Final report for EFP 09-02: Best Use Coalition's Halibut Deck Sorting EFP

EFP 09-02

The focus of exempted fishing permit (EFP) 09-02 was to explore ways to reduce halibut bycatch mortality rates on trawl catcher processor vessels targeting flatfish and cod in the Bering Sea. The Best Use Cooperative's (BUC) application for the EFP was submitted to the NMFS Alaska Region in March of 2009 and was approved by NMFS in late April, 2009. The field work was performed in May-June of 2009. The principal investigator was John Gauvin who developed the study in consultation with Martin Loefflad of the NMFS Alaska Fishery Science Center's Fisheries Monitoring and Analysis (FMA) Division and Gregg Williams of the International Pacific Halibut Commission (IPHC).

Project Objectives

The main objective of EFP 09-02 was to evaluate the potential for reducing halibut discard mortality rates by modifying the halibut handling procedures currently on Amendment 80 vessels. For the EFP, catch handling procedures were modified so that halibut were sorted out of the trawl codend on deck and returned to the sea from the deck via a chute constructed for this purpose. This would return the halibut to the water faster than would otherwise be possible under existing regulation. Procedures for the EFP required full accounting of the number and length of each halibut via a census of halibut collected on deck and in the factory (halibut missed during sorting on deck) as well as assessment of viability for each halibut collected in the two locations.

The reason the EFP focused on modifications to catch handling procedures was that Amendment 80 vessels are currently required to place all of the net's contents into below-deck holding tanks without sorting any of the catch on deck. This requirement is to ensure that the on-board observers have an opportunity to sample all the fish in the catch. In terms of halibut bycatch mortality rates, however, the inability to sort halibut out of the catch on deck means that halibut, a prohibited species in flatfish fisheries, are returned to the sea only after they come out of the vessel's holding tanks and pass over the vessel's flow scale. This occurs slowly as the contents of the below-deck storage tank move across a conveyer belt towards the processing area. The "no sorting on deck" requirement results in some of the halibut remaining out of the water for several hours before being returned to the sea. As such, halibut discard mortality rates, which are based on viability assessments done by observers in the processing area, currently average 75% across the typical Amendment 80 fishery targets.

In its application for this EFP, the BUC noted that reducing halibut mortality rates is an important component of the Cooperative's overall work to help prevent halibut prohibited species catch (PSC) limits from constraining its target groundfish catch. Other components of the Co-op's work to control halibut bycatch are improvements in halibut excluder devices and more effective use of the bycatch hotspot avoidance system (Sea State) that the fleet has been using for many years. A prime motivator for the Amendment 80 fleet in these endeavors is that the sector is in the second year of a four year phased-in reduction of its halibut PSC mortality cap. This reduction of 200 MT (total) was approved as part of Amendment 80.

In addition to looking at potential for reducing halibut mortality, the EFP pilot study collected data on the fraction of the halibut catch that can be feasibly sorted out on deck and the time needed to complete sorting and halibut measurement/viability assessment under the fish handling procedures of the EFP. Other qualitative information of interest were such things as how much extra effort deck sorting would take, how well alternative accounting methods for halibut catches and mortality rates might work on Amendment 80 vessels, and how these may vary by vessel size, deck layout and target fishery.

Finally, the Best Use Cooperative also contracted with Archipelago Marine Research (AMR) of British Columbia, Canada to evaluate the feasibility and efficacy of using an electronic monitoring (EM) system to monitor adherence to the deck sorting and halibut handling/discard protocols during the EFP. To this end, an EM system was installed on one of the EFP vessels by AMR and the system functioned throughout that vessel's participation in the EFP. The results of the EM feasibility study included in the summary of findings below and AMR's full report is attached to this report as an appendix.

Summarized Findings for EFP 09-02

Phase I of the EFP field work was conducted from May 27 – June 27, 2009 on three Amendment 80/BUC Co-op vessels: F/T *Cape Horn,* F/T *Constellation* and the F/T *Ocean Peace. T*he EFP vessels fished under the EFP but used their own Amendment 80 allowances of halibut PSC and groundfish. Although the pilot study relied on catch and PSC that was part of the participants' normal fishing allowances, an exempted fishing permit was needed to allow the EFP vessels to handle halibut differently from the manner in which they are currently required to handle halibut during their regular fishing activities.

To potentially help to defray the costs of participation in the EFP (costs for carrying two sea samplers on each EFP vessel in addition to each vessel's two regular observers, constructing specialized halibut discard chutes for the EFP, additional time and labor needed to sort halibut from the catch on deck) participating vessels were afforded the opportunity to utilize the halibut mortality savings from the EFP if they were able to achieve savings. This in theory would allow EFP participants to harvest fish in 2009 beyond what was possible under their pro-rata quotas of halibut PSC assuming their halibut allowances would be used before their groundfish allowances were fully harvested (a common occurrence in past years). The halibut mortality savings from the EFP (deemed Phase II of the EFP) would be determined on a formula based on the difference between the official halibut discard mortality calculated from official halibut mortality rates applied to catches per target fishery and the actual halibut mortality rates achieved during the EFP (in the target EFP fisheries) calculated from onboard viability assessments.

Table 2reports the target fisheries, areas fished (NMFS Reporting Areas), EFP fishing dates, total number of EFP and non-EFP tows per vessel (tows where weather did not allow deck sorting) and other relevant summary information.

Table S1: Target fisheries, Areas fished, EFP fishing dates, number of EFP and non-EFP tows per vessel and EFP project staff and Sea Samplers aboard each of the three participating EFP Amendment 80 vessels during Phase I of EFP 09-02.

EFP Vessel:	***Cape Horn***	***Constellation***	***Ocean Peace***
Target Fishery/Area	Arrowtooth/Area 517 Cod/Area 521 (one tow) Flathead/Area 513	Arrowtooth/Area 517 Yellowfin-Btm poll/Area 514 Flathead-cod /Area 521, 513	Arrowtooth/Area 521 Yellowfin/Area 514
EFP fishing dates	May 28 - June 16, 2009	May 29 - June 26, 2009	May 30 - June 10, 2009
Total no. EFP hauls	82	153	46
Total no. non-EFP hauls	0	0	3
EFP Project staff aboard	*None*	K. McGauley (6/9-6/27)	K. McGauley (5/27-6/9)
Sea Samplers	J. Colling, R. Cartright	L. Cocas, R. Wolfe	K. McPeck, M. Cliff

The EFP results are presented in more detail in Table 4 of the Results section. Briefly, total EFP groundfish catch was 3,592.4 mt which included an incidental catch of 67.25 mt of halibut. Deck sorting for halibut went very well overall with crew members able to sort out approximately 85% of the total number of halibut in the EFP on deck and over 93% of the total by weight. In terms of numbers of halibut caught in the EFP there were a total of 19,649 individual halibut of which 16,986 were sorted out on deck, 2,663 in the factory. In total, only three deck halibut were not assessed for viability because they fell overboard before viability assessment by the sea samplers could occur.

The average halibut mortality rate for halibut sorted on deck was 45% (Table 4) which amounts to just 60% of the current average mortality rate assigned to the Amendment 80 vessels for the target fisheries of the EFP (75% is the average mortality rate applied to the BS/AI flatfish fisheries currently) . Average sorting time on deck for the EFP overall was approximately 27 minutes based on the time net was brought aboard to time the last halibut went back in the water or deck sorting was completed, whichever was longer. In practice, this included the time it took the crew to sort out the halibut (as little as 10 minutes on some tows) and the time it took the sea sampler on duty to measure and assess viability for each halibut.

The discard mortality rate for halibut recovered in the factory (missed during deck sorting operations) was approximately 84%. For factory halibut it took on average approximately 186 minutes to return the last halibut from a factory to the sea. The mortality rate for factory halibut in the EFP is somewhat higher than the rate currently assigned to halibut in the target fisheries for the EFP (75% on average). This may have been a result of the EFP requirement to collect all halibut missed during deck sorting by the factory crew where the halibut were placed in baskets or totes so the sea samplers could census the halibut catch and the fraction of halibut sorted on deck could be calculated. Given the overall set of duties for the sea samplers, viability assessments for factory halibut were frequently performed after all fish from a given tow had passed over the flow scale. The requirement that catch in the holding tank remain in the tank until the halibut sorting activities on deck were completed and the sea sampler was present in the factory also probably contributed to the higher mortality rate for halibut collected in the factory as well. Or it could just be a random difference from the average given that the 75% average rate applied to the fishery overall is calculated from observer data collected across a whole fleet of flatfish vessels over the course of a year.

Halibut mortality savings:

Table S2 reports halibut mortality savings per EFP vessel based on the difference between each EFP vessel's halibut catch assessed at the official halibut mortality rate for its target fishery assignment and the halibut mortality rate actually achieved in the EFP. As can be seen from the table, the EFP concluded with a total estimated 17.15 mt of halibut mortality savings for use in Phase II. NMFS in-season managers and FMA (Observer Program) completed their review of EFP 09-02 data and calculations from Phase I on September 11, 2009. At that time the EFP holder's calculations of the halibut mortality savings from the EFP listed below were approved by NMFS and EFP participants were authorized to utilize their portion of the savings below in Phase II of the EFP. As will be described below, EFP participants did not actually utilize the Phase II savings.

Table S2. EFP halibut mortality savings by vessel:

Vessel	Halibut mortality savings (mt)
Cape Horn	9.168
Constellation	6.113
Ocean Peace	1.869
Total:	**17.150**

Summary of results by Archipelago Marine Resources (AMR) for the Electronic Monitoring portion of the halibut deck sorting EFP project:

Despite some minor issues, the EM system performed very well and was successful in providing 100% data collection for the duration of EFP participation by the vessel it was installed on (totaling 21 days and 82 fishing events). Imagery was nearly complete, the majority of which was assessed as high quality for monitoring halibut deck sorting activities. Weather conditions (i.e. water droplets or condensation in the cameras) did not significantly hamper imagery analysis at the chute. A thorough review of the imagery showed that halibut could be reliably identified and counted in the discard chute. Crew handling procedures for halibut could also be easily assessed. Camera imagery for the trawl deck area provided a wider field of view and correspondingly did not resolve catch handling operations as clearly. Although none were caught during the EFP, it was the opinion of AMR that catches of large sharks or marine mammals being sorted and discarded on the trawl deck could have been easily detected, as would incidents of fish being discarded other than through the discard chute.

The EM portion of the overall study identified some areas for future improvements. After reviewing image data during catch stowage with each of the three camera configurations, it was evident that none were capable of fully monitoring all of the halibut deck sorting protocols and that more cameras were needed to meet these objectives. As was found in other studies (e.g., Bonney et al., 2008) monitoring can be enhanced through the strategic placement of multiple cameras, including both close up and wide view cameras, and overlapping views. Two cameras were insufficient for the *F/V Cape Horn* and four would have yielded a more comprehensive view of the trawl deck, while still providing sufficient detail of the discard chute to validate data collection, catch handling, and discarding practices. Multiple cameras of the trawl deck area would improve monitoring assessments but the ability to identify and count catch items would likely still prove difficult. Camera requirements for other vessels in the fleet are likely to differ depending on vessel size and deck layout. The smaller vessels would likely only require two or three cameras.

<u>Perspectives on the findings from EFP 09-02:</u>

The project showed that halibut mortality rates on Amendment 80 trawlers can be reduced by sorting halibut out of the catch on deck so as to return them to sea as quickly as possible. Most of the modified halibut handling procedures used for the EFP appeared to be feasible for the EFP vessels in the arrowtooth, flathead sole, rex sole and Pacific cod fisheries – though probably not as feasible in the spring yellowfin sole fishery. This is because catch amounts per haul in that spring yellowfin sole fishing are typically greater than for most flatfish target fisheries and with the already low halibut bycatch rates in spring yellowfin sole fishing, the feasibility of sorting through the haul to remove a few or even no halibut is relatively low. Fall yellowfin sole fishing, however, is generally more like the cod and flathead sole fishing done in the EFP in terms of catch amounts per tow and size and number of halibut per tow so it might be a good candidate for reductions in halibut mortality rates with deck sorting.

The study overall was a valuable first step to look at potential for reducing halibut mortality rates and general feasibility. It is important to keep in mind, however, that because of design and cost issues, the project's value for evaluating relevant scientific questions may not be as high as some may have wanted. For example, these data are not ideal for analysis of relationships such as correlation between halibut viability and haul size (or tow time, bottom temperature, surface temperature). This is because on many tows, the halibut handling protocol of the EFP and specifically the requirement to measure and do viability assessment on every halibut served to significantly increase the time it took to return the halibut sorted on deck back to the water. In this regard, the EFP data show that it took an average of 27 minutes to sort and account for halibut length and viability for each EFP tow. But on many tows the deck crew was able to sort the halibut out of the catch on deck in as little as 10 minutes according to EFP participants and discussions with sea samplers following the EFP.

This outcome was due in part to the design of the study and limits on resources. Because sea samplers were working on 12 hour shift and therefore only one was available at any time to account for halibut lengths and condition, halibut sometimes sat in a holding trough awaiting measurement and viability assessment by the sea sampler on duty. Conceptually, the delay is really not part of the process of sorting halibut and returning them to the sea, it was due more to the limited resources available in the EFP to measure the halibut catch and account for viability. If an alternative set up for the EFP had been used, such as having numerous sea samplers working on deck each shift, this would have sped up the accounting and viability assessments and halibut viability assessments and would likely have been higher on average. Most problematic here for covariate analysis is that, as noted below, there is no way to separate the effects of halibut sorting and handling time by the crew from the added time needed for sea samplers in the EFP to account for halibut catch and viability.

In light of this, a time stamp on each halibut viability assessment would have made the data more useful for analysis of covariates. Such a time stamp would have enabled us to at least look at viability rates for halibut sorted first compared to ones at the end of a backlog during a particular tow. This would have been helpful for inferences about the effects of holding time awaiting viability assessment. But a time stamp was not feasible because recording a time for each halibut by the sea sampler would clearly have involved even more time needed before getting halibut back in the water. For this reason, recording time data with each halibut was abandoned at the start of the EFP fieldwork.

The underlying tradeoff here was one of balancing competing objectives of collecting information on feasibility versus collecting scientific data. The complement of sea samplers for the EFP was based on minimizing costs per EFP vessel given that the objective of looking at average reduction in mortality rate and fraction of halibut that could be sorted out on deck. For those objectives, it was decided that project participants should have two sea samplers (one sea sampler per 12 hour shift) to record halibut length and viability. In retrospect, this had a potentially larger effect on the results than was anticipated but there was no way of knowing from the outset that the crews' halibut sorting activities would occur faster than halibut accounting and viability assessment by the sea samplers.

A follow up study to explicitly look at all the separate factors affecting viability of individual fish would clearly require a different design and a larger scientific data collection crew or more flexibility in the permit to allow crew members to assist in recording scientific data. In the end, however, our data are useful for looking at halibut mortality rate reduction under a set up where halibut are sorted on deck and catch amount and viability rates are accounted for with one sea sampler available per 12 hour shift. This is valuable for knowing something about how halibut mortality rates could be reduced assuming that every halibut needs to be measured and assessed for viability by a single sea sampler. But EFP participants envision other more potentially efficient arrangements such as mechanized length or weight assessment that is potentially faster. For viability assessment, EFP participant want to explore whether a random sub-sample of viabilities could be used to accurately characterize viability while potentially avoiding the slowdowns and bottlenecks that sometimes occurred during the EFP. These ideas are discussed below in the context of recommendations for next steps for further work on deck sorting halibut.

Despite these acknowledged shortcomings, the study did show that significant halibut mortality savings could be attained with modifications to the procedures for handling halibut on Amendment 80 vessels. Although the 17 MT of halibut mortality savings from the EFP were not actually used by EFP participants, participants felt the savings were considerable and that more work is merited to explore how to reduce halibut mortality rates on Amendment 80 vessels. They believe that the ability to generate mortality reductions is very important in terms of the objective of optimizing flatfish catches under the halibut mortality allowance constraints particularly if halibut bycatch rates had remained as high as they were for the first part of this fishing year.

Finally, it must be recognized that these halibut mortality savings came at considerable cost to both industry participants and fishery managers. Cost s to managers were such things as EFP development, analysis of the permit application, and review of EFP data to confirm the calculations of halibut mortality savings. These add up to an estimated 170 hours of additional agency work according to the NMFS Alaska Region.

Thinking beyond the pilot study, further work to change halibut handling requirements to allow sorting on deck in a larger fishery-wide setting would also need to take into account a broader set of considerations. These include the question of how to best quantify the catch of halibut, and apply the right mortality estimate in season. If a census is not viable for either halibut catch or viability, then the proper mix of sampling approaches and precision tradeoffs would need to be worked out. The tradeoffs between post debriefing analysis and development of mortality rates to be applied "fleet wide" versus *in situ* measurement of viability rates and application of these data in-season to a fishing cooperative would need to be resolved. Additional work to determine the best use of the video technology would also be required given that the initial findings for the EM portion of the project were encouraging but further work is needed to ensure EM can monitor crew compliance with the sorting protocols. There are certainly ways to address all of these challenges, but as with all issues involving federal fisheries off Alaska, rigorous work will need to be applied before modifications in halibut handling procedures can be adopted into the regular fishery.

Detailed Report on EFP 09-02

<u>Methods</u>

<u>EFP Experimental Design</u>

The specific catch handling protocol and procedures for halibut sorting, viability assessment and accounting for the EFP were as follows:

1. Once EFP fishing started, all tows were to be EFP tows except where weather conditions did not allow for halibut sorting on deck. Prior to setting, these non-EFP tows were marked in the logbook by an asterisk next to the tow number. The Captain was responsible for informing everyone, prior to setting, whether or not the upcoming tow was a non-EFP/weather tow.
2. For each EFP tow, the codend was brought on deck and pulled forward of the live tank hatch so there was sufficient room to sort the halibut as the codend was being dumped into the holding tank. The codend was dumped at a reasonable rate of flow to allow sorting of halibut out of the catch.
3. Only halibut were removed from the catch on deck. As in regular Amendment 80 fishing, it was however permissible to remove large sharks and marine mammals from the net on deck provided that the observer on duty was informed (note: no large sharks or marine mammals were caught during the EFP).
4. The vessel deck crew was responsible for sliding the halibut from the trawl alley and into the vessel-designed halibut holding area via a chute designed for this purpose. The objective was to move all halibut to the location where the sea sampler was stationed on deck to collect data without lifting the halibut.

5. The two Sea samplers assigned to each vessel (working 12-hour shifts) completed an independent census of halibut for each EFP tow. The census included length, a count and a viability assessment of each halibut (1) on deck and (2) in the factory. The weight of each halibut was obtained from the IPHC published length-to-weight reference table. Whereas sub-sampling for viabilities on deck was an option for the sea samplers when there were large numbers of halibut in the tow (>200), this option was never exercised during the project.
6. A vessel crew member on each vessel was responsible for feeding the halibut to the sea sampler from the holding area. The crew member worked with the sea sampler to ensure that the rate that the halibut arrived on the chute/measuring area allowed the sea sampler adequate time to enumerate and measure each halibut and to assess viability for each halibut. The sea sampler collected and recorded all EFP data on forms.
7. Halibut sorting on deck and in the factory were carried out under the sea sampler's direct supervision: a sea sampler was always present while sorting occurred on deck or in the factory.
8. When one of the two regular observers working on each EFP vessel (not involved with this EFP project) encountered halibut in their samples, the halibut was provided to the sea sampler on shift as part of their halibut census. Halibut was never included in the observer sample.
9. Factory crew working on the conveyor belt downstream of the sorting area brought any missed halibut back to the sorting area and gave it to the sea sampler on duty.
10. For each EFP tow, the sea sampler recorded sorting time (in minutes) needed to work through sorting and accounting for halibut (1) on deck and (2) in the factory. On deck, the start time was when the net was brought on board and the codend passed the stern ramp. The end time was the time when all halibut sorting on deck, measurements, and returning fish to the water was completed. The factory sorting time was from the time fish first entered the live tank to when the last fish from a given tow passed over the flow scale.
11. The sea samplers provided the total halibut count and weight per EFP tow (deck and factory) to the observer(s) for use in their ATLAS reporting. Each lead vessel observer was also provided with copies of the Project deck sheets and an electronic copy of the EFP Excel spreadsheet for their debriefing verification of weights.

To ensure that EFP crews, captains, sea samplers, and observers fully understood the catch handling procedures listed above, copies of the EFP were provided to each party approximately one week before the EFP field work commenced. Additionally, a "pre-EFP Project" meeting conducted by the principal investigator was held in Dutch Harbor on May 27, 2009. Attendees included NMFS Observer Program personnel, the EFP vessel captains, mates and numerous crew members from the participating vessels, as well as all the sea samplers and observers assigned to each of the three EFP vessels. Copies of the Exempted Fishing Permit and a Sea Sampler "Briefing Sheet" outlining the requirements and procedures were also distributed to all those attending the meeting.

Collection of Electronic Monitoring Data

A field technician from Archipelago Marine Research, Ltd (AMR) installed an Electronic Monitoring (EM) system on the *Cape Horn* on May 27th. The system included 3 live-feed video deck cameras: one focused on the discard chute/halibut data collection area and 2 cameras for deck overviews. A large screen monitor was placed near the observer station in the factory which allowed the sea sampler and observer on duty to monitor on-deck activities while in the factory. Winch and hydraulic sensors recorded fishing activity and a GPS unit tracked the location of the vessel. The video footage, sensor and GPS data was recorded to a hard drive which was sent to AMR on June 30 for review. A satellite modem was also installed to periodically send sensor and GPS data to AMR in Victoria, BC but a malfunction prevented any data transmissions.

<u>EFP Data Accounting</u>
The sea samplers transcribed their deck and factory halibut data (lengths, viabilities, frequencies) from the plastic length frequency strips provided by the Observer Program to waterproof deck sheets. Sorting times for each area were also noted. They were given a copy of the Project Excel spreadsheet in which to enter data over the course of EFP fishing. The data fields to be completed by the sea samplers for each haul included: Project haul number, vessel haul number, whether or not the haul was an EFP tow and, if so, were the deck halibut sub-sampled for viabilities, target or predominant species (verified later by BUC), Official Total Catch (OTC), set and retrieval dates and times, halibut length frequencies per viability category and sorting times for both deck and factory.

The EFP included an allowance for excluding tows from the EFP if weather was deemed unsafe for deck sorting. To reduce the chance for biasing the results, tows not to be included in the EFP had to be identified prior to setting the net. In actuality, this exemption was only needed for three tows on one vessel over the course of the project.

Halibut counts, weights and mortality (amounts and rates) for deck and factory per haul were calculated automatically once the raw length frequency and viability data were entered into the spreadsheet. The sea samplers sent the data in spreadsheet format once per day via email to the project manager aboard the *Ocean Peace* and later aboard the *Constellation.* (The project field manager, Katy McGauley, switched between these two vessels after the Ocean Peace decided to opt out of the EFP to do its AFA pollock fishing due to lack of halibut bycatch allowance to continue the EFP or any Amendment 80 fishing). The field manager collated and summarized the data in a master spreadsheet and sent daily data updates which included estimated halibut mortality savings per vessel to each of the participating vessels and to the Permit holder.

<u>Halibut mortality: calculations and formulas, standard DMRs and estimations of mortality savings</u>
EFP discard mortality rates (DMRs) were calculated from the raw viability data of the halibut sorted on deck and of those halibut that were missed during deck sorting and ended up in the factory (not sorted from the codend on deck). These mortality rates were calculated using the standard formula found in the 2007 IPHC Report of Assessment and Research Activities (Williams, 2007): Per this IPHC Report, the general model for calculating the DMR for halibut caught by gear ***g*** is:

$$DMR_{\boldsymbol{g}} = \sum_{i=1} (\boldsymbol{m}_{i,g} \times \boldsymbol{P}_i)$$

where ***m*** is the mortality rate for gear ***g*** (trawl, longline or pot), and ***P*** is the proportion of halibut in condition ***i***, where 1 is excellent, 2 is poor, 3 is dead:

Gear (*g*)	m_{exc}	M_{poor}	m_{dead}
Trawl	0.20	0.55	0.90

For each EFP tow, the weight of those halibut assessed as excellent was multiplied by 0.2, poor by 0.55 and dead by 0.90. The resultant sum was the EFP halibut mortality for that tow. The calculations were performed separately for those halibut sorted on deck and for those found in the factory. Note that there was no sub-sampling for viabilities, although there were 3 instances of a deck halibut (30.6 Kg. total) accidently slipping away before being assessed for viability. For each of these two tows on the *Constellation*, the calculated mortality rate of those assessed was applied to the total halibut weight for that haul.

The "official" mortality was calculated using the target fishery mortality rates listed in the 2009 annual groundfish specifications (www.fakr.noaa.gov/sustainablefisheries/2009_10hrvstspecs.htm) which are the official halibut DMRs for the BSAI trawl fisheries in 2009 (Table 1 below) based on observer viability data from 1996 – 2006 (Williams, 2007). The total weight of the halibut for the tow was multiplied by the official DMR for that target. The official target by tow was provided by Sea State, Inc via Beth Daudistel at BUC and was based on the predominant species by week and NMFS Reporting Area (the normal procedure for assigning catch to a target fishery for purposes of DMR attribution).

Table 1. Official DMRs by BSAI Trawl fishery for 2007-2009

IPHC DMR - BSAI Trawl	
Target	DMR
Arrowtooth	0.75
Cod	0.70
Flathead sole	0.70
Other flatfish	0.74
Bottom Pollock	0.74
Rockfish	0.76
Rock sole	0.80
Yellowfin sole	0.80

The EFP halibut mortality savings was simply the "official" mortality minus the EFP halibut mortality generated from the viability data collected in the project. The savings were calculated separately for deck and factory halibut per tow per vessel and the totals summarized by deck and factory for each vessel. The spreadsheet containing these calculations was submitted to NMFS FMA and Alaska Region in July 2009 as part of NMFS' review of the EFP to determine the extent of halibut mortality savings for Phase II of the EFP (as required by EFP 09-02).

Results

Operations

Phase I of the EFP field work was conducted from May 27 – June 27, 2009 on three Amendment 80/BUC Co-op vessels: F/T *Cape Horn,* F/T *Constellation* and the F/T *Ocean Peace.* To understand the results in the context of the EFP, it is important to recall that the field experiment was designed to impart realistic incentives for reducing halibut mortality to the EFP participants. To accomplish this, the EFP vessels fished under the EFP but used their own Amendment 80 allowances of halibut PSC and groundfish. Given that halibut bycatch has been high this year in flatfish targets (relative to the what occurred in the first year under Amendment 80 Co-op fishing in 2008), EFP vessels were this spring facing a relatively high probability of closure due to attainment of halibut PSC caps before reaching groundfish catch limits. In fact, one of the EFP vessels (*Ocean Peace*) had, prior to EFP fishing, actually used more of its halibut allowance to date than it had budgeted for. To avoid creating a situation where that vessel would be unable to participate in the third and fourth quarter fisheries upon which it depends, the captain of that vessel stated at the outset of the EFP that he would participate with the understanding that he might have to curtail EFP activities and possibly halt all Amendment 80 fishing by mid-June if halibut rates in the EFP were as high as they were just prior to the EFP. Another option outlined by the captain of the *Ocean Peace* was to conduct part or all of the EFP in the yellowfin sole target fishery. Halibut bycatch rates are generally very low in spring yellowfin fishing so the overall feasibility of sorting halibut on deck was expected to be lower (as noted in the EFP application) due to larger haul amounts and smaller size of halibut taken as bycatch.

Table 2 summarizes the target fisheries, areas fished (NMFS Reporting Areas), EFP fishing dates, total number of EFP and non-EFP (weather) tows per vessel as well as the project staff and sea samplers aboard each of the boats.

Table 2. Target fisheries, Areas fished, EFP fishing dates, number of EFP and non-EFP tows per vessel and EFP project staff and Sea Samplers aboard each of the three participating EFP Amendment 80 vessels during Phase I of EFP 09-02.

EFP Vessel:	***Cape Horn***	***Constellation***	***Ocean Peace***
Target Fishery/Area	Arrowtooth/Area 517 Cod/Area 521 (one tow) Flathead/Area 513	Arrowtooth/Area 517 Yellowfin-Btm poll/Area 514 Flathead-cod /Area 521, 513	Arrowtooth/Area 521 Yellowfin/Area 514
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Sea Samplers	J. Colling, R. Cartright	L. Cocas, R. Wolfe	K. McPeck, M. Cliff

With the limits on halibut bycatch usage on the vessel detailed above, The *Ocean Peace* did one EFP trip only, first targeting arrowtooth flounder in Area 521 (4 fishing days) then moving to the Kuskokwim Bay area to target yellowfin sole (8 days). The *Constellation* did an arrowtooth flounder trip in Area 517 (6 days), a yellowfin sole trip near Kuskokwim Bay (9 days) and a final flathead/cod trip in Areas 521 and

513 (13 days). Note that the *Constellation*'s arrowtooth trip was cut short because they lost a net when it hung up on a wreck, forcing them to return to Dutch Harbor to replace the gear. The *Cape Horn* completed two EFP trips: one targeting arrowtooth/rex sole in Area 517 (11 days) and a combined arrowtooth/flathead trip in Areas 517 and 513 respectively (6 days). The first *Cape Horn* trip also included one cod target tow in Area 521. Three non-EFP tows were called by the captain on the *Ocean Peace* due to weather where the captain felt deck sorting activities would be unsafe. For these tows, all personnel were informed prior to setting that the upcoming haul was not an EFP tow and that the normal Amendment 80 procedures would be in place for that haul.

<u>Halibut discard chutes</u>

Each EFP vessel was responsible for the design and construction of the halibut holding area and discard chute where the sea sampler was stationed to collect length and viability data just prior to discarding the halibut overboard (Figure 1). The chutes on the *Ocean Peace* and *Cape Horn* were nearly identical in design with a ramp leading into the holding area from the trawl alley and the discard chute/measuring area slightly elevated so that the halibut had to be fed to the sea sampler one by one (Figure 2). The chute on the *Constellation* was of a slightly different design: there was a ramp leading into the holding area from the trawl alley but the holding area was on the same plane as the discard chute with a removable door dividing the sections (Figure 1). In retrospect, this latter design proved somewhat less effective because halibut accumulated in the holding area and when the divider was lifted to allow a halibut to move towards the sea sampler, it was hard to keep the other accumulated halibut from sliding forward as well. Also, the Constellation's chute proved to be slightly too short (157 cm from the divider to the discard window) – for halibut larger than about 150 cm, the divider had to be removed to allow for measurement (Figure 2). For the chutes used on the *Cape Horn* and *Ocean Peace*, a flow of water from a deck hose was used to provide seawater to halibut kept in the holding area in order to improve viability for halibut collected in that area. This was not done for the chute used on the *Constellation* because it would have further aggravated the tendency for multiple halibut to slide forward when the divider was opened.

Despite the inherent limitations in the chutes developed by the EFP participants, over the course of the project only 3 deck halibut (out of almost 17,000) accidently slipped overboard before they could be measured or assessed for viability. All these occurred on the *Constellation* when the halibut quickly slid over the divider (when the holding area was full) or under the partially open divider while measuring a large halibut or sliding fish into the data collection area) and out the discard window. Additionally, one factory halibut slipped overboard prematurely on the *Cape Horn*. For those halibut that unfortunately eluded direct measurement (0.023%), lengths were visually estimated and mortality rate assignment was done as detailed below.

With the discard chutes at deck level, the sea samplers were positioned somewhat awkwardly to collect halibut data (Figure 3) and this resulted in discomfort when collecting halibut data on deck for extended periods of time.

Figure 1. Clockwise from top: halibut holding areas and discard chutes on the *Cape Horn*, *Ocean Peace* and *Constellatio*n (pictured with Permit holder, John Gauvin (r) and the skipper of the *Constellation*, TJ Durnan).

Figure 2. Left: Crew member feeding a deck-sorted halibut to the sea sampler on the *Ocean Peace*. Right: Sea sampler on the *Constellation* collecting data on a larger halibut.

Figure 3. Sea samplers somewhat awkwardly positioned to collect halibut data on the *Constellation* (left) and the *Ocean Peace* (right).

Halibut sorting performance on deck and in the factory

Deck sorting for halibut went very well overall with crew members able to sort out approximately 85% of the total number of halibut in the EFP on deck and over 93% of the total by weight. The average halibut mortality rate on deck from the project overall was approximately 45% and the average rate for halibut missed during deck sorting operations and recovered in the factory was approximately 84%. Average sorting time on deck for the EFP overall was approximately 26 minutes (from the time net brought aboard to time last halibut went back in the water or deck sorting completed, whichever was longer) whereas for factory halibut it took approximately 186 minutes on average to return the last halibut from a haul to the sea.

Based on informal telephone conferences between the principal investigator and the EFP captains following the project, the captains thought that things went well overall considering the rigorous sorting and accounting protocol of the EFP. Captains felt that deck crew generally did well with sorting and that sea samplers worked very diligently to follow the halibut accounting protocol including the long hours supervising factory sorting operations to oversee accounting of halibut missed on deck. Captains felt overall that sorting time on deck could have been decreased if each halibut did not have to be measured and assessed for viability. Captains felt that things would go better if a slightly different protocol were used where halibut could be sorted in a similar manner (allowing for some improvements in chute design) and then fed onto some sort of scale or length measurement recording device which would record individual halibut numbers or weights. This they felt would help avoid the “bottle neck” that occurred when halibut backed up awaiting measurement and viability assessment by the sea samplers.

A notable difference from the overall level of performance (% sorted by number on deck) occurred during the time when two of the EFP vessels targeted yellowfin sole: only 49.3% of the halibut were deck sorted on the *Ocean Peace* when fishing yellowfin sole compared to 90.2% in the arrowtooth target; 53.7% were deck sorted on the *Constellation* compared to 93.3% in the arrowtooth target. For arrowtooth flounder and flathead and cod target tows, groundfish catch amounts per haul were smaller and halibut were generally larger which in combination apparently facilitated deck sorting operations. Sorting times for the non-yellowfin target fisheries were generally lower and for the most part the crew could complete sorting faster than the halibut in the haul could be measured and assessed for viability.

The general opinion by those in the field was that deck sorting as conceived in this first EFP effort was not conducive to achievement of halibut mortality savings in the spring yellowfin sole fishery. Part of this was thought to be due to the nature of that fishery which tends to have relatively few and generally smaller halibut on average than yellowfin fishing at other times of the year.

According to Katy McGauley, the field project manager, the vessel crew members on deck made a very good effort to sort the halibut from the landed catch – they were diligent and effective. At times there were as many as 9 crew members on deck looking for halibut (Figure 4). The sorting in the factory also went very well. According to the field project manager’s observations and accounts from sea samplers, the factory crew are accustomed to assisting the observer and were very cooperative in ensuring that the sea sampler on duty was provided with all the halibut that came out of the tank. Whenever a halibut landed in the observer’s sample or slipped by the sorters and ending up in the processing area, it was always given to the sea sampler.

Figure 4. Crew on the *Constellation* sorting halibut from a flathead tow.

Average and vessel-specific deck and factory sorting times are included in Table 4. The *Cape Horn* average deck sorting time (21.5 minutes) was considerably faster than the average sort times of the *Constellation (*27.6 minutes) and the *Ocean Peace* (31.2 minutes). These reported "sorting" times included both the time needed to sort out the halibut and the time it took to complete the measurement and viability assessments for each halibut. On some tows, the sorting took only a fraction of the overall sorting/accounting time and this may well have affected the outcome in terms of halibut viabilities according to the EFP vessel captains. Halibut that had been sorted were collected in a holding trough outside the trawl alley at the entrance to the halibut chute. Also, included in sorting time were specific situation that occurred such as mechanical issues. For instance, on one vessel a codend could not be sorted immediately due to an equipment breakdown in the factory which temporarily halted processing operations. The Amendment 80 prohibition on mixing fish from different hauls complicated this situation for deck sorting was a factor here because the codend then had to be held on deck and deck sorting could not occur until the factory operations were resumed and a tank was then fully emptied for fish from the next haul.

Halibut Viability Assessment

According to the field project manager, the sea samplers worked hard on this project and did an impressive job. Based on the field project manager's conversations with the sea samplers, sea samplers felt overall that the viability assessment and halibut data collection went smoothly and quickly due in part to the crews' assistance feeding the halibut to them one by one. One suggested that there be another category between "excellent" and "poor" in the viability assessment grading system for assessing halibut viability on trawl vessels. Overall, most thought that assessment of viability was straightforward and not difficult. Sea samplers also expressed the opinion that most of the halibut in the factory were poor or dead and that smaller bags, efficient deck sorting and less time spent on deck seemed to positively affect the halibut viability. The sea samplers all agreed that for the yellowfin sole portion of the project, haul size, mud, and the general difficulty in sorting the yellowfin bags were important factors to consider.

EFP Data Accounting

The data spreadsheet format for recording EFP data worked well. The sea samplers had little to no problems maintaining the file, providing the halibut weights and numbers to the vessel observers and transmitting the data to the project manager. One glitch that was encountered was the file size restriction on the vessels' email accounts (generally one megabyte). This would not have been a problem if the computers on the boats had MS Excel 2007 installed (the 2007 file version was about 300 kb in size). Because they all had only the 2003 version of Excel installed on their computers, the file size exceeded the limit (2003 files were about 1.2 mb). This required that the satellite internet provider (Amos Connect) be contacted to temporarily lift the size restriction so the vessel could receive the larger files. To reduce cost (~$20/mb), one vessel requested that only the necessary halibut and haul data be copied and pasted daily into a smaller file for transmission to the project manager who then pasted it into the master spreadsheet (Excel 2007). Also, one of formulas in the 2007 Excel file was not compatible with Excel 2003 ("SUMIFS"). This affected only the mortality calculations so the vessel personnel could not see the calculated mortality amounts and rates but these were included in the summarized EFP data update provided daily to each of the vessels.

<u>Calculations of Estimated Halibut Mortality Savings and EFP Data Synopsis</u>

Table 4 summarizes by vessel the groundfish catch (Official Total Catch or OTC), halibut catch (numbers, metric tons, rates), the EFP halibut mortality amounts and rates on deck and in the factory calculated from halibut viabilities, the "official" halibut mortality (by target fishery) and the estimated halibut mortality savings. Table 5 summarizes the EFP data by vessel and target fishery.

The project concluded with a total estimated 17.15 mt of halibut mortality savings for use in Phase II: the total deck mortality was 28.29 mt while the total factory EFP mortality was 3.82 mt for a total of 32.11 mt EFP mortality. The mortality based on the official DMR was 49.26 mt. The overall EFP mortality rate was 47.75% compared to the average 73.25% official DMR based on a weighted average of fishing within the different fishery targets for which different official DMRs apply. Deck halibut mortality was 45.12%, overall factory mortality was 83.86%. Total EFP groundfish catch was 3,592.4 mt which included an incidental halibut catch of 67.25 mt (19,649 fish of which 16,986 were sorted out on deck, 2,663 in the factory). In total, three deck halibut were not assessed for viability, and 4 deck and 8 factory halibut had their lengths estimated.

The estimated halibut mortality "provisional savings" broken down by vessel are shown in Table 3. The table shows the accumulated savings calculated on a tow by tow basis for each vessel.

Table 3. EFP Phase I provisional halibut mortality savings by vessel:

Vessel	**Provisional Hbt mortality savings (mt)**
Cape Horn	9.168
Constellation	6.113
Ocean Peace	1.869
Total:	**17.150**

Table 4. EFP data summarized by vessel.

Vessel	No. tows EFP	No. tows non-EFP	Total EFP Catch (mt)	EFP Halibut Catch: Sorted on deck no.	EFP Halibut Catch: Sorted on deck Wt. (Kg)	EFP Halibut Catch: Total no.	EFP Halibut Catch: Total Wt. (Kg)	% deck sorted By no.	% deck sorted By wt.	Avg sorting time (min) Deck	Avg sorting time (min) Factory	EFP Mortality Rate (%) Deck	EFP Mortality Rate (%) Factory	EFP Mortality Rate (%) Total	EFP Mortality (mt) Deck	EFP Mortality (mt) Factory	EFP Mortality (mt) Total	Official Hbt Mortality (mt)	Hbt Mort Savings (mt)
Cape Horn	82	0	846.9	9301	32,070.8	10760	34,277.8	86.4%	93.6%	21.5	119.6	44.28%	84.81%	46.89%	14.20	1.87	16.07	25.24	9.168
Constellation	153	0	1940.2	6062	22,952.3	7060	24,607.5	85.9%	93.3%	27.6	172.7	44.72%	81.26%	47.18%	10.26	1.35	11.61	17.72	6.113
Ocean Peace	46	3	805.2	1623	7,673.4	1829	8,367.4	88.7%	91.7%	31.2	321.8	49.84%	87.05%	52.92%	3.82	0.60	4.43	6.30	1.869
Project Totals	**281**	**3**	**3592.4**	**16986**	**62,696.5**	**19649**	**67,252.7**	**86.4%**	**93.2%**	**26.4**	**181.6**	**45.12%**	**83.86%**	**47.75%**	**28.29**	**3.82**	**32.11**	**49.26**	**17.150**

Table 5. EFP data summarized by vessel and target fishery (CH=*Cape Horn*, Con=*Constellation*, OP=*Ocean Peace*).

Target/Vessel	Total Catch (mt) CH	Con	OP	All	Halibut Catch (mt) CH	Con	OP	All	Halibut Mortality savings (mt) CH	Con	OP	All	EFP Mortality Rate CH	Con	OP	All	IPHC Mort. Rate
Arrow	563.4	433.8	198.6	1195.8	24.949	8.643	7.939	41.531	8.394	2.253	1.845	12.492	41.35%	48.93%	51.76%	44.92%	75%
Yellowfin	-	575.8	606.6	1182.4	-	0.506	0.428	0.934	-	0.046	0.023	0.070	-	70.83%	74.52%	72.52%	80%
Flathead	280.0	415.3	-	695.2	9.304	7.427	-	16.731	0.767	1.810	-	2.577	61.76%	45.63%	-	54.60%	70%
Cod	3.6	472.4	-	476.0	0.025	7.747	-	7.773	0.007	1.898	-	1.905	43.57%	45.46%	-	45.46%	70%
Btm poll	-	42.9	-	42.9	-	0.284	-	0.284	-	0.106	-	0.106	-	37.57%	-	37.57%	74%
All Targets	846.9	1940.2	805.2	3592.4	34.278	24.608	8.367	67.253	9.168	6.113	1.869	17.150	46.89%	47.16%	52.92%	47.74%	73.25%

Target/Vessel	Avg. Haul size (mt) CH	Con	OP	All	Avg. Haul duration (hrs) CH	Con	OP	All	Avg. deck sort time (min) CH	Con	OP	All	% Deck sorted (by wt.) CH	Con	OP	All
Arrow	8.54	12.05	11.68	7.14	2.80	2.45	2.39	2.64	18.3	28.9	22.9	22.2	96.02%	94.56%	93.50%	95.24%
Yellowfin	-	16.45	20.92	18.47	-	2.56	2.82	2.68	-	39.0	36.0	37.6	-	71.69%	58.50%	65.64%
Flathead	18.66	10.56	-	12.96	2.44	2.22	-	2.32	36.5	20.2	-	25.2	86.94%	86.55%	-	86.77%
Cod	3.61	11.52	-	11.33	1.33	2.38	-	2.35	8.0	23.8	-	23.4	100.00%	93.59%	-	93.61%
Btm poll	-	14.31	-	14.31	-	1.83	-	1.83	-	17.3	-	17.3	-	91.65%	-	91.65%
All Targets	10.33	12.60	17.50	12.91	2.72	2.39	2.66	2.53	21.54	27.53	31.17	26.4	93.56%	91.34%	91.71%	92.52%

Additional Issues Identified by the Field Project Manager

Other issues that arose included:

- Transcription error: a sea sampler on the *Constellation* forgot to transcribe factory halibut data from the length strip to the deck sheet. His initial deck sheet showed zero factory halibut, but the observer on duty noted that she did in fact see at least one halibut pass by. The sea sampler then realized he had forgotten to transcribe the data before erasing the tick marks on the length strip. Halibut numbers and lengths were estimated for the factory portion of this haul (5 small halibut).
- Deck view obstruction: on the *Ocean Peace* the sea samplers had difficulty monitoring the entire deck from their data collection station near the discard chute because their view was obstructed by the gantry. They could fully monitor deck activities only if they moved to another part of the deck.
- Killer whale predation on halibut during the EFP: In the regular fisheries for flatfish and cod, killer whales sometimes follow longline and trawl vessels in the Bering Sea and can sometimes be seen taking fish from longlines or feeding on discards. While more common for longline vessels targeting sablefish, for trawlers whale encounters seem to occur more frequently when fishing for Greenland turbot. During the EFP, whales were noted during fishing operations and could occasionally be seen eating halibut sorted from the deck. Specifically, whales were sighted from time to time during five days of operations on the *Constellation* and two days of operations on the *Ocean Peace*. In both cases, the vessel was targeting arrowtooth flounder with some turbot being taken in combination with the arrowtooth flounder. Whales were also seen occasionally from these same vessels when targeting flathead sole but the whales stayed relatively far away and did not appear to be feeding on discards. On the *Cape Horn*, whales were seen at a distance on two occasions while targeting arrowtooth/Rex sole but were not seen taking halibut that were discarded. There is no way to estimate the fraction of halibut released from the deck that were eaten by the killer whales on tows where the whales were following the EFP vessels. It was noted that the whales generally seemed to concentrate on offal discards from turbot but did at times eat some of the halibut when in close proximity to the vessel. It is not known if halibut sorting operations on deck make the halibut more vulnerable to predation by whales than under normal Amendment 80 operations where halibut are discarded from the discard chute in the factory.
- Long hours in the factory for the sea samplers: even though working 12-hour shifts, the sea samplers did express a desire to have more or longer breaks and that working long, tedious hours in the factory was challenging (particularly during yellowfin sole fishing). The requirement in the EFP that no fish could be sorted on deck or in the factory (fish that had not yet passed over the flow scale) unless a sea samplers was present created a difficult work schedule for the sea samplers.
- Codend or fish left on deck: As was described above, there were a few instances when a codend or a few tons of fish from a bag were left on deck for 1-6 hours until tank space became available. This occurred three times on both the *Constellation* and the *Ocean Peace* during the

yellowfin sole fishery and once on the *Cape Horn* when they brought up a large bag of fish while targeting Arrowtooth. Leaving the fish on deck probably reduced the deck halibut viability to some degree but the number of times this occurred relative to the overall number of EFP tows is quite small so effect on the overall results is probably quite small.

Conclusions and directions for future work on deck sorting

The project showed that halibut mortality rates on Amendment 80 trawlers can be reduced by sorting halibut out of the catch on deck so as to return them to sea as quickly as possible. Most of the modified halibut handling procedures used for the EFP appeared to be feasible for the EFP vessels in the arrowtooth, flathead sole, rex sole and Pacific cod fisheries – though probably not as feasible in the spring yellowfin sole fishery. This is because catch amounts per haul in that spring yellowfin sole fishing are typically greater than for most flatfish target fisheries and with the already low halibut bycatch rates in spring yellowfin sole fishing, the feasibility of sorting through the haul to remove a few or even no halibut is relatively low. Fall yellowfin sole fishing, however, is generally more like the cod and flathead sole fishing done in the EFP in terms of catch amounts per tow and size and number of halibut per tow so it might be a good candidate for reductions in halibut mortality rates with deck sorting.

The preliminary findings from the project are generally consistent with expectations: smaller catch amounts per tow, focusing on target fisheries where halibut are relatively bigger and therefore deck sorting of halibut is more efficient, proper handling and discarding of the halibut on deck, and shorter haul duration appear to be related to the lower mortality rates for halibut removed on deck under the EFP protocol relative to the rates in the regular fishery. These factors combined with the very important factor of getting the halibut back in the water faster than occurs in the regular fishery are all likely to be jointly responsible for the lower halibut mortality rates attained in the EFP. It is important to keep in mind, however, that the additional time (time out of water) needed for halibut measurement and viability assessment probably affected the halibut viability rates in the EFP relative to the envelope of the possible. This added time is related to measurement of the effects of the different halibut handling protocol on halibut viability rates under the protocol of the EFP. At such it likely confounds rigorous assessment of the degree to which factors such as towing time, haul size, sorting effectiveness and other factors that are in the control of a fishing captain are correlated with per tow viability rates.

A potential modification for the chutes would be one where sea samplers or observers doing halibut catch accounting or viabilities would not have to work bent over or on their knees for prolonged periods of time. Similar improvements in the sorting area might allow crewmembers to sort halibut from the groundfish catch more efficiently and with lower physical demands. One idea here might be to design the chutes along the lines of sorting belts where the fish put on the belt would be lifted via a conveyor belt to the area where measurement or weighing occurs. For some vessels, the chute would need to be removable to allow access to storage area or offload hatches when catch sorting operations are not occurring. A sorting belt that uses a powered conveyor belt may pose some fabrication and installation challenges.

A potential direction for the halibut handing protocol might be one where halibut could be enumerated and weighed via a scale or length recording device placed on the halibut chute (on deck) that electronically records and stores individual halibut lengths or weights. If this is technically feasible and affordable, it could allow for a faster pace of returning the halibut to the sea while accurately recording their weights. Under this approach, sub-sampling for viability might be done so that viability sampling would not take as long and therefore not affect the time needed to return halibut to the water as occurred to some degree in the EFP.

Mechanized enumeration of halibut catches and sub-sampling for halibut mortality at a level that would provide adequate information on viabilities but would minimize time needed to return halibut to the water would be a big step forward for the practicality of deck sorting halibut. Based on the findings of this EFP, participants generally found that shorter tow times and smaller catch amounts per tow were workable for most of the fishing targets evaluated in the EFP (save spring yellowfin sole). The extra labor to sort halibut on deck and consequent slower pace of production are compensated by lower halibut mortality rates and hopefully the additional groundfish catch that not being constrained by halibut bycatch would provide. This may prove increasingly important as the 200 mt reduction in halibut mortality available to the Amendment 80 sector becomes fully implemented in 2011 and especially in years of relatively high spatial overlap between the halibut biomass in Bering Sea and flatfish and cod fishing locations.

Follow up discussions with EFP captains and EFP vessel owners since the EFP has consistently reinforced their interest in accounting for halibut catches mechanically instead of with additional observers or sea samplers. Additional personnel on the vessels who are not involved with producing fish products is expensive and reduces space needed for crew members. EFP participants are interested in exploring mechanical devices to account for halibut catches at a pace that is closer to the 10 minutes (approximately) that captains believe is the time the crew will need to sort the halibut from the catch if deck sorting is allowed in regular fisheries. This is therefore a logical area of focus for additional field work on deck sorting.

Another function of having sea samplers on deck in the EFP was to help oversee the crew's deck sorting activities. This task may however be better suited to electronic monitoring provided the challenges identified in the pilot work by Archipelago Marine Resources can be met. Future work on deck sorting with EM as a monitoring tool might therefore focus on designing the monitoring system and review of the EM data around the specific monitoring objectives for deck sorting on deck. This would hopefully be built around an acceptable standard for review of the EM data that is known from the outset so that it could be incorporated into the field testing.

One thought here is that a mechanical device for taking lengths or weights of halibut could be equipped with a time/date stamp for each halibut. Having the sea samplers write down specific times for each halibut they measured and assessed for viability was not possible in the EFP last summer because this would have further slowed the pace of recording lengths and viabilities for each fish and further increased the time needed to return the fish to the sea. But having this done by a mechanical device that included a time stamp would probably not slow down the pace of getting halibut back in the water and it would provide some key information that could be matched to the EM data collections in order to facilitate and improve the review of the EM data and spot check for accuracy of halibut accounting. Future field work on deck sorting might look at how EM and length or weight recording devices could work together to improve accuracy and efficiency.

Finally, sub-sampling for halibut viability could help to speed up the process of accounting for halibut viabilities and getting the halibut back in the water as fast as possible. Participants felt that after thinking about what occurred in our EFP last summer, sub-sampling may be key to reducing the time that halibut spend out of the water awaiting viability assessment. To this end, future field work on deck sorting may be able to utilize the data set of halibut viabilities from EFP 09-02. The variability in those data may be useful for looking at the accuracy tradeoffs of sub-sampling for halibut viability in any future field tests. Optimally, the data would allow us to understand the tradeoffs in precision of different random sampling designs such as taking viability samples from a sample (e.g. 5 or 10% of the halibut) caught over the course of a given number of vessels in any future field work on deck sorting.

The study overall was a valuable first step to look at potential for reducing halibut mortality rates and general feasibility. It is important to keep in mind, however, that because of design and cost issues, the project's value for evaluating relevant scientific questions may not be as high as some may have wanted. For example, these data are not ideal for analysis of relationships such as correlation between halibut viability and haul size (or tow time, bottom temperature, surface temperature). This is because on many tows, the halibut handling protocol of the EFP and specifically the requirement to measure and do viability assessment on every halibut served to significantly increase the time it took to return the halibut sorted on deck back to the water. In this regard, the EFP data show that it took an average of 27 minutes to sort and account for halibut length and viability for each EFP tow. But on many tows the deck crew was able to sort the halibut out of the catch on deck in as little as 10 minutes according to EFP participants and discussions with sea samplers following the EFP.

This outcome was that due in part to the design of the study and limits on resources. Because sea samplers were working on 12 hour shift and therefore only one was available at any time to account for halibut lengths and condition, halibut sometimes sat in a holding trough awaiting measurement and viability assessment by the sea sampler on duty. Conceptually, the delay is really not part of the process of sorting halibut and returning them to the sea, it is due more to the limited resources available in the EFP to measure the halibut catch and account for viability. If an alternative set up for the EFP had been used, such as having numerous sea samplers working on deck each shift, this would have sped up the accounting and viability assessments and halibut viability assessments and would likely have been higher on average. Most problematic here for covariate analysis is that, as noted below, there is no way to separate the effects of halibut sorting and handling time by the crew from the added time needed for sea samplers in the EFP to account for halibut catch and viability.

In light of this, a time stamp on each halibut viability assessment would have made the data more useful for analysis of covariates. Such a time stamp would have enabled us to at least look at viability rates for halibut sorted first compared to ones at the end of a backlog during a particular tow. This would have been helpful for inferences about the effects of holding time awaiting viability assessment.

But a time stamp was not feasible because recording a time for each halibut by the sea sampler would clearly have involved even more time needed before getting halibut back in the water. For this reason, recording time data with each halibut was abandoned at the start of the EFP fieldwork.

Despite these acknowledged shortcomings, the study did show that significant halibut mortality savings could be attained with modifications to the procedures for handling halibut on Amendment 80 vessels. Although the 17 MT of halibut mortality savings from the EFP were not actually used by EFP participants, participants felt the savings were considerable and that more work is merited to explore how to reduce halibut mortality rates on Amendment 80 vessels. The reason savings from the EFP were not used was according to EFP participants because halibut bycatch was less problematic in the second half of the year despite being quite high at the beginning of the fishing yea. EFP participants were therefore able to do all the flatfish fishing they wanted to do within their regular PSC allowances as part of the BUC fishing activities. Halibut savings for the EFP were not transferable or usable on other vessels. Despite the fact that the savings were not utilized, EFP participants and the BUC membership overall believe that the development of a way to reduce halibut mortality rates is very important in terms of the objective of optimizing flatfish catches under the halibut mortality allowances available to the Amendment 80 sector.

Finally, it must be recognized that these halibut mortality savings came at considerable cost to both industry participants and fishery managers. Costs to managers were things such as EFP development, analysis of the permit application, and review of EFP data to confirm the calculations of halibut mortality savings. These add up to an estimated 170 hours of additional agency work according to the NMFS Alaska Region.

Thinking beyond the pilot study, any further work to change halibut handling requirements to allow sorting on deck in a larger fishery-wide setting would need to take into account a broader set of considerations. These include the question of how to best quantify the catch of halibut, and apply the right mortality estimate in season. If a census is not viable for either halibut catch or viability, then the proper mix of sampling approaches and precision tradeoffs would need to be worked out. The tradeoffs between post debriefing analysis and development of mortality rates to be applied "fleet wide" versus *in situ* measurement of viability rates and application of these data in-season to a vessel or fishing cooperative would need to be resolved. Additional work to determine the best use of the video technology would also be required given that the initial findings for the EM portion of the project were encouraging but further work is needed to ensure EM can monitor crew compliance with the sorting protocols. There are likely ways to address all of these concerns but as with all issues involving federal fisheries off Alaska, rigorous work will need to be applied before modifications in halibut handling procedures can be adopted into the regular fishery.

Acknowledgements

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work challenges, and reviewed the preliminary EFP data so that the participants could receive timely credit for the halibut mortality savings. The countless hours of work done by the above NMFS Region and Science Center staff was critical to the success of the EFP. Finally, the PI and BUC wish to thank the field project manager (Katy McGauley of the Alaska Groundfish Databank) and all the sea samplers, deck crew and EFP captains on the Cape Horn, Constellation, and Ocean Peace. Without all their tireless effort and skill at making this work at sea, our halibut mortality reduction project would not have been successful.

Works Cited

Bonney, J and K. McGauley. 2008. Testing the Use of Electronic Monitoring to Quantify At-sea Halibut Discards in the Central Gulf of Alaska Rockfish Fishery. EFP 07-02 Final Report .

Williams, Gregg. 2007. Pacific halibut discard mortality rates in the 2006 open access and CDQ groundfish fisheries, and recommendations for discard mortality rates needed for monitoring halibut bycatch in 2008 CDQ fisheries. *In:* IPHC Report of Assessment and Research Activities, 2007. P 315, 326.

Appendix 1: EM Report for BUC Halibut Deck Sorting Pilot Study by Archipelago Marine Research (Ltd.)

AN EVALUATION OF AN ELECTRONIC MONITORING SYSTEM FOR MONITORING HALIBUT DECK SORTING ACTIVITIES FOR FLATFISH VESSELS PARTICIPATING IN EFP 09-02

1. INTRODUCTION

The Best Use Cooperative (BUC) recently completed a field experiment to evaluate the effectiveness and feasibility of sorting halibut bycatch from the target catch on deck to reduce halibut mortality rates in Bering Sea flatfish fisheries. Each vessel participating in the BUC's halibut sorting EFP was required to carry two at sea samplers in addition to the existing two observers for a total of four persons monitoring catch during Phase One of EFP 09-02. While this intensive level of human effort may have been needed for the pilot study, in the longer term this level of manpower would be both costly and logistically complex. Accordingly, BUC wished to examine if a technology based approach could be considered for monitoring deck sorting of halibut.

Over the past decade, Archipelago Marine Research Ltd. (Archipelago) has pioneered video-based EM technology, carrying out over 30 studies spanning diverse geographies, fisheries, fishing vessels and gear types, and fishery monitoring issues. EM has been successfully tested for a range of monitoring issues including fishing location, catch, catch handling, fishing methods, protected species interactions, and mitigation measures. The efficacy of EM for monitoring issues varies according to fishing methods and has been reviewed in McElderry (2008).

BUC contracted with Archipelago to evaluate the efficacy of EM for monitoring fish handling protocols as set forth in the EFP. This study involved the placement of an EM system aboard one of the three BUC vessels involved in the Halibut Deck Sorting EFP to collect data for the entire duration of their participation in the study.

2. METHODS

EM Equipment

The EM system used for this project was custom manufactured by Archipelago. A basic EM system, shown schematically in Figure 1, consists of up to four closed circuit television cameras, a GPS receiver, a hydraulic pressure sensor, winch sensors, and a system control box. Technical specifications for the EM system are provided in Figure 2. Additional components provided for this study included a satellite modem communications system and a large waterproof display monitor, to provide camera monitor views at the observer sampling station.

The EM system control software can be set in a variety of ways for data recording. For the purposes of this study, the system was powered continuously to record sensor data (e.g. location, time, speed, hydraulic activity, event, etc.) at a 10-second frequency. Image data recording was also set to record continuously following the first instance of fishing activity (elevated hydraulic pressure) once the vessel was at sea (outside Dutch Harbor). All data were recorded onto a 500GB hard drive which would last for about 50 days of continuous operations. The satellite modem was programmed to transmit an hourly synoptic report consisting of vessel location, activity, and EM system functionality. This communications device was very new and included on this study to help Archipelago continue beta testing the device and to help troubleshoot the EM system if any technical problems occurred during the trip.

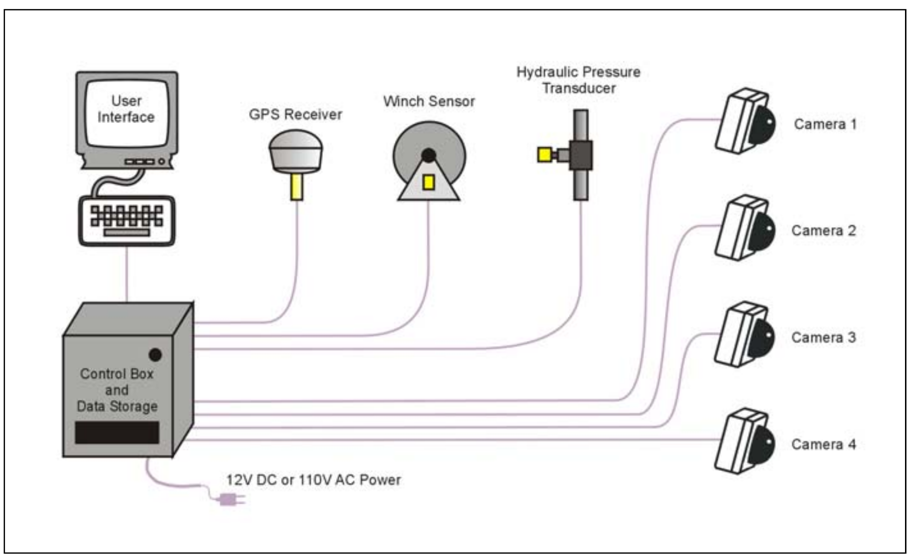

Figure 1. Schematic of standard EM system.

Deployment of EM System on Fishing Vessel

The EM system was installed by an Archipelago EM technician on the factory trawler *F/V Cape Horn* on May 27, 2009 in Dutch Harbor, Alaska. The two cameras, mounted on the rear gantry, used 3.6 mm wide angle lenses, and collected image data at the rate of five frames per second. One camera focused on the halibut holding area and discard chute/data collection area while the second camera captured an overview of the trawl deck (Figure 3). These camera set-ups were intended to monitor the entire area where fish would be handled on deck, with catch either being directed into the fish hold or, in the case of halibut, placed onto the discard chute. The crew activities where imagery was needed included net emptying, deck sorting, and halibut handling procedures. At the time of install the skipper and EM technician examined the camera positioning and agreed that two cameras were sufficient to monitor the fishing deck despite the option for use of up to four cameras. Once at sea, minor changes to camera positioning were made pursuant to the objective of improving the view of fish handling operations on deck.

Control Box

Dimensions	8” x 8” x 13” (20 x 20 x 31 cm)
Weight	11 lbs, 5.2 kg
Chassis/Container	Welded Aluminum (splash-proof)
Video Storage	Removable hard disk up to 500 Gigabytes
Recording Time	Configuration dependent, up to 1000 hrs
Recording Channels	4
Video Resolution	VGA (640-480 pixels)
Video Compression	Windows or DivX
Frame Rate (FPS)	Up to 30 total FPS – DivX
Serial Data Input	2 - RS232 I/O channels, 6 channels optional
Operating System	Microsoft Windows XP Embedded on Solid State Disk
Operating Software	Autonomous at-sea execution, user configurable recording operations according to sensor input events

1. Power Specifications

DC Power	12 to 16 VDC
AC Power (adaptor)	90 to 240 VAC
Operating Current	6 Amps
Protection	20 Amp fuse, Battery deep discharge prevention
Protection	Low current (20 mA) Sleep Mode

Digital and Analogue to Digital Inputs (Sensor Inputs)

4 – 10 bit, 0 – 5 VDC analog inputs
2 – 16 bit, pulse (event) counters
32 – programmable digital I/O lines

Available Sensors and options – GPS, Radio Frequency ID Tag, pressure, rotation, acoustic receiver, contact closure, power supply monitor, Iridium satellite modem (ship to shore).

2. Standard Camera

Housing	Powder coated cast aluminum, sealed to IP66
Power	12 VDC
Resolution	480 TV lines, analog NTSC signal
Lenses	2.9 (fisheye) to 16 mm (telephoto)
Light rating	1 – Lux
Aiming	Fixed aim, internally adjustable for Pan, Tilt, Rotation.

Figure 2. Technical Specifications of an EM system.

Figure 3. Images of the original camera views and placement of EM equipment on vessel. Left: view of halibut holding area and discard chute. Right: view of trawl alley.

The hydraulic pressure sensor was installed by the vessel engineer and was tapped into one of the warp winches on the rear gantry. The GPS receiver and satellite modem were installed by the EM technician, also on the rear gantry. The control box was mounted in the factory close to the observer's monitor. The skipper and EM technician examined the options for placement of the winch rotation sensor and decided that it would not be installed, due to lack of a suitable installation location, redundancy with this and the hydraulic sensor, and time constraints imposed by vessel's fishing schedule.

Once the install was complete, the EM technician provided a demonstration of the EM system to vessel personnel, sea samplers, and observers. The demonstration included a review of the EM user interface, functionality testing, and approaches to follow if any problems were identified. These individuals were then responsible for monitoring the status of the EM system throughout the fishing trip.

Analysis of EM Data

Data analysis was carried out by Archipelago staff in Victoria, BC and was facilitated using a custom software application which integrates time series and spatial plots of the sensor data with synchronized playback of all camera images. This application allowed imagery data to be played at a wide range of speeds, from frame-by-frame to twelve times real-time.

The analysis and critique was done by a single data technician for consistency; however, input and feedback were given by other members of staff based on their areas of expertise.

The analysis of EM Data did not attempt to monitor the operations for adherence to the EFP protocols *per se* as it was expected that the presence of observers and sea samplers during these operations would ensure compliance. Instead, all of the analysis focused on answering the following questions:

- Could EM distinguish species to ensure that the only species discarded on deck was halibut?

- Could EM verify that discarding on deck only occurred via the approved halibut discard chute?

- Were halibut handled in the prescribed manner?

- If there was reason to believe that the discarding protocols were not followed, could EM be used to count the number of halibut discarded (via the chute or otherwise)?

- How well does EM work under various fishing situations (e.g., catch levels, day/night, weather affects, etc.)?

As mentioned, camera positioning was changed during the fishing trip. The first step in image analysis was to examine catch stowage operations from the entire data set to identify the total number of camera configurations present in the imagery data. Once each configuration was identified, one fishing event representing each was selected and assessed for their ability to answer the questions listed above.

The next step in analysis was to identify time and location of individual fishing events and catch processing activities, to assess the quality and completeness of EM data, and to gain an understanding of the ability of imagery from each catch stowage operation to monitor EFP catch handling protocols. All of the data available were reviewed at various speeds to identify the following information, recorded in an MS Excel spreadsheet, for each fishing event:

- Time and location information for gear setting– As described in Figure 4
- Time and location information for gear hauling – As described in Figure 4
- Time and location information for catch stowage completion – Defined as when the last fish was placed in the holding tank and/or the last halibut sorted on deck was released, whichever took longer.
- Image quality rating – A combined assessment of imagery from both cameras during the catch stowage operation on its ability to answer the EFP catch handling questions listed above:
    - High – The imagery was very clear and a good view of fishing activities was present. Focus was good, light levels were high, and all activity was easily seen.
    - Medium – The view was acceptable, but there may have been some difficulty assessing exactly how fish were handled. Slight blurring, water droplets on the lens, or slightly darker conditions hamper, but did not impede analysis.
    - Low – The imagery was difficult to assess. Some camera views may be unavailable or overexposed, imagery blurred, lighting poor or diminished. Some but not all aspects of the image analysis could be carried out.

- Unusable – Imagery for all cameras was missing or of such poor quality that none of the analysis could be performed.

- Camera set-up –When changes to camera position were noted, each unique set up was assigned a numerical code.

- Additional notes – Notes were made if anomalies were identified in either the sensor or image data set.

The third step in analysis was to examine the influence of catch volume and the ability to monitor handling procedures. Using observer data, catch levels were categorized as high (>30 MT), medium (~15 MT), and low (<1 MT). Two catch stowage events for each category were examined and assessed.

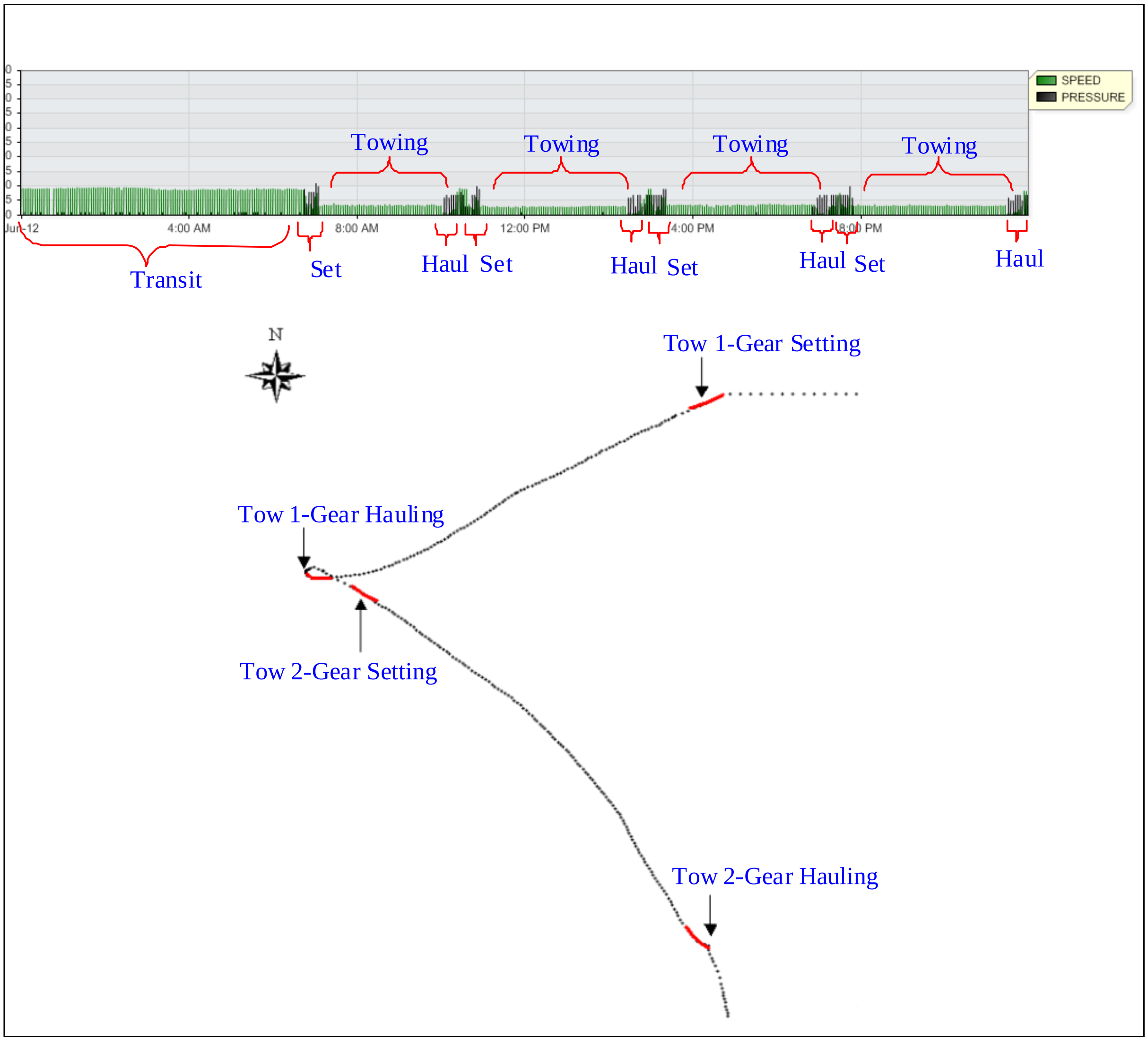

Figure 4. Example of sensor data from the *F/V Cape Horn*. The time series graphs (upper) show vessel speed (knots), and hydraulic pressure (psi). Gear setting and gear hauling were associated with spikes in hydraulic pressure and changes in speed. Towing was associated with constant and relatively low speed. The spatial plot (lower) shows an example of the vessel's cruise track, with gear setting and hauling highlighted in red.

3. Results

EM System Deployment and Data Capture

The EM system operated continuously for a period of 21 days from May 28th, 2009 at 01:04, when the vessel departed Dutch Harbour, Alaska, until June 17th, 2009 at 01:27, when the system was shut down prior to arrival in port in order to dismantle and pack up the equipment. There were no instances of power interruption and the sensor and image data were 100% complete for the data collection intended. The GPS and hydraulic pressure sensor operated very well and vessel activity such as transit, fishing activity (gear setting, towing, and gear retrieval) could be easily distinguished (Figure 4). The onset of catch stowage operations was evident from sensor data and an examination of image data was necessary to confirm when all fish were cleared from the deck and stowage operations were completed. Over the entire fishing trip, the vessel completed 82 fishing events. A total of 435 hours of image data were collected during the study, totalling 227 GB of hard drive storage, of which 226 hours corresponded to fishing activity (net in the water) and 60 hours corresponded to catch stowage operations.

Unfortunately, the satellite modem did not operate properly during the study and no real time EM status reports were available. The equipment was examined after the study and the problem was identified. As mentioned, this equipment was at an experimental stage of development and its deployment enabled us to resolve integration issues, making it more reliable for future uses of the technology.

Image quality for the most part was rated as high throughout the project. Initially, one of the cameras was providing over-exposed, washed out images during daylight operations which at this latitude and season was almost all the time. The problem was evident once the vessel began fishing operations and we were able to determine that the factory settings of internal dip-switches were incorrect. We were able to instruct vessel personnel of the correct settings and the problem was resolved within the first three days of the trip. Out of the 82 fishing events recorded, image quality for 65 (79%) was rated as high, 4 (5%) were medium, and 13 (16%) were low due to the over-exposure issue described above. Figure 5 provides examples of image quality, including the over exposed image mentioned above. The sole reason for low quality assessments was the camera dip switch problem. Medium quality imagery was generally related to the accumulation of water droplets on the camera dome surface.

Figure 5. Example imagery to illustrate the different image quality assessments. From left to right: high, medium, and low.

Image Data Assessment

The following findings are drawn from all three stages of data analysis carried out.

Three different camera configurations were identified during the initial scan though the data. Each camera configuration is shown in Figure 6 and briefly described below:

- The first configuration, established during the initial EM system installation, captured the port side scupper, where halibut were being released, the discard chute and data collecting area, the halibut holding area, most of the trawl alley, and part of the starboard side of the deck with enough overlap between camera images to allow for continuity.

- The second configuration provided a more close up view of the halibut discard chute and no change to the trawl deck camera. This change showed more detail of the fish measurement and handling within the chute but lost sight of the port side scupper and parts of the discard chute. Also lost was the overlap between the two camera views.

- The third configuration involved adjustments to both cameras but no changes to the lenses. The discard chute camera was shifted to show the scupper and more of the measurement area, but less of the holding area prior to measurement. The fish deck camera was shifted downward to show part of the discard chute, less of the starboard side trawl deck, and nothing outboard of the starboard trawl alley. As with the second configuration, the camera views did not overlap.

After reviewing each configuration, it was evident that none of these set-ups were fully capable of addressing all of the EM monitoring objectives for the EFP halibut deck sorting protocol because changes made to improve the monitoring of one protocol were generally at the expense of another. This was later confirmed when all catch stowage events were reviewed. The simple solution to this problem would be to increase the number of cameras from two to three or four.

The review of catch stowage imagery throughout the analysis indicated that EM could reliably distinguish halibut once they were placed in the discard chute area. The close up view in configuration 2 and 3 made this easier than the initial configuration. Water droplets and condensation on the camera lens reduced the ability to easily and quickly identify halibut across the chute but imagery viewers were still confident in their ability to identify halibut in such conditions. The analysis confirmed that each fish was always visible to the camera for an adequate period of time, with the sea sampler and crew mostly working on the other side of chute which allowed an un-obstructed view of the catch.

The ability for EM to verify that no catch was discarded outside of the approved discard chute was not as easily assessed with the available camera views. Only one of the cameras provided a view of the trawl deck and, while configurations 1 and 2 were better, none sufficiently covered the trawl deck and surrounding area to sufficiently monitor possible incorrect movements of fish. The single camera view made it hard to determine what the crew were doing, particularly during high catch conditions. Water droplets or condensation on the lens made this even more challenging.

All three camera configurations were considered suitable for detection of large sharks or marine mammals, which are allowed to be sorted and discarded on deck. Identification of these catch items to species may require additional camera views of the trawl deck.

Throughout the analysis, halibut handling methods were easily determined once they entered the discard chute. It was clear to the imagery reviewer that halibut were being slid and not picked up by the tail or grabbed by the gills. Water or condensation on the lens did not seriously impede this assessment. Halibut handling in the holding area of the discard chute was more difficult to assess with camera configuration 2 and 3, where there was no overlap between camera views.

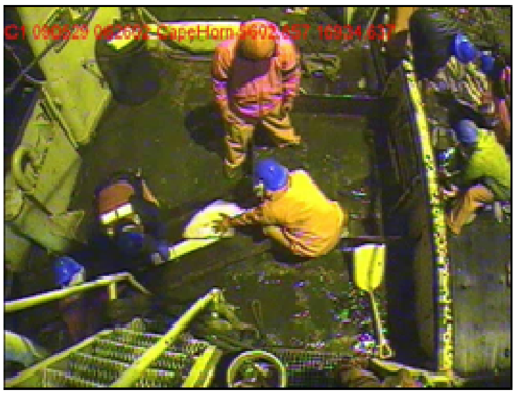

Figure 6. Examples of both camera views from each camera set-up. All images on the left correspond to camera one and those on the left to camera two. From top to bottom: camera set-up one, two, and three.

The camera view of the trawl deck provided a good general understanding of halibut sorting. All camera configurations posed difficulties when trying to make a detailed assessment. In addition, large volumes of fish on the trawl deck, being sorted by numerous people, made watching each person's halibut handling behaviour difficult. Total catch volume and halibut discard volume had a direct effect on how much time it would take to monitor halibut handling in the trawl alley as more people and higher activity levels increase the amount of time to monitor individual activities. Even with the limitations posed by camera views in this study, and events with high catch volumes, reviewers could easily detect instances of improper halibut handling such as throwing fish or handling them by the tail. Increasing the number of cameras and providing close up views of the trawl deck would make these assessments easier but the complexity of the catch sorting operations would also require multiple passes through the imagery to fully monitor all activities.

EM image data was also assessed for the ability to count the number of halibut discarded on a given tow in cases where there may be reason to believe that the prescribed protocol for discarding was not followed. As mentioned above, once halibut were passed to the discard chute area, halibut could be reliably identified and counted. In the trawl deck area the camera view was not sufficient to clearly resolve individual halibut for identification and counting. However, the area could be reliably monitored to determine if any fish, halibut or otherwise, were removed from the trawl deck other than through the discard chute or fish well. Multiple cameras of the trawl deck would improve our ability to make this assessment.

4. Conclusions and Recommendations

Despite some minor issues, the EM system performed very well and was successful providing 100% data collection for the entire fishing trip, totalling 21 days and 82 fishing events. Imagery was nearly complete, the majority of which was assessed as high quality for monitoring halibut deck sorting activities. Weather conditions (i.e. water droplets or condensation in the cameras) did not significantly hamper imagery analysis at the chute. A thorough review of the imagery showed that halibut could be reliably identified and counted in discard chute. Crew handling procedures for halibut could also be easily assessed. Camera imagery for the trawl deck area provided a wider field of view and correspondingly did not resolve catch handling operations as clearly. Large sharks or marine mammals being sorted and discarded on the trawl deck would likely have been easily detected, as would incidents of fish being discarded other than through the discard chute.

The study also identified some areas for future improvements. After reviewing image data during catch stowage with each of the three camera configurations, it was evident that none were capable of fully monitoring all of the halibut deck sorting protocols and that more cameras were needed to meet these objectives. As found in other studies (e.g., Bonney et al., 2008) monitoring can be enhanced through the strategic placement of multiple cameras, including both close up and wide view cameras, and overlapping views. Two cameras were insufficient for the *F/V Cape Horn* and four would have yielded a more comprehensive view of the trawl deck, while still providing sufficient detail of the discard chute to validate data collection, catch handling, and discarding practices. Multiple cameras of the trawl deck area would improve monitoring assessments but the ability to identify and count catch items would likely still prove difficult. Camera requirements for other vessels in the fleet are likely to differ depending on vessel size and deck layout. The smaller vessels would likely only require two or three cameras.

The addition of two more cameras would double the data storage requirement from about 80 to 160 GB per week. This volume is not large by present day hard drive capacity standards. There may be an opportunity to optimize data storage by triggering image capture when catch stowage events are taking place instead of continuous image recording. We suggest that a winch rotation sensor be installed on the Gilson winch in order to detect when the net codend is being handled on deck. The EM system could be configured to commence recording with Gilson winch activity, then continue for duration of 1-1.5 hours after winch activity ceased. This would ensure that imagery was recorded for the entire catch stowage event.

While the satellite modem did not function properly, problems such as those identified in this study are being identified and resolved and the technology will become very reliable, much as VMS currently is. The ability to remotely monitor EM system performance will allow for much better remote monitoring and troubleshooting, and will aid in the field effort planning.

Moving forward, there are some issues that will require further discussion. One issue involves discussion of the specific role that EM would have in monitoring halibut deck sorting protocols. An idea that the BUC is currently considering for future deck sorting field research would have a more mechanized process for moving fish through the chute and obtaining lengths or weights of individual halibut either via a hopper scale, flow scale, or automated length measurement device. Either of these would allow for a time stamp and other individual record information for each halibut that was measured or weighed. When this idea is further fleshed out prior to additional field research, it would be useful to consider how to best monitor sorting protocols. Also, with a hopper, flow scale, or automated length taking device it would likely be possible to record lengths/weights directly to the EM system and provide a much more robust way to audit deck sorting.

Another issue concerns the EM requirements for the Amendment 80 vessels that already use EM to monitor crew activities inside fish bins (for vessels that are permitted to have crew members inside fish bins to move fish). It would seem practical for the needs of bin monitoring and deck sorting to be addressed with a single more comprehensive EM system for those vessels.

Lastly, if future field research to explore the practicality of deck sorting of halibut, any aspects that include EM for monitoring fish handling protocols would benefit from a more defined set of data processing and reporting protocols. For example, one approach to data processing and review might be an audit-based approach, comparing EM derived estimates with those prepared by on board personnel. Knowing that an audit-based approach would be used from the outset would allow the research to incorporate that potential data review protocol into the research design. This would help better inform operational requirements and cost issues involved with EM-based monitoring.

5. References

Bonney, J., and K. McGauley. 2008. Testing the Use of Electronic Monitoring to Quantify At-sea Halibut Discards in the Central Gulf of Alaska Rockfish Fishery EFP 07-02Final Report. Alaska Groundfish Data Bank. Kodiak, Alaska, USA. 50 p. Online at: http://www.fakr.noaa.gov/npfmc/current_issues/groundfish/EM_Phase1508.pdf

McElderry, H. 2008. At Sea Observing Using Video-Based Electronic Monitoring. Background paper prepared by Archipelago Marine Research Ltd. for the Electronic Monitoring Workshop July 29-30, 2008, Seattle WA, held by the North Pacific Fishery Management Council, the National Marine Fisheries Service, and the North Pacific Research Board: The efficacy of video-based monitoring for the halibut fishery. Online at: http://www.fakr.noaa.gov/npfmc/misc_pub/EMproceedings.pdf.