MARINE MAMMAL
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University of British Columbia

Availability of Prey for Southern Resident Killer Whales

Technical Workshop Proceedings

November 15-17, 2017

Editors: Andrew W. Trites
David A.S. Rosen

Hosted by:

Marine Mammal Research Unit

Institute for the Oceans and Fisheries
University of British Columbia
Vancouver, BC, Canada

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Executive Summary

This workshop assembled scientists and managers with technical expertise on killer whales and Chinook salmon to identify and evaluate short-term management actions that might increase the immediate abundance and accessibility of Chinook salmon for southern resident killer whales, given the current size of Chinook salmon stocks. The workshop did not consider ways of producing more Chinook salmon (which will be the subject of a subsequent workshop), but rather considered ways of making more of the fish that are presently in the ocean available to southern resident killer whales (SRKW).

Workshop participants presented and discussed technical information on the prey requirements of SRKW, the availability of Chinook salmon, and current protections for SRKW. Participants then split into four groups with an even distribution of expertise to review three potential non-exclusive Management Actions:

A. Increase the abundance of Chinook for SRKW by reducing coast-wide fishery removals.
B. Increase the abundance of Chinook for SRKW by adjusting fishery removals at specific times and in specific areas of SRWK habitat.
C. Increase the accessibility of Chinook by decreasing underwater noise and the physical presence of vessels where SRKW forage.

Action A. One way to significantly increase the numbers of fish in SRKW habitat—and thereby increase the foraging success of SRKW—might be to prevent fisheries from catching Chinook earlier in their migration before they enter SRKW foraging areas. However, there was considerable uncertainty among workshop participants about the underlying theory and the practical capacity to implement this coast-wide action. The scientific justification and confidence in this action producing the desired benefits to SRKW were ranked ***unknown*** **or** ***low***.

Action B. A more directed approach that evoked greater scientific confidence was to limit fisheries in times and places that correspond to SRKW foraging activities. The assumption of this action is that limiting fishing where SRKW normally feed would reduce direct competition with them, and increase their foraging success. Most of the vessels fishing within SRKW habitat are recreational. While scientific confidence in this action was greater than for the "blanket" closures of fisheries throughout BC, there were still concerns about its potential effectiveness. Chief among these were uncertainties about how much prey are needed for SRKW to successfully forage and meet their needs, uncertainty in predicting foraging patterns and identifying which locations are most important, and whether partial or total fishery closures within SRKW habitat would significantly increase the numbers of Chinook that SRKW could capture. The scientific justification and confidence in this action producing the desired benefits to SRKW were ranked ***low*** **to** ***medium***.

Action C. This action was designed to increase Chinook accessibility to SRKW by decreasing acoustic and physical disturbance from vessels. This action was considered and discussed in the context of all vessels—and not fishing vessels alone (which are believed to make up a relatively small portion of all the vessels encountered by SRKW). Reducing incidences of disturbance can be achieved by 1) excluding all vessels from important SRKW habitat, and 2) implementing a 200 m exclusion zone around SRKW. Such a protective bubble would limit how close vessels could approach SRKW, but would not protect whales if they chose to approach vessels within their habitat. The scientific justification and confidence in this action producing the desired benefits to SRKW were ranked ***medium* to *high***.

Based on the current state of knowledge and best available data, workshop participants had higher confidence in the effectiveness of Action C (limiting vessel disturbances to make the Chinook that are already present easier for SRKW to catch) than they did in increasing the abundance of Chinook by closing or adjusting fisheries (Actions A & B).

With >900 stocks of Chinook salmon migrating through BC waters at different times and strengths, there is currently insufficient evidence to support being able to surgically manage fisheries to avoid catching the stocks destined for SRKW habitat. Nor is there evidence that fishery reductions would add significant numbers to the estimated 600,000 Chinook thought to currently move through inside waters to Puget Sound and the Fraser River.

It will be critical to employ well-thought-out experimental designs that allow continual evaluation of the effectiveness of any Management Action enacted. This is likely to be important for the stakeholders and public seeking reassurance that SRKW will realize the full benefit of the intended action.

Performance measures that can be used to determine whether SRKW captured more Chinook can include improvement in body condition of SRKW, increased use of foraging areas, and less time travelling and feeding (and more time resting and socializing). However, use of these metrics requires a commitment to data collection and analyses (and forethought into how to interpret them) so that the effectiveness of the actions can be assessed and modified as necessary.

This workshop was a first step in bringing together scientists and managers with killer whale and Chinook salmon expertise from Canada and the United States to identify and evaluate short-term management actions that might be taken to increase the immediate abundance and accessibility of Chinook salmon for SRKW, given the current size of Chinook stocks. Going forward will likely require a smaller group of managers and scientists with expertise in killer whales and Chinook to develop detailed strategies, design the experimental implementations, and identify the required analyses to ensure that any of the Management Actions undertaken are effective in improving the status and well-being of southern resident killer whales.

Overview of Workshop

Goals. To identify short-term management actions that might be taken to increase the immediate abundance and accessibility of Chinook salmon for southern resident killer whales, given the current size of Chinook stocks. Thus, we evaluated short-term fishery management actions that would provide immediate benefits to southern resident killer whales (SRKW). We did not consider ways of producing more Chinook salmon, but rather considered ways of making more of the fish that are in the ocean available to SRKW to ultimately increase the birth rates and decrease the death rates of SRKW.

Terminology. **"**Availability" means being able to be used or obtained. This term is used by some to mean accessibility, while for others it reflects the combination of both accessibility and abundance. We used this later definition when referring to the availability (i.e., availability = abundance + accessibility) of prey for killer whales. "Accessibility" was defined as the ease of obtaining or using prey; and "abundance" referred to the quantity or amount of Chinook salmon in areas where killer whales forage.

Assumptions & Limitations. For the purposes of attaining the goals of the workshop, we assumed that:

1. The SRKW population trajectory is in decline and will not improve under current conditions.
2. The status of SRKW is related to the abundance and accessibility of Chinook salmon.

Workshop participants did not consider the veracity of these assumptions, and focused instead on evaluating management actions that could increase the abundance and accessibility of adult Chinook salmon (currently in the ocean) within regions where SRKW forage. Potential actions regarding rebuilding Chinook stocks are to be addressed in a future workshop. Thus, we only considered short-term actions that could be implemented through existing legislation and regulations.

Participants. Participants with technical knowledge about killer whales, Chinook salmon, and fisheries management were invited from Canada and the United States. These included 46 individuals working for state and federal governments, consulting companies, nonprofit organizations, and universities (Appendix A).

Proposed Management Actions. Given the afore-mentioned conditions, five potential (non-exclusive) Management Actions were developed in consultation with Fisheries and Oceans Canada (DFO) and US National Marine Fisheries Service (NMFS) biologists and managers. However, workshop participants proposed facilitating discussions by grouping the five potential actions into these three:

A. Increase abundance of Chinook coast-wide by reducing removals by fisheries.
B. Increase abundance of Chinook in specific-areas and times by adjusting removals by fisheries.
C. Increase accessibility of Chinook by decreasing acoustic and physical disturbances.

The goal of these three Management Actions was to increase the short-term abundance or accessibility of 4-5+ year old Chinook salmon in areas where SRKW forage. SRKW consume Chinook 3+ years old, but prefer Chinook that are 4 years and older.

Workshop Structure. On Days 1 and 2 of the workshop, experts gave presentations in their fields to inform the scientific validity of any of the three potential management actions (Appendices B and C). Day 3 of the workshop was dedicated to working in four groups to independently discuss the possible actions.

Discussions were guided by (but not limited to) a series of criteria developed in consultation with NMFS and DFO prior to the workshop (Appendix D).

The overall goal was for workshop participants to consider how the three actions could be implemented, and the likelihood that they would increase the abundance and accessibility of Chinook for southern resident killer whales to consume. While consensus building within groups was desirable, care was taken to document all opinions.

Summary of Discussions on Potential Management Actions

The following summaries reflect the discussions held on Day 3 of the workshop concerning each of the Management Actions. Notes combining information transcribed during group discussions, and from tables filled out by workshop participants are contained in Appendices F, G and H.

The summarized discussions that follow contain 1) the rationale underlying the three proposed Management Actions; 2) the scientific confidence of the workshop participants in the feasibility of implementing each Management Action, and whether it would provide the desired benefit to SRKWs; 3) associated uncertainties and unintended consequences associated with each action; and 4) ways in which the actions might be experimentally implemented to evaluate the effectiveness of each action, and refine them as necessary.

A: Increase abundance of Chinook coast-wide by reducing removals by fisheries

Selectively reducing fishery catches (commercial and recreational) throughout British Columbia would leave more fish in the ocean and thereby increase the abundance of Chinook. However, it is less certain which fish not taken by fisheries would ultimately move “downstream” and enter areas where SRKW forage. Nor is it clear how many more fish might join those already moving through key foraging areas used by SRKW as a result of this action.

Based on the evidence presented at the workshop, scientific confidence that this Management Action was feasible or would provide the desired benefit to SRKWs was overwhelmingly <u>low</u> or <u>unknown</u>.

The lack of endorsement for taking this action was primarily due to:

- Concern over being able to obtain real-time scientific information on the movements of different salmon stocks to implement selective fishery reductions coast-wide;
- Uncertainty concerning whether reducing catches in “distant” fisheries would increase the abundance of Chinook by enough to improve SKRW body conditions. Mathematical models indicate that such an action would not significantly increase the biomass of Chinook salmon for SRKW. This is partly based on the observation that some of the >900 Chinook salmon stocks in BC waters that are most prevalent in SRKW diets are also currently the most abundant Chinook runs.
- A general consensus that fishery actions that focus on key stocks targeted by SRKW would be more effective than general coast-wide fishery reductions. Key stocks thought to be most important to SRKW during spring and summer are returning to Puget Sound (pre-May and post-Aug), the Fraser River (May–Aug), lower southwest Vancouver Island (Aug–Sep), and lower Strait of Georgia (Aug–Sep). Puget Sound fish are present during summer, but in lower proportions relative to Fraser Chinook.
- Uncertainty about how many more fish SRKW need and could be provided by reduced fisheries given that about 600,000 Chinook move through inside waters (300,000 Fraser River and 300,000 Puget

Sound). Percentages of Fraser-bound fish caught before they enter the river is relatively low for some stocks, such as the 5-year-old spring and summer Chinook (about 3–4%)—and higher for some 4-year old fish (~25%).

- Recognition that not every fish saved from fisheries will be available to SRKW due to density dependent effects. It is not a linear relationship, as seen after 1990 when ocean fisheries were reduced in response to declines of wild Chinook runs. Returns of some Chinook stocks increased following fishery restrictions, while others did not.
- Recognition that the percentage of spring and summer Fraser Chinook caught in offshore mixed-stock commercial and recreational fisheries that are headed to Juan de Fuca Strait is small.
- Recognition that in-season adaptive management would be difficult to implement to make this an effective action. It would likely be too late to close fisheries in-season by the time it was recognized that salmon numbers of particular stocks consumed by SRKW were low. Large offshore aggregate fisheries are managed based on pre-season abundance forecasts of Canadian and US stocks in those fisheries. These forecasts are not updated in-season, and would be challenging to do so until after fishing occurred.
- Increased availability of Chinook resulting from fishery closures may be partially offset by removals by other predators (e.g., NRKW). In other words, SRKW may not consume the fish left by fisheries.
- The possibility of other unintended consequences, whereby efforts to leave more Chinook in the ocean might increase the numbers of other consumers. For example, NRKW might be the ultimate beneficiaries of increased Chinook abundance—and might ultimately encroach on SRKW habitat as their numbers increase. Similarly, seals and sea lions might also increase by initially consuming more Chinook in terminal areas, and later preying on juvenile fish (in the case of seals)—with unintended impacts on overall Chinook numbers.
- And finally, there may be challenges for international coordination, and impacts to First Nations and Indian tribes.

Despite these concerns, a few workshop participants favoured this Management Action—on the premise that any precautionary measure was worth implementing, despite it having a low probability of success.

In contrast to this belief, most participants agreed that implementing sweeping changes lacking scientific justification would ultimately prove counterproductive to efforts to recover SRKW due to a lack of stakeholder and public buy-in, and a potential perception that this action was based on political rather than scientific considerations.

B: Increase abundance of Chinook in specific-areas and times by adjusting removals by fisheries

This Management Action is also designed to increase the abundance of 4-5+ year old Chinook salmon of key stocks — but within "core SRKW areas" at biologically appropriate times of the year. In other words, to increase the abundance of large Chinook salmon where and when SRKW are foraging.

One means of increasing Chinook abundance during times that SRKW seek prey would be to create refuges (or exclusion zones) over a portion of SRKW critical habitat when SRKW are expected to be present. Operationally, this might be accomplished by imposing selective area closures during specific months, and redistributing fishing effort to places not used by SRKW. The period of highest recreational fishing use in Canada is from June to early September (Father's Day to Labour Day).

Adjusting removals by fisheries in specific areas used by SRKW at specific times of year was considered to have more merit than coast-wide fishery closures (Management Action A) for several reasons. Most notably, adjusting fishing effort by time and space is more likely to directly increase the abundance of Chinook for SRKW at specific times, and in specific areas where they are likely to forage. It would avoid the “dilution” effect of fishing in areas and at times “upstream” of where SRKW forage.

In addition to an increased likelihood of providing greater benefits to SRKW, this type of targeted fishery closure would likely have a lower socioeconomic impact than would broad (“upstream”) fisheries closures. Such an approach would likely result in higher stakeholder and public buy-in.

An additional positive effect of selective fisheries closures would be to alleviate potential physical and acoustic disturbance (see Management Action C), although the ultimate benefit of this would depend upon the proportion of fishing vessels present relative to other vessels (which may be very low).

Despite having more merit than Management Action A, workshop participants ranked their scientific certainty of the effectiveness of increasing Chinook numbers by adjusting fishery removals within SRKW critical habitat to be <u>low</u> to <u>medium</u>. In general, the effectiveness of area-based closures was ranked low, while the effectiveness of maximum size limits on fish caught was ranked higher.

The uncertainty expressed over implementing this Management Action reflects several critical unknowns, such as how much prey are required for SRKW to meet their needs. It was unclear, for example, what the desired abundance of specific Chinook stocks should be at specific times of year. Using current “conditions” as a baseline was considered problematic because catches and abundance are lower now than they have been historically, while the number of other competing predators consuming Chinook (including NRKW) are higher.

There was some consensus that the abundance of Chinook that occurred in previous “good” SRKW years could provide a baseline measure of what targeted abundance should be. However, in the absence of this knowledge, it is unknown what level of increase or stability is required to measurably change SRKW condition or demographics. Some predictive models indicate a 30% rise in Chinook abundance is required—a level approaching the “best” historic years—while other models indicate that a complete fishery closure would still be insufficient to produce SRKW recovery, given the broad ecological and physical changes that have occurred in the North Pacific Ocean.

Some uncertainty was also expressed in the ability to identify which locations are most important, and what times of year are most critical for SRKW.

In considering this action, it was generally felt it should only be applied to:

1) Fisheries that catch a significant portion of the key stocks of 4+ Chinook sought by SRKW (e.g., those that catch >5% of returning fish);
2) Fisheries whose catches consist of a high proportion of 4+ year old Chinook (e.g., >10-20% of the fishery); and
3) Fisheries occurring within the time and high-use areas of SRKW foraging (based on field observations of SRKW).

For commercial fisheries, these actions would apply to locations with the highest Chinook catch. However, these areas are generally outside (to the north) of SRKW range (with the exception of Fishery Management Area 123). Similarly, the critical time for closures would likely be during summer (but not exclusively) when the greatest numbers of Chinook are caught.

Ideally, closures of commercial and recreational fisheries would accommodate real time changes in the presence and absence of foraging SRKW. However, differences in the spatial and temporal scale at which recreational and commercial fisheries operate make it more difficult to effectively adjust recreational fishery removals of Chinook compared to adjusting commercial fishery removals in real time. An action that adapts to the daily movements of SRKW would likely be too difficult to effectively communicate and logistically manage. The effectiveness of such an action would also likely prove to be too difficult to evaluate.

Additional questions were raised regarding how SRKW might react to partial closures within their critical habitat. For example, would whales bypass areas where fishing was occurring and concentrate foraging efforts in undisturbed areas where abundance is theoretically higher? Similarly, would lots of Chinook in a noisy site with lots of vessel disturbance be as effectively beneficial for SRKW as would feeding on a lower abundance of Chinook in a quiet, undisturbed location? These questions highlight the considerable uncertainty about the relative importance of Chinook abundance vs. the accessibility of Chinook within an area. Killer whales tend to spend a large proportion of time in small areas, but it is unclear how big an area is required to be effective, or what degree of connectivity is needed between areas.

Field studies are planned to define SRKW foraging patterns and their relationship to fishing efforts. In the meanwhile, the picture is far from clear.

Implementing this Management Action would be complex given that the three pods of the SRKW population (J, K and L) use different foraging areas, and are not equally dependent on the same Chinook stocks.

For example, K and L pods feed during winter off the US west coast down to California. The stocks important to these two pods vary in size and robustness (Klamath, Columbia, and coastal Chinook salmon stocks). The potential to mitigate numbers of Chinook belonging to the different stocks through control of fisheries is also likely to prove unfeasible. It was noted, for example, that stocks in southern California are at dire numbers, and there are few immediate options to revitalize these stocks, either through fisheries management or other actions.

During winter, J pod can be found foraging in the Strait of Georgia where Chinook winter abundance has been high over recent years (and fishing effort low relative to summer months), suggesting that fishing limitations may have minimal additive benefit to J pod.

While fisheries might be adjusted to increase the quantity of Chinook available, they might also be adjusted to increase the quality of individual Chinook consumed (through size-limits that leave bigger fish in the ocean). Body size of Chinook has become smaller over time, which means that each Chinook consumed by SRKW is now providing fewer calories on average than it did in the past.

Another point of consideration relates to the predictability of foraging patterns of SRKW from one year to the next. While SRKW are generally considered to be predictable in their annual movements, there can be considerable variability between years. Thus, the effectiveness of specific fishery closures under Management Action B is inherently limited by the natural unpredictability of SRKW foraging behaviour.

Given the foregoing uncertainties, workshop participants recognized that implementing this (or any) Management Action must be done experimentally (with a statistically appropriate experimental design), so that the effectiveness of the action can be evaluated and adaptively changed as required. This would entail evaluating the effectiveness of specific closures on an ongoing basis, and suitably adjusting the specific implementation of this Management Action as necessary. Specific monitoring would be required to ascertain the effect of this action on Chinook abundance and SRKW foraging behaviour within specific areas.

Determining whether restrictions placed on fishery catches have positive effects on SRKW is problematic. Determining whether foraging success improves will require concurrent studies of salmon movements and SRKW foraging efficiency (using longer-term observations and underwater tracking technologies).

While the ultimate goal of this action is to improve the population dynamics of SRKW by increasing their birth rates and reducing death rates, such measures of population recovery may respond on time scales that are too long to be linked to the proposed actions.

Estimates of SRKW body condition were generally felt to be a more useful short-term metric of nutritional status of individual whales, with the caveat that changes in physical condition can be caused by a number of factors (such as disease) and are not necessarily indicative of inadequate prey. Nevertheless, correlating metrics of SRKW health (body condition, hormones) with salmon abundance could help to identify when salmon abundance is too low and fisheries need to be restricted. Obtaining aerial images of SRKW returning in May, and again in the fall will provide essential monitoring data on changes in body condition relative to the abundance of Chinook.

Implementing this Management Action would require continued studies of SRKW diet and foraging behaviour (times and locations) to inform the management of key Chinook stocks important to SRKW at the proper times of year. It would also require implementing an adaptive management strategy, with annual evaluations of winter and summer SRKW distributions and stock-specific Chinook abundances.

C: Increase accessibility of Chinook by decreasing acoustic & physical disturbances

Some workshop participants felt the accessibility of Chinook in areas where SRKW forage would be significantly increased if 1) disturbances caused by the presence of vessels was reduced by 50%, and if 2) disturbances caused by underwater noise from vessels were reduced by 100%. Other workshop participants merely wanted significant reductions without specifying target levels. Reducing the frequency of physical and acoustic disturbances would theoretically facilitate SRKW being more successful at capturing prey—thereby allowing them to be in better physical condition and have higher survival and birth rates. This Management Action would specifically minimize acoustic interference with echolocation during hunting and communication between pod members, and would minimize physical interference from vessels that may disrupt surface chases, preclude prey sharing, or cause animals to cease foraging and move out of an area. One model suggests that increasing the accessibility of Chinook salmon (i.e., the ability of SRKW to catch them) by 30-50% would significantly improve the demographics of SRKW.

This proposed action to minimize the negative effect of vessels on SRKW incorporates 1) vessel exclusion zones in key foraging areas (akin to Management Action B), and 2) a protective exclusion zone around SRKW at all times. Workshop participants recognized that it is unrealistic to close all potential SRKW foraging areas at all times. However, they emphasized the need for quality data to make decisions about which areas should be closed, and at which times of year to do so. Implementing this action requires a rigorous experimental design to evaluate its effectiveness.

It was further recognized that SRKW often forage in the presence of many vessels (recreational and commercial fishing, whale watching, and recreational vessel traffic). Given this overlap between vessels and SRKW, this action would be minimally effective if it is only applied to fishing vessels because numbers of fishing vessels are believed to be relatively small compared to other types of vessels (although significant numbers of fishing vessels may gather in prime areas at certain times). It is not clear how challenging it might be to implement this action for different classes of vessels from a regulatory view, involving multiple legislative changes (i.e., Fisheries Act, Transport Canada, etc.).

There was general consensus that a 200 m exclusion zone was reasonable — despite the scientific questions surrounding the biological effectiveness of this distance (a portion of the participants suggested a more precautionary 400 m zone, but no one suggested a distance less than 200 m, which is the approach distance currently required in the United States). This Action would theoretically provide "bubble" protection around whales as they move into known foraging areas.

Unfortunately, building a moving bubble around SRKW has its limitations, even when perfectly implemented. For example, it would not prevent whales from moving into a foraging area where vessels are already present. While regulations would prevent approaching the whales closer than 200 m, it cannot legislate against whales moving towards vessels and exposing themselves to vessel noise and movements that may degrade their foraging environment. Nor would operators necessarily be required to limit their acoustic footprint if they are already in the area.

One means of reducing the potential for vessels to affect the ability of SRKW to access Chinook would be to require them to pull their gear and turn off their fish finders or engines (if safe to do so) should whales approach within a specified distance within identified foraging areas. Speed restrictions could also be implemented within critical foraging areas used by SRKW.

As a side note, it was mentioned that the majority of recreational Fishfinders operate at two frequencies (50 and 200 kHz), and are preset to the lower frequency that has a broader and deeper cone of ultrasound coverage than the higher frequency. The hearing range of killer whales extends from ~0.6 KHz to >100 kHz, with the greatest sensitivity between 20–50 kHz. To avoid potential impacts within the hearing range of SRKW, manufacturers or users could preset their devices to the higher 200 kHz frequency to prevent overlap with the SRKW dynamic range, and users could be educated about using the higher setting around whales.

Mediating vessel behaviour when killer whales approach them is particularly problematic in transportation corridors within SRKW critical habitat that have high numbers of moving vessels. Under such circumstances, there seems little chance of creating a "quiet zone" for the whales. Although whales might be expected to avoid such noisy corridors and move to less disturbed areas, the presence of salmon may motivate them to stay put.

Finally, while the intent of this Management Action is to improve the foraging of SRKW by making it easier for SRKW to catch the fish that are present, it would likely have to be implemented for all killer whales (transient and resident) because it is unrealistic to expect operators to readily distinguish between the two ecotypes of killer whales.

Workshop participants ranked the scientific certainty that reducing physical and acoustic disturbances by vessels would significantly increase the accessibility of Chinook for SRKW as <u>medium</u> to <u>high</u>.

This range in certainty is higher than the other two Management Actions considered, and reflects the extent and importance of knowledge gaps. While there was an accepted link between noise and poor foraging success, the dose-response of SRKW foraging behaviour in relation to vessel noise and numbers was less clear. Other identified potential knowledge gaps include sound profiles of critical areas, and diurnal pattern of SRKW foraging. It was felt that these questions could be clarified through further studies, while the exclusion zone should be experimentally implemented. Despite these gaps, vessel exclusion zones were generally felt to be a prudent measure.

The efficacy and design of exclusion zones can only be improved through intensive monitoring during implementation. Operator compliance evaluations could include AIS (Automatic Identification System) monitoring, cameras and radar. As has been demonstrated in other marine programs, education of vessel operators (particularly recreational) is often as important as regulatory enforcement. Specific guidance would also likely be required for those fishing (target messaging in key areas such as Salmon Bank), and perhaps as part of licensing procedures.

The biological effectiveness of this action on SRKW would have to be closely monitored. While this action is likely to improve targeted foraging opportunities for SRKW, it is unclear what effect it will have on their well-being. Evaluating the efficacy should include potential short-term effects such as behavioural measures (e.g., the amount of time whales spend in feeding areas), the acoustic levels within those areas, and an analysis of foraging success vs. acoustic profiles, and longer-term studies on changes in physical condition and hormone profiles of SRKW.

In addition to implementing an experimental framework to evaluate the benefit of areas of action versus no action, restricting the movement and presence of vessels should be done adaptively. This would entail establishing connections between SRKW health and Chinook abundance (e.g., scenarios indicate suite of options for high Chinook/low whale condition, low Chinook, etc.).

Conclusions

What Actions to Take

The four discussion groups had evenly balanced expertise on killer whales, Chinook salmon and fisheries management — and came to similar conclusions about the scientific justifiability of the Management Actions considered, and the likelihood that they would provide the desired benefit to SRKWs (Table 1).

Overall, there was little confidence (unknown–low) that reducing fishery catches coast-wide would benefit SRKW, and slightly more confidence (low–med) that restricting catches within specific areas of SRKW critical habitat would significantly increase Chinook abundance.

In contrast to doubts about being able to significantly increase the numbers of fish in SRKW habitat, there was greater confidence (med–high) that reducing acoustic noise and physical disturbances by vessels would significantly increase the ability of SRKW to catch the salmon that are present in foraging areas.

Measuring Efficacy of Actions

There are a number of performance measures that can be used to assess the effectiveness of Management Actions on SRKW. However, each requires a commitment to data collection and analyses, and forethought about how to interpret them. Possible metrics include:

Body Condition. Aerial photographs of SRKW retuning in May, and again in the fall will provide essential monitoring data on changes in body condition relative to the abundance and accessibility of Chinook during spring and summer, as well as relative measures of feeding conditions during winter when the SRKW are believed to be primarily along the outer coast of the United States. An invaluable database of body conditions has grown in recent years, but is not yet sufficient to determine an ideal body condition or what a significant improvement looks like.

Table 1. Scientific justifiability of the Management Actions and the likelihood that they would provide the desired benefit to SRKWs. Note that the likelihood of success correlated positively with scientific justification — "?" represents unknown.

Management Action	Scientific Justifiability			
	?	Low	Med	High
A. Increase abundance of Chinook coast-wide by reducing removals by fisheries	X	X		
B. Increase abundance of Chinook in specific-areas & times by adjusting fishery removals		X	X	
C. Increase accessibility of Chinook by decreasing acoustic & physical disturbances			X	X

Physiological Status. Significant advances have been made in developing ways to assess the well-being of free-swimming whales. Fecal samples, respiratory (blow) samples, blubber biopsies, and skin samples are increasingly used to assess health, nutritional status, exposure to disease, stress levels, and reproductive status. Validation of methodologies to assess and interpret physiological status relative to environmental conditions (i.e., perceived stressors) is ongoing.

Area Use. The percentage of time a whale spends in particular areas is likely to be a useful metric. This is based on the assumption that more time moving between areas is indicative of lower available prey—while less travelling is presumed to reflect relatively good foraging.

Activity Budgets. The percentage of time killer whales engage in resting, foraging, travelling, and socializing is presumed to reflect feeding conditions—as it has been observed that killer whales typically travel more and forage less in bad salmon years and in the presence of vessels (they also tend to do less resting and socializing).

Acoustic Behaviour. Foraging activity could be captured by hydrophones. Changes in the frequency of calls between SRKW might reflect changes in feeding conditions.

Foraging Success. Individual SRKW might be followed from shore or from a distance on the water to document successful prey captures. Suction-cup electronic tags that record underwater behaviours can be attached for brief periods to determine where, when and how frequently SRKW catch Chinook and whether they are more successful following implementation of the Management Action.

Reproduction & Survival. The overall goal of all the Management Actions considered during this workshop was to support SRKW recovery by ultimately increasing the number of female calves, increasing calf survival, reducing the interval between calving times, increasing success at age of first reproduction, and increasing reproductive potential (improved age & sex composition of pods). However, changes in reproduction and survival rates occur over relatively long periods and are unlikely to be useful or dependable measures of the immediate effects of the actions considered.

Future Refinement and Planning

This workshop was an important first step in bringing fisheries managers and killer whale and Chinook salmon experts together to identify and evaluate short-term management actions that might be taken to increase the immediate abundance and accessibility of Chinook salmon for SRKW, given the current size of Chinook stocks.

As a next step, a smaller group of managers and scientists with expertise in killer whales and Chinook could develop detailed strategies, design the experimental implementations and required analyses to ensure the effectiveness of the actions taken to improve the status of southern resident killer whales.

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Appendix A: Participants

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Appendix B: Agenda

Availability of Prey for Southern Resident Killer Whales

November 15-17, 2017

@ The University of British Columbia
Marine Mammal Research Unit
Institute for the Oceans and Fisheries

Day 1 — Workshop Objectives & Goals ***Earth & Ocean Sciences – Room 5104, 2207 Main Mall***	
8:15 am to 9:00 am	**Registration & Continental Breakfast**
9:00 am to 9:20 am	Introductions & Overview—*Andrew Trites, David Rosen, Sheila Thornton, Jennifer Nener*

Day 1 — Prey Requirements of Southern Resident Killer Whales (SRKW)	
9:25 am to 9:40 am	SRKW demographics and status changes since 2012—*Eric Ward*
9:40 am to 10:00 am	Influence of genetics & social structure on the prey needs of SRKW—*Mike Ford, Eva Stredulinsky*
10:00 am to 10:30 am	Coastal occurrence based on sightings & acoustic data—*Ruth Joy*
10:30 am to 10:50 am	**Break**
10:50 am to 11:15 am	Coastal occurrence based on tagging & acoustic data—*Brad Hanson*
11:15 am to 11:30 am	Occurrence based on acoustic data in Strait of Georgia, La Perouse & Swiftsure—*John Ford*
11:30 am to 12:00 pm	SRKW & NRKW foraging behaviour—*Jennifer Tennessen, Marla Holt, Brianna Wright*
12:00 pm to 12:15 pm	SRKW seasonal diet from predation & fecal samples— *Brianna Wright Brad Hanson*
12:15 pm to 1:00 pm	**Lunch**
1:00 pm to 1:30 pm	SRKW foraging needs & interpretation of body condition—*Dawn Noren*
1:30 pm to 2:00 pm	Photogrammetry measures of body condition in SRKW & NRKW—*John Durban*
2:00 pm to 2:15 pm	Hormone assessments of nutritional and reproductive status of SRKW—*Sheila Thornton*
2:15 pm to 2:45 pm	Behavioural response of SRKW to acoustic disturbance—*Marla Holt,*

	Dawn Noren
2:45 pm to 3:00 pm	Impacts of boat disturbance on KW foraging—*Lance Barrett-Lennard*
3:00 pm to 3:30 pm	**Break**
3:30 pm to 4:00 pm	Behavioural response of SRKW to physical disturbance—*Rob Williams*
4:00 pm to 5:00 pm	Synthesis & discussion of key points from Day 1—*John Ford*
5:30 pm to 7:30 pm	**Dinner**—*Sushi @AERL* – room 107

Day 2 — Availability of Chinook Salmon

Aquatic Ecosystems Research Laboratory – Room 107, 2202 Main Mall

8:00 am to 8:45 am	**Continental Breakfast**
8:45 am to 9:00 am	Housekeeping & Goals for Day-2
9:00 am to 9:20 am	Conclusions of the Independent Science Panel on the Effects of Salmon Fisheries on SRKW—*Sean Cox*
9:20 am to 9:35 am	Effects of Chinook abundance on SRKW—*Eric Ward*
9:35 am to 9:45 am	Recreational fishery interactions with killer whales—*Martin Paish*
9:45 am to 10:20 am	Overview of abundance trends and status of Chinook consumed by SRKW—*Mary Thiess, Robert Kope*
10:20 am to 10:40 am	Trends in body sizes of Chinook—*Jan Ohlberger*
10:40 am to 11:00 am	**Break**
11:00 am to 11:45 am	Factors influencing the abundance, distribution, overall and age-related abundance and production of Chinook—*Gayle Brown*
11:45 pm to 12:00 pm	Ocean conditions and predicted changes in Chinook abundance & distributions—*Robert Kope*
12:00 pm to 12:40 pm	Overview of past and present management of commercial, recreational and First Nations & Treaty Indian fisheries for Chinook salmon in the Pacific Salmon Treaty—*Wilf Luedke, Jeff Grout, Kirt Hughes, Teresa Ryan*
12:40 pm to 1:25 pm	**Lunch**
1:25 pm to 1:45 pm	Historical overview of trends in Chinook catch among fisheries and regions within the jurisdiction of the Pacific Salmon Treaty—*Wilf Luedke, Bryan Rusch*
1:45 pm to 2:05 pm	Fine-scale catch and effort data with emphasis on southern BC areas—*Wilf Luedke, Bryan Rusch*
2:05 pm to 2:15 pm	Fine-scale catch and effort data with emphasis on US areas—*Kirt Hughes*

2:15 pm to 3:15 pm	Synthesis and discussion of key points from Day 2—*Brian Riddell*
3:15 pm to 3:30 pm	**Break**

Day 2 — Evaluation of Potential Mitigation Measures

3:30 pm to 4:00 pm	Overview of current protections for SRKW—*Lisa Jones, Lynne Barre*
4:00 pm to 4:15 pm	Potential mitigation measures—*Andrew Trites*
4:15 pm to 5:00 pm	Overview of mitigation table—*Andrew Trites, David Rosen*
5:30 pm to 7:30 pm	**Dinner**—*Mahoney & Sons – UBC – 5990 University Bvld*

Day 3 — Evaluation of Potential Mitigation Measures (cont.)

Earth & Ocean Sciences – Room 5104, 2207 Main Mall

8:15 am to 8:45 am	**Continental Breakfast**
8:45 am to 9:00 am	Housekeeping & Goals for Day-3
9:00 am to 10:30 am	Option A: Increase abundance of Chinook coast-wide by reducing removals by fisheries—*small working groups*
10:30 am to 10:45 am	**Break**
10:45 am to 11:30 pm	Option B: Increase abundance of Chinook in specific-areas by adjusting removals by fisheries—*small working groups*
11:30 am to 12:00 pm	Option C: Increase abundance of Chinook at specific times of year by adjusting removals by fisheries—*small working groups*
12:00 pm to 12:45 pm	**Lunch**
12:45 pm to 1:30 pm	Option D: Increase accessibility of Chinook in specific areas at specific times of year by decreasing acoustic disturbance—*small working groups*
1:30 pm to 2:00 pm	Option D: Increase accessibility of Chinook in specific areas at specific times of year by decreasing physical disturbance—*small working groups*
2:00 pm to 3:00 pm	Review working group discussions / decisions for the 4 Options—*Andrew Trites, David Rosen, Lynne Barre, Sheila Thornton*
3:00 pm to 3:30 pm	**Break**
3:30 pm to 4:15 pm	Review working group discussions / decisions for the 4 Options—*Andrew Trites, David Rosen, Lynne Barre, Sheila Thornton*
4:15 pm to 4:45 pm	Synthesis & discussion of key points from Day 3—*Mark Saunders*
4:45 pm to 5:00 pm	Next steps / Closing remarks—*Andrew Trites, Sheila Thornton, Jennifer Nener*

Appendix C: Participant Presentation Summaries

The following synopses of workshop presentations were provided by participants, and have been edited for style.

November 15, 2017

Day 1 – Prey Requirements of Southern Resident Killer Whales (SRKW)

A. SRKW status and demographic update (*Eric Ward, NWFSC*)

- SRKW are likely to continue to decline. How quickly that happens depends on what assumptions we make about future environmental conditions, sex ratios at birth being different from 50:50, potential effects of inbreeding, and other factors that reduce fecundity or survival.
- SRKW are an anomaly in that they are the only killer whale population in the NE Pacific that hasn't increased exponentially. This is true since the 1970s, including the period since the last 2011-2012 workshops.
- As noted in the last independent panel report and work since, there is increased opportunity for competitive effects of other killer whale populations on SRKW (NRKW in particular have spatial overlap with SRKW).
- Recent trends in SRKW appear to be somewhat decoupled from aggregate salmon indices. In the last 5-10 years, salmon indices have been at or near historic highs and these periods have seen high population growth of other killer whales. But the trajectory for SRKW is somewhat opposite.

B. Influence of sociality on the prey needs of Southern Resident Killer Whales (*Eva Stredulinsky, DFO*)

- Splitting of RKW groups is correlated to coast-wide Chinook abundance
- This relationship is amplified by:
  1. High proportions of physically mature males &/or lactating females in the groups (i.e. nutritionally-needy individuals)
  2. Leadership capacity within the group (i.e. multiple old, mature females)
  3. Lower maternal relatedness among group members (this can occur through deaths of common ancestors as well as group growth)
- Prey sharing is a prevalent behaviour in RKWs, where animals share prey with their closest maternal relatives
  - Adult RKW females are the primary provisioners of their groups, sharing consistently even in years of low salmon abundance (which makes them particularly vulnerable to food shortages).
  - Adult males share the least with their group. This is likely because they have huge caloric requirements and they are also the least maternally related (on average) to their group.
- While a mother's provisioning of her daughters stops at daughter's reproductive maturity, sons are provisioned throughout their lifetime
  - Adult males depend on close female relatives to be provisioned, and, in the absence of such relatives, their survival decreases. This relationship is especially apparent in years of low salmon abundance.
- Relevant notes from outside of this presentation:
  - According to SRKW photogrammetry work (J. Durban, H. Fearnbach et al.), while adult males have females

provisioning them, they consistently have the best body condition of all age-sex classes. So it seems, in general, they are only vulnerable to food shortages when they are lacking older female animals to provision them.

C. Killer whale genetics, and paternity in the southern resident population (*Michael Ford, NOAA*)

Main points

- The whales have highly skewed male reproductive success – ~50% of the current population descended from just two males
- Four apparent cases of close inbreeding (2.5% of all inferred matings)
- Less close inbreeding is certainly occurring, but hard to detect with current data
- Consequences of inbreeding in the population still under study - will have results next year
- No evidence of inbreeding avoidance
- Population has had low effective size (~25) for at least several generations

Implications for prey conservation/use

- Old, large males are important and they need a lot of food, but the population may not need very many of them
- Inbreeding depression may mean population needs more prey than a comparable outbred population
- Based on the work by Eva Stredulinksy, the whales seem to put a lot of resources into males, and this seems almost maladaptive from a population perspective even if it perhaps makes sense from an individual whale perspective

D. Coastal occurrence of SRKWs based on sightings and acoustic data (*Ruth Joy, SMRU Consulting*)

Project goals

1. To better understand the fine-scale spatial and temporal distribution of SRKW during “Chinook season” (May-October), focusing on current and proposed Canadian Critical Habitat.
2. To better understand where foraging occurs.

- Multiple datasets: some opportunistic presence only, some more systematic with associated effort.
- One of the key datasets was collected by Brian Gisborne with 2887 tracklines of effort distributed across 815 days. He observed SRKW 158 times across effort mostly concentrated in the spring/summer/fall months.
- The 2nd key source of data is that from the BCCSN and OrcaMaster datasets. These are presence only datasets for which we will have to derive either a pseudo effort datalayer from absence data, or else a presence only approach. We’d like to avoid making assumptions about ‘effort’.
- The overarching methodological plan is to fit a Bayesian spatial-temporal model using approximate methods (instead of particle MCMC) to estimate the probability of SRKW presence in the Salish Sea in the months from May to October. We will be incorporating as much data as we can (scared about the Chinook data now though!!), with the intent to start with integrating Brian’s data with the sightings databases.
- Deliverable date is March 2018.

E. Coastal occurrence of southern resident killer whales based on satellite tagging and acoustic recorder detections (*Brad Hanson, NWFSC*)

- Acoustic recorder detections and satellite-linked tag location data from SRKW have provided a much more complete picture of SRKW fall, winter, and spring occurrence
- Acoustic recorder detection data showed that the area near the Columbia River was used much more than expected by K/L pods
- Satellite tagged members of K and L pods ranged from Cape Flattery, Washington to Pt. Reyes, California, remaining on the continental shelf, and generally close to the coast
- High use sites for K/L pods included areas off the Columbia River and Gray's Harbor, northern California, and the northern Olympic Peninsula
- K/L pods primarily occur in a relatively narrow band of the continental shelf near the coast
- Satellite tagged members of J pod ranged from the continental shelf waters of the central west coast of Vancouver Island to northern Georgia Strait
- High use sites for J pod included northern Georgia Strait and the western end of Juan de Fuca Strait
- K/L and J pods appear to have nearly exclusively separate winter ranges
- In general, SRKWs appear to display similar range and site fidelity patterns between years

F. Assessment of potentially important SRKW habitat outside of designated Critical Habitat (*John Ford, DFO & UBC*)

No summary provided

G. Dtags as a tool for behavioural studies of resident killer whales (*Brianna Wright, DFO*)

See: Wright, B.M., Ford, J.K.B., Ellis, G.E., Deecke, V.B., Shapiro, A.D., Battaile, B.C. & Trites, A.W. 2017. Fine-scale foraging movements by fish-eating killer whales (*Orcinus orca*) relate to the vertical distributions and escape responses of salmonid prey (*Oncorhynchus* spp.). Movement Ecology 5:3.

H. Acoustic cues recorded from animal-borne tags to quantify foraging events in endangered fish-eating killer whales (*Marla Holt, NWFSC*)

- 34% of dives contained echolocation click bouts
- The majority of click bouts were slow clicks on repeated shallow dives, interpreted as searching for prey at the surface. This makes SRKW vulnerable to vessel masking noise and boat presence
- Dive depth and year were important explanatory variables of click presence
- Co-occurrence of buzzes and prey handling sounds indicate prey capture
- Males had higher presence of buzz and prey handling sounds on per dive basis, consistent with having higher feeding rates to support a larger total body size
- Integration of the acoustic data analysis results with other tag sensor data is critical input for the development of the foraging detector, presented by J. Tennessen
- Results ultimately will be used to predict foraging in order to determine vessel and noise effects on behavior, including different phases of foraging that involve the use of sound

I. **Using kinematic data from multisensor tags to identify predation events by southern resident killer whales (*Jennifer Tennessen, NWFSC*)**
    - Kinematic detection of predation events can be an effective way to identify and quantify subsurface foraging behavior, particularly when other data streams such as acoustics may be incomplete or absent. The significant kinematic variables that predicted occurrence of visually-confirmed prey capture events were the maximum standardized peak in the jerk signal (rate of change of acceleration), roll at maximum jerk peak (roll in the dorsal-ventral axis during the time of jerk peak) and vertical rate of ascent.
    - We built a detector using these three predictor variables and validated its performance with acoustically-confirmed prey capture events, achieving nearly an 80% true positive rate and < 1% false positive rate.
    - We ran the detector on the full data set and found that dives containing predation event detections were longer, deeper, initiated with a greater vertical rate of descent, male predation rate was 2x that of females, and males were more likely than females to be successful on deep dives.

J. **SRKW Winter Diet: Scale/Tissue Samples (*Brianna Wright, DFO*)**
    - Scale/tissue samples collected from 42 successful SRKW foraging events (October to March; 1975 to 2016) indicate that Chinook remains a component of the diet throughout the year.
    - Other salmonid species identified within the winter prey sample set include chum, coho and steelhead.
    - Further research on winter diet is required to characterize the species composition.

K. **Seasonal diet of southern resident killer whales (*Brad Hanson, NWFSC*)**
    - SRKW annual seasonal diet is generally dominated by Chinook
    - Predation event samples and feces show similar diet patterns, but feces shows more diversity
    - Chinook are the primary species in summer diet and originate mainly from the Fraser River
    - In early fall coho increase in prevalence in diet
    - Chum predominate over Chinook in fall prey samples collected in Puget Sound
    - Fall fecal samples show Chinook still are a slightly greater proportion than chum with greater diet diversity
    - Limited data are available on winter/spring diet of J pod in their Salish Sea range
    - Although coastal winter/spring diet (K/L pods) is dominated by Chinook, particularly from the Columbia River, Central Valley, and Puget Sound, diet is more diverse than is other seasons
    - Prey consumed in coastal waters were from a relatively narrow band of shallow water
    - Chinook consumed by SRKW tended to be younger than those consumed by NRKW

L. **Southern resident killer whale foraging needs and interpretation of body condition (*Dawn Noren, NWFSC*)**
    - Southern Resident killer whale population requires a significant amount of kcals per day.
    - Individual prey requirements are dictated by sex and age. Required kcal consumption increases with age, and due to the sexual dimorphism, males require more kcals/day than females, beginning around the age of 13 when “sprouting” of the large dorsal fin can start to occur.

- Lactating females may require 50% higher kcal/day compared to non-lactating females, but data from animals in human care suggest that this higher level of energy requirement typically occurs during the earlier (0-6) months of the >12 month-long lactation period. Furthermore, the relative increase in energy requirements for lactating females varies across females as well as across lactating periods in multiparous females.
- Although two studies (Noren 2011 and Williams et al. 2011) used different approaches to estimate prey requirements of Southern Resident killer whales, the results were only slightly different. Estimates of total consumption of Chinook salmon by Southern Resident killer whales using the two different methods were similar and suggest that the population of Southern Resident killer whales may consume a significant proportion of Fraser River Chinook during summer months. A third study (Hanson et al. in prep) that assessed consumption of specific salmon runs also found that the percent consumption of Chinook abundance varied by run, and that Chinook consumption by Southern Resident killer whales is potentially significant relative to the Chinook abundance for some runs.
- Chinook availability may be inadequate to support SRKW population growth to recovered status.
- Morphometrics are being used to assess body condition in Resident killer whales. Efforts are being made to 1) assess how blubber thickness changes with body mass during gestation and lactation in healthy whales in human care, 2) assess relationships between blubber thickness (an indicator of nutritional status) and girth:length ratios, and 3) determine whether these measurements are correlated to body condition and cause of death in stranded killer whales from the Northeast Pacific Ocean.
- Lactating females, including well-fed individuals, can lose weight and show signs of decreased condition. Body mass and blubber thickness measured at three sites (1 lateral and 2 dorsal sites) on a primiparous female in managed care concomitantly decreased during the first 3-4 months of lactation. Blubber thickness at three sites on a multiparous female did not seem to change much during the gestation period, despite her body mass increasing as the fetus developed. Unlike the primiparous female, the multiparous female, who was much larger and older, did not lose body mass or show a reduction in blubber thickness during the first three months of lactation.
- Blubber thickness at three sites (dorsal, lateral, and ventral) measured on the anterior dorsal fin insertion girth increases significantly with body length (age).
- Blubber thickness measured at the three sites also tend to increase with the ratio of the anterior dorsal fin insertion girth/body length (degree of robustness), but the relationship is only significant for the dorsal blubber thickness.
- There is no relationship between body length and the degree of robustness when all killer whales (neonates through adults) are included.
- As expected, degree of robustness is greater in killer whales that have died from ship strikes, blunt force trauma, and short-lived diseases.
- It is difficult to differentiate killer whales that died from extended periods of illness from those that may have starved to death because both groups of animals are less robust.
- Killer whales that died from extended periods of illness tended to be the least robust, but the sample size is low.

- Morphometrics can provide information on body condition, but in order to determine the proximate mechanism (poor nutrition or disease), other biological samples (e.g., breath, blubber biopsies to asses lipid content and fatty acids that can elucidate nutritional status, fecal material, etc.)

M. Photogrammetry and body condition (*John Durban, SWFSC*)

- In March 2017, an independent science panel reviewed recent research on southern resident killer whales (SRKWs) and concluded "*There are multiple lines of evidence that indicate the presence of poor body condition in SRKWs*" (Matkin et al. 2017*). Photogrammetric studies of whale body condition represented a significant component of this research.
- Collaborative research was summarized, and some new data were presented. Notably, inference was made from large (population-wide) sample sizes of photogrammetry measures collected from SRKWs between 2008 and 2017 and comparative data from northern resident killer whales (NRKWs) from 2015 and 2016.
- The key conclusions were:
  - Body condition of SRKWs has been declining since 2008.
  - Declines in body condition have been linked to known mortalities in several cases, including 5/6 most recent mortalities (the other death attributed by blunt force trauma).
  - SRKWs were in worse condition than NRKWs in 2015 and 2016.
  - J-pod (as indicated by the J16 matriline) was in worse condition in May compared to September, in both 2016 and 2017.
  - These data are consistent with nutritional stress in SRKWs.

* Matkin, C. O, M. J. Moore, and F.M.D. Gulland. 2017. Review of Recent Research on Southern Resident Killer Whales (SRKW) to Detect Evidence of Poor Body Condition in the Population. Independent Science Panel Report to the SeaDoc Society. DOI 10.1575/1912/8803

N. Hormone assessments of nutritional and reproductive status of SRKW (*Sheila Thornton, DFO*)

- Hormones, metabolites, and metabolic byproducts provide information relevant to stress physiology, reproductive status, nutritional status and health of SRKW, and are important factors in assessing the physiological status of an animal.

Reproductive hormones

- Blood samples from captive KWs have provided some parameters for the pattern and range of reproductive hormone levels during gestation (~18 months) and post-parturition (Suzuki 2003, Robeck et al, 2006, 2016, 2017; O'Brien 2017).
- Progestagens are a class of sex steroid hormones that bind to and activate the progesterone receptor. In captive KW, progestogen levels rise immediately after conception and remain elevated for the duration of the pregnancy, then begin to fall in the week prior to parturition and return to baseline within days post-partum (Robeck et al, 2016).
- In captive KW, testosterone values rise in the luteal phase, and if conception occurs, values continue to rise, and are significantly different from pre- and post-conception values by the fifth month of gestation (Robeck and Monfort, 2006, Robeck et al, 2017).
- Metabolic assessment of wild cetaceans is limited, due to difficulty in obtaining

samples for analysis; however, advances in analytical techniques and approaches have been successful in determining hormone levels in fecal samples, respiratory samples ('blow'), and blubber biopsies.

- Wasser et al (2017) evaluated fecal progesterone (P4) and testosterone (T) levels in SRKW, and classified pregnant females by early stage gestation (high P4, low T) and mid- to late-stage gestation (high P4, high T). demonstrated ~69% fetal loss in SRKW (24 unsuccessful pregnancies in 12 females – fecal samples collected from 2008-2014). Seven of these unsuccessful pregnancies (33%) were likely from the second half of gestation.

Stress hormones

- Glucocorticoids (GC; cortisol and corticosterone) are steroid hormones produced in the adrenal cortex that regulate glucose metabolism through stimulation of gluconeogenesis, mobilization of amino acids, inhibition of glucose uptake in muscle and adipose tissue, and stimulation of fat breakdown.
- Glucocorticoids are shown to increase due to external or internal stressors and have widespread genomic and non-genomic effects. Glucocorticoid receptors are expressed in almost every cell in our body.
- Thyroid hormone (triiodothyronine, T3) produces an overall increase in metabolic processes within the body. In response to extended nutritional and thermal stress, T3 levels fall to conserve on-board energy stores and reduce metabolism.
- In captive animals, serum cortisol methods were validated using sera obtained from captive KW (Suzuki et al, 2006), and assessed in males and pregnant females (Robeck et al, 2016, 2017). These studies indicate that significant circadian and seasonal oscillation occurs, and these fluctuations differ between sexes (e.g., captive females exhibit decreased cortisol in summer months, n=11 animals over 28 pregnancies; males NSD with season; n=14).
- A low T3/GC ratio is thought to be indicative of nutritional stress, whereby an animal is reducing overall metabolic rate through T3 suppression, and elevating GCs to stimulate mobilization of endogenous stores to support metabolic processes.
- Wasser et al (2017) found that the unsuccessful mid- to late-stage gestation SRKW pregnancies were correlated with a low T3/GC ratio (significantly lower than successful pregnancies), and suggested that nutritional stress is impacting pregnancy success and limiting population growth.
- While significant progress has been made in hormonal analysis from various matrices collected in the field, diurnal and seasonal variability of GCs need to be taken into account to obtain better resolution of impacts (e.g., noise vs nutritional stress), and caution must be undertaken when temporally extrapolating these hormonal "snapshots, as the impacts of intermittent foraging bouts on the immediate hormonal state of the animal may lead to erroneous conclusions.

O. Behavioral response of SRKW to acoustic disturbance (*Marla Holt, NWFSC*)

- Effects of sound exposure including auditory, behavioral and physiological effects
  - Frequency range of best hearing sensitivity in killer whales is 20-50 kHz, then don't hear well below 600 Hz or above 114 kHz
- SRKW soundscape/critical habitat is dominated by vessel traffic
- Vessel noise has potential to mask acoustic signals of whales
  - Vocal responses to noise should be interpreted as an anti-masking strategy by the whales

- Energetic cost of vocal responses in bottlenose dolphins are small (Noren et al.) relative to other costs of boat disturbance such as loss of foraging time
- Number of vessels and vessel speed are important explanatory variables of noise exposure in SRKW
- Boat sonar use (for navigation at 50 kHz) has the potential to affect resident killer whale auditory function (e.g. masking) or behavior
- There is a high need to understand how vessel attributes, operating behavior and associated noise affect SRKW behavior, especially foraging behavior given the implicated energetic cost associated with loss of foraging time with boat disturbance

P. Energetic costs of killer whale responses to disturbance (*Dawn Noren, NWFSC*)

- Overall, the energetic costs of surface active behaviors in response to disturbance are relatively low due to the propensity of killer whales to perform tail slaps (very low energetic cost) more often than other more expensive surface active behaviors (e.g., breaches), and that in general, surface active behaviors are performed sporadically.
- Energetic costs of producing echolocation clicks and social sounds, as well as modifying the total cumulative energy of sounds produced in response to acoustic disturbance, are relatively low. Though, producing sounds at depth can slightly reduce a killer whale's total body oxygen stores at depth, which may slightly shorten total dive duration. This magnitude of the impact is directly related to the total cumulative energy of the sounds produced, which is dictated by duration, frequency, and amplitude (loudness) of the sounds.
- Energetic costs associated with changes in swim speed and daily activity budgets are relatively low.
- Cumulative energetic costs associated with all changes in behavior combined are relatively low.
- Time spent foraging can be significantly reduced in the presence of vessels and is likely to have the largest impact on vital rates.
- Future work should model the combined effects of increased energy expenditure and lost foraging opportunities on killer whale body condition and fitness.

Q. Anthropogenic activities affect accessibility of salmon for resident killer whales (*Lance Barrett-Lennard, Coastal Ocean Research Institute*)

- Aggregations of fishing vessels on SRKW foraging hotspots decreases accessibility of salmon prey due to an interference effect.
- SRWK often pursue salmon at or near the surface. These chases are readily disrupted by nearby vessels.
- In view of the small size, declining average body condition and negative population trajectory of the SRKW population, fishing restrictions on foraging hotspots and measures to increase minimum approach distances of boats to SRKW should be considered, especially in years of poor salmon returns and/or when killer whale body condition is poor.

R. Responses of killer whales to boats (*Rob Williams, Oceans Initiative*)

Responses of killer whales to boats (based on experimental data from focal whales)

- Subtle, but significant effect of 1 boat following guidelines
- More dramatic avoidance response to 1 boat breaking guidelines
- Avoidance responses disappear with many (4-17) boats

- Based on scan-sample data of all whales, all activity states:
- Time-discrete Markov chain modelling of scan-sample data: evaluate effects of boats and location
- Activity budgets differed inside and outside Robson Bight Michael Bigg Ecological Reserve (i.e., spatial variability in behaviour has to be taken into account when considering area based management tools to mitigate disturbance)
- Activity budgets differed in the presence and absence of boats
- Whales were more likely to travel and less likely to feed when boats were present than when boats were absent
- Replicating the study with SRKWs
- NMFS-funded study (2003-2005)
- Had to create no-boat (control) data based on no boats within 100m, because boats were ubiquitous
- NRKW study had 12X larger sample overall, & 8X larger sample of no-boat data (within same zone in RBMBER)
- The two studies (Williams et al (2006) & Lusseau et al (2009)) reported similar findings
- Effect sizes were 18% (NRKW) and 25% (SRKW) reduction in feeding in presence of boats relative to control conditions

Physical presence vs noise (NRKW)

- Difficult to tease apart the physical presence from the acoustic effect, but there are a few lines of evidence to suggest that crowding (i.e., physical presence) does matter:
  - Dose-response curve to ship noise: Received level alone was essentially uninformative, despite relatively large sample size. In other words, this is empirical evidence that behavioural context matters
  - Kayaks: Lusseau (NOAA tech report) found that presence of kayaks (and no other power boats) caused NRKWs to increase the probability that they would switch to travel activity state, but no evidence to suggest that they would decrease probability of switching to feeding state, than when no boats were around.

Population viability analyses

- Lacy et al (2017) did individual based models of SRKWs, running scenarios on prey (Ford/Ward), PCBs (Hall), and noise (a factor that could increase (mitigation) or decrease (additional noise & masking) foraging success proportionally
- The best estimate is that SRKWs need 30% more Chinook than the long term average – akin to the best year (1979?) we had in the dataset
- That alone is insufficient to reach recovery target.
- Meeting recovery target required both prey abundance & accessibility

Foraging areas: focal follows

- Identifying & protecting feeding hotspots
- We already have a lot of data to tell us where we could do fine-scale management of fishing (e.g., time-area closures) around SRKW feeding hotspots (Ashe et al. 2010)

Niche partitioning

- Beerman et al. (2016) found that NRKWs partitioned their foraging habitat, with females and calves foraging closer to shore and males foraging throughout Johnstone Strait.
- It would be worth reanalyzing focal follow data (e.g., Williams et al. 2009, Ashe et al. 2010) to explore whether SRKWs have a similar niche partitioning

Physics

- more noise equals less acoustic habitat
- SRKWs are losing a lot of acoustic communication space, and some acoustic foraging space (Williams et al. 2010).

- As we try to make noisy areas quieter, let's also try to keep quiet areas quiet.

Conclusions

- Presence and noise of boats do disrupt feeding activities in SRKWs and NRKWs
- We can identify areas used preferentially for feeding (Salmon Bank).
- One population viability analysis found that we need a 30% increase in Chinook salmon accessibility to reach one stated SRKW recovery goal (Lacy et al. 2017)
- One risk assessment tells us that it may only take a 5-10% chronic impact on foraging efficiency (i.e., a 5-10% drop in accessibility of Chinook salmon) over long-term average salmon accessibility to cause serious, population-level effects (Williams et al. 2016)
- What proportional increase in abundance would it take to reach a 30% increase in accessibility, given other predators in the system (Chasco et al. 2017)

S. Synthesis & discussion of key points from Day 1 (*John Ford*)

- SRKW are not doing well and we are not likely to reach the recovery criteria without making serious changes
- SRKW population status is an anomaly – NRKW, Alaskan, Biggs KW are all doing well
  - Lower survival, fecundity, fewer reproductive females, fewer juveniles
- The current number of reproductive females is about the same as 1976 – same probability of a population increase?
- This year there have been a few unexpected deaths
- Recent trends decoupled from Chinook – some record high abundances (but they were high migrating Chinook (and thus available to Alaskan KW?)
- Social stability of KW correlated with Chinook abundance
- Male survival is lower if socially disconnected
- Paternity patterns indicate a few old males (J1, L4) sired many offspring
- No real evidence of inbreeding avoidance
  - Contrasts to NRKW – many number of clans is the difference? Perhaps just fewer options available to SRKW
  - Cost of inbreeding might be less than losing the benefits of group living
- Slight increase in survival with heterozygosity
- No evidence that SRKW group was significantly larger in the relatively recent past (prior to settlement)– was thought that historical group number was much higher
  - Interesting for recovery targets
- Studies outside Core Area
- Passive acoustic monitoring, satellite tagging: Habitat distinction between K,L and J's
  - J's don't go south of Cape Flatery, make use of upper Georgia Strait
  - Whales tend to vocalize less in winter compared to summer
- Recent modelling work with variety of data sets off SW Vancouver Island and Juan de Fuca Strait – focus on presence only models, machine learning, maximum entropy models
- Area of entrance to Juan de Fuca – important to both NRKW
  - Acoustic monitoring suggests NRKW found more frequently and in higher numbers than previously thought – especially G clan
  - Possibility for competition should be factored in
- Foraging dives are kinematically distinct
  - match well with what would be expected for Chinook predatory behavior – buzzes, clicks, crunching – prey sharing
  - Males higher frequency of buzzes and clicking, fair amount of surface foraging, make more deep dives compared to females
- Capture rate of males higher than females
  - hasn't been seen with focal fallow studies in NRKW
- Steelhead relatively important for SRKW

- DFO SRKW winter diet – Chinook predominated, chum second, lower Fraser important
- Summer, fall, winter – reviewed existing info and new data on fall in Puget Sound
  - number chum jumped to similar numbers seen in NRKW – important not to lose sight of importance of chum especially when Chinook numbers are low
  - Fecal samples in Puget sound – higher numbers of Chinook
  - Outer coast – Chinook, steelhead, halibut
  - Hunting in shallow water
  - Taking younger Chinook than NRKW
- SRKW in summer maybe requiring 13-60% of selected runs available to whales over course of summer
  - Chinook availability may be inadequate to support SRKW recovery
- Blubber thickness to body length ratios
- Relationship to girth length ratio
- High amount of precision with high resolution drone photos
- 2016 SRKW are in poorer condition than in 2008
  - Not just females but calves themselves are showing poor body condition
  - Comparing NRKW better condition across the board
  - J Pod in better condition in September than in May at least in recent years – same observation in NRKW
  - Inconsistent with Wasser – SRKW coming in early in summer in good body condition based on hormone analysis
  - Transients much more robust in body condition –growing despite high levels of contaminants – not metabolizing blubber
- Successful and unsuccessful pregnancies based on hormone assessments
  - Do not know if aborted or lost as neonates in first weeks or months
  - Could be combo of both
  - High calf mortality in first 6 months
  - Periodic nutritional stress – often associated with unsuccessful pregnancies
- Cautionary notes in interpreting hormone levels – one good bout of feeding can adjust hormone levels but not body condition
  - T3 elevation
- Metabolic cost of vocalization is not that much
- A lot of interannual variability in anticipated decrease in noise exposure based on DTAG work
  - Coincided with increase in vessel speed
  - Vessel speed and vessel counts are important variables (not distance)
  - Distance effect could be lost?
  - There were a lot of other variables that complicated boat and acoustic scene
  - Boat sonar hasn't received enough attention – supposed to be directional and narrow but not in practice – needs more attention
- Surface active behaviours and swimming are also minor in energetic cost
  - But overall activity will be affected close to boats because of the reducing foraging abilities (proportion of time spent feeding is lower – up to 6 times reduced prey intake)
- Compilation of non-systematic observations is important
- How animals find prey aggregations, pursue, what can get in the way
  - Easily affected by boats
  - Chases can occur over 100s of meters, as well as prey sharing, which is a problem if boats are in the way
  - Different of escape responses of chinook and chum
- SRKW need 30% more Chinook than long term average as well as increased feeding efficiency by decreasing noise
  - Further work needed on noise
  - Big gap – how noise levels and frequency content affect echolocation ability

Discussion

- Sheer numbers and recovery rates suggested in recovery plans are not necessarily helpful with the SRKW – we will never be satisfied

- Consider number of reproductive females instead?
- Body condition? Can be assessed with both aerial photogrammetry and hormone analysis
- Males appear to be more vulnerable than females based on caloric need, but we will first see the problem in females
- Vulnerability of males is buffered by prey sharing
- Percentage of time animals spend foraging has reduced, as well as time resting, and more time is spent travelling
- Comparisons between NRKW and SRKW extremely powerful

November 16, 2017

Day 2 – Availability of Chinook Salmon

T. Conclusions of the Independent Science Panel on the Effects of Salmon Fisheries on SRKW (*Sean Cox, Simon Fraser University*)

- NOAA and DFO appointed an expert science panel to provide an independent review of the evidence available and advice on future research.
- In 2012, the panel concluded that the SRKW population increased at an average rate of 0.71% per year, and would be expected to increase at about 1% per year in the long term if sex ratio at birth were 50:50.
- The panel believed that the existing delisting criterion of 2.3% growth rate was unlikely to be achieved given current circumstances or by reducing Chinook salmon fisheries. But if the total abundance continued to increase, a point would be reached where a reappraisal of their status would be likely.
- The evidence for strong reliance on Chinook salmon in the summer was convincing, but it was also clear that SRKW switch to alternative, more abundant chum salmon when Chinook of suitable size and quality are not readily available in the fall.
- Photographic evidence supported the assertion that poor condition, which was linked to mortality, and by implication to fecundity, may reflect nutritional stress. However, unless a large fraction of the population experienced poor condition in a particular year, and there was ancillary information suggesting a shortage of prey in that same year, malnutrition remained only one of several possible causes of poor condition.
- The maximum long-term increases in abundance of Chinook salmon that might theoretically be available to SRKW would be achieved by eliminating all ocean fishing (typically at least 20% increase in ocean abundance of age-4 and age-5 hatchery and wild fish due to elimination of ocean fishery interception of immature fish) and by maximizing recruitment through manipulation of freshwater exploitation rates to maximize recruitment (6- 9% increase in recruitments of wild fish; no impact on hatchery fish).
- The best potential for increased Chinook salmon abundance was restoration of freshwater habitat, reducing downstream migration mortality and a change in ocean conditions.
- The panel saw many potential reasons why not all foregone Chinook salmon catch would be available to SRKW, and was therefore skeptical that reduced Chinook salmon harvesting would have a large impact on the abundance of Chinook salmon available to SRKW.
- The statistical analysis by NOAA and DFO scientists were excellent, but the Panel believed considerable caution was warranted in interpreting the correlative results as confirming a linear causal relationship between Chinook salmon abundance and SRKW vital rates.

- The Panel was not confident that understanding the interaction between Chinook salmon fisheries, other predators and SRKW vital rates, was sufficient to expect the model predictions of increased SRKWs to be accurate. The Panel expected the model predictions to overestimate the impact of reductions in Chinook salmon catch on SRKW.

U. Effects of Chinook abundance on SRKW (*Eric Ward, NWFSC*)

- In the previous workshops, NOAA and DFO pursued studies described as 'correlative' linking indices of salmon abundance to killer whale demographics
- These kinds of studies have been problematic for a number of reasons. These include low sample sizes, analyses largely on a single population, results and estimates that are sensitive to the time period used or stocks included. The take home for us at NOAA has been this line of work is probably not likely to be informative with respect to identifying the Chinook stocks that are most important to whales
- I provided several recommendations for metrics. It seems like metrics that are informative with respect to measure change are important. Combined with well-designed data collection, it seems like we also want to try to have high power to detect change.
- I also provided some thoughts on new data collection. Instead of demographic rates, it seems like some of the more fine resolution data in space or time would be more promising (photogrammetry or health info)

V. Recreational fishery interactions with killer whales (*Martin Paish*)

No summary provided

W. Abundance Trends & Status of Chinook Salmon Consumed by SRKW (Canadian Stocks) (*Mary Thiess, DFO*)

- Due to the complex range of Chinook Salmon life histories, it is often difficult to estimate abundance of a given Chinook population over time and space (i.e., there are multiple age classes in a given return year for any given stock).
- Differences in life history strategy among Chinook populations of interest to SRKW may help identify factors limiting SRKW recovery (i.e., poor returns of age-4 and age-5 Spring and Summer run stocks to the Fraser River via Juan de Fuca Strait).
- Many of the reductions in total Chinook abundance have been absorbed through reduced fisheries impacts, rather than reduced terminal runs.
- Many of the Canadian Chinook Salmon stocks that are important prey for SRKW are also of concern under the Wild Salmon Policy (e.g., Fraser Spring and Summer Runs).

X. Recent trends in abundance of Chinook salmon stocks (Washington, Oregon, California) (*Robert Kope, NWFSC*)

Recent years

- Except for the extreme southern end of range, abundance of most stocks has not declined in the past 6 years.
- Columbia River summer and upriver bright stocks have had recent record high abundance.

Immediate outlook

- Nearly all runs appear to be lower than last year.
- Nearly all Columbia River Chinook and coho stocks have returned at levels below forecast and below their 10-year averages.

- The outlook for California stocks in the next few years is bleak.

Y. Trends in body sizes of Chinook (*Jan Ohlberger, University of Washington*)

- Many Chinook salmon populations along the West coast of North America are returning at younger ages compared to a few decades ago. However, age trends vary within and among regions, with BC populations showing no consistent trend toward younger mean ages.
- The size-at-age of older fish has declined in most populations coast-wide. Among those population examined, an exception are the southernmost populations from CA and southern OR, as well as some Puget Sound populations.
- The causes of declining mean body sizes are likely complex and involve multiple drivers, which should be further investigated in future studies. Potential drivers include fishing, climate change, hatchery practices as well as predation by a growing number of Alaskan and Northern resident killer whales.

Z. Factors influencing abundance and productivity of Chinook salmon consumed by SRKW (*Gayle Brown, DFO*)

- Trends identified in propensity toward earlier maturation, within the 6 stocks of focus in the presentation and also observed in other Chinook stocks from southeast AK to OR can be expected to reduce abundance of Chinook that appear to be most common in the diet of SRKW
- The same expectation holds for trends observed in decreasing size at age in older, larger female and male Chinook in the Big Qualicum, Quinsam, Lower Shuswap and Harrison rivers
- Trends toward early age of maturation and declining size at age are factors that each likely have the potential to reduce Chinook stock productivity
- Fisheries having higher exploitation rates on older, larger fish may also be contributing to reduced numbers of these fish returning to spawn and accessibility to SRKW
- Preliminary analyses of DFO data on fecundity of female Chinook suggests that a trend toward reduced fecundity may exist in at least two stocks – Lower Shuswap River and Quinsam River.
- Trends toward earlier maturation and declining size at age are likely to reduce the productivity of affected Chinook stocks even if survival rates and the productive capacity of rearing and spawning environments were at average levels
- A study that investigates the likely causal factors leading to changes in Chinook stocks as noted in my presentation could be useful to assess whether the trends are short-term and may reverse or are longer-term and may not reverse

AA. Climate change and Pacific Northwest salmon: a review of what might happen (*Robert Kope, NWFSC*)

No summary provided

BB. Chinook Salmon: Ancient Fishing (*Teresa (Sm'hayetsk) Ryan, University of British Columbia*)

- Chinook salmon has special significance to First Nations in British Columbia as a food source and as part of the legacy of First Nations cultures, including their connections to killer whales
- Ancient Aboriginal fishing technology captured high volumes of fish such as the use of stone tidal salmon traps; a current project is being developed to test these stone traps as a rebuilding mechanism for

salmon populations and measuring the delivery of marine derived nutrients from salmon to the forest ecosystem

- Consistency in the size and abundance of resources was much different in the past than it is today; Babine and Elwha Chinook and the Columbia River 'June Hogs' (Chinook) were known for their very large size; these large fish would be important to killer whales
- In the past, Aboriginal fishing strategies incorporated mechanisms for allowing the largest fish and female fish to pass through to escapement facilitating consistent qualities for reproductive success of larger fish; today many tribes are working to restore salmon
- Several tribes/First Nations in the Pacific Northwest are experiencing severe hardship as a result of the decline in salmon populations; as an example, the Yurok tribe allocation has been reduced from 100,000 to 650 fish in the Klamath River fisheries
- Habitat impacts have caused declines in many fish populations such as the Klamath and also in other California and Columbia River Chinook populations with many listed under the *Endangered Species Act*

CC. Overview of past and present management of Chinook fisheries. Historical overview of trends in Chinook catch among fisheries and regions within the jurisdiction of the Pacific Salmon Treaty (*Wilf Luedke, Bryan Rusch DFO*)

- In the 1970s-80s there was generally high chinook productivity, high fishing effort and fleet capacity, high exploitation led to a co-operative effort to reduce fishing … through the PST.
- Chinook production became more variable, and declined in many areas, after consecutive El Nino in the early and late 1990s and general changes in ocean conditions. Productivity has remained low in some systems. Other factors such as freshwater habitat degradation, hatchery influences, age specific exploitation are some underlying factors. There are exceptions such as the south Thompson River, Columbia River, and more recently Cowichan River chinook.
- Since 1985 the Pacific Salmon Treaty has defined the overarching management of Chinook from southeast Alaska to Oregon. Renegotiation about every 10 years provides opportunity for adaptive management of Chinook. Significant reductions in catch were implemented in each of the last 3 PST agreements. Over the period of the PST, coast-wide catches of Chinook have been reduced by about 50%. The fisheries offshore of the west coast of Vancouver Island have been reduced by over 70%.
- Canada also implemented several policies and programs to reduce fishing over-capacity and effort, to improve selectivity of fisheries, and become more precautionary in fishery management.

DD. Fine-scale catch and effort data with emphasis on southern BC areas (*Wilf Luedke, Bryan Rusch*)

- In the Juan de Fuca area recreational fisheries were restricted beginning in 2009 with greater restrictions starting in 2012 under 'Zone Management' of Fraser spring and summer chinook.
- These restrictions reduced impact on larger age 4 and age 5 wild chinook returning to the Fraser and other areas of the Salish Sea.

EE. Fine-scale catch and effort data with emphasis on US areas (*Kirt Hughes*)

No summary provided

FF. Synthesis and discussion of key points from Day 2 (*Brian Riddell, Pacific Salmon Foundation*)

- Unclear whether there is clear seasonality in SRKW feeding and diet
- Important to acknowledge that SRKW pods have different trends
- The projected value in fisheries reductions is probably overstated
- Natural mortality rates likely substantially higher than shown – probably true but no way to measure, measured in past
- All Chinook stocks are different and marine survival must be taken into account
- Hatchery production is much bigger than natural production – competition in marine environment
- Metrics must be developed to conduct assessments on the effect of Chinook on SRKW
  - Due to small populations size the ability to measure things statistically is probably not a good metric
- Recreational sounders operate at two frequencies – consider the upper range (~200 kHz), which may not have as big of an effect on SRKW
- There needs to be a lot of consultation and be prepared for push back
  - Education and communication is key
  - Evidence based and measurable – people need to be armed with good information
  - BC boaters may be causing more interference than recreational fishers
- Determine/use indicator populations for Chinook
- Fisheries recoveries and trawls provide reliable data for Chinook distribution coast-wide
- Smaller Chinook – younger maturing fish in southern stocks
- One of the biggest concerns is loss of larger, older aged fish
  - Random breeding in hatcheries always results in selecting younger aged fish – now starting to compensate by selectively breeding older fish
- Fecundity needs to be measured by size and age
- Climate change – reality is the situation we have today is the situation we will be dealing with for a long time
- How are we going to conserve Chinook and minimize the effects?
- Synchronicity in stocks is much greater now – alarming because no noise to create balance
- Appropriate harvest rate needs to be determined by productivity of stock. A stable value does not make sense.
- Need long-term conservation plans. Cannot compensate for reducing fisheries.

Discussion

- Exploration of the conclusion from the Independent Science Panel that that restrictions in fisheries may not lead to net increase in available Chinook salmon because forgone salmon available to predators
  - What is the evidence that 4 and 5-year-old chinook are taken by pinnipeds in open water?
  - Overall, they do not make up a huge proportion of pinniped diet – but hard to know for certain because don't swallow otoliths
- The reasonable expectation is that reducing fishing is going to give fewer results than expected
- Most Chinook fisheries are fished at less than half of sustainable harvest rates already
- The biggest consumers of biomass are killer whales, then sea lions
- In some areas like the Cowichan, pinnipeds are selectively eating Chinook
- At the mouths of rivers harbour seals take both juveniles and returning adults
- Most predation by other marine mammals occur in estuaries – not direct competition for SWKW
  - Overall feeling – pinnipeds are not a big part of accessibility issue for SRKW
- Of large concern is the decline in body size of older fish

- KW may be selecting for this, cropped off the bigger size classes
- Now northern residents have increased – will start to move down size classes
- Fisheries are also taking larger fish
- Combination of both

- Chinook are such great prey for SRKW for numerous reasons: predictable in time and location, high lipid content, big
- Must start to look at biomass
  - Declining trend in SRKW pop size despite abundance of Chinook staying relatively the same (except for the lower end of their range)
  - Take a step beyond biomass and look at caloric content – monitor oil content?

GG. Southern resident killer whale recovery (*Lynne Barre, NOAA*)

Background

- Southern Residents listed as endangered under the Endangered Species Act in 2005
- Critical Habitat designated in 2006
- Recovery Plan completed in 2008
- 10 Years of Research and Conservation Report 2014
- Species in the Spotlight Action Plan 2016

Recovery Program

- Open, transparent and inclusive process for recovery planning and implementation
- Comprehensive recovery program to address all of the threats- limited prey, high levels of contaminants, disturbance of vessels and sound (also risk from oil spills/disease)
- Science-based decision making http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/

Highlights for Recovery Implementation

http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/planning_implementation.html

Contaminants and Health

- Coordination on water quality and contaminants with Puget Sound Partnership, Action Agenda for Puget Sound, http://www.psp.wa.gov/action_agenda_center.php
- Report and recommendations for PBDEs, https://www.eopugetsound.org/articles/report-potential-effects-pbdes-puget-sound-and-southern-resident-killer-whales
- Oil spill response plans, http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/rpi_oil_spills.html
- 2015-2017 SRKW health workshops
  - What is causing decreased reproduction?
  - What is causing increased mortality?
  - Recommendations and priorities, http://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/killer_whales/srkw_healthpriority_dec2015.pdf
- Update on body condition, http://www.seadocsociety.org/?s=killer+whale+body+condition
- Next steps: Health database, develop health index, photogrammetry and links to biomarkers and prey, track and sample animals of interest (fecal, breath), body condition and blubber thickness/content, and stranding investigations- causes of death, disease and pathogens

Vessels and Sound

- Be Whale Wise, www. bewhalewise.org
- 2011 Vessel Regulation implementation and review (Technical Report available soon)
- Dtag research studies
- Land-based viewing, thewhaletrail.org
- Coordination with Port of Vancouver ECHO project, https://www.portvancouver.com/environ

ment/water-land-wildlife/marine-mammals/echo-program/

- Petition to consider Whale Protection Zone, http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/vessel_regulations.html

Prey

- Coordination with coast wide salmon recovery effort
- Bilateral expert panel review of salmon fisheries and SRKW (Hilborn et al. 2012), http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/effects_fisheries.html
- Next steps: 2018 workshop focused on increase prey abundance

ESA section 7 Consultations

- Ensure that federal actions will not jeopardize endangered Southern Residents or modify/destroy critical habitat. Types of actions:
  - Fisheries plans and regulations
  - Hatchery production and plans
  - Hydropower actions
  - Upland projects (Flood Insurance Program)
  - Water treatment plants, sewer outfalls
  - In-water construction
  - Pile driving sound, increase in vessels (docks, marinas), dredging (contaminated sediments)
  - Tidal and wave energy projects, LNG terminals
  - Navy and Coast Guard operations
  - Research on Southern Resident killer whales

Mitigation for actions that impact quantity, quality and availability of salmon prey for the whales

- Reductions in prey abundance short-term and long-term (fishery/hatchery/hydro/habitat) minimized through caps, hatchery production offsets, timing of hatchery reductions, mitigation for impacts to salmon and their habitats
- Contaminants minimized through monitoring inputs, mixing zones, threshold levels, spill prevention and cleanup plans
- Sound/acoustic impacts (i.e., pile driving, docks, marinas, sonar, seismic) minimized through monitoring and shut downs, promoting vessel regulations and guidelines
- Workgroups and research to fill data gaps and inform risk analyses

Developing coastal critical habitat

http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/critical_habitat.html

Education and Outreach

http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/rpi_education_outreach.html

HH. Southern Resident Killer Whales and DFO's Species at Risk Program: Protection and recovery (*Lisa Jones, DFO*)

Species at Risk Act

- Purpose to prevent wildlife from becoming extinct, secure recovery of listed species (Extirpated, Endangered and Threatened), manage species of Special Concern to prevent them from becoming at further risk
- Provides legal protection to individuals of species and for habitat critical to survival and recovery of listed species

Northern (NRKW) and Southern (SRKW) Resident Killer Whales: SARA timeline and process

- 2003: NRKW listed as Threatened & SRKW listed as Endangered
- 2008: Recovery Strategy finalized; identifies recovery goals, 3 key threats (prey availability, contaminants & disturbance), strategy for recovery, Critical Habitat (amended in 2011)

- 2017: Action Plan finalized; identifies 98 recovery measures to address threats and recovery populations
- 2017: Science-based Whale Review and Symposium held; identifies 5 new recovery measures and additional threat of vessel strikes

SRKW Critical Habitat (CH)

- Existing CH identified in the *Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada*. (DFO 2011) and protected from destruction by CH Order.
- Additional habitat of special importance (proposed additional CH) to SRKW identified as waters off southwestern Vancouver Island, including Swiftsure and La Perouse Banks (Ford et al. 2017); process started by SAR team to consider this additional habitat as CH in an amendment to the Recovery Strategy. Includes proposed new CH for NRKW as well.

Work planning and implementation phase of SAR recovery process

- 98 recovery measures in Action Plan being prioritized and relevant activities (management, science, education) to abate the identified threats to RKW are being identified; activities may be carried out by DFO, in collaboration with DFO or identified for lead by other groups.
- 35 of these recovery measures address the threat of reduced prey availability, with 24 identified as high priority
- 3 of these recovery measures are a combination of research and management approach

Other "Protections"

- Marine Mammal Regulations:
  - Proposed amendment to introduce a 100m minimum approach distance, with alternative approach distances tailored for particular circumstances possible
  - Provision prohibiting flight maneuvers of aircraft intended to bring the aircraft closer to a marine mammal.
  - Provision to allow Minister of Fisheries and Oceans to authorize, by licence, activities that may disturb marine mammals, but would otherwise provide benefits to the conservation and protection of the species.
  - Provision that requires reporting to DFO of any accidental contact with a marine mammal (e.g., entanglement, collision).
- Licensing requirements, and Fishery Notices could be used to provide a form of protection
- Be Whale Guidelines provide voluntary guidelines for responsible behavior around marine mammals to reduce disturbance to them.

November 17, 2017

Day 3 – Evaluation of Potential Mitigation Measures

II. Synthesis and discussion of key points from Day 3 (*Mark Saunders, Year of the Salmon*)

- There was a good balance of fish and whale scientists and managers, and a lot of common ground between them.
- The four discussion groups assessing the three Management Actions all seemed to be heading to the same end.
- A small group of whale and Chinook people—both managers and scientists—should hold a subsequent meeting to develop the detailed strategies.
- The devil is in the details and the challenge will be to find the time for these busy people to do the work. It might be two meetings—one to design the strategies and required analyses, and then one once the work is completed.
- My overall impression is that there is a reasonable likelihood that tactics targeted at the stocks we know the whales utilize could result in more fish for the whales.
- How much fish is required could be potentially be calculated by stock reconstructions for photogrammet-

ric baseline years when the SRKW appear healthy. The challenge is to determine what combination of tactics (size limits, space and time closures) will actually provide demonstrably more fish.

- I suspect it is important to provide more large fish, which is complicated given the declining size-at age.
- Making better use of what fish are available could be realized by improving foraging success by reducing vessel disturbance both physically and acoustically.
- The declining size at age for Chinook as a key research gap. If killer whales/fisheries are selecting for large fish are they genetically modifying the population?
- At the very least, SRKW are at the end of the gauntlet and are consuming smaller fish. If smaller fish are of lower energetic value and if northern resident populations continue to grow, the impact on SRKW will grow.
- The larger fish are much larger targets given acoustic target strength is related to the swim bladder and increases exponentially with length. It could be small fish are actually harder to detect and catch. Interesting that the Chinook dive response would effectively reduce their target strength as the swim bladder collapses with depth and a down turned fish presents a smaller cross section target.

Appendix D: Management Action Tables

The following sheets were completed by workshop participants, and formed the basis for group discussions of the three Management Actions on Day 3. Definition of terms are in Appendix E.

Reduce Removals by Fisheries to Increase Coast-Wide Abundance *Page 1/3*

1. Broad Management Objectives	**A. Increase Abundance of Chinook Coast Wide**	
2. Broad Actions	**Reduce removals of Chinook by fisheries**	
3. Targeted Sector	**Commercial**	**Recreational**
4. Desired Increase *Describe the baseline and intended outcome of the Management Action*		
5. Specific Actions *How will the broad Management Action be attained?*		
6. How to Implement *Provide specific details on how any of the following might be implemented.*		
7. What Stocks to Manage		
8. Desired Reductions *Describe the proposed reduction sought in the proposed implementation method to achieve the Management Objective.*		
9. Where to Implement		
10. Time of Year to Implement		

11. Scientific Confidence *How scientifically justifiable is this Management Action?*	• Low • Medium • High • Unknown • No consensus	• Low • Medium • High • Unknown • No consensus
12. Scientific Basis *What science informs this Management Action?*		
13. Knowledge Gaps *What information is missing and needed to evaluate whether this Management Action will achieve its intended goal?*		
14. Likely Benefit *What is the likelihood that the Management Action will significantly benefit SRKWs e.g., improve birth and survival rates; body condition, increase resting times, etc.?*	• Low • Medium • High • Unknown • No consensus	• Low • Medium • High • Unknown • No consensus
15. Performance Measures *What specific metrics can be used to quantify the effect of the proposed Action on SRKW? e.g., Where, when, and how should the information be collected? What would the information mean?*		

16. Timeframe *How long would the Management Actions have to be implemented before the stated goal is achieved (i.e., the threat is abated)?*	• Short (weeks) • Medium (months) • Long (years) • Short duration for many years • Unknown • No consensus	• Short (weeks) • Medium (months) • Long (years) • Short duration for many years • Unknown • No consensus
17. Evaluation Criteria *What thresholds can be quantified to facilitate adaptive management and determine whether the Management Actions need adjusting?*		
18. Other Considerations *What needs to be discussed or taken into account before deciding to implement this Management Action?*		
19. Effects on NRKW *What is the potential effect of the Management Action on northern resident killer whales?*		
20. Effects on Other Species *What is the potential effect of the Management Action on other species (e.g., seals, sea lions, etc.)?*		
21. Comments *Anything missing that should be noted?*		

1. Broad Management Objectives	**B. Increase Abundance of Chinook at Specific Times and in Specific Areas**	
2. Broad Actions	**Adjust removals of Chinook by fisheries**	
3. Targeted Sector	**Commercial**	**Recreational**
4. Desired Increase *Describe the baseline and intended outcome of the Management Action*		
5. Specific Actions *How will the broad Management Action be attained?*		
6. How to Implement *Provide specific details on how any of the following might be implemented.*		
7. What Stocks to Manage		
8. Desired Reductions *Describe the proposed reduction sought in the proposed implementation method to achieve the Management Objective.*		
9. Where to Implement		
10. Time of Year to Implement		

11. Scientific Confidence *How scientifically justifiable is this Management Action?*	• Low • Medium • High • Unknown • No consensus	• Low • Medium • High • Unknown • No consensus
12. Scientific Basis *What science informs this Management Action?*		
13. Knowledge Gaps *What information is missing and needed to evaluate whether this Management Action will achieve its intended goal?*		
14. Likely Benefit *What is the likelihood that the Management Action will significantly benefit SRKWs e.g., improve birth and survival rates; body condition, increase resting times, etc.?*	• Low • Medium • High • Unknown • No consensus	• Low • Medium • High • Unknown • No consensus
15. Performance Measures *What specific metrics can be used to quantify the effect of the proposed Action on SRKW? e.g., Where, when, and how should the information be collected? What would the information mean?*		

16. Timeframe *How long would the Management Actions have to be implemented before the stated goal is achieved (i.e., the threat is abated)?*	• Short (weeks) • Medium (months) • Long (years) • Short duration for many years • Unknown • No consensus	• Short (weeks) • Medium (months) • Long (years) • Short duration for many years • Unknown • No consensus
17. Evaluation Criteria *What thresholds can be quantified to facilitate adaptive management and determine whether the Management Actions need adjusting?*		
18. Other Considerations *What needs to be discussed or taken into account before deciding to implement this Management Action?*		
19. Effects on NRKW *What is the potential effect of the Management Action on northern resident killer whales?*		
20. Effects on Other Species *What is the potential effect of the Management Action on other species (e.g., seals, sea lions, etc.)?*		
21. Comments *Anything missing that should be noted?*		

1. Broad Management Objectives	**C. Increase Accessibility of Chinook in Specific Areas at Specific Times of Year**	
2. Broad Actions	**Decrease <u>physical and acoustic disturbance</u> of foraging killer whales by vessels**	
3. Targeted Sector	**Commercial** (fishing, whale watching, shipping)	**Recreational** (fishing, whale watching, boating)
4. Desired Increase *Describe the baseline and intended outcome of the Management Action*		
5. Specific Actions *How will the broad Management Action be attained?*		
6. How to Implement *Provide specific details on how any of the following might be implemented.*		
7. What Pods to Manage		
8. Desired Reductions *Describe the proposed reduction sought in the proposed implementation method to achieve the Management Objective.*		
9. Where to Implement		
10. Time of Year to Implement		

11. Scientific Confidence *How scientifically justifiable is this Management Action?*	• Low • Medium • High • Unknown • No consensus	
12. Scientific Basis *What science informs this Management Action?*		
13. Knowledge Gaps *What information is missing and needed to evaluate whether this Management Action will achieve its intended goal?*		
14. Likely Benefit *What is the likelihood that the Management Action will significantly benefit SRKWs e.g., improve birth and survival rates; body condition, increase resting times, etc.?*	• Low • Medium • High • Unknown • No consensus	
15. Performance Measures *What specific metrics can be used to quantify the effect of the proposed Action on SRKW? e.g., Where, when, and how should the information be collected? What would the information mean?*		

16. Timeframe *How long would the Management Actions have to be implemented before the stated goal is achieved (i.e., the threat is abated)?*	• Short (weeks) • Medium (months) • Long (years) • Short duration for many years • Unknown • No consensus		
17. Evaluation Criteria *What thresholds can be quantified to facilitate adaptive management and determine whether the Management Actions need adjusting?*			
18. Other Considerations *What needs to be discussed or taken into account before deciding to implement this Management Action?*			
19. Effects on NRKW *What is the potential effect of the Management Action on northern resident killer whales?*			
20. Effects on Other Species *What is the potential effect of the Management Action on other species (e.g., seals, sea lions, etc.)?*			
21. Comments *Anything missing that should be noted?*			

Appendix E: Table Definitions

Workshop participants received tables prior to the workshop with the following column headings and examples in an attempt to quantify and identify specific actions, goals, and methods of implementation regarding the broad management goals.

1. Broad Management Objective:

- **Option A:** Increase abundance of Chinook coast-wide by reducing removals by fisheries
- **Option B:** Increase abundance of Chinook by reducing removals by fisheries
- **Option C:** Increase accessibility of Chinook in specific areas at specific times of year

2. Broad Action:

- **Option A:** Reduce removals of Chinook by fisheries
- **Option B:** Adjust removals of Chinook by fisheries
- **Option C:** Decrease acoustic and physical disturbance of foraging killer whales by vessels

3. Targeted Sector: Commercial or Recreational

4. Desired Increase: Describe the baseline and intended outcome of the Management Action

Examples:

- Numbers of fish in foraging areas
- Accessibility of fish in foraging areas (e.g., uninterrupted foraging time and space)
- Unknown

5. Specific Actions: How will the broad Management Action be attained?

Examples:

- Reduce removals (com)
- Reduce daily possession limits (rec)
- Reduce annual limits (rec)
- Reduce number of harvesters (com & rec)
- Reduce fishing effort (com & rec)
- Reduce physical overlap with foraging whales and key foraging areas (com & rec).
- Reduce acoustic levels around foraging whales and in key foraging areas (com & rec)
- Other measures (e.g., gear restrictions, size limits, hatchery vs. wild retention, etc.)

6. How to Implement: Provide specific details on how any of the following might be implemented

Examples:

- Regulatory measures
- Licenses
- Openings
- Size limits
- Retention limits
- TAC—Total Allowable Catch

7. What Stocks to Manage:

- All Chinook populations
- Targeted populations (which ones?)
- Which pods (Option D)?

8. Desired Reductions: Describe the proposed reduction sought in the proposed implementation method to achieve the Management Objective

Example:

- % decrease or reduction sought in removals, effort, presence, etc.

9. Where to Implement:

Examples:

- Coast wide
- In foraging areas
- Seaward of foraging areas
- In SRKW Critical Habitat

10. Time of Year to Implement

Examples:

- Year round
- Seasonal
- Spring
- Summer
- Fall

11. **Scientific Confidence:** How scientifically justifiable is this Management Action?
    - Low
    - Medium
    - High
    - Unknown
    - No consensus

12. **Scientific Basis:** What science informs this Management Action?
    - Itemized list of important information

13. **Knowledge Gaps:** What information is missing and needed to evaluate whether this Management Action will achieve its intended goal?
    - Itemized list of important information

14. **Likely Benefit:** What is the likelihood that the Management Action will significantly benefit SRKWs e.g., improve birth and survival rates; body condition, increase resting times, etc.?
    - Low
    - Medium
    - High
    - Unknown
    - No consensus

15. **Performance Measures:** What specific metrics can be used to quantify the effect of the proposed Action on SRKW? e.g., Where, when, and how should the information be collected? What would the information mean?
    - Itemized list of performance measures for SRKW, Chinook abundance, and Chinook accessibility

16. **Timeframe:** How long would the Management Actions have to be implemented before the stated goal is achieved (i.e., the threat is abated)?
    - Short (weeks)
    - Medium (months)
    - Long (years)
    - Short duration for many years
    - Unknown
    - No consensus

17. **Evaluation Criteria:** What thresholds can be quantified to facilitate adaptive management and determine whether the Management Actions need adjusting?
    - Itemized list of threshold criteria and performance measures

18. **Other Considerations:** What needs to be discussed or taken into account before deciding to implement this Management Action?
    - Itemized list of considerations

19. **Effects on NRKW:** What is the potential effect of the Management Action on northern resident killer whales?
    Examples:
    - Unknown
    - Unlikely to have any effect
    - Might benefit them, etc.
    - Itemized list of considerations

20. **Effects on Other Species:** What is the potential effect of the Management Action on northern resident killer whales?
    Examples:
    - Unknown
    - Unlikely to have any effect
    - Might benefit them, etc.
    - Itemized list of considerations

21. **Comments:** Anything missing that should be noted?
    - Itemized list of comments

Appendix F: Notes from Group Discussions—Increase coast-wide Chinook abundance by reducing fisheries

These notes combine information transcribed during group discussions, and from tables filled out by workshop participants. They capture the 'as is' comments of participants on this potential Management Action, and are provided without interpretation.

1. **Option A: Increase abundance of Chinook coast-wide by reducing removals by fisheries**

2. Broad Action:
- Reduce overall removals of Chinook by fisheries

3. Targeted Sector:
- Most groups did not distinguish in their discussions between commercial and recreational fisheries, given the overall lack of support for this option
- However, consideration of this option did serve to generate a broader discussion regarding the relationship between SRKW and their prey

4. Desired Increase:
- From KW point of view need: more food, feed frequently, well-distributed prey, more abundance than observed in periods of decline
- Overall goal of Action is to increase abundance of stocks of importance (from prey ID)
- You would think that the primary need is to increase abundance in stocks that have had recent declines, but some stocks most prevalent in prey samples are also the most abundant runs
- Not just a need to increase abundance (biomass), but must also consider size/age given SRKW prey preferences
- Prime goal therefore is increase in Yr 4 & 5+ biomass to level of "good" years (but not necessarily best)
- Question of what levels of prey to use as a comparative baseline
- Current baseline: catches and abundance are lower than historic; other predators are higher than historic numbers
- Many stocks doing OK - don't know exact level of increased abundance needed
- Example: Harvesting 3-4% of Fraser before they get to the river. Overall in summer/inland 300,000 Fraser/300,000 Puget Sound=600,000 fish moving through Inland waters; what more is needed?
- Action viewed as a blunt instrument – 100% closures would reallocate pressure to terminal and freshwater fisheries
- Some First Nations would benefit some fisheries; not others

5. Specific Actions
- Harvest linked to abundance estimates: adaptive management, harvest control rule
- In years of low abundance reduce harvest rates: reductions in TAC, effort, IFMP, closures.
- Therefore also need to set threshold for what qualifies as low abundance year
- Current management approach: align with managing fisheries for fish stocks and add consideration for SRKW
- Challenge: by the time you realize salmon numbers are low, too late to impose meaningful management
- For recreational fisheries, while bag limits can address removing fewer fish, they generally target bigger fish (therefore minimal relief for SRKW that rely on larger older Chinook)
- Is it feasible to introduce additional recreational size limits?
- Limiting fisheries related incidental mortality - need to better understand effects of catch and release
- Suggestions for pilot study using tidal harvesting (First Nations traditional approach which also mirrors KW behaviour)
- Potential for license buybacks

6. How to Implement

- Generally felt that time and area restrictions (see Options B & C) are a more feasible approach. However, this Option could be implemented through:
- Change in harvest response
- Closures via IFMP
- License buyback
- Allocation reductions
- Shift pressure to terminal
- Adjust daily, annual limits, catch and release, size limits (recreational)

7. What Stocks to Manage

- Total closure may result in an overall increase of 20-30% increase in Chinook abundance in the critical habitat of SRKW
- Next step down: All stocks of Fraser River and those in US waters
- If not total closure, need to target what the whales are eating; some are largest stocks
- May take a stock-specific view and manage coastwide — get to it though differences in time/space importance
- But what about overall role of California stocks — biologically important to SRKW, but no harvest (nor likely to recover in foreseeable future)

8. Desired Reductions

- Tough to give number
- Model Fraser River returns to river with timing to look at density- build box car model link to metabolic needs of whale
- Sufficient to increase in Yr 4 & 5 biomass to level of good years (but not necessarily best)
- Proposed reduction would be cessation of anthropogenic pressure on Chinook population.
- Alternate proposed reduction would be to cease ocean removals of Chinook. However, if ocean fishery closures occur, a reallocation to terminal fisheries may result in a net increase in overall removals

9. Where to Implement

- By definition, Coast wide (California to SEAK) on any stocks that are potentially available to SRKW
- A small minority felt that such actions were warranted ("can't hurt") as a preventative measure
- Majority preferred some version of Management Option B/C

10. Time of Year to Implement

- By definition, all the time.
- Majority preferred some version of Management Option B/C

11. Scientific Confidence

- Low: even with precautionary approach, not well supported
- High confidence that coastwide closures will likely increase abundance short term (especially if terminal/FW fisheries are included), but:
- long term effect is unknown
- other predators may benefit
- no consensus on whether this will result in improvements for SRKW
- Additionally, most recreational fisheries are terminal
- Loss of support for hatcheries will likely result and lead to a possible decrease in abundance
- In theory, you would increase removals in that you will be focused on mature fish (terminal fishery). More efficient salmon management on a terminal fishery; however, allocation difficulties would result

12. Scientific Basis

- Good evidence that Chinook availability are impacting SRKW
- Body condition indicative of overall poor nutrition in the RKW population; food limited
- Stocks of importance identified from prey samples (John Ford et al; Hanson, Mike Ford)

- Knowledge of foraging areas
- Caloric need modelling
- Very little consensus, if any, that this type of Action will appreciably increase abundance to SRKW.
- Total closure *may* result in an overall increase of 20-30% increase in Chinook abundance
- But, most modelling indicates a lack of significant increase in key biomass *for SRKW*

13. Knowledge Gaps

- Foraging efficiency and predation rate?
- What are the current removals on stocks of importance?
- What is the NRKW contribution to the reductions of 4 and 5+ yr olds that enter into SRKW range?
- Will this lead to more fish for the whales?
- How do you perform fishery sampling without fisheries?
- Winter diet of J Pod – will Chinook management actions be enough given the variable nature of their diet?
- Continued scientific study likely unneeded, given lack of enthusiasm for this option (although many of the same Knowledge Gaps apply to other Options under consideration)

14. Likely Benefit

- Consensus was that benefit was likely "Low"
- Some discussion of overall reductions in fisheries would help even if small impact, and a few (one) said it should be done as precautionary measure even if not likely to have any benefit
- Another aspect of precautionary approach: broad view of all stocks, even if not seen in diet samples; these other stocks could be important or fill gaps if primary prey stocks decline

15. Performance Measures

- Very little support for this Option. However, it did lead to a broader discussion of potential performance measures for some variant (such as Options B and C):
- Needs to be something done every year, seasonally
- Whale measures- compare to baselines of when whales were doing better
- Body condition- use 2008 as baseline and look at differences
- Pregnancy rates- more successful pregnancies, photogrammetry and hormones
- Monitor demographics (pregnancy rates, birth rates, age-specific survival)
- Body condition (particularly of females and calves)
- Foraging behaviour (although questions of how to interpret), including foraging bout length (within a year)
- Hormones (stress, nutritional status)
- Foraging efficiency (Dtags)
- Fisheries surveys to monitor ocean abundance of salmon in SRKW range
- Evaluate abundance outside the range of SRKW (evaluate effects of predation)
- Monitor terminal run size

16. Timeframe

- Short term: immediate effect on Chinook abundance;
- Medium (months)- whale body condition could be observed over months (but for several years), also observable changes in SRKW foraging behaviour
- Long (years) – annual basis for salmon abundance measures, and also to observe any significant impact on SRKW population characteristics

17. Evaluation Criteria

- Percent reductions in catch compared to previous years- measure overall abundance through state escapement surveys (including age composition)
- Hard to link to longer term SRKW population level impacts
- Body condition improvements beyond a set threshold
- Modelling (FRAM?)
- Demographic changes that favour an increased trajectory

- Changes in observed foraging success is observed

18. Other Considerations

- Economic impacts of coastwide fishery reductions are less likely to benefit killer whales and more likely to impact broad stakeholder groups
- Public pressure: coastwide closure is often suggested and is widely supported in some advocacy circles, so need better communication to provide clear rationale of why this isn't the best option
- Support of other more viable options can help explain more surgical approach to provide more reliable benefit vs coast wide blunt approach with more uncertainty and bigger impacts to other sectors
- Most feel a clear benefit has to be demonstrated to warrant consideration; a small minority felt it was still feasible as a precautionary measure
- Loss of motivation to maintain hatcheries will have a negative effect

19. Effects on NRKW

- Beneficial
- Coastwide fishery reductions would increase prey for NRWK (and also competition from this group)
- Likely more substantial effect on NRKW, as higher up on migration route.

20. Effects on Other Species

- Likely minimally beneficial
- Could increase number of competitors

21. Comments

- What is the baseline we are working with (KW distribution and condition, Chinook supply)? Are we setting the bar too low?
- Don't forget: Chum, coho and steelhead also very important
- Generally more terminal fisheries, some marine fishing for chum; stock ID of chum needed, chum may be able to fill key gap if the summer Chinook are limited
- Details of Chinook population needed (m/f)
- Unknowns on ecosystem-based effects
- If successful, what would the new salmon set point be? What would the efforts be habitat capacity and productivity?
- Forage fish management

Appendix G: Notes from Group Discussions—Increase Chinook abundance at specific times and places

These notes combine information transcribed during group discussions, and from tables filled out by workshop participants. They capture the 'as is' comments of participants on this potential Management Action, and are provided without interpretation.

1. Option B: Increase Abundance of Chinook in Times and Specific Areas

2. Broad Action:

- Adjust removals of Chinook by fisheries

3. Targeted Sector:

- Focus on fisheries that meet two criteria – those exploited at high rates (over 5%), and are known to be a component of the KW diet
- *Commercial*
  - Locations: those with highest Chinook catch; generally outside (to the north) of SRKW range
  - Seasons: those with highest Chinook catch - summers
- *Recreational*
  - Locations: Area 121 and 123 sport catch, pockets of fisheries in and around vicinity of mouth of Fraser River
  - Seasons: some all year, some summer

4. Desired Increase:

- Overall goal is to increase abundance of 4 & 5+ yr old Chinook at key times/places important for SRKW foraging
- Maintain summer abundance, and seek opportunities to increase winter abundance
- Increase Chinook (chum and coho, too) in key foraging areas over broader time (into October for chum)
- Commercial fisheries already catching low percentage of important stocks (some weak stocks) when overlapping with whales
- West Coast Troll fishery in May, August, September, so only small increases may be possible
- On whale side, want to decrease number of individuals in poor body condition – possibly use 2008 body condition as baseline
- Question: Would we need as much of an increase in abundance if only want the fish in SRKW habitat?

5. Specific Actions

- Overall: Reduce catches where the fisheries overlap with foraging killer whales
- In locations where foraging occurs, and within the seasons where foraging occurs, identify the important stocks that contribute to that time/area abundance, and manage accordingly
- But need to know when they are moving through an area, and where those fish originate
- There is a sequencing as you go down the coast; further north, fish are not in the SRKW habitat
- Effort reductions, allocations, or closures may all be options.
- Selective area closures in summer months; redistribution of fishery to other areas when feasible
- Identify current removals on the stocks of importance
- Spring stocks are not as exploited in commercial fishery; e.g., removals on LF may be managed
- Move fisheries to river mouths? That is where most of the fish are already removed
- Bump up harvest in areas after they have gone by core SRKW feeding areas
- *Commercial*
  - Summer June/July/Aug:
    - Expand Swiftsure fishery closure,
    - Other locations: Sharingham to Port Renfrew (not a lot of fishing effort

remote, most prey samples from there), smaller areas around Victoria or West Side of San Juan Island
    - April/May: Shoulder areas could also be important (less whale presence in inland in May in recent years)?
    - North fisheries: Upstream effects of catching fish that would then head south and be available to the whales later: Langara etc. (AK/PST fisheries) represent largest catches, no size limits, South Thompson catches, WCVI catches, large fish mostly 4-5 year olds
    - In years when abundance low implement size limits
    - Trade-offs: reductions in northern fisheries less direct/diffuse/diluted, not all of the fish would then be “available” to the whales, so less direct benefit
    - Limit troll fishery? Only occurs in two areas
- *Recreational*
    - Size limits: Reduce catch of 4, 5+ yr olds (Fraser); 85 cm
    - Mark selective (in US): focus on catch of hatchery fish (longer term option for Canada; if Fraser aren’t marked they wouldn’t get “caught”)
    - Recreational fishery in winter in northern Strait of Georgia (small scale)
    - J-pod winter feeding areas: size limits (less data on J-pod age and runs of prey in winter in the this area)
    - J-pod Jan/Feb diet data show a few older fish in prey samples
    - North fisheries: similar tradeoffs (i.e., less direct benefit to SRKW) applies also to recreational fisheries

6. How to Implement

- *General*
    - Two approaches (non-conflicting): limit fishing in areas where SRKW are foraging and limit fishing in northern areas to allow more Chinook to reach those critical SRKW foraging areas
    - Create refuge areas over a specific percentage of critical habitat during a time when SRKW use that habitat.
    - Focus on hot spot foraging areas
    - To be most effective, probably need to consider a total no-go zone (i.e., no boats of any kind – fishing & boating)
    - One option would be that you could do anything in an area except Chinook fishing, but this does not simultaneously mediate disturbance (see Option D)
    - Animals spend a large proportion of time in small areas. How big does an area need to be to be effective? Do we need connectivity between areas?
    - Correlating body condition to salmon abundance could Inform development of low abundance trigger (could inform other management actions outside fisheries as well)
    - However, still need to refine metrics for evaluating whale condition (body condition, reproduction, hormones)
- *Commercial*
    - Selective closures and redistribution of effort
    - Implemented through time-area closures under the Fisheries Act
    - Integrated Fisheries Management Plans: must be implement in hypothesis-driven approach (presumes valid evaluation methods)
    - Data exists to look at fine scale place and time for fisheries effort, catch, and standing stock
    - Explore real time management based on CTC indices (perhaps linked to measures of SRKW health such as whale body condition indicators)
    - Possible closure of only some important areas to test effect
    - Potential option of license buybacks
    - Create management measures to protect specific stocks in troll fisheries.
    - Imposing size limits probably not feasible in commercial context
- *Recreational*
    - Selective closures and redistribution of effort implemented through changes in Fisheries Act
    - Possible closure of only some important areas to test effect

    - Potentially incorporate tidal fishing effort (although much of it is upstream of SRKW predation)
    - Impose size restrictions (although need data on survival of catch-and-release)

7. What Stocks to Manage

- Those known to be a part of the diet and are exploited
- In other words, stocks that migrate through SRKW habitat and are targeted by SRKW at specific times of year
- Could identify and focus on stocks that primarily support SRKW (decrease NRKW competitive influence?)
- Focus on core habitat areas (near shore) at key times of years.
- Focus on Fraser River for summer inland feeding areas
- Winter: coastal feeding areas
- Stocks that we know the whales eat; focus on more local/coastal than far north migrating stocks (this may be more overall abundance that fishery driven, long-term issue)
- Summer (JKL pods): Haro Strait (US), Strait of Juan de Fuca (Cdn), Swiftsure Bank and Pt Renfrew.
- Winter (relevant only to pass-through): (J pod) Comox Area, Swiftsure, (K&L pods) Columbia River, coastal WA.

8. Desired Reductions

- Seasonal, hourly, and location-specific redistributions of fishing effort, with aim to increase abundance in a percentage of habitat (i.e., catch reduction in portion of habitat)
- Overall goal is to reduce catch of 4, 5+ yr old for key stocks Chinook in feeding areas
- However, difficult to give quantitative reduction goal; no knowledge on how much is enough
- Best available knowledge indicates a 30% rise in abundance is required (approaching “best” historic years)
- Uncertainties include effect of other predators on “newly available” fish, changes in the impact of abundance over time
- It may be possible to redistribute fishing rather than reduce fishing
- Some effort will drop as a natural consequence (10%) of sporadic closures, particularly in commercial fishing

9. Where and when to Implement

- Generally, in core SRKW foraging areas (near shore) in those times of importance, and in areas where directed fisheries and bycatch occur on stocks of importance
- Goals: Open the tap, increase the flow of fish, then increase the accessibility of the fish in areas where whales are feeding
- Therefore need to:
    - Increase accessibility by limiting fishing in these (hotspot) areas/times:
        - Summer (JKL pods): Haro Strait (US), Strait of Juan de Fuca (Cdn), Swiftsure Bank and Pt Renfrew.
        - Winter (relevant only to pass-through): (J pod) Comox Area, Swiftsure, (K&L pod) Columbia River, coastal WA.
    - Increase abundance:
        - Alter fishing effort in other times/place to ultimately make abundance higher at these times/places
        - Focus on certain northern areas to get more fish to the whales?
- Must consider relevant time of year as well:
- Suggested period Canada: June to mid-September? (this is the highest use period – Father’s Day to Labour Day)
- Puget Sound: May, fall months? SRKW probably not spending a lot of time in Puget Sound.
- San Juan Islands (same as in Canada)
- Columbia River area? SRKW are not going down the coast very far. Most not going down past La Push.
- Exception: Range is year round for J Pod

11. Scientific Confidence

- Generally medium (combination of high and low aspects).
- Medium to High confidence we can make smart decisions once data is available,

- Lower confidence that we currently have the data to make surgical, well-supported mitigation measures
- Locally more confident that Actions would have effect on abundance, but really don't know the extent or what its ultimate impact will be on SRKW

12. Scientific Basis

- Detailed raw data available to be surgical on places and times, although only partial knowledge of SRKW foraging locations
- Need to get a specific working group together to iron out details based on:
  - Whale distribution and prey consumed
  - Chinook distribution- where and when caught and by whom

13. Knowledge Gaps

- SRKW use of west side of Vancouver Island,
- Better diet data. Example: J-pod diet in winter in Georgia Strait
- October and later seasonal body condition
- How long can whales fast? How important is summer feeding to carry through more difficult foraging winter period? Key times of year for KW nutrition?
- Development of CPUE baseline and differences/variability for whales (compare with recreational CPUE?)
- Diet info indicates preference for 4+ but may be biased on surface sampling/sharing
- Unknown whether wild or hatchery stocks, male or female important
- Better aggregate model of seasonal occurrence (and foraging behaviour). That is, need a good, time-specific overlap (human/whale) foraging map.
- What stocks are important – further information is required
- Where and when should closures be implemented to will have the greatest impact on stocks of importance?

14. Likely Benefit

- Low, Medium
- Some uncertainty. For example: If action increases fish abundance, will SRKW stay in area longer (reap benefit)?
- Most critical: Don't know where whales will be, so don't know if they will reap the benefits
- Also, low benefit in winter due to low fishing effort, and elevated in summer due to seasonal increase in fishing effort

15. Performance Measures

- Catch reduced in particular areas (Note: are these offset by increased effort in other areas? Catch amount the same but not in place and time where whales are foraging)
- Body condition/photogrammetry- develop index, early May real time data on whales to inform June/summer salmon season, eye patch measurements (note: not all whales usually seen in early May)
- September condition: trigger chum actions for fall, trigger for actions to support increased prey in winter/coastal by comparing condition in different years (may be better condition in September than May during a year, but is September condition worse than in previous Septembers?)
- Improved CPUE for the whales: higher density of fish assumed to support more efficient foraging
- Increased use of areas that have the closures/reductions/size limit (more time in inland waters, SW side of San Juan)
- Comparison of foraging behaviour in foraging areas/times (vs. pre-5 yr period)

16. Timeframe

- Short duration for many years
- Restrictions in overlap areas would be within same season, while flow-through would be on months timescale.

17. Evaluation Criteria

- Adaptive strategy: every year evaluate winter and summer whale distribution and Chinook abundance
- Further refine body condition as an indicator: identify high, med, low as criteria, how many individuals in different condition
- Pregnancy rates/other hormones indicators, reproductive rates
- CPUE for the whales (longer term observations and Dtag data)

- Comparison of foraging behaviour in foraging areas/times (vs pre-5 yr period)
- Possible comparison between selected open/closed areas.
- Determine how many 4+ show up to summer critical areas (acoustic survey, but not great in past)
- Evaluation criteria of the management change – AEQ – adult equivalency
- Options for retention limits – issues with survivorship (introduces uncertainty)
- Evaluating the fishery would use AEQ; need a different metric to evaluate effect of decreased removals (i.e., need to quantify the amount of increase of the targeted stocks in the specific location and time)
- Degree of uncertainty re: understanding spatial assessment - "Faith-based management"
- Adaptive management aspects could move to Objective A (coast wide closures) as an option in response to noted declines

18. Other Considerations

- Accommodate real time changes on when and where the whales go and feed, adaptive process so you can adapt
- But, challenges if too changeable to be able to communicate and evaluate effectiveness
- Economic impacts
- Coordination between US/Canada
- In future think about pod difference K/L pods vs J pod
- Need to monitor how fishing effort responds.
- Canadian commercial fisheries doesn't really overlap in time/space with SRKW (except 123)
- How large is the area and when?
- Allocation policies – e.g., rec fisheries actions have implications for commercial TAC

19. Effects on NRKW

- Neutral to positive
- Goal of time/area considerations to benefit SRKW, positive benefits to NRKW that overlap with SRKW (Gs)
- Overlap at Swiftsure – may actually lead to greater competition

20. Effects on Other Species

- Likely positive
- Potential increase in other predators, i.e., salmon sharks, sea lions

21. Comments

- Fishing restrictions also lowers disturbance (although extent depends on proportion of industry boats to other vessels).
- May also decrease depredation
- This Option would be easier to convince public that it would benefit whales, and therefore get buy in
- Hatchet instead of a sledge hammer.
- What are key or critical times of year for nutrition? Would be easier if they were synchronous breeders.
- What will the seasonal foraging map look like?
- If there are stocks of less importance to SRKW, then could focus fishing on them
- Tag fish on their way into the Strait and see where they get caught

Appendix H: Notes from Group Discussions—Increase Chinook accessibility at specific times

These notes combine information transcribed during group discussions, and from tables filled out by workshop participants. They capture the 'as is' comments of participants on this potential Management Action, and are provided without interpretation.

1. **Option C: Increase accessibility of Chinook in specific areas at specific times of year**

2. Broad Action:

- Decrease acoustic and physical disturbance of foraging killer whales by vessels

3. Targeted Sector:

- All vessels (not just fishery-related)
- SRKW forage in areas where there are many vessels, recreational and commercial fishing, whale watching, recreational vessel traffic.

4. Desired Increase:

- *General*
  - Increased foraging success and prey sharing opportunities
  - Models suggest a goal of 30-50% increase in accessibility
- *Specific*
  - Create quiet area/acoustic sanctuary from vessel sound that interferes with foraging efficiency and communication
  - Lower boat numbers that may physically interfere/preclude quality foraging opportunities

5. Specific Actions

- Some actions are static while others require changes in the presence of whales.
- Selective exclusion zones to minimize acoustic and physical disturbance.
- Bubble areas: Minimal approach distance (protective bubble)
- Speed restrictions in critical SRKW foraging areas
- Reduce noise in critical frequencies from echosounders

6. How to Implement

- Regulatory tools different depending on different goals (e.g., fishery closures, MPAs)
- In many cases education may be more effective than regulation (also hard to "enforce" in legal system)
- Specific guidance for fishers (target messaging in key areas such as Salmon Bank), perhaps in licenses
- *Exclusion zones*
  - MPA or Transport Canada vessel regulation, or ATBA by regulation
  - No-boat areas should coincide with a proportion of coastal key foraging areas
  - Need to make decisions about how/where/when – unrealistic to close all potential SRKW foraging areas all the time
  - Should closures be seasonal or only when whales present?
  - Should closures only come into effect when the whales are in poor condition and/or salmon abundance low?
  - As this is not a matter of interference rather than direct competition, such closures must apply to all boaters, including commercial whale watchers
  - Increase enforcement in no-go zones
  - can work in association with vessel limitations (vs. exclusion) – e.g., limit number of vessels viewing whales – Whaleless Wednesdays
- *Bubble areas*
  - consideration of 200 m no-approach zone seems reasonable (although see Knowledge Gaps)
  - limiting approach/viewing guidelines through vessel regulations
  - additional consideration for fishers: should they pull up gear and get out of the way if are/will be in the presence whales? Define "in the presence" by distance.

- *Echosounder*
  - Reduce or alter use of sonar in the presence of whales
  - default frequency overlaps with whale auditory spectrum
  - short-term: voluntary educational program to change from default
  - longer-term: whale friendly settings (“whale mode”), goes to sleep when not in use
- *Speed restrictions*
  - Limit speed in the presence of whales
  - not really an issue when active fishing
  - more of an issue with recreational boaters

7. What Pods to Manage

- Most regulations would apply to all SRKW pods
- Exclusion zones may be more selective: All pods in summer, possible only J-pod in winter.
- Question of whether applies to all killer whales, including transients (difficult for most people to tell apart)

8. Desired Reductions

- *Exclusion zone*
  - 100% compliance (zero presence)
- *Distance/approach*
  - high compliance
- *Overall goals:*
  - 50% reduction in vessel impacts (based on Lacey et al 2017)
  - Minimize cumulative noise within sensitive frequencies within foraging habitat and provide opportunity for sufficient foraging in completely undisturbed areas.
  - Protecting them regardless of location to allow minimal disturbance.
  - Minimize physical deterrence of foraging.
  - Reduced competition

9. Where to Implement

- Bubble zone should be in effect everywhere.
- Speed restrictions in foraging habitats
- Exclusion zones:
  - In potential (largely summer) primary foraging zones or critical habitats; others to be considered as required
  - Maybe consider specific area uses by different pods
  - Focus on inland (not coastal areas)
  - Suggested areas: West side of San Juan Island, Boundary Pass, Swanson Channel, mouth of Fraser River, SW edge of Vancouver Island/N side of Strait of Juan de Fuca, Harrow strait, Columbia River, Puget Sound, Juan de Fuca Strait, northern Strait of Georgia

10. Time of Year to Implement

- *Exclusion zones*
  - Summer issue primarily for acoustic and physical disturbance
  - Seasonal by area; partial exclusions based partly on X% of foraging time
  - Mainly summer (possibly winter for J-pod)
- *Bubble zone*
  - all the time

11. Scientific Confidence

- Overall Medium to High
- Definite link between noise and poor foraging
- But Low confidence when focused just on fishing vessels, as not convinced fishing is large contributor in many cases. However, may have a significant impact in certain areas and immediate areas (partic. for sonar)
- High for presence/speed, although considerable debate on regarding response relationship between vessel presence (not noise) and foraging efficiency

12. Scientific Basis

- Considerable body of knowledge, although gaps remain
- High confidence in importance of several foraging areas, but important to note that whales are not always there
- Location of prey sample collection

- Overflight data- DFO data (boats/effort), San Juans area
- Soundwatch/Straitwatch data on where vessels not following guidelines/regulations
- Good evidence that use more energy to echolocate in noisy environment.
- Profiles of echosounders (83 kHz) overlap with orca acoustic profiles.
- Known that noise affects communication
- Good evidence (although not consensus) of reduction of foraging opportunities and other social behaviours with physical presence of vessels.

13. Knowledge Gaps

- Best available information on foraging areas
- Winter feeding habitat has not been fully explored
- Overlays of all boat activity (including recreational fishing effort) and SRKW foraging
- Need baseline data for performance measures - background noise levels in protected areas,
- What is right distance for approach? Scientific justification for 200 or greater distances
- What is the effect of different size bubbles?
- Unclear what current foraging efficiency is (including ight time foraging effort and success rate)
- or how it would change with recreational fishing vessel noise levels or vessel presence. Not sure of sensitivity profile.
- Need ability to differentiate physical and acoustic effects of vessel presence
- Direct competition has not been quantified
- Sonar impacts have not been quantified
- Need to know what the hunting range is.
- How does detectability of smaller fish bladders (due to decreasing size at age) affect killer whale foraging abilities

14. Likely Benefit

- Overall: Medium to High
- High for minimal approach distance
- Unknown/difficult to know how exclusion/protected areas will correlate to either fish presence or whale presence in a given time period
- Unclear what effect control measures will have on SRKW population if only talking about fishing vessels
- Likely to improve targeted foraging opportunities, but unclear what effect will have on population

15. Performance Measures

- Presence of whales should increase in protected areas, more foraging, improved rates of success
- Need experimental framework to evaluate benefit of areas of action vs no action
- Behavioural studies, such as study of foraging success vs acoustic profiles
- Longer-term: changes in physical condition and hormone profiles of SRKW

16. Timeframe

- Should have an almost immediate behavioural effect
- Changes to individual health and population characteristics are longer-term

17. Evaluation Criteria

- Acoustic monitoring (incl Dtags)
- Increases in foraging success rates, time spent foraging (and potential data contrasts for open areas)
- increased body condition, reproduction, long term demographic
- AIS/VMS
- Level of compliance/enforcement
- Radar/cameras to monitor no-boat areas for compliance rates
- Observations on vessel proximity on whales
- Potential for observer data on compliance akin to Soundwatch/Straitwatch
- Activity budgets

18. Other Considerations

- This only works if it is applicable to all vessels!
- Shipping lanes
- Ship strike risk

- What is enforceable?
- Exclusion of boats may have incidental negative (displacement) effects on other individuals
- First Nations
- vessel safety implications
- consultation via IFMP
- Ability of fishermen to identify SRKW
- Would need to apply to all whales
- Socio economic impacts / needs consultation

19. Effects on NRKW

- None to some small benefit to NRKW, but smaller than for SRKW

20. Effects on Other Species

- Unknown, likely little to no benefit
- Perhaps some acoustic benefits (particularly other cetaceans)

21. Comments

- Side benefits to no boat areas for multiple species
- Consider using language to support an adaptive process and build in connections between SRKW health and Chinook abundance (e.g., scenarios indicate suite of options for high Chinook/low whale condition, low Chinook, etc.).
- Voluntary change in sonar setting seems an “easy” fix
- Boater education an important method (changes in speed may also affect behaviour – also other boaters)
- Discussions focused on salmon fishery, but others may have significant effect (at other times of year)
- Reducing physical presence will also bring down acoustic overlap (sonar, engine)

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