management practices would affect the estimator. See Appendix 4 for References cited by Dr. Allen.

Discussion on management approaches included:

- Dr. Leaman noted that successful programs draw on expertise of participants. If we define the management objectives and then tap into expertise within the fishing community, the harvesters can control using many tools that they have control over (including behavioral changes, knowledge of ground, gear changes). Sometimes we spend too much time defining how to achieve goals, rather just focusing on the results.
- Dr. Forrest noted that many tools have led to bycatch reduction particularly in the Bering Sea and British Columbia, and that a good outcome of this workshop would be a summary of the tools and incentives that have been successfully applied to reduce or avoid bycatch. This could feed into the gap analysis; it would be useful to know the degree to which these programs are operating and not, including the number of boats in the various programs.

- Ms. DiCosimo responded that there was a recent publication by Dr. Mark Fina (*Fisheries*, 2011, Vol 36) that is a relatively straightforward comparison of different catch share programs in the US, which might be informative. Ms. DiCosimo organized a symposium at last August's American Fisheries Society Annual Meeting that included presentations for each catch share programs and can share those presentations.
- Ms. DiCosimo also noted that in January 2010 the Commissioners formed a Halibut Bycatch Work Group II. An IPHC technical report is posted on the Commission website. The group was tasked with three objectives: 1) review progress on reducing bycatch mortality, 2) review the objectives identified by the first working group, and 3) examine how best to incorporate bycatch into assessment and management. The report is pretty comprehensive for each region and is a helpful compendium of information.
- Dr. Allen noted that a talk yesterday mentioned comparing electronic monitoring with the vessel log, which seems to be an agreement analysis (where two different methods are trying to quantify the catch). Electronic monitoring is used to verify fishers' reported catch. Under the current method of verifying fishers' reported catch, if a fisher's reported catch is not within 10% of the electronic monitoring results the fisher's reported catch is not accepted. It is replaced by the electronic monitoring results. Using this current method of verifying fishers' reported catch, it was suggested that the electronic monitoring was being considered as a gold standard or reference. The agreement between the two independent methods (electronic monitoring versus fisher) for measuring the haul could be assessed using Lin's concordance correlation coefficient (1989 and 2000), that is the reproducibility between the two independent methods is assessed. Lin's concordance correlation coefficient requires a minimum of 10 data points and can be used for non-normal data, for example count data. Lin's concordance correlation coefficient can assess reproducibility between more than 2 methods (Barnhart et al., 2002 and 2007). Agreement analysis should be supported by appropriate graphics. It was recommended that scatter plots of paired data are displayed along with the line of perfect agreement (45° line through the origin) and Bland-Altman plots (Bland and Altman, 1986, 1995, 1999 and 2007; Krouwer, 2007). When reproducibility between two methods are being assessed and one of the methods is considered a gold standard then the interpretation of the results differ than when neither of the methods are a gold standard. When using reference data the assessment is to determine if it is possible to replace the reference or gold standard method with another method. When neither of the methods can be considered as a reference then the assessment determines how interchangeable are the results--- that is do two methods give similar results. Agreement analysis has been extensively researched within medical statistics, for example Carstensen (2010).

Future Research - *Suggestions for future research on the impacts and management of halibut bycatch?*

Note: These suggestions for future research are further summarized along with all the other research recommendations from the Workshop in Appendix 3.

Dr. Steve Martell opened the discussion with several points about how to do as much as possible to eliminate bycatch and waste, including:

- The need to identify the single most critical issue impacting bycatch, noting that the current system assumes that the amount of bycatch is known and discounts the CEY using several assumptions about wastage and mortality rates.
- Another critical issue is to evaluate and improve the structural assumptions in the model regarding size selectivity vs. age selectivity because few fisheries have a constant selectivity. These structural assumptions, especially selectivity, are key assumptions, particularly when using a constant selectivity assumption for all of the management regions in the coast wide assessment.
- One way to get better estimates of wastage and discards is to put more observers on boats, to get a better count on wastage (nothing short of 100% observer coverage or electronic monitoring is essential).
- The idea of removing the U26 and the impacts on spawning biomass is based on critical assumptions of mortality rates and constant growth; it could be worse if growth rates continue to decline. If there were a size-dependent natural mortality rate, then you would expect to see some compensation in the spawning biomass loss ratio. Further research on the impacts of changes in size-at-age on fishery management reference points is necessary and fairly straight forward to conduct.
- We should do our best to eliminate bycatch and wastage and develop economic incentives within the fishery to foster better stewardship of the resource.

Dr. Robyn Forrest added the following list of research recommendations, some of which had come up over the course of the workshop:

- An examination of the structural assumptions of the stock assessment model (particularly with respect to fishery selectivity) and of the analyses presented at the meeting.
- Continuation of bycatch monitoring and discard mortality rate reduction programs, and identifying clear objectives for these programs.
- Continuation of research and reporting of successful co-operative programs and successful incentives for reduction of bycatch.
- Systematic research into retrospective bias in stock assessment model.
- Conducting an adaptive management experimental fishery to look at the effects of reducing the size limit on fishing behavior.
- Extending analyses on the impacts of bycatch and reduction in size limit to include migration.
- Revisiting the halibut Harvest Policy, given large changes in size at age and understanding of halibut ecology.
- Supporting the IPHC's Management Strategy Evaluation efforts and recommending the approach be used to analyze performance of alternative management procedures in the face of large uncertainty in the causes of apparent declines in size at age and under alternative assumptions about selectivity (e.g., length-based vs. age-based).

Discussion of the need for future research included:

- Dr. Ianelli noted that in the Gulf of Alaska, the Council has a PSC limit that could vary with abundance, and suggested that this type of floating cap instead of a hard cap should be considered in the management program.

- Dr. Hare noted that the result from his analysis on impact of female spawning biomass was conditional, and just looked at 2008 and across all fisheries for U26, and agreed with Dr. Martell and Dr. Forrest that further research is needed.
- Dr. Hare also suggested that US managers consider individual bycatch caps to reduce halibut bycatch.
- Dr. Kruse recommended that the annual stock assessment should consider incorporating halibut catch and size data from the NMFS annual/biannual trawl survey. Trawl survey data provide another wealth of information on the status and geographic distribution of halibut stocks. Owing to mesh size, the NMFS surveys may also help inform the retrospective bias in the estimates of recent recruitments.
- Dr. Martell agreed, mentioning a need to create a universal assessment that incorporates everything into the annual stock assessment, including data on the spatial nature of fishery. He noted that developing ways to be more efficient must start from the fishing industry.
- Dr. Allen stated that model-based estimators developed within the Bayesian framework were not discussed. The workshop focused on design-based estimators. Examples of model-based estimators can be found within Hirst et al. (2004), Millar and Fryer (2006), and Millar and Hirst (2007).
- Dr. Ianelli suggested building better incentives for fisherman to reduce bycatch, including fee-based approaches.
- Dr. Leaman noted that the Commission is looking for a more structured process to develop their research agenda and explained that there used to be a 5-year plan, but it was discontinued because there was a lot of coherence of views on necessary research. The Commission is looking to resurrect this planning and would welcome input from the Council.
- Dr. Ianelli noted that the present analysis on the impact of bycatch on the halibut stock used limited data (from 2008) and made a number of assumptions and should not be construed as general result. Further analysis on this topic is needed and it was noted that there would be variability in the downstream effects of bycatch on halibut stocks. [Dr. Leaman later clarified that the analysis used 2010 bycatch amounts but the fraction of U26 and O26 was based on 2008 length frequency data, which were the data available at the time.]

Closing Remarks: **Dr. Jim Balsiger** thanked everyone for presenting and participating. One thing that struck him was Dr. Leaman's observation that they were focusing on the decline in size rather than dramatic increase in size after 1920s. He recognized the long list of ongoing management actions that had been mentioned, which speaks tremendously to the effect that the fishing industry can have when they have the right tools. Dr. Balsiger was optimistic that there was substantial industry support through participation in the workshop, both as Panelists, presenters, and participants. He noted the number of Council members and Commission members in attendance. He also liked the idea of a pilot project to experimentally reduce minimum size in some areas to observe changes in fishing behavior, and conduct a real world experiment. Dr. Balsiger noted upcoming meetings in the next few months, and thanked Ms. DiCosimo, Mr. Williams, Mr. Oliver, and Dr. Leaman for arranging the meeting.

Appendix 1: Day 1 Presentations

Following are the list of presentations from Day 1, plus any additional clarifications in response to questions from the Panel members. See website for the presentation slides and audio recordings.

Presentations: Halibut Ecology

- **Dr. Steven R. Hare** (IPHC) gave a presentation titled "*Recent trends in removals, exploitable biomass, female spawning biomass, and size-at-age."* There were no questions.
- **Dr. Bruce M. Leaman** (IPHC) gave a presentation titled "*Review of IPHC halibut diet studies."* There were no questions.
- **Dr. Kerim Aydin** (NMFS AFSC) gave a presentation titled "*Halibut in an ecosystem context: groundfish diet collections and food web modeling."* In response to questions, Dr. Aydin noted that:
    - There was a backlog in data processing, which just caught up to the 2007 and 2009 surveys, and that most information presented was from survey data; only pollock, cod and arrowtooth have additional observer data.
    - There is now large sample of grenadiers, which eat other grenadiers and squid, and create an isolated food web.
    - There has not been research on how much energy content different species provide that has been specific to halibut, but there have been several general studies, including a baseline study comparing pollock to other fish, and that there is ongoing work in the Gulf of Alaska to look at variation in energy content of pollock.
    - In the Bering Sea, there is a lot of variation in winter and fall conditions, which might impact energy content. For arrowtooth, there have been several diet studies, which show that these fish have a primarily benthic diet; they tend to eat a lot of shrimp when they are small and then switch to pollock as they grow.
    - There was a suggestion for an additional study to look at differences for larger halibut by area, breaking down the Gulf survey by region.
- **Dr. Tim L. Loher** (IPHC) presented "*Size-at-age and growth and of Pacific halibut: Process and Mechanisms*." Following Dr. Loher's presentation there were suggestions from other panelists to:
    - Re-test archived otoliths with the current break-and-bake method, which might smooth the change in size at age, and to look at additional data associated with the otoliths (e.g. stomach content, location) to look for more specific trends.
    - Calculate the fishing mortality rate that is required to get to the Type II mortality that is seen. It was discussed that current fishing mortality rates are within realm of reasonable, around 70-75%, and that current harvest rates are below what has been historically seen in the fishery.

- **Mr. Tom Jagielo** (TJC) presented "*Synopsis of theoretical and empirical evidence concerning the causes of halibut slow growth and potential differences in natural mortality by sex*." Following Mr. Jagielo's presentation in response to questions he clarified that:
    - There is nothing directly in the literature on the exploitation rate for a long-lived fish, since halibut live longer than silversides and cod, but there is some research on selectivity patterns in commercial fisheries and mortality rates, which concluded that fishing does not cause size evolution.
    - The slide on intra-specific competition did not contain updated data.

Presentations: Impacts of Halibut Bycatch

- **Ms. Jennifer Cahalan** (PSFMC) and **Ms. Jennifer Mondragon (**NMFS Alaska Region) presented *"Catch estimation in the Alaskan groundfish fishery*." In response to questions, Ms. Cahalan and Ms. Mondragon clarified that:
    - Currently, vessels choose when to take observers, however the deployment plan is currently being reworked and this will change.
    - There are estimates for state waters, but there isn't much observer data, and that for small boats (with no observers) they estimate removals based on data from larger sized vessels.
    - Data normality varies by species and how prevalent they are (with rare species showing non-normal distributions). Dr. Allen asked about the intercept used in the ratio estimator. It was clarified that the estimator assumes a zero intercept and linear relationship.
    - Dr. Ianelli noted that more than the required 30% of vessels are covered, up to 50%, because of logistics of taking observer on trips.
- **Dr. Steven R. Hare** (IPHC) presented *"Accounting for bycatch and wastage mortality in the IPHC harvest policy*." In response to questions following his presentation, Dr. Hare confirmed that:
    - A harvest rate of 20% translated into an F_{35} to F_{37} fishing rate.
    - He was not aware of any more recent data for discard mortality rates for commercial fisheries where halibut is bycatch, and noted that the rates vary by fishery type, but that the rates have been pretty static.
- **Dr. Steven R. Hare** (IPHC) presented "*Potential yield and female spawning biomass gains from reduced bycatch levels*." There were no questions.
- **Dr. Steve Martell** (UBC) presented *"Impacts of halibut bycatch and wastage on halibut coastwide yield and spawning biomass."* Following Dr. Martell's presentation there were comments to clarify that:
    - The Gulf of Alaska area referenced in his paper includes Area 3A and 3B, and excludes Area 2C because trawling is prohibited.

- The analysis Dr. Hare presented took into account the impact of U32 bycatch on spawning biomass, rather than assigning it all directly to the fishery, whereas Dr. Martell's analysis did not make this distinction between size groups.

- **Dr. Juan Valero** (IPHC) presented "*Current understanding of Pacific halibut migration patterns*." Comments following Dr. Valero's presentation included that:
    - Light-based location and movements of fish with PAT tags can be difficult to estimate at high latitudes, but this could be improved by integrating depth, temperature and geomagnetic information.
    - There is age information for around two thirds of recovered tags that could be incorporated into the model to estimate migration rates by age. Although migration rate estimates are not currently being used in the halibut stock assessment, migration rates are being used for harvest strategy work that includes spatially-structured models with migration..
- **Mr. Tom Jagielo** (TJC) presented "*Current understanding of halibut migration."* Following Mr. Jagielo's presentation, there was some discussion of the relative movement into the Gulf of Alaska and the Bering Sea:
    - To examine this type of migration closely would require accurate estimated scanning rates for each area, and a few factors would have to be dealt with, including vessels with pooled landings, fish that migrate to Russia, and those caught on board vessels without scanning equipment, in order not to bias mortality rate estimates.

Presentations: Management of Halibut Bycatch

- **Mr. John Gauvin (**Groundfish Forum), **Ms. Julie Bonney** (Alaska Groundfish Data Bank), and **Mr. Kenny Down** (Freezer Longline Conservation Cooperative) presented, "*Management programs and industry initiatives to reduce halibut mortality rates and amounts in North Pacific groundfish fisheries*." Following these presentations, there were clarifications made about these programs:
    - Mr. Down noted that his cooperative has 28 active vessels, which might be up to 30 in 2012 in Bering Sea, and 6-8 in Gulf of Alaska. Mr. Gauvin said that there are 24 trawl vessels under Amendment 80, with 17 of these that are active.
    - Allocation of bycatch is done by company, then from each company to their vessels since most companies have multiple vessels. Mr. Down noted that there is a single voluntary fishery cooperative for Pacific cod, which divides up cod catch and corresponding halibut bycatch shares.
    - In response to a question about the drop in bycatch between 2004 and 2006, Ms. Bonney noted that there was a reduction in 2006.
- **Mr. John Gauvin (**Groundfish Forum) and **Mr. Kenny Down** (Freezer Longline Conservation Cooperative) presented, "*Amendment 80: Rationalization of the non-pollock trawl catcher-processors in the Bering Sea/Aleutian Islands."* The presenters clarified that:

- Mr. Down explained that lower rates are due to strict regulations; all fish have to be carefully released, halibut never come onto the boat, but are all released outside the boat. He noted that in a "race-for-fish" fisherman speed haul even if they see a lot of halibut bycatch, whereas this doesn't happen when there is a cooperative in place.
- Mr. Gauvin explained that before Amendment 80, some halibut would get back into the water right away, but others would be onboard 6-8 hours and were not good shape when discarded. Now, they are trying to release all halibut in less than 20 minutes. In 2009, the average was about 26 minutes, but with the cooperative, they might be able to restructure work to more frequent but shorter hauls.
- Mr. Gauvin noted that the time halibut spend in the tank drives the mortality rate and that generally the style of fishing has changed since Amendment 80, from loading up to catch as many as possible, to trying to optimize the quality of target fish.

- **Dr. Juan Valero** (IPHC) presented *"Re-evaluating the minimum size limit in the Pacific Halibut commercial fishery."* After the presentation, Dr. Valero added:
  - When asked if selectivity was a function of length and Dr. Valero clarified that there was an assumption that selectivity changed overtime with changes in size at age.
- **Dr. Steve Martell** (UBC) presented "*Effects of reduced minimum-size limits on halibut biomass, yield, and wastage."* After presenting, Dr. Martell clarified:
  - There is an increase in spawning biomass because of the lower mortality rate due to less wastage in the directed fishery.
  - When fish grow slowly, an individual fish might be caught several times before it reaches the minimum size, and with a non-zero discard mortality rate, this increases the overall total mortality rate.
  - In a model where arrowtooth, not halibut, is the source of density, the result would be generally the same as the model with the density dependent growth scenario.
- **Mr. Martin Loefflad** (NMFS AFSC) presented "*Planned Changes in the Alaskan Observer Program*." After the presentation, Mr. Loefflad clarified that:
  - For boats less than 40' fleet, there are challenges to putting extra people onboard, and that they are looking into electronic monitoring possibilities. Dr. Allen noted that in Northern Ireland self-sampling is used, where fishermen bring samples of hauls back to port.
- **Ms. Sarah Williams** (NMFS Northwest Region) presented, "*Halibut individual bycatch quota (IBQ) in the Northwest Trawl Catch Shares Program*." There were no questions.
- **Mr. Barry Ackerman** (Fisheries and Oceans Canada) presented "*Management and monitoring of Pacific halibut bycatch in B.C.'s trawl commercial groundfish fishery*." After presenting, Mr. Ackerman noted that:
  - The Canadian trawl industry is limited entry and includes 142 licenses, about 50 of which are active.
  - After the fishery had been closed, they decided to reopen it in February 1996 and had about 3 months to create the program.

- The 100% observer coverage was not initially well received, but because the fishery had overshot quota by so much, it was felt to be necessary.
- The program costs about $3 million, of which the government pays about $900,000 to cover management costs, while the fishermen pay for observers.
- The fishermen's behavior changed with observers and the quota, including that fishermen now often do an exploratory trawl to see what bycatch comes up, and that they keep the time on deck very low, 16 minutes on average.

- **Ms. Chantelle Caron** (Fisheries and Oceans Canada) presented *"Management and monitoring of Pacific halibut bycatch in the Hook & Line/Trap commercial groundfish fishery in British Columbia*." In response to questions, Ms. Caron noted that:
  - The logbook audit score depends on the amount of fish observed on a percentage basis.
  - The logbook is taken as the official record if the fisherman passes the audit (testing 10% of the sets against the electronic monitoring). They use electronic monitoring for the entire official record if they fail.
  - Currently, only about 20-30 trips out of a few thousand trips require full electronic monitoring.

Appendix 2: Participant Feedback (Public Comment)

During the morning of Day 2, Dr. Jonathan Raab facilitated a discussion whereby workshop attendees provided their views first on halibut ecology and then on impacts and management of halibut bycatch. Panel members provided feedback to attendees, where appropriate.

Participant Feedback/ Panel Responses: Halibut Ecology

James Whitethorn (West Brothers Group) directed a question to Dr. Hare about the cause of decline in Area 2C. He explained that a flaw that he sees in the assessment model is that there are more square miles of area, which results in extra biomass, which mean extra apportionment in some areas. He noted that Area 2C decreased in biomass in the past four years because the area is smaller than other areas. Mr. Whitethorn suggested returning to a closed area model (used prior to 2007) and look at historical averages as a baseline, and that fish should not be apportioned until the old model is run parallel to the current model.

- Dr. Leaman responded that the Commission would be reviewing the model later this summer.
- Dr. Hare responded that the Commission switched from the closed area model to coastwide because the closed area method was overestimating the biomass, and harvest rates were well in excess of anything sustainable, although harvest rates might still be too high in the west.
- Mr. Whitethorn noted that last year they could have had a higher harvest rate, closer to historical rates, which would still have been sustainable.

Bob Alverson (Fishing Vessel Owner's Association) made several comments, noting that the size limit for halibut was increased in 1974 to 32 inches and at that time there was not a Pacific cod fishery. He asked about the risks of considering a size reduction in isolation of other competing species populations (such as cod and arrowtooth flounder).

- Dr. Leaman responded that there is always concern about unintended consequences, changes in species composition are difficult to predict, and that the Commission aims to take a precautionary approach.
- There was some discussion about the potential reduction in U26 bycatch and what the contribution of U26 halibut is to the fishery.

Julie Bonney (Alaska Groundfish Data Bank) spoke about halibut ecology, size and age and possible management strategies, including changing the minimum size and its impact on the halibut population. She posed the question: what should we test to see if there is a population response? Ms. Bonny suggested that the Commission look at the management of the fisheries, hypothesize about potential change and test these hypotheses.

- Mr. Jagielo suggested that this idea is in line with using an adaptive management strategy to test hypothesis through in-field management and research.

- Ms. O'Connell noted that the restructured observer program will start in 2013 and is expected to provide more data, including the size distribution of discarded halibut in the directed fishery.
- Ms. Bonney responded that within the directed fishery, there are several assumptions that need to be confirmed, including the size selectivity of the fishery, the discard percentage, but you do have a good idea about the growth parameters. Ms. Bonney suggested that if the issue is competition among smaller halibut that fishing more of these fish (with a lower minimum size limit) could reduce competition and change the size composition of the stock.
- Dr. Ianelli noted that Ms. Bonney was identifying density-dependent growth response, which is one of the hypotheses that should be looked at again.

Heather McCarty (McCarty Associates) explained that she works with fishermen in the Gulf and the Bering Sea. Ms. McCarty recommended that management programs and approaches, which were not explicitly included in the morning's list of topics, should be considered and recommended that there be a panel lead for management as a topic in the afternoon session.

- Mr. Jagielo agreed and Dr. Martell noted that both size of age and ecology have important implications for management.

Chris Oliver (NPFMC) discussed the change in size at age, noting that this is a remarkable change that doesn't seem to happen in nature. He suggested looking at other fish species to see if there is anything akin to this order of magnitude change in size at age. He pointed out that slow growth and reduced size at age are not necessarily the same thing; that fish could grow quickly and stop, getting stuck at a small size at mature age.

- Dr. Neilson said this has been observed in haddock with time series starting in 1963, but that he is not sure if the scale of the change is the same as for halibut, and agreed that it would be interesting to look into this.
- Dr. Kruse noted that there have been changes in body-size for salmon and pollock in the Gulf of Alaska; age 10 pollock have doubled in size since 1982. He wondered if there is a common mechanism here, changes in energy flows or density-dependence, that would help explain the root mechanism for the changes in size at age for halibut.

Leonard Herzog (Area 4 Fisherman) explained that one of the big ecological changes is that most of the halibut biomass is now in the Bering Sea, and that a full third of the entire stock is now in Area 4CDE. He suggested looking specifically at what is happening in Area 4CDE separately from a coastal look at size-at-age. Mr. Herzog suggested that there is not the same handling issue for halibut that are 26 to 32 inches that you find in the Gulf. Since the smaller stock is robust, perhaps there is something going on in the northern areas of the Bering Sea that isn't happening in the Gulf and is concerned that this will lead to an increase in bycatch in the future.

- Dr. Ianelli asked Mr. Herzog to clarify whether fishermen are using larger hooks to avoid smaller fish in his area?

- Mr. Herzog responded that if they don't change their fishing practices, they won't handle smaller fish (26-32"), so the change in minimum size is moot in the Bering Sea. Because of this, Mr. Herzog recommended that the Bering Sea should be looked at separately from the full coastwide analysis, using the NMFS trawl data.
- Dr. Hare noted that most of the biomass has always been in the Bering Sea, but the Exploitable biomass (Ebio) is mostly in Areas 3AB, and that Ebio has not been increasing in Area 4.

Joel Hanson (The Boat Company) posed three questions about the diet studies. He noted that up to 30% of halibut diet is fish offal, and asked if there have been any studies about nutritional value of offal compared to whole fish? Mr. Hanson noted one presentation indicated that prey size depends on predator size, and large halibut eat large fish—he wondered about the composition across all size classes and if large fish consume a lot of arrowtooth flounder? If there were an increase in the number of halibut in the Gulf of Alaska, would they take care of some of the abundance of arrowtooth?

- Dr. Leaman agreed that having more information on this would be helpful, and that he was not sure about the nutritional value of offal.
- Dr. Aydin guessed that this would probably not be an effective population control since arrowtooth are a small portion of the halibut diet.

Ricky Gease (Kenai River Sport Fishing) asked how these models account for reducing the minimum size limit to reduce density-dependent competition, including halibut interaction with arrowtooth flounder?

- Dr. Hare explained that in work that he did about a decade ago, the best correlate found was halibut itself (age 10+), indicating intra-species competition, but noted that arrowtooth flounder were not included in that study. He noted that arrowtooth flounder have a biomass five times the size of halibut, so they probably are a factor in growth response, and that there is no way to know the effect of changing size limit until it is tested.

Roland Maw (United Cook Inlet Drift Association) recommended re-analyzing otoliths to see the difference in test methods and how this might affect the curve of size-at-age and other models derived from that graph. Mr. Maw also noted that he doesn't see a lot of food in halibut stomachs in the longline fisheries; he suspects voluntary regurgitation, and noted that diet studies need to take this into account.

- Dr. Leaman answered that the otolith re-aging project is underway, and they are also sectioning the otoliths to get growth increments. He noted that this only looks at the growth of the survivors, and isn't representative of the whole population.
- Dr. Leaman also explained that aging differences might have exaggerated the changes in size at age for older ages, but there is still a decline in size at age since late 1980s with the same test methods. He also noted that regurgitation has been accounted for in longline fisheries for a long time.

- Dr. Aydin noted that he does check the mouths of halibut for signs of regurgitation, and if there are any signs, they do not use that fish in their study. They do not use long line caught fish, which they assume are hungry since they go after bait.

Richard Yamada (Alaska Charter Association) noted that arrowtooth flounder have shown up in the past 5-6 years, and that he has noticed that halibut nursery areas have become overrun with arrowtooth flounder. There are about 5-7 arrowtooth flounder for every halibut. He asked if there have been studies on arrowtooth flounder migration, and suggested that competition for food is a big factor in size-at-age for halibut. Mr. Yamada, who fishes inside waters, pointed out that this is a big problem for recreational fishermen, who now have to put in lots of effort to catch halibut.

- Dr. Ianelli responded that there has not been any tagging or migration analysis on arrowtooth flounder, but there is a bottom trawl survey that includes arrowtooth flounder, which shows the distribution. He agreed that population and migration studies on arrowtooth flounder should be considered for future research.
- Dr. Forrest noted that they see a lot of arrowtooth flounder in Canada, and that a stock assessment is planned for the next two to three years.

Participant Feedback/ Panel Responses: Impacts and Management of Halibut Bycatch

Dr. Jonathan Raab led a facilitated discussion where workshop attendees provided their views on halibut ecology and panel members provided feedback.

Linda Behnken (Director of the Alaska Longline Fisherman's Association) noted that she hoped to develop a joint understanding of the impact of bycatch on halibut stock and that it would be helpful to identify what metrics need to be included in any evaluation of bycatch. The metrics she identified were: the effect on yield and spawning biomass, the components of stock (particularly the U26 and O26), growth rates by area, the distribution of bycatch by area, and the accuracy of bycatch estimation. Any evaluation that doesn't include all of these is oversimplified and is not meaningful. Ms. Behnken recommended that the panel should specify what the metrics are as an output from these meeting.

Ms. Behnken noted that there is lot of uncertainty in managing the halibut stock, but there is a lot known about the directed fishery, size classes, and more known about O26, whereas there is little known about the U26 portion of the stock, including its growth rates and migration. She recommended that this need to be looked at and should be a focus of future research, including whether the current trawl assessment is giving good information on this portion of stock.

She noted that Dr. Valero concluded that if the minimum size limit were reduced, then the harvest rate for the directed fishery would need to be reduced by 50% to avoid the increased risk to the stock from increased capture of immature female halibut. In Dr. Hare's presentation, he noted that most of the trawl bycatch is around 26 inches, which are also immature fish. That bycatch can be accounted for through a direct deduction in the CEY or by adjusting the harvest rate. Until 2010, all bycatch was accounted for through a harvest rate adjustment; now a direct deduction is taken for bycatch/wastage of O26U32 fish. With this new accounting for the

O26U32 fish, the target harvest rate was changed from 20% to 21.5% (and 15% to 16.5% in Area 3B and 4) which is an 8% change. Dr. Hare noted that accounting for the U26 bycatch as a direct deduction would change the harvest rate by about the same percentage, but it is unclear in what area that deduction should be taken, so it is still factored into the harvest rate. If the effect of allowing the directed fishery to harvest fish U32 inches results in a 50% reduction in the harvest rate to protect stocks, why does bycatch of these same size fish only affect the harvest rate by 8%-16%??

- Dr. Hare noted that there are two issues, first that in the work that he and Dr. Valero did, when you drop the minimum size, this changes the definition of the exploitable biomass (to include the 26-32" fish, which increases Ebio), so it requires dropping the harvest rate. When they did the other study, they didn't change selectivity or the definition of Ebio. Dr. Hare noted that these two studies couldn't be directly compared because they have a different definition of Ebio.
- Ms. Behnken responded that if there is that dramatic an effect of fishing the 26-32" fish that requires half the harvest rate, then the impact of the stock in that class size should have a larger impact on the harvest rate.

Roland Maw discussed selectivity and recovery rate. He described what happens when he offloads: there is a separation of the halibut by size, and his tally sheet reports the number of fish by size class. He noted that a 32" fish generates about 80oz of useful fillet, which sells for $10/lb, resulting in a $6.50 ground price. In contrast, a 26" fish generates about 25oz of fillet, which results in $3.25 ground fish price. For an IFQ user, they would rather use their quota to deliver bigger fish. If there is a consideration of reducing size limit, a market analysis is essential. Mr. Maw described "finger fish"—when he offloads, if a fish is on margin of 10-12 lbs (each fish is weighed), then a finger goes on scale to avoid falling below the minimum. He suggested that if the size limit were lowered, then the finger fish would fall from the 10-15lb category to the next category.

Mr. Maw discussed the discard mortality rate, where 16% is the value used in the longtime industry. He noted that this number is from pre-IFQ days and that fishing behavior has changed; they are doing shorter sets, rather than doing long sets. If they do a longer set, there has been a dramatic increase in sleeper shark depredation, where they take a bite out of the bigger fish, and there is an issue with sand fleas. Mr. Maw believes that the mortality rate is closer to 10%, and is worth more study to get a more accurate number into the models.

- Dr. Forrest responded that she has heard suggestions before that selectivity might move to the right, as fisherman may move away from areas with small fish to areas with bigger, more valuable fish. She asked what the price difference would need to be to have this happen and suggested 100% observer coverage may be necessary. She also suggested that is a good topic for an experimental management approach.
- Mr. Maw responded that they will have observer coverage coming in soon, but this might not detect the selectivity change because he is already avoiding areas where the smaller fish are because big fish are worth more. He group tries to fish with a minimum size of 33 or 34 inches.
- Dr. Martell pointed out that there is economic value to be gained by decreasing size, but could increase economic efficiency and decrease the mortality rate. He also noted that

the expected wastage is taken off the top from the CEY, but this doesn't prevent fisherman from cheating, so 100% observer coverage and individual responsibility for each vessel is also needed.

- Dr. Hare noted that a reduction in size would need to be accompanied with a change in the selectivity curve, but overall quota should not increase. They would need to assess the response by fishing industry before there would be any increase in quota.

Leonard Herzog (Area 4 fishermen) noted that about half of the halibut biomass is in the Bering Sea, and even through Area 4CDE has small fishery that was cut by a third, it is the area where bycatch is taken and biomass is growing. He suggested that the panel focus on Area 4CDE and on migration. He noted that two reports on migration were presented, and believes that they call into question the huge changes that the IPHC made in management when they moved from an area specific to a coastal style. He noted that none of recent PAT tags were found outside of 4CDE and that 93% of PIT tags stayed inside 4CDE and another 6% were from a nearby area. He noted that 99% of the PIT tags had nothing to do with the Gulf of Alaska; he believes that migration is critical. Mr. Herzog recommended looking at the Bering Sea and the Gulf as different areas, and even taking a look at 4CDE on its own.

James Whitethorn (West Brothers Group) recalled numbers from an Alaska Dept. of Fish & Game meeting for bycatch wastage for the crab pot fishery and that they were deducting from the quota in 2C by 303,000 lbs, whereas a presenter suggested a lower number. He hopes that the panel will correct this data and the quota.

- Dr. Leaman responded that this issue was flagged at the 2012 annual meeting, and they will look to update the data with State of Alaska help.
- Mr. Whitethorn also suggested that the trawl fleet should have 100% observer coverage and boats under 60 feet should have 100% electronic monitoring. Mr. Whitethorn noted that for his small boats, they have very short weather windows and could miss opportunities if they need to wait for an observer, and they may need to cut a crewmember to make room for an observer. He also noted that he thinks everyone should pitch in to help conserve halibut, and every harbor should be monitored, every lodge should be equipped with a monitor to get accurate count on halibut and bycatch wastage.

Bob Alverson (Fishing Vessel Owner's Association) explained that there is a wastage estimate that is estimated for commercial fishery. In last couple weeks he has realized that it's generated by 30% of the best producing survey sites as a proxy for the whole area because there isn't full observer coverage yet. This assumes that 60% of halibut caught are U32, but his fleets aren't seeing that; with traditional, skate-top gear, it's a lot of work to pull up these fish. He believes that the first year of observer program will show this. Mr. Alverson also noted that, in regards to bycatch in Gulf from trawl fisheries, it was distressing to hear the observer union talk about water hauls to comply with requirements and NMPS talk about issues with accuracy and gaming the system in Kodiak. He doesn't believe that they'll be getting an accurate read on trawl bycatch and is wondering if there has been an error parameter study, especially with lack of observer on

under 60 ft vessels. He also noted that small fish contribute to spawning biomass, and wondered about the difference between some of the presentations regarding the contribution of the U32 bycatch on the cap.

- Dr. Leaman noted that the size composition of catch vs. landing was open to examination, and that observers might be able to give some insight on this. When the observer program started in British Columbia, they measured every fish discarded and compared with survey catches and found identical composition; so the size composition of wastage is probably comparable to survey.
- Dr. Hare added that they would welcome better data, and are trying to account for all sources of mortality; the only other information they have is their survey, realizing that they don't pick hot fishing spots. The key assumption is that they are catching the same proportion of U32 and O32 as commercial fishers, which may be overstated.

Bill Hayes (US Seafoods) noted that he's dealt with bycatch issues for over twenty years and all of the captains that he fishes with are all dedicated to, and have spent years and many dollars to, minimize halibut bycatch. Before Amendment 80, most of their fisheries shut down due to halibut bycatch, not their target species. He noted that they have two observers when fishing in the Bering Sea, and they are not ever both down in the factory at the same time, they trade off and they do a good job with estimates of the catch and discards. Mr. Hayes explained that fishermen have been pining for tools to do a better job with halibut bycatch management and all prohibited species; he supports John Gauvin's program for halibut deck sorting; it is instrumental for saving halibut. As captains, they hate discarding perfectly good fish or killing fish they can't use. Mr. Hayes also endorsed a rationalized system in Gulf of Alaska. He believes that Amendment 80 in Bering Sea has worked well and would be good in the Gulf. The larger halibut are mostly in the Gulf, which is where the biggest savings from deck sorting would be.

- Dr. Leaman noted the fisherman behavior makes a huge difference, for example they change behavior when given individual bycatch caps. He asked if that is the type of feedback they need?
- Mr. Hayes responded affirmatively; noting that he had the freedom to use a halibut excluder all of A season and for every pound caught, he delivered about 180 lb of fish, so the value of halibut is enormous. They can never have zero bycatch, but they can minimize the mortality rate, particularly in the Gulf. In the Bering Sea, it is more difficult because the halibut are the same size as their target species.
- Dr. Leaman also clarified that deck sorting would be more effective in the Gulf because of the size differential, but is that because the additional time makes a difference in the Bering Sea?
- Mr. Hayes responded that in the Bering Sea, it is hard to sort halibut because smaller halibut are going by during the sorting process and it's hard to sort through them in a timely manner. If the halibut are larger, they can effectively sort them all in short period of time.
- Dr. Ianelli asked what Mr. Hayes thought about linking bycatch limits to actual abundance of halibut (i.e., the PSC would change with halibut abundance)?
- Mr. Hayes responded that he was not sure; he sees areas of halibut abundance and the fish don't stay there. If they make one tow and see lots of halibut, then they move on. He also uses halibut excluders, so doesn't see as much halibut on deck.

Julie Bonney (Alaska Groundfish Data Bank) commented that one significant policy issue is to determine if bycatch is a conservation concern or an allocation issue. She noted that halibut wags the dog for everyone, and drives the fisheries. In every individual quota management program presented yesterday, they are significantly below the halibut cap allocated to the fishery. In the Canadian model, they are at 30% of the cap. Only in the Gulf of Alaska, which is still operated as a limited-access fishery, is this still an issue. On the policy side, it makes sense to reduce the cap in those areas where they aren't using the total bycatch amount.

Ms. Bonney explained that in the GOA Rockfish program, people spent millions of dollars to change their gear. If you set up a system where everyone is trying to do a good job, then the halibut don't end up driving the fishery, as long as fisherman have individual tools to reduce their halibut bycatch. The issues of allocation and cap drive the conversation in the wrong direction. Managers need to set up incentives to get everyone to do everything they can to reduce bycatch and wastage. The magnitude of the fishery in the North Pacific vs. Canada is different. The halibut rate determines how much target fish they can catch. In the North Pacific, most of her fishers fish 200-270 days per year and are at the 30% level for observer coverage. The floating cap that Dr. Ianelli raised in an intriguing idea since bycatch is driven by the total biomass in the system, but the only indicator for total biomass is from bottom trawl surveys and there is very little data from the Gulf of Alaska. Is there a better method to estimate total biomass?

Ed Richardson (Marine Conservation Alliance) noted that they have two observers on board boats fishing pollock and 99% of hauls are observed which he results in fairly accurate estimates. His fleets look at timely length frequencies so they know the size of the halibut they catch; they pay attention to the NMPS survey, and the timing and location of bycatch, so they know a lot about their halibut catch. They can see patterns emerging and react to them. In recent years, halibut bycatch is higher and there are a lot of small fish. It is a very difficult environment for trawlers in the Bering Sea. They think that there could be two population foci, and potential different management strategies. For fishing management practices, it takes a few years to see a pattern and another few to get to a solution, especially if they need new gear. To do this, you need to have the tools, including rationalization. Mr. Richardson believes that wastage has to do with slow growth, which is interacting with minimum size. The results depend on how the fishery is modeled, so there is a need to come to an agreement on the model. For future research, Mr. Richardson recommended some work that Martin Dorn did on the pollock stock assessment in the Gulf and has modeled the Gulf ecosystem, which could be a great start for future research.

Karl Haflinger (Sea State Inc.) hoped that the Commission will look at the question of benefits of bycatch reduction to the halibut stock. He found the presentations from Dr. Hare and Dr. Martell to be confusing since they came to different results. He thinks it would be useful for the public to have some recognition of differences between these approaches, particularly regarding how the under 32 inch yield contribution was derived and if the model accounted for density-dependence.

- Dr. Hare clarified that the fundamental difference in the two analyses is how the U26 component is dealt with. For the O26, both result in about the same 1:1 ratio (reducing bycatch increases yield by the same amount). The big player is bycatch of little halibut, which have much greater value left in water than taken out because of their contribution to future spawning biomass. Dr. Hare explained that Dr. Martell used 1:1 ratio for U26 as well. On the conservation side, the U26 bycatch is where future yield will come from, so it is worth more than one-to-one in future yield.
- Dr. Martell agreed with Dr. Hare, in that most of the analysis was the same for O26, but he didn't analyze U26. Dr. Martell also noted that the definition of yield loss ratios is different in the two models. They also both made a lot of similar assumptions (e.g., using the same mortality rate same for U26 and O26), which could be examined. He noted that when there are lots of competitors, the fish need to spend more time feeding, which exposes them to more predation, which could lead to higher mortality.

Joel Hanson (The Boat Company) took note of the migration study and hoped that additional research will take place in this field. He appreciated the discussion on Canada's 100% observer program; questioned if 30% observer coverage is enough to see "observer effect"? He expressed support for 100% electronic monitoring of small vessels, with the possible exception of open skiffs. Mr. Hanson asked Dr. Martell about his graph that showed historical and projected mortality rates, and which inputs caused the immediate and robust growth in mortality rates in the Gulf? He hypothesized that if the retrospective bias were considered next year, that mortality rates for the directed fishery would not increase, but probably go down in the future. He asked to what extend is the precautionary principle observed while the numbers of halibut bycatch in the Gulf is kept constant?

- Dr. Hare responded that the current harvest policy was developed 10 years ago, and factors in bycatch as a reduction in recruitment to the stock. In the simulations the female biomass drops. They looked at both density-dependent growth response and flat growth. Dr. Hare noted that these analyses are dated at this point, but that the basis of the harvest policy was precautionary. It is in the process is being upgraded and needs to be updated to reflect current conditions.
- Dr. Martell responded that the forward projections in his analysis used assumptions about recruitment (he used low, medium and high), but the same fishing mortality rates come out because the model assumes a 20% exploitation rate across the whole coast. The V-shaped recovery pattern is artifact from the IPHC age structure and the assumption of a constant recruitment. Dr. Martell noted that he would probably need to include a stochastic element in the model in order to pass peer review.

Julianne Curry (Petersburg Vessel Owners Association) noted that she is uncomfortable with the focus on bycatch as an allocation issue. The directed fisheries would say that this is an allocation issue; allocating who is responsible for bycatch, since they see a reduction in their yield. Ms. Curry suggested that future research include a focused study on the migration of halibut and the downstream effects of bycatch on other regulatory areas. Ms. Curry also mentioned that she is uncomfortable with the assumption that a change in size limit means a change in fishery practice and would require 100% observer coverage. She noted that the halibut

fishery operates in time-period constraints; people are trying to maximize their trip, and save money on bait and fuel. She mentioned that she heard that someone mentioned only collecting diet information from trawl fishing, however she knows that halibut are opportunistic feeders, and are not just going after line bait because they are hungry.

- Dr. Martell agreed with the need for a migration study, but first recommended using the historical tagging data to develop an integrated assessment model to see the effects on downstream ecology.

John Gauvin (Alaska Seafood Cooperative) discussed the idea of the floating cap for halibut linked to biomass. He noted that his cooperative's captains in the Bering Sea say that the biomass of halibut that overlaps with their target fish has increased; that the ratio of halibut in their catch has gone up over time, so the cap for halibut would be going up right now, though downstream, they are seeing less. He believes that fisheries in the Bering Sea have learned to avoid halibut and since Amendment 80 in 2007, they have done a good job avoiding catching halibut. The captains do a lot to avoid catching halibut and stay under the cap, including spending a lot of money, using halibut excluders, and sharing information to avoid halibut hotspots. He questioned, from an equity perspective, if it makes sense to lower their cap because they had done such a good job lowering their halibut bycatch. They don't know about their ability to avoid halibut in the future; the extent of halibut overlap with their target species will change over time. They want to be able to catch their ground fish and not be punished with lower cap. Their rationalization program required an increase in retention of target fish, and they have been able to improve that. The directed fishery needs to use tools they have to either not catch undersized fish or figure out how to market them. Mr. Gauvin expressed concern about the lack of good information about discard rates. It troubles him to use proxy data from survey to estimate discard and recommended using cameras. Finally, he noted that his captains think they can fish for arrowtooth flounder in high abundance areas with little halibut bycatch. He thinks that arrowtooth flounder must be competing with halibut, so they could try to fish down some of these areas because the market for arrowtooth bigger than has been before and it's a way to test the competition hypothesis.

- Dr. Ianelli asked Mr. Gauvin to comment on economic efficiency when it comes to avoiding bycatch.
- Mr. Gauvin responded that halibut bycatch has constrained available yield of target groundfish in the Gulf, and sometimes the Bering Sea, so they leave a lot of fish in the water. They need to be able to catch groundfish efficiently given constraints of halibut bycatch, and one way is choosing when to fish and using halibut excluders. He noted that using halibut excluders can results in a loss of 10-30% of the target catch, but is worthwhile to avoid having the fishery shut down because they reach the halibut cap.

Paul MacGregor (At-Sea Processors Association) noted that a chart that was shown yesterday showed a drastic reduction in bycatch in the mid-1980s, and there was a reference to that being the target, but foreign fleets at that time cheated by avoiding observer coverage in areas with high bycatch. They had a manual that described how to cheat and in 1985 there was a big investigation. It was this scheme that resulted in low bycatch in 1980s. Mr. MacGregor noted that he had asked the Commission previously not to use the chart without a footnote about this

time period, and that it is not a relevant or appropriate reference point for bycatch levels. He also supported the idea of a gap analysis for a way to account for bycatch mortality and that it would be a good time to do an audit now that they are restructuring the observer program. He (facetiously) suggested that they could eliminate bycatch by getting rid of observers since only observed boats seem to have bycatch.

Duncan Fields (NPFMC) asked about a pie chart showing the age of predators and halibut diet, noting that the only overlap is pollock; he wondered how the growth of arrowtooth flounder competes with halibut since pollock seems to be the only overlap in diet. Regarding management approaches and programs, Mr. Fields wondered if there is any place in the treaty between the two countries that specifies that dead halibut have to be discarded. Should we use retention as an incentive for bycatch reduction?

- Dr. Leaman noted that the idea is to minimize bycatch, not necessarily to discard dead halibut, but the process is to reduce total bycatch without turning it into a target fishery.
- There was some discussion about the idea of keeping bycatch. Mr. Fields suggested two possible approaches: a comprehensive rationalization approach, or bycatch allocation IFQ of bycatch that is not the target species, and noted his concern about a public policy that wastes a significant amount of halibut.
- Dr. Martell asked if transferability between gear types is part of the solution?
- Mr. Fields answered that it could be, but you would need to know the portion of market share for each gear type.
- Dr. Martell agreed that it is a lose-lose situation to discard dead fish.
- Dr. Leaman noted that the halibut fishery is constrained by halibut bycatch every year, but the two countries agreed on reductions on bycatch, which have not been met, at least in the US.

Kurt Cochran (F/V Marathon**)** noted that the observer program has changed over time and that the new program will include random selections for coverage. He noted that most fishermen don't actually game the system, but do respect the law. He also commented that most of the time the coverage is more than 30% and that observer coverage is already pretty robust. Mr. Cochran asked noted that he doesn't have a problem with 100% observers, but believes that fishing practices are the same with and without the observers.

Appendix 3: Summary of Ideas for Future Research

The bulleted list of potential future research summarizes the numerous suggestions made during the course of the two-day workshop (both during the two specific panel discussions on future research as well as other times when suggestions were made). The list includes all suggestions made by one or more Panelists and does not imply consensus. See the actual meeting summary for who made the initial recommendation and more context for each recommendation.

Inter-species Interaction

- Investigate density interaction with other species, especially those species with similar life phases, including arrowtooth flounder.
- Examine whether the decline in size at age has origins with competition during early life stages with other flatfishes (yellowfin sole, rock sole, flathead sole, arrowtooth, others).
- Examine the relative abundance of the other flatfishes in the Gulf of Alaska during the 1950's from trawl surveys or commercial catches and the environmental conditions in the Gulf of Alaska during that time to see what the stock assessment could tell us about halibut recruitments and the rate of fishing on halibut in previous periods.
- Compare age-specific spatial distribution of potential halibut competitors to see if they eat the same prey in the same areas as halibut and if prey is in limited supply.
- Investigate changes in size at age for other species (e.g., GOA pollock, Pacific salmon), to see if they offer insights into the mechanisms for reduced halibut size at age. Examine if there are common ecological explanations (energy flow to pelagic vs. benthic) or biological explanations (stock density-dependent effects).

Halibut Size at Age

- Look at the time from the 1920s to 1980s when the size at age was increasing, to see if there is an opportunity to learn about the mechanisms that lead to this; this may help explain when and how populations of halibut responded in a positive way to help us understand the current decline.
- Examine spatial, temporal and age-specific patterns in size at age to help elucidate causal mechanisms. For instance, size at age was relatively stable for ages 6-10 over 1993-2003 and then declined; for the older ages, size at age generally declines steadily over 1993-2011. Determine if these changes are associated with differences in diet among young/small and old/large halibut, and if these differences, when analyzed spatially, help elucidate ecological mechanisms behind the decline in size at age.

Halibut Migration Studies

- Examine the current migration data (spatially and temporally) to determine if size, sex, age, and/or growth rates influence the propensity to migrate and if the annual migration rates are density dependent.
- Extend analyses on the impacts of bycatch and reduction in size limit to include migration.

Climate Impacts

- Update previous work on climate effects on the ecosystem (e.g. that climate changes recruitment; strong/weak recruitment leads to increases/decreases in stock size) to see if this analysis still holds true with current data.
- Further study the influence of climate on growth or size; one study demonstrated climate effect on early growth, but this issue warrants further research.

Fishing as a Cause of Evolution

- Investigate the connection between fishing and size at age; fishing as a cause of evolution should be a research priority so this potentially low chance, but high-risk, mechanism can be eliminated.
- Consider reaction-norm-based approach to disentangle evolutionary effects versus phenotypic plasticity; an approach that has been used for Atlantic cod and includes examination of growth and age and size at maturity. Density-dependence tends to lead to predictable changes in these growth and maturation. For instance, higher fish densities tend to lead to slower growth, which tends to delay maturation. When you find patterns that diverge from expectations owing to density-dependence, it may be indicative of an evolutionary genetic effect.
- Collect baseline genetic data now against which future genetic samples could be compared.
- Calculate the fishing mortality rate that is required to get to the Type II mortality that is seen. It was discussed that current fishing mortality rates are within realm of reasonable, around 70-75%, and that current harvest rates are below what has been historically seen in the fishery.

Otolith Re-testing

- Re-evaluate archived otoliths with contemporary methods to eliminate potential methodological impacts on the observed trends. A sub-sampling approach may be an efficient means to quickly resolve this issue.
- Calculate growth increments from otoliths (break and bake) from the time period of increasing size at age as this may help to understand when and how different sizes of halibut responded.
- Examine growth increments on otoliths and compare ocean conditions to see the impact of ocean temperatures on regulation of physiology, affecting growth and survival.

Diet Studies

- Investigate a possible shift in diet of halibut from the period of increased growth rate to the present (e.g., pollock abundance in the Gulf of Alaska then and now) and its effect on halibut growth.

Statistical/ Sampling Changes

- Investigate Bayesian approaches in lieu of the types of estimators discussed. Model-based estimators developed within the Bayesian framework were not discussed; the workshop focused on design-based estimators. Examples of model-based estimators can be found within Hirst et al. (2004), Millar and Fryer (2006), and Millar and Hirst (2007).
- Consider using the regression estimator, rather than ratio estimator; if there is a significant intercept then the regression estimator will be more precise.

Management Approaches

- Consider creating better incentives for fisherman to reduce bycatch, including fee-based approaches.
- Continue bycatch monitoring and discard mortality rate reduction programs, and identify clear objectives for these programs.
- Continue research and reporting of successful co-operative programs and successful incentives for reduction of bycatch.
- Conduct an adaptive management experimental fishery to look at the effects of reducing the minimum size limit on fishing behavior.
- Consider a floating cap; in the Gulf of Alaska, the Council has a PSC limit that could vary with abundance, and this type of floating cap, instead of a hard cap, should be considered in the management program.
- Revisit the halibut Harvest Policy, given large changes in size at age and understanding of halibut ecology.
- Consider individual bycatch caps to reduce halibut bycatch for the US.

Additional Analyses

- Consider incorporating halibut catch and size data from the NMFS annual/biannual trawl survey into the annual stock assessment. Trawl survey data provide another wealth of information on the status and geographic distribution of halibut stocks. Owing to mesh size, the NMFS surveys may also help inform the retrospective bias in the estimates of recent recruitments.
- Conduct systematic research into retrospective bias in stock assessment model.
- Investigate the use of length frequency data from the Bering Sea.
- Continue research on Dr. Hare's analysis on impact of female spawning biomass, which just looked at 2008 and across all fisheries for U26.
- Examine the structural assumptions of the stock assessment model (particularly with respect to fishery selectivity) and of the analyses presented at the meeting.
- Create a universal assessment that incorporates everything into the annual stock assessment, including data on the spatial nature of fishery.
- Look at the Bering Sea tagging and migration data on a finer scale, especially in Area 4. It appears that there is some heterogeneity there, and a breakout seems to be workable with the existing data.

Appendix 4: References Provided by Panel

Dr. Leaman listed the following references:

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Dr. Allen provided the following references:

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Appendix 5: Meeting Attendees

In-Person Meeting Attendees

ROLE	NAME	AFFILIATION
PANELISTS	Michelle Allen	Agri-Food & Biosciences Institute
	Bob Clark	ADF&G
	Jane DiCosimo	NPFMC
	Robyn Forrest	Fisheries and Oceans Canada
	Steven Hare	IPHC
	Jim Ianelli	NMFS AFSC
	Tom Jagielo	Tom Jagielo Consulting
	Gordon Kruse	University of Alaska-Fairbanks
	Bruce Leaman	IPHC
	Steve Martell	University of British Columbia
	John Neilson	Fisheries and Oceans Canada
	Tory O'Connell	Sitka Sound Science Center
FACILITATORS	Jonathan Raab	Raab and Associates
	Stephanie Stern	Concur
PARTICIPANTS	Alan Haynie	NMFS AFSC
	Allison Dauble	ODFW
	Anne Vanderhoeven	Bristol Bay Econ Dev. Group
	Barry Ackerman	DFO Vancouver
	Becca Robbins Gisclair	Yukon River Drainage Fisheries Assoc.
	Bill Hayes	US Seafoods
	Bill Tweit	NPFMC
	Bob Alverson	FVOA
	Bob Krueger	AK Whitefish Trawler Assoc.
	Brent Paine	United Catcher Boats
	Bruce Turner	PFMI
	Chantelle Caron	Fisheries and Oceans Canada
	Charlie Swanton	ADF&G
	Christie Donich	Homer Charter Assoc.
	Claude Dykstra	IPHC
	Craig Faunce	NMFS AFSC
	Dan Areill	Marine Stewardship Council
	Dan Hull	NPFMC
	Dave Benson	NPFMC
	Dayr Lowry	Washington State Fish and Wildlife
	Don Ashley	F/V Gold Rush Fisheries
	Duncan Fields	NPFMC
	Ed Dersham	NPFMC
	Ed Richardson	MCA
	Eric Olsen	FVOA
	Glenn Merrill	NMFS AK Region
	Glenn Reed	PSPA
	Gregg Williams	IPHC
	Heather Gilroy	IPHC

PARTICIPANTS	Heather McCarty	McCarty Assoc., Juneau
	Jason Jannot	NWFSC/WCGOP/NOAA Fisheries
	Jay Herbert	Area 4 Fishermen
	Jeff Jones	State of Alaska
	Jennifer Cahalan	PSMFC/NMFS AFSC
	Jennifer Hagen	Quileute Tribe
	Jennifer Mondragon	NPFMC
	Jim Balsiger	NMFS and IPHC
	Jim Humphreys	Marine Stewardship Council
	Jim Whitethorn	West Brothers Group
	Joel Hanson	The Boat Company
	John Gauvin	Alaska Seafood Cooperative
	John Henderschedt	NPFMC
	John Whiddon	Pacific Seafood
	Juan Valero	IPHC
	Julianne Curry	Petersburg Vessel Owner's Association
	Julie Bonney	Alaska Groundfish Data Bank
	Karl Haflinger	Sea State Inc.
	Kerim Aydin	NMFS AFSC
	Kevin Delaney	Biologist
	Kirsten MacTavish	IPHC
	KJ Herman	F/V Windward Fisheries
	Kyungman Ko	MIFATN of Korea
	Kris Norosz	Icicle Seafoods, Inc.
	Kurt Cochran	F/V Marathon
	Leonard Herzog	Area 4 Fishermen
	Linda Behnken	ALFA
	Lisa Thompson	NMFS AFSC
	Loh-lee Low	NMFS AFSC
	Martin Loefflad	NMFS AFSC
	Matt Upton	U.S. Seafoods
	Melinda Ashley	F/V Gold Rush Fisheries
	Melvin Grove	Prince William Sound Charter Boat Assn.
	Merrick Burden	Marine Conservation Alliance
	Michael Lake	Alaskan Observers Inc.
	Mike Szymanski	Fisherman's Finest
	Neil Davis	DFO Vancouver
	Nicole Kimball	ADF&G
	Patricia Nelson	NMFS AFSC
	Paul MacGillivray	Fisheries and Oceans Canada
	Paul MacGregor	At-Sea Processors Assn.
	Peggy Parker	Halibut Assn. of North America
	Ralph Hoard	IPHC
	Ray Webster	IPHC
	Rebecca Reid	Fisheries and Oceans Canada
	Richard Yamada	Alaska Charter Assn.
	Ricky Gease	Kenai River Sport Fishing
	Roland Maw	United Cook Inlet Drift Assn.

PARTICIPANTS	Roy Hyder	NPFMC
	Ruben Hanke	Kenai River Sport Fishing
	Ruth Christiansen	ADF&G
	Sam Cotten	NPFMC
	Sarah Williams	NMFS/NWR
	Sharie Teeple	Gross and Assoc.
	Steve Ignell	NMFS AFSC
	Susan Robinson	Fisherman's Finest
	Teresa A'mar	NMFS AFSC
	Thomas Wilderbuer	NMFS AFSC
	Tom Gemmel	Halibut Coalition
	Tom Ohaus	SEAGO
	Tracee Geernaert	IPHC

Webcast Participants

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Aaron Williams	Jonathan Pollard
Alexander Kotlarov	K McGauley
Andrew Jensen	Karla Bush
Andy Mezirow	Kathy Hansen
Aregash Tesfatsion	Ken L Larson
Barbi Failor	Kyungman Ko
Barry Ackerman	Lara Erikson
Barry Kaufmann	Lauri Sadorus
Ben Fissel	Linda Arnold
Beth Concepcion	Linda Gibbs
Beverly Minn	Lisa Newland
Brad Robbins	Loh-lee Low
Brenda Dale	Lynn Mattes
Brian Walker	Margaret Bauman
Bruce Gabrys	Marissa Merculieff
Bud Graham	Mark Russell
Carol Batteen	Mary Furuness
Caroline McKnight	Maura Sullivan
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Charles Piston	Michael Lake
Chris Johnston	Mike Joe
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Dan Falvey	Pat Livingston
Dan Martin	Paul Clampitt
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Diane Scoboria	Pete Wedin
Dick Curran	Peter Thompson
Don Ashley	Phillip Lestenkof
Earl Krygier	Ray Melovidov
Ed Hansen	Richard Tuluk
Edward Richardson	Russ Hare
Ernie Weiss	Sarah Webster
Gail Bendixen	Scott Meyer
Gerald Kristianson	Shannon Davis
Gerry Merrigan	Simeon Swetzof jr.
Gway Kirchner	Stephani Zador
Heath Hilyard	Stephanie Madsen
Heather Reed	Steve Kaimmer
Huyen Tran	Steve Wischniowski
Jack Tagart	Tamara Briggie
Jason Gasper	Theresa Peterson
Jason Good	Thomas Wilderbuer
Jason Jannot	Timothy Evers
Jay Walker	Timothy Thomas
Jeff Farvour	Tom Pearson
Jeff Kauffman	Tracee Geernaert
Jennifer Hagen	Wes Erikson
Joan Forsberg	Young Hoon Lim
Joel Cladouhos	
Jon Warrenchuk	