RESEARCH PLAN

A. Project Title

Title: Bycatch characterization in the Pacific halibut fishery: A field test of electronic monitoring technology.

Short Title: Bycatch characterization in the Pacific halibut fishery.

B. Proposal Summary

The long term focus of this research is to improve our understanding of the ecosystem impacts of halibut fishing through improved monitoring of longline fishery bycatch and to provide data on mortality of bycatch species for input to stock assessments. We will be comparing and evaluating the effectiveness of electronic monitoring (EM) and the currently utilized National Marine Fisheries Service (NMFS), North Pacific Groundfish Observer Program (NPGOP) monitoring methods to operate effectively in a commercial longline (hook-and-line) setting. This is a cooperative study with the commercial fishing industry and relies on our ability to sample on various vessel configurations.

Bycatch rates in the Pacific halibut fishery are not well estimated. The majority of vessels operating in this fishery are not required to have NMFS / NPGOP monitoring; hence estimates of bycatch are not based on direct observation of the fishery.

Previous research by one of the partners in this proposal documented successful EM of Pacific halibut longline fishing from chartered research vessels (Ames, 2005; Ames *et al.*, 2007). While this work supported the use of EM to monitor bycatch, the research was not conducted under commercial fishing conditions. In the commercial fishery a much broader range of environmental and physical factors affect the vessel operations. As a result, these methods are not yet proven under commercial fishing conditions.

This request for funding is consistent with the NPRB priorities of evaluating potential improvements to bycatch estimation methodology (2.c.ii) and cooperative research with the commercial industry (5.2).

C. Project Responsiveness to NPRB Research Priorities or Identified Project Needs

This proposal directly addresses research priority number 2: General Research Priorities on Ecosystem Components, subheading c.ii: Fish and Invertebrates, Bycatch estimation and gear induced injury and mortality. This research will directly assess the applicability of EM to commercial fisheries monitoring and bycatch estimation. EM results will be compared to results from standard NMFS / NPGOP methods to evaluate the effectiveness of both methods. This information is key to determining the most cost effective and efficient bycatch monitoring methods for this fishery.

This project also addresses the issues raised in research priority number 5: Cooperative Research with Industry, Subheading 2: Fisheries Monitoring. Cost efficient monitoring of fisheries in a fashion that does not interfere with the vessel operations is desired by the industry. The success of this project depends on industry cooperation and participation.

D. Soundness of Project Design and Conceptual Approach

Completion of this project provides data on the effectiveness of EM for monitoring of bycatch and the ecosystem impacts of commercial halibut fishing. It also provides comparison between current standard monitoring methods (NMFS / NPGOP) and EM methods. Ultimately this research will provide fishery managers and analysts with the information to make sampling methodology decisions and recommendations, providing a means to develop statistically defensible bycatch estimation methods**.** If the EM methodology proves effective under commercial fishing conditions, EM may become a standard sampling method, especially for those portions of the commercial fishing fleet that are currently not monitored by onboard observers. This is a cooperative study with industry and relies on our ability to sample on a wide range of vessel sizes and configurations participating in the fishery.

The goal of this project is to test the ability of EM systems to operate in a commercial setting by comparing best estimates of bycatch based on a "census" of numbers of species hooked, with estimates of bycatch based on review of video monitoring, and estimates based on standard NMFS / NPGOP observer monitoring.

The majority of the vessels operating in the commercial Pacific halibut longline fishery in Alaska are not currently subject to at-sea harvest monitoring. For the most part, Pacific halibut is harvested under Individual Fishing Quotas (IFQ) held by the fishery participants. The fishery consists of approximately 1,800 vessels, the vast majority of which are less than 60ft. in length. In terms of harvest, vessels over 60ft account for 15% of the landings but about 38% of the landed catch. Many of these vessels also hold sablefish (black cod) IFQ permits. The NMFS monitors catch and bycatch on sablefish IFQ vessels that are greater than 60ft in length at a 30% coverage rate with 100% coverage for vessels 125ft and greater. Vessels holding only Pacific halibut IFQ are not monitored at-sea; halibut fishing is monitored only when the fishing occurs aboard vessels that are required to carry NMFS observers in compliance with regulations for monitoring sablefish longline fishing As a result, only about 12% of the total harvest from the directed halibut fishery is monitored by the NMFS / NPGOP during combined trips where vessels harvest both sablefish and halibut.

Bycatch rates in the halibut fishery are not well estimated. In the context of ecosystem monitoring and catch accounting, this lack of information is problematic. In the North Pacific Fisheries Management Council, Scientific and Statistical Committee meeting notes (December 2005) a specific recommendation is made for improved bycatch estimation in the Pacific halibut fishery, specific to the Gulf of Alaska skate stock assessment (North Pacific Fisheries Management Council, 2005). The Resource Ecology and Ecosystem Modeling group (REFM Division, AFSC) is recommending improvements be made to bycatch estimation in halibut longline fisheries and in fisheries that are currently not observed: vessels under 60ft LOA (Aydin *et al.*, In Review). Additionally, seabird bycatch estimation in the longline fisheries is of increasing concern, especially in light of the status of albatross populations (S. Fitzgerald, REFM Division, AFSC Pers. Comm.). Accurate catch and bycatch estimates are a necessity for fisheries managers, stock assessors, and research scientists to understand the ecosystem effects of fishing.

Digital (video) monitoring of bycatch on longline vessels targeting Pacific halibut was investigated by the International Pacific Halibut Commission (IPHC) in 2002 (Ames, 2005) and again in 2004 (Ames *et al.*, 2007). In both instances the research was conducted in controlled research conditions aboard contracted longline vessels, although gear was fished in a manner consistent with normal commercial fishing. Based on results of the 2002 study, improvements were made to the video technology (camera placement, recording speed *etc.*). These improvements significantly increased the accuracy of the EM relative to onboard IPHC observers (Ames *et al.*, 2007). In their comparison of the observer-based estimates of bycatch and the video-based estimates of bycatch, they found no statistically significant differences using a sign test in all but one species (grenadiers). In the 2002 study, there was no difference between video and observer estimates of the bycatch of grenadiers. The sign test may not be the most appropriate test to use for this type of data analysis however, since it was developed to be used in cases where the data are continuous.

The power of the sign test was low due to the high degree of similarity of the observer and EM data sets, and in all instances except the case of Alaska skate, the probability of a type II error was reported to be less than 0.30. In some cases, the video analyst was able to document more individual fish than the observer noticed, while in other cases, the video record appeared not to capture individuals noted by the observer. These discrepancies were attributed to fish dropping off the line, misidentification by the video reviewer or observer, and cases where the video reviewer or observed failed to record the status of a particular hook.

The 2004 data (Ames *et al.*, 2007) were collected aboard one vessel (65ft length overall), from 18 stations (longline sets), and approximately 9,000 hooks. This is a relatively small sample size as compared to what we might expect in a commercial operation over the course of a month. In addition, the variety of vessels and vessel configurations operating in the fishery is expected to affect the ability to effectively place and monitor video equipment.

In the proposed study, we are planning to provide EM systems to four vessels operating in the Bering Sea in the late summer and fall of 2007. An additional four vessels operating in the Gulf of Alaska will be equipped with EM the following spring (spring 2008). These time periods and locations were chosen to reflect the major patterns of fishing exhibited by the Pacific halibut longline fleet. Each vessel will have EM on board for a period of one month with two vessels (one larger, one smaller) operating simultaneously per month.

The EM systems will be similar to those used in the Ames *et al.* (2007) study. Since the available data are limited to a single vessel fishing 18 longline sets in August 2004, the increased variability due to vessel size and configuration, weather and environmental conditions, and fishing areas can not be assessed at this time.

Since we are interested in how this technology will perform under actual fishing conditions, it will be important to implement the study on a number of different fishing vessels operating in different areas and conditions. In addition, diversity in harvest amounts and species composition will be important components. It is necessary to cover the range of conditions that will typically arise in this type of fishery.

This study has two main objectives as follows:

1. Catch and bycatch data collection using several methods
    a. Estimation of bycatch and bycatch rates from data collected using EM on commercial longline vessels.
    b. Estimation of bycatch and bycatch rates from data collected using standard NMFS observer monitoring on commercial longline vessels.
    c. Hook-by-hook documentation (by a second observer) of fish species on the fishing gear.
    d. Accounting of retained bycatch based on a census of all bycatch (non-halibut) species landed on the vessel.
2. Evaluations of the relative efficiency, cost, and bias of each of the two bycatch estimation methods (EM, NMFS Observers) relative to a standard (hook-by-hook, and hook-by-hook comparisons with observer) to determine their suitability for use in fisheries management.

Proposed Methods: Field

On each vessel included in the study group, we will place a full EM system (see details below), a NMFS / NPGOP observer to conduct standard observer sampling, and a hook-status observer to obtain observations of fish species for each hook on the retrieved gear (inclusive of species groups, empty hooks, and landing/release category). The hook-specific counts of each species will provide a pseudo-census of the fish on the incoming gear. Although each fish on the line will be enumerated (and identified to species), it is possible that the hook-status observer will misidentify a fish or fail to count a hook (and the fish attached). In that sense, this is not a true census of the fish on the longline gear; however, it does provide a second observation of the same population of hooked fish. Based on data collected by these three methods, the estimates and comparisons outlined in the previous section can be met.

We will have only one total count of the line by an on-deck observer; hence we will be limited in our ability to assess the validity of our "census". However, we will have a random sample of gear segments where we have a count (tally) from the NMFS / NPGOP (standard) observer and the hook-status observer. These can be directly compared to assess the variability in tallies between observers.

In addition, since, as part of their normal sampling duties the NMFS / NPGOP observers ask crew to set aside a number of fish of each species so that the observer can obtain length and weight information, there are a known number of fish brought onboard. These fish could be considered a complete census of all non-target species retained by the vessel. These fish will be easily identified as landed by both the hook-status observer and the video reviewers. Since these fish are in the video camera view for a longer period of time than discarded fish would normally be, both the video reviewer and the hook-status observer have a longer period of time to identify the fish. This may influence the degree of agreement between the two measuring systems; however, these data may be useful in assessing both NMFS / NPGOP observer error and video reviewer error.

For all three sampling methods (hook-status, video, NMFS / NPGOP), a standard set of species and species group codes will be provided. In addition, species identification materials similar to those used by the NMFS / NPGOP will be distributed to observers and EM reviewers.

On many of the smaller vessels, we may not be able to place two observers simultaneously. This means that on those boats we will not be able to complete a full analysis since we will not have both observers onboard collecting data. On these vessels we will be able to compare the EM results with the hook-status results only. While smaller (less than 50 ft length) vessels represent about 65% of the deliveries by the fleet, the harvest from these boats comprises only about 32% of the total halibut landings.

We may have some opportunity on smaller vessels (e.g. under 50 ft.) to assess video by placing EM equipment and a hook-status observer on-board during some fishing trips. For some of the smallest boats, these opportunities may be available on single day trips only. Larger boats that can not accommodate two observers may be able to take a single observer for longer trips (several days). Taking advantage of these opportunities will allow us to assess the consistency of the video equipment operation on smaller vessels where standard observation methods can not be applied due to space limitations (both in terms of space on deck and available sleeping quarters).

Vessels that agree to participate in the study will need to set gear that consists of segments containing equal numbers of hooks while the observers are sampling. Since some vessels may have both halibut and sablefish IFQs, they may fish mixed gear: sets with some 'halibut' segments with fewer hooks and some 'sablefish' segments with more hooks. Since we will be randomly sampling gear segments, the segments fished should be of equal size (equal hook spacing) while observers are on deck sampling. This requirement is not expected to limit our ability to solicit vessel participation in the research study.

Based on data collected during the first season, the independence of gear sets within vessels will be assessed to determine whether increased sample size can be achieved by pooling observations across vessels. This would improve our ability to detect differences in the sampling methods. We will be measuring the differences between estimates obtained from EM and estimates obtained from standard NMFS / NPGOP observer methods (and differences between both of those and 'census' data). If those differences are consistent between vessels of various sizes, we may be able to assume independence of (the differences in methods) sets nested within vessels. If however those differences vary across vessel sizes, then our analyses will need to take those differences into account, and our effective sample size may be reduced to the number of vessels participating in the study. This will reduce the power of our analyses.

EM System

The EM systems will consist of sensors recording vessel activities and GPS positions, two video cameras mounted on an outboard boom such that the cameras are approximately 4.5 meters from the incoming gear. One camera will be focused with a wide angle to record all of the gear as it leaves the water, therefore recording any fish that drop off the line before being landed. The second camera will have a closer focus of the gear and catch at the roller.

There are two main computer components of the EM system: a data logging computer, and a video computer. These will be located in a tamper-proof container on board the vessel. The data logger computer will record the output from the various sensors and the GPS receiver. The video computer will digitize and record the video images captured by the two cameras. Video data will be stored on removable hard disks. A more detailed description can be found in Ames *et al.* (2007).

We will have two individuals review a sample of the video record so that we can evaluate the repeatability of the EM observations. With the exception of the analysis of repeatability of the video review, the number of fish of a given species on either a longline set, or a longline segment of gear, will be based on the observations of a single video reviewer. For the purpose of establishing a standard for comparison with other observational methods, these observations are assumed known without error (depending on the assessment of repeatability of video reviewer observations).

Standard NMFS / NPGOP Monitoring

The methods used by the NMFS / NPGOP observers are well documented in the NMFS / NPGOP Observer Sampling Manual (NMFS, 2006). These methods will be used by the standard observer with a few minor exceptions.

In cases where the participating vessel generally fishes both halibut and sablefish, hence uses longline gear consisting of two different hook spacings, we will need the vessels to set only one gear configuration for each gear set while the observers are working on deck. Since the observer will randomly select several segments of a longline to sample, it will be important that the segments are of equal size (numbers of hooks) in order to extrapolate the data from sampled segments to the entire longline. An average number of fish per hook, weighted by the proportion of hooks in the sampled segments, could be used to expand the observed fish to the unobserved portions of the gear. However, the number of hooks on each segment is not observed directly (it is taken from vessel records); hence this would likely increase the variance associated with the estimates of total fish on the longline set.

For most comparisons in the analysis (see below), we will be using the total number of fish of each species counted on each segment for comparisons, hence the estimator is simply the number of fish of a given species counted by the observer. Observer counts of numbers of fish per gear segment will need to be expanded to the entire longline for the comparison between the video estimate of the number of fish of a given species for the longline set and the observer estimate of the number of fish for the same longline set.

To estimate the total number of fish of a given species on the longline set, the mean number of fish per sampled segment of gear is expanded to the entire set. Let

$F_{v,s,i}$ = the number of fish of a given species in segment i, i=1, …n of set s on vessel v.

$N_{v,s}$ = the total number of segments in set s fished by vessel v

$n_{v,s}$ = the number of sampled segments in set s fished by vessel v

$\hat{F}_{v,s}$ = the estimated number of fish of a given species in set s of vessel v

We then have the total catch in numbers of fish as

$$\hat{F}_{v,s} = N_{v,s}\left[\frac{1}{n_{v,s}}\sum_{i=1}^{n_{v,s}} F_{v,s,i}\right] \text{ with variance } V\hat{a}r(\hat{F}_{v,s}) = N_{v,s}^2\left[\frac{\sum_{i=1}^{n}(F_{v,s,i}-\hat{F}_{v,s})^2}{n_{v,s}(n_{v,s}-1)}\right].$$

Note that these fish are of a specific species and may be the landed portion only of the catch or the total number of fish recorded. Those subscripts have been omitted for simplicity.

<u>Hook Status Monitoring</u>
The 'hook-status' observer will obtain the hook status for each hook in a set, sequentially recording the status of each hook into four categories (Table 1). Each category is defined by a species code for the species observed to be on the line and a status code identifying the final disposition of the fish. The differentiation of when fish drop off the line (landed, before hook leaves the water, and after hook leaves the water) will aid in resolving discrepancies between the video records and the observer records.

Table 1: Hook Status Definitions

Hook Status	Definition
E	Empty Hook
Spp.ID-L	Fish that are brought onto the vessel either as catch (halibut and other species of value) or at the request of the observer for species identification.
Spp.ID-R	Fish that are intentionally removed from the line by the rollerman. These are species that are not desired by the vessel and would be discarded if brought on board.
Spp.ID-A	Fish that unintentionally come off the hook **AFTER** the hook leaves the water and are not later retrieved. This would not include halibut and other valuable fish that come off the hook after the hook leaves the water but are retrieved by the crew. Fish that are valuable, come off the hook after the hook leaves the water, but are not retrieved by the crew would be included in this category.
Spp.ID-B	Fish that unintentionally come off the hook **BEFORE** the hook leaves the water and are not later retrieved. This would not include halibut and other valuable fish that come off the hook before the hook leaves the water but are retrieved by the crew. Fish that are valuable, come off the hook before the hook leaves the water, but are not retrieved by the crew would be included in this category. Note that data collected in this category may be inaccurate due to the difficulty of obtaining observations of all potential occurrences.

This hook-status record will be aligned with the video record so that direct comparisons can be made for each hook in the sample. In cases where hooks become misaligned due to missed hooks (by either the observer or the video reviewers), realignment will be based on gear segment changes, individuals of obvious species, hook tangles, and other easily identifiable and relatively unique events.

Since the hook-status observer will focus entirely on each hook coming from the water, the amount of time (number of hooks) that can be sampled will be limited by that person's ability to keep track of large numbers of hooks. The number of hooks that can be sampled will depend in part on the speed with which the gear is retrieved. In general, it is probably unreasonable to expect the hook-status observer to sample sets that take more than 3 hours to retrieve. In a given day, the hook-status observer could be expected to sample (no more than) three such sets. If additional sets are fished during the day, these sets may not be monitored.

The hook-status observer will also be required to record the vessel information, date, set number, and gear segment number for all samples. In some of the comparisons with data collected using other methods, the gear segment or set will be the sampling unit (unit of replication).

Since every fish on the longline is documented by the hook-status observer, the total number of fish of a given species on the gear is known, assumed without error.

There are four main hypotheses that we are interested in testing (Figure 1). For each of the comparisons listed below, the tests described will be conducted using the complete data set, and where available the data set consisting of non-target species fish landed onto the vessel. This second set of comparisons will be to a known quantity of fish examined in hand by the NMFS / NPGOP observer. Although this is a potentially small portion of the total data, it may provide for a comparison with a true known census of retained fish.

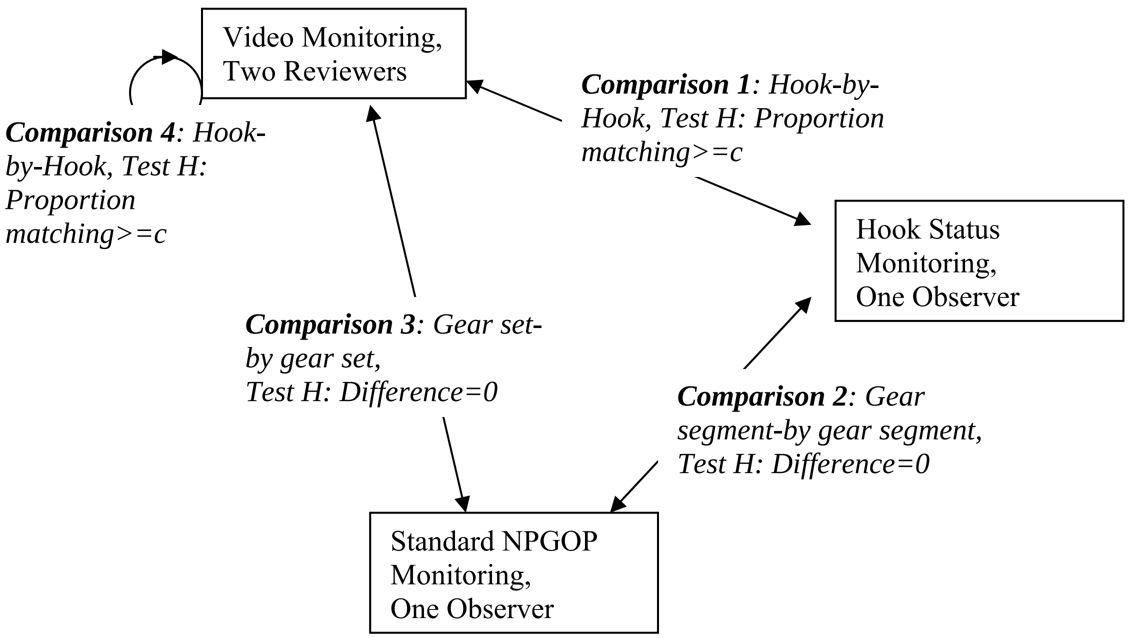

Figure 1: Data sources and comparisons used to assess the viability of video monitoring.

First, in comparing the video monitoring to the hook-status monitoring, we are interested in whether the observations made remotely by a video reviewer are consistent with those made by an observer stationed on the vessel. In this case, for each hook observed, the observed species of fish for the two monitoring methods match or do not match. Hence we have binomial data, which may be over-dispersed due to vessel and / or area affects. In an analysis of the data from Ames *et al*. (2007), it did not appear that the data were over-dispersed (due to gear segment or set dependence within the vessel), hence we assume there are no effects due to gear sets within vessels or gear segments within sets. Given that assumption, we can estimate the proportion of observations that match according to the following.

Let

$X_{i,v}$ =I{matching species identification for hook i on vessel v}, $X_{i,v}$={0,1), i=1, …, n_v

v = index on the vessel, v=1, …. V.

We then have the estimated proportion of hooks with matching observations (for a given species) as

$\hat{p}_v = \frac{\sum_{i=1}^{n_{j,k}} X_{i,v}}{n_v}$ with variance $V\hat{a}r(\hat{p}_v) = \frac{\hat{p}_v(1-\hat{p}_v)}{n_v}$. The overall proportion of matching observations is then $\hat{p} = \frac{\sum_{v=1}^{V_{j,k}} \hat{p}_v}{V}$. This is a two stage sample, hence we have variance $V\hat{a}r(\hat{p}) = \frac{\hat{p}_v(1-p_v)}{V} + \frac{\sum_{v=1}^{V} \hat{p}_{s,v}(1-\hat{p}_{s,v})}{Vn_{s,v}}$.

We will test the hypothesis that the probability of matching is equal to or greater than some predefined constant (e.g. 0.95). This is essentially a one sided (paired) test where we reject the null hypothesis for values of $\hat{p}$ smaller than $\hat{p}_o + \Phi^{-1}_{1-\alpha} V\hat{a}r(\hat{p})$ where $\hat{p}_o$ is the proportion of matches under the null hypothesis ($H_o : p \geq \hat{p}_o$) and $\Phi^{-1}_{1-\alpha}$ is the inverse normal probability.

If we can assume that there are no vessel effects (in the proportion of matches between gears), then this will simplify further to a test where the number of hooks observed is the sample size and $\hat{p} = \frac{\sum_{i=1}^{n_v}\sum_{v=1}^{V} X_{i,v}}{Vn_v}$ with variance $V\hat{a}r(\hat{p}) = \frac{\hat{p}(1-\hat{p})}{Vn_v}$. This should be a more powerful test due to the larger sample size. In both cases, transformations of the data will be used as appropriate to meet the underlying assumption of normality.

In the second comparison, we are testing whether the hook-status observer's identification of fish on the incoming gear is the same as the identification made by an observer operating under standard methods. We can assess whether the two observers are counting the same number of fish in each gear segment (skate, magazine). This will allow us to assess standard NMFS monitoring methods against the same standard (hook-status monitoring) as used to evaluate the video monitoring. We will use ANOVA and t-test (or appropriate non-parametric tests) methods to test the hypothesis that the difference between the two observers in the number of fish (of a given species) counted in a segment of gear is zero.

Assuming that we have vessel effects (and area affects) that can not be ignored, we have the following model: $Y_i = \beta_0 + \beta_1(method) + \beta_2(vessel \quad size) + \beta_2(Area)$ where there are *i*=1 to *n* segments of gear observed and Y_i is the number of fish observed on gear segment *i*. We will be testing the hypothesis that β_1, the coefficient on the sampling method used is equal to zero (there is no effect of sampling method on the estimated number of fish observed on a gear segment). We can also test the hypothesis that β_2=0 or $\beta_3$0; there are no vessel effects, or there are no area effects, on the number of fish observed on a segment of gear. If the power of this analysis is sufficient, we may be willing to assume that there are no vessel or area affects on the ability of the two methods to assess the number of fish on a gear segment.

If we can assume that there are no effects of vessel size (or area) on the differences observed numbers of fish for the two sampling methods (NMFS / NPGOP and EM), then we can use a standard paired t-test. In this case, we have the difference, $d_i = F_i - H_i$, where F_i, is the number of fish observed by the

NMFS / NPGOP observer of gear segment *i*, and H_v is the number of fish observed by the hook status observer of gear segment *i* over all gear segments in the study. The paired t-test will test the hypothesis that the mean difference is zero, $\hat{d} = 0$ where $\hat{d} = \frac{\sum_{i=1}^{n} d_i}{n}$. This second test may be the more powerful analysis as a result of having a much larger sample size.

The third comparison is between the video monitoring and the standard NMFS / NPGOP monitoring. We will test whether the estimated number of fish per longline set (for a given species) is different between the two monitoring methods. We will test the hypothesis that the mean of the differences in the paired estimates is zero.

Using the terminology previously defined, we have the mean difference between the two sampling methods, averaged over all vessels, as

$\hat{d} = \frac{\sum_{s=1}^{S}\sum_{v=1}^{V}(\hat{F}_{s,v} - R_{s,v})}{SV}$ where $\hat{F}_{s,v}$ is as previously defined (under Standard NMFS / NPGOP methods) and $R_{s,v}$ is the total number of fish observed by the video monitor on set *s* and vessel *v*. This is a standard multi-stage sample, with variance $V\hat{a}r(\hat{d}) = \frac{\sum_{v=1}^{V}(\hat{d}_v - \hat{d})^2}{V(V-1)} + \frac{\sum_{v=1}^{V}\sum_{s=1}^{S}(\hat{d}_{s,v} - \hat{d}_v)^2}{VS(S-1)} + \frac{\sum_{v=1}^{V}\sum_{s=1}^{S}V\hat{a}r(\hat{F}_{s,v})}{VS}$.
Note that at the most nested level, the variance of $H_{s,v}$ is zero, since that is the number of fish observed by the hook-status observer and is assumed known without error. We will reject the null hypothesis that the mean difference, $\hat{d}$, is equal to zero for those values of $\hat{d}$ that are greater than $\tau_{v(1-\alpha/2)}\sqrt{V\hat{a}r(\hat{d})}$, or less than $-\tau_{v(1-\alpha/2)}\sqrt{V\hat{a}r(\hat{d})}$ where $\tau_{v(1-\alpha/2)}$ is the inverse students t-distribution with *v* degrees of freedom and where α is the size of the test (generally 0.05).

Lastly, to assess the repeatability of the video monitoring, we will compare (hook-by-hook) the identification of fish by the two video reviewers for a sample of the video record. This will entail testing the hypothesis that the probability of matching is greater than some predefined constant (e.g. H: p>=0.95). This analysis is essentially the same as the one described in Comparison 1.

The comparisons being made are outlined in Figure 1. These comparisons and tests will be conducted using both the full data sets (portions that are sampled by both methods in the comparison) and the data for landed fish only. In cases where parametric tests can not be used due to failure of the necessary assumptions (distributional, normality of residuals, etc.), then analogous non-parametric tests will be used or alternate models with less rigid assumptions will be fit.

At present, there are very limited data available to evaluate sample size requirements. Data from Ames (2005) is based on observations from two vessels (both over 60ft), and video camera configurations that were found to be less than optimal. The more relevant data (Ames *et al.*, 2007) consists of observations from one vessel only and does not include observations from standard observer methods or multiple video reviewers. For these reasons a power analysis was not conducted.

In this study, there are several assumptions being made that may affect the interpretability of the results. We are assuming that observers, both the hook-status observer and NMFS / NPGOP observer, are accurate in their assessments of fish species while the fish is still on the longline gear. This assumption will be assessed using comparisons between each observer's (hook-status and NMFS / NPGOP) tallies of each species on a segment of gear. However, since these the two observer's counts may vary in opposite directions, this is not a complete verification of the observer data. We will additionally compare a count of the hook-status reports for landed fish with the known number of fish of each species landed by the NMFS / NPGOP observer. This comparison will be able to verify the hook-status observer species identifications.

We will be assuming that the video reviewer is able to identify species of fish in the video accurately to species or species group. This assumption will be verified by comparing the observations of two reviewers on a sample of the video record.

In addition to the above requirements, since we will be operating in a more diverse environment, we will need to be sure that coverage of the fleet is sufficient to allow additional sample size analysis. To that end, in the first season of sampling, we are planning to install video equipment on 4 vessels; 2 in each of the two size categories: 0-to 60ft length, and >60ft length. In addition to video monitoring, each vessel will also have hook-status observers present. In the larger vessels, and smaller vessels where possible, we will also have a standard NMFS / NPGOP observer conducting routine sampling. All vessels will operate with the video equipment for a period of one month, with each trip being observed by video and one or two observers.

E. Timeline and Milestones

The Pacific halibut fishery is open in the Gulf of Alaska from approximately March 1st through November 15th each year. Approximately 44% of the total harvest for the season occurs before mid-June (RAM division, Alaska Regional Office, NMFS, 2006 estimates). The summer months (July, August and September) encompass another 38% (approximate) of the harvest.

In the first season (late summer 2007) we will focus on field activities in the Bering Sea (July or August through November). Based on these results, sampling may be adjusted for the next season.

A preliminary report summarizing the results of the first phase and any changes to the sampling design will be written in the fall of 2007 through the spring of 2008, available before March of 2008.

We will continue this work into the 2008 season (May through June or July) in the Gulf of Alaska. The total of the field work will encompass one entire fishing year, although it will be split between two calendar years.

A final report will be written in the fall of 2008, available by the close of 2008. Study results will also be presented at North Pacific Fisheries Management Council (NPFMC) Meetings, NPFMC Statistical and Scientific Committee meetings, and to the various commercial fishery industry groups (such as the North Pacific Vessel Owners Association).

In addition to the presentations to be given in late 2008, our outreach and education will include development of a web page with a description of the study and results as they become available. This web page will be established during the summer of 2007.

A timeline for this study is presented in Table 2.

Table 2: Summary of proposed study activities, accomplishments, and deliverable products.

	Activity / Accomplishment	*Deliverable*
June 2007	Outreach to Halibut Fleet to solicit commitments for participation. This outreach will be conducted in collaboration with the Fishing Vessel Owners Association.	List of participating vessels of various configurations
July	Contract for Video Equipment in place	Contracted Video Services
July / August	Contract for observer coverage in place	Contracted Observer Coverage
August	Install EM equipment on study vessels	EM equipped Vessels ready for study implementation
August	Prepare database	Database ready
July (August) – September 2007	Commence field activities in the Bering Sea	Data Collection
August - October	Data entry and initial summary	Database of first field season complete
November 2007 – February 2008	Analysis of first season results inclusive of any necessary revisions to sampling design, preparation of preliminary findings and tech memo	Technical Memo, revised sampling design if necessary
February 2008	Presentation of preliminary findings to fishing groups, North Pacific Fisheries Management Council, SSC	Presentation of study results
February – March 2008	Outreach to Halibut Fleet to solicit commitments for participation in second field season	List of participating vessels of various configurations
March – June (July) 2008	Continued field activities in Gulf of Alaska	Data
August (July) – October 2008	Analysis of all results	
October – November 2008	Preparation of final report	
December 2008	Publication of report	Published Report
December 2008	Presentation of findings to fishing groups, North Pacific Fisheries Management Council, SSC	Presentation of study results

F. Project Management

Dr. Leaman will be responsible for provision of the EM data collection and summary capabilities. This includes contracting for the lease, installation, maintenance, and transport of EM systems, and also the summarizing of observations from the recorded observations on a hook-by-hook basis. Dr. Leaman has experience in longline fisheries data and has previously published analyses of observer and EM data. Senior project contact at the IPHC will be Mr. Gregg Williams, who has extensive experience with observer and longline fisheries data.

Dr. Karp will coordinate the provision and tasking of observers, including the provision of summarized hook-by-hook and sampling data. Dr. Karp has extensive experience in observer programs and has previously published analyses of observer programs and data. Senior project personnel at NMFS will include Ms. Jennifer Ferdinand, Ms. Lisa Thompson, Mr. Jason Anderson, and Ms. Jennifer Watson.

Ms. Cahalan will conduct the primary analyses of all EM and observer data. Ms. Cahalan is experienced in analyses of count data and fisheries programs. Ms. Cahalan will provide PSMFC oversight and coordination of observer contracts and staff functions. Mr. Dave Colpo, senior staff at PSMFC, will provide PSMFC support.

Reports will be produced cooperatively.

NMFS is the federal agency responsible for collection of observer data in the federal groundfish fisheries off Alaska. In addition, NMFS is responsible for the assessment and management of stocks of non-target species caught in the halibut IFQ longline fishery. The IPHC is responsible for research, assessment, and management of Pacific halibut throughout its range in the NE Pacific Ocean. Dr. Leaman is the Executive Director of the IPHC and oversees all of IPHC activities. This work will provide data to enhance and complement the ongoing research on management of non-target species caught in the halibut fishery. In addition, the data will be shared with NMFS Sustainable Fisheries, NOAA Office for Enforcement, and the staff of the North Pacific Fishery Management Council to assist in the development of monitoring programs for the halibut and other longline fisheries. As a partner with NMFS, the PSMFC has played an active role in helping address issues associated with observer data collection and other catch and fishery monitoring programs.

All three of these organizations have extensive experience managing research projects focused on fisheries monitoring and management Alaskan waters. Each of these organizations can supply experienced staff to effectively implement this research.

The halibut fishing industry (Fishing Vessel Owners Association, Seattle WA) will assist in this program in furtherance of its Action Plan for addressing the monitoring of non-target catch, as a component of certification of the halibut fishery by the Marine Stewardship Council.

G. References

Ames, R. T. 2005. The efficacy if electronic monitoring systems: a case study on the applicability of video technology for longline fisheries management. International Pacific Halibut Commission Scientific Report number 80. Available: http://www.iphc.washington.edu/halcom/pubs/scirep/SciReport0080.pdf. (January 2006).

Ames, R. T., B. M. Leaman, K. L. Ames. 2007. Evaluation of video technology for monitoring of multispecies longline catches. North Am. J. Fish. Mgmt (In Press).

Aydin, K.Y., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. In Review. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Island large marine ecosystems through food web modeling. NOAA Technical Memo.

(NMFS) National Marine Fisheries Service. 2006. North Pacific Groundfish Observer Sampling Manual. North Pacific Groundfish Observer Program, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115. http://www.afsc.noaa.gov/FMA/Manual_pages/MANUAL_pdfs/manual2006.pdf.

(NPFMC) North Pacific Fisheries Management Council. 2005. Statistical and Scientific Committee meeting notes, December 2005, http://www.fakr.noaa.gov/npfmc/minutes/SSCDec05.pdf.