Fisheries Monitoring and Analysis Division Redesigns Observer Sampling

by
Jennifer Cahalan and Jennifer Ferdinand

The Fisheries Monitoring and Analysis Division (FMA) monitors groundfish fishing activities in the U.S. Exclusive Economic Zone (EEZ) off Alaska and conducts research associated with sampling commercial fishery catches, estimation of catch and bycatch mortality, and analysis of fishery-dependent data. The goal of the Division is to provide high quality commercial fishery data to other programs to be used in fisheries management, stock assessment, and research efforts. Much of this goal is accomplished by the Division's North Pacific Groundfish Observer Program (NPGOP), which deploys over 400 individual observers to vessels and processing facilities in the North Pacific. These observers provide the National Marine Fisheries Service (NMFS) with more than 35,000 observer-days each year and collect a range of information for a suite of data users involved in fishery management, stock assessment, catch estimation, and quota monitoring.

Fishery-dependent data demands change with time, and each year the NPGOP receives requests to modify or add data elements. In January 2008, FMA implemented several long-awaited sampling and database changes that had been recommended in various independent reviews as well as by in-house staff. These changes fundamentally altered the way observers collect and record their data. Modifications were made to both the methods used to collect data at sea and to the Alaska Fisheries Science Center (AFSC) database that houses the observer data. One of the most substantive changes is that observers are now asked to collect and individually record at least three samples for species composition from each sampled haul or fishing event. Previously, samples were pooled together. These changes allow NMFS to better understand the statistical properties of the data and the estimates derived from that data. In particular, we are now capturing the data in a way that allows us to assess within-haul variance.

In order to implement change, the FMA's Information and Monitoring Technologies Program aggressively redesigned the two databases which store observer data: 1) the at-sea database used by observers to enter and transmit data, and 2) the repository AFSC database where the data reside long-term. Now in place and implemented, the data entry and storage mirror the sampling conducted in the field. The relationships between samples and subsamples and hauls and trips are reflected in the structure of the database.

In an effort to reduce data errors, FMA also removed the burden from observers of computing most of the calculations required for in-season fishery management. This allows observers, for the most part, to record only what they see or measure. This represents a large step toward utilizing database and computer technology to eliminate the subjectivity and potential error when observers calculated information for NMFS. It is worth noting that it was not so long ago that observers did extensive catch and bycatch estimation calculations by hand and transmitted them to NMFS weekly via Morse code. In addition, past data recording protocols did not distinguish a calculated value from an actual measurement, causing confusion among data users.

Automation of most computations within the at-sea and AFSC databases results in fewer computational errors and increased flexibility. If in the future different extrapolation algorithms are preferred, the database can be reprogrammed and the data can be resummarized. In the previous system, because computed values were entered into the database by observers and were not distinguishable from measured data points, such flexibility was lacking. Computers also provide consistency unachievable by humans.

Coinciding with the changes to FMA's sampling protocol was NMFS' implementation of Amendment 80 to the Fishery Management Plan (FMP) for Groundfish of the Bering Sea and Aleutian Islands Management Area. Amendment 80 greatly improved the sampling tools available to observers. Virtually all catcher processor vessels in the Bering Sea now have dedicated observer sampling stations and motion compensated (MC) scales facilitating their work. These MC scales, particularly those that are embedded in conveyor belts ("flow scales"), increase an observer's ability to accurately and precisely measure the size of larger samples—from several hundred kilograms to several tons— which an observer would not be able to weigh otherwise. Without flow scales, the size of samples observers can take is limited by the amount of fish they can move and weigh on their platform or hanging scales. The labor involved limited the size of samples to approximately 300 kg total per sampled haul.

Despite the fact that FMA is now asking observers to take three samples from each sampled haul instead of a single sample previously required, we do not expect the total size of the sample to decrease relative to the haul size. The sample fraction is the total size of the sample as a percentage of the haul size. Because of the improved tools available to observers in highly diverse fisheries and the elimination of many ad-hoc calculations previously required of observers, we do not expect dramatic decreases in sampling fractions. In many cases, we hope the sampling fraction achieved by observers will increase.

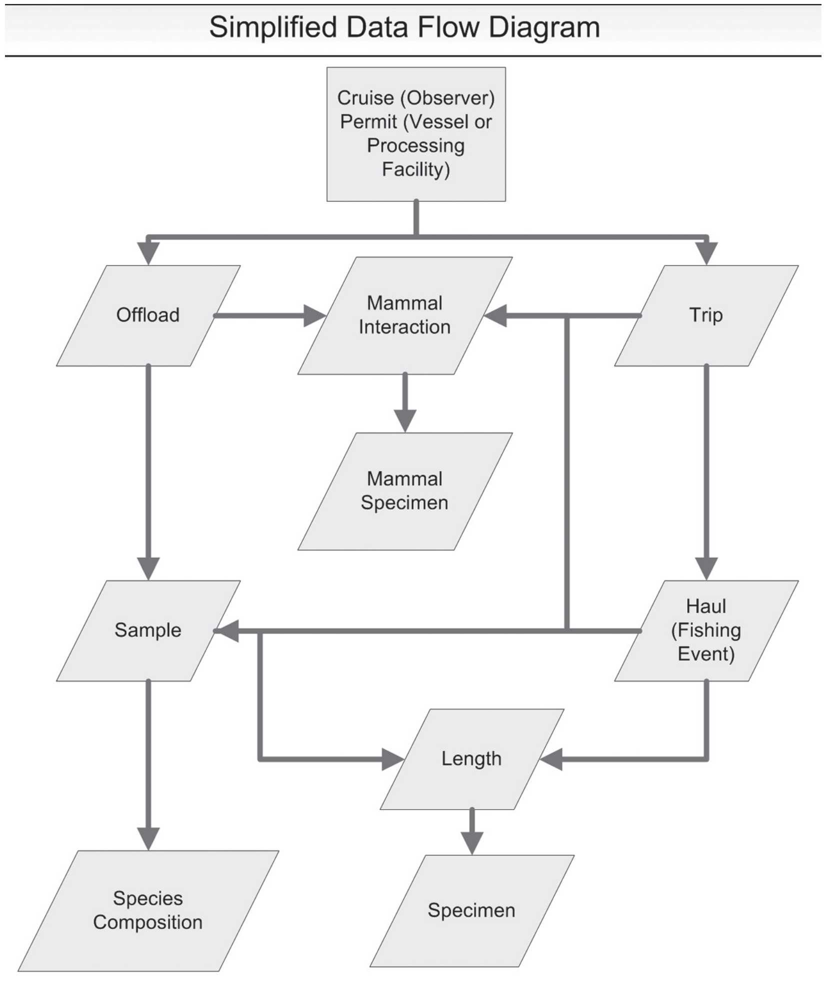

Figure 1. Simplified diagram of North Pacific groundfish observer data flow in 2008.

Changes in Sampling Design from Previous Years

The changes implemented in 2008 affect both the field data collection methods and data recording and storage protocols. The database changes include the unique identification of observed trips and the unique identification of samples taken from observed hauls. This change allows for trip-specific imputation methods to be used in cases where not all hauls are sampled in a given trip. In addition, this change allows design-based estimators of variance to be used, which could allow data users to assess uncertainty surrounding catch and bycatch estimates based on the observer data. Because data were previously not available at the sample level, calculating these variances was not possible.

The redesigned database is structured to mirror the sample collection methods. Trips are linked to observer cruise and vessel, hauls are linked to trips, and samples are linked to hauls. Other data collected, such as biological specimens (otoliths, scales), marine mammal information, and fish lengths are all recorded in relation to where they were sampled. Hence, length data can be recorded as coming from a sample, a haul, or an offload. The simplified data flow diagram (Fig. 1) shows the different resolutions at which an observer can now record data. This new flexibility allows for sampling and data recording at different events. For example, observers can collect fish lengths from an offload at a processing facility, from a specific fishing event, or from a sample.

As in the past, observers are trained and required to use random sampling methods to select their samples whenever possible. Under the new methods, they are also asked to take at least three samples from each fishing event, unless it is physically or logistically impossible to do so, in which case they are required to consult with FMA staff. The preference is for systematic samples to be collected beginning at a single random start point. This systematic spacing of samples ensures that samples are spread throughout the haul and should capture any stratification effects or sorting of the catch. Note that these are the general cases and observers will tailor their sampling to the specific vessel and situation.

Observers are also trained to maximize the size of the samples they take. In some fisheries, primarily those where flow scales are available to the observer, this may increase the sampling fraction (total weight of samples as a percentage of the haul) and thereby increase the precision of the catch estimates. The increase in precision will be largest for species of fish that are less common in the catch (rare species).

Additionally, observers will now be recording total weights (and/or numbers) for all species in the sample. Previously, observers were allowed to collect very large samples but only record data for some of the species in the sample, generally species where retention was legally prohibited, or species of particular interest to the vessel. As a result, it was impossible to distinguish samples where a particular species did not occur from samples where the species was present but not recorded in the data. The sizes of the samples within a single haul varied greatly, presenting analysis and interpretation problems. This practice is no longer allowed, and all fish in a sample will be completely enumerated.

NPGOP Sampling on a Broad Range of Vessels

There is a wide diversity of vessel types fishing in the North Pacific, with the majority of catch taken with trawl gear (Fig. 2). Observers face a variety of sampling situations on this broad range of vessels and must apply their training to implement effective sampling schemes. The sampling platforms provide an array of sampling challenges including large hauls where flow scales are not available to weigh fish, hauls with very diverse species composition, and less diverse hauls where flow scales are used to measure the size of very large samples. Sampling conditions aboard commercial vessels are often worsened by adverse weather and the fast pace of routine fishing operations.

While on board vessels, observers are tasked with many duties including monitoring for compliance with fishing regulations, documenting interactions with endangered species, and collecting data used in fisheries management. The majority of the observer's time consists of data collection, recording, and editing. Sampling fishing events often entails being on deck, frequently in adverse weather conditions, lifting samples of fish weighing 40 kg or more (88 lb) totaling 300 kg (600 lb) or more for a single sampled haul, collecting other biological data, and obtaining biological samples such as otoliths, scales, and stomachs. The space available for an observer to store fish from their samples is usually limited on commercial fishing vessels, as is the amount of time unsorted fish are available to the observer. These factors (space, availability of unsorted catch, physical demands on observers) tend to limit the size and number of samples that observers can take for any given sampling day. This may restrict the sampling fraction that can be reasonably expected for a single haul. Because of these logistical constraints, sampling fewer hauls in a trip or in a day does not allow larger samples to be taken from the sampled hauls.

Examples of the different gear types observed help illustrate both the sampling capabilities and sampling constraints. Observers work on a large number of different catcher vessels (Fig. 3). For a typical trawl catcher vessel, the work environment is on deck with limited space where observers can only obtain relatively small samples (Fig. 4). The mean size of samples for these vessels is 5% of the haul weight.

In the past, some observers on trawl catcher vessels were able to take larger samples for certain species, but all the species in the sample were not included in the data. In these cases, samples could be up to 90% of the haul (depending on gear type, size of haul); however, on average, these samples comprised 61% of the haul weight. Larger samples where all species are accounted for are not possible because the observer doesn't have time to collect and process samples between hauls, space to store fish from a sample to be processed later, or physical ability to move larger samples. In addition, mixing

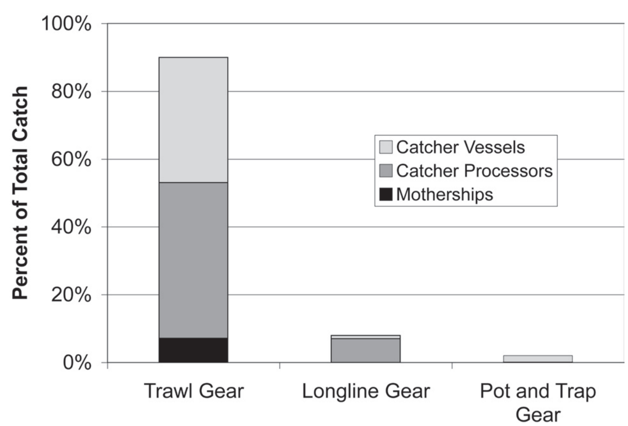

Figure 2. Types and fishery contributions for gears fished by the Alaskan commercial fishery (2006).

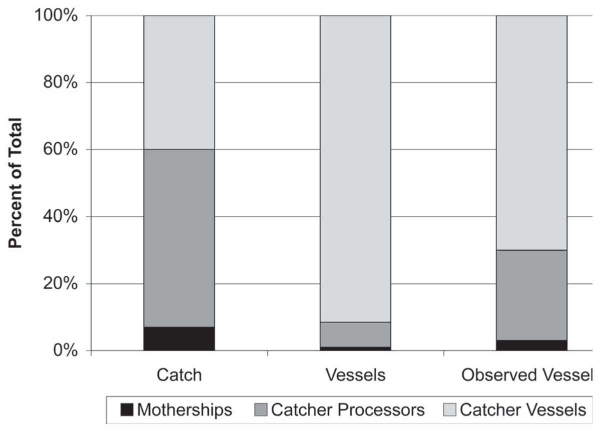

Figure 3. Percentage of catch, vessels, and observed vessels by vessel type.

sample sizes for different species caused interpretation problems for end users of the data. Our reviewers recommended we cease this practice.

On trawl catcher processors, often equipped with flow scales, observer samples ranged from less than 1% of the haul to 80% of the haul (average 2%). The large variation is due to widely different fisheries as well as different vessel conditions. Larger samples for some species were previously collected on these vessels and they caused the same interpretation problems as noted above. These variable sample sizes are no longer allowed under the new protocols implemented in 2008, and the data interpretation issues are now corrected.

On longline and pot vessels, observers were typically able to sample 33% of each sampled haul (Fig. 5). This is not expected to change substantively when following the new protocols. Observers are attempting to maintain this sampling fraction for species composition (a tally of all organisms on a selected part of the longline or in selected pots); however, that sample fraction will be broken into at least three samples.

Sampling Methods

Detailed descriptions of the sampling methods can be found in the Observer Sampling Manual, prepared each year by the FMA Division. The manual is available on the AFSC website at http://www.afsc.noaa.gov/FMA/document.htm.

Observer training includes random sampling theory and methods. While the application of these methods varies slightly by gear type, there are important generalities and limitations to the methods used by observers to select random samples.

Randomly sampling commercial fishing events usually begins at the vessel level. In the North Pacific, this is out of the FMA Division's control. Rather, there are three sampling strata defined in regulation by vessel size and gear type: vessels 0–59 ft in length overall (LOA), vessels 60–124 ft LOA and all vessels fishing pot gear, and vessels 125 ft and greater in LOA. Each of these strata is sampled by observers at different rates, if at all, and observer coverage rates are defined relative to fishing effort (days fished or gear retrieved).

The 0–59 ft LOA vessel stratum is not sampled by observers. Catch and bycatch for these vessels is based, at least in part, on industry and vessel reports of harvest.

All non-pot vessels between 60 and 124.5 ft are required to have 30% of their fishing days observed per quarter in a given fishery. Vessels of any size using pot gear are required to have 30% of their effort observed (30% of pots pulled). Observer placement in this stratum is not random. Vessel operators choose when to take an observer to meet these requirements.

On the largest vessels (vessels 125 ft and larger), observers are aboard on all trips and typically sample between 50% and 100% of the fishing events. For some fisheries, two observers are required to be aboard at all times, enabling every fishing event to be observed.

Within each sampled trip, fishing events (hauls, longline, or pot sets) are either randomly selected to be sampled or all fishing events within the trip are sampled. Observers randomly select hauls to be sampled using a simple random sample design. A random number table has been developed for use by the observers. This random number table randomly designates which hauls to sample, with the restriction that no more than four hauls are to be sampled consecutively. Stratified sampling designs are not used because sampling of hauls would become predictable, and in some cases, vessels may alter their fishing practices during sampled hauls. On some vessels, observers are required to sample every fishing event and two observers are assigned to the vessel to meet that objective. If there is a single observer assigned to a trip, the observer has the ability to randomly select a break period of 6 hours, allowing the observer a longer rest period. A random break table has been developed for this purpose.

Once it is determined that a haul will be sampled, the observer is responsible for assessing the fishing activities and best determining how to sample the unsorted catch. The observer establishes a sampling frame, defines the sampling units (potential samples), and randomly selects samples. Sample frames and units are defined differently depending on the situation on the particular vessel. Sampling options that are available to observers on large catcher-processor vessels are often dramatically different from those available on small catcher-vessels. There are three types of sample frames generally used by the observers: temporal (sample units defined by time), spatial (sample units defined by location or space), and a combined temporal-spatial frame.

Observers are trained and encouraged to use a systematic sample whenever it is logistically feasible. This ensures that samples are taken throughout the haul and are not (by random chance) all from the same section of the catch. In addition, it allows time between samples for the observer to process the sample, e.g., identify fish to species or species group, weigh (or enumerate) fish, obtain lengths and biological samples. When using a systematic scheme to select samples, the sample unit is defined by either space or time (or both, as described above). The observer determines the proportion of samples to be selected (e.g., one-third), and determines the sample spacing (e.g., select every third unit). The first sample unit is determined randomly, and sample units are then selected according to the predetermined spacing until the end of the catch is reached. This systematic sample is generally treated as a simple random sample during data analysis.

For each sampled fishing event, the entire weight of the catch is measured when scales are available or the weight is estimated by the observer. There are several methods for generating the estimated haul weight depending on gear type and vessel type.

For trawl vessels, catch weights are generated by either completely weighing the harvest using a flow scale, or by estimating the volume of the harvest (codend or bin volumes) and expanding by the density of fish. From within sampled hauls, a random sample of the harvest is obtained from which the species composition of the haul is estimated. Again, the samples are selected using a spatial or temporal sampling frame. The size of the sample may vary depending on the vessel type and configuration, the size of the haul, and the gear used.

For pot and longline vessels, the catch weight for the haul is estimated from a randomly selected sample, generally a third of the set. All fish on a selected portion of the gear (hooks, pots) are enumerated. Observers also collect weight samples to determine mean weight per fish. The FMA Division expands the tally information by the sampling fraction to estimate the total number of fish harvested (catch and bycatch). The number of fish is further expanded by the mean weight per fish to estimate the total haul weight.

Within a predetermined percentage of the species composition sample (and on occasion from without) a subsample of randomly selected fish is taken, and the fish lengths are determined. Otolith samples also are taken from some of these fish for later age determination.

In addition to sampling at sea during fishing operations, groundfish observers also sample vessel deliveries to processing plants. Observers assigned to processing plants are responsible for verifying as many delivery weights as possible, collecting delivery information, assisting vessel observers in their sampling duties, and collecting length data and fish age structures as documented in the Observer

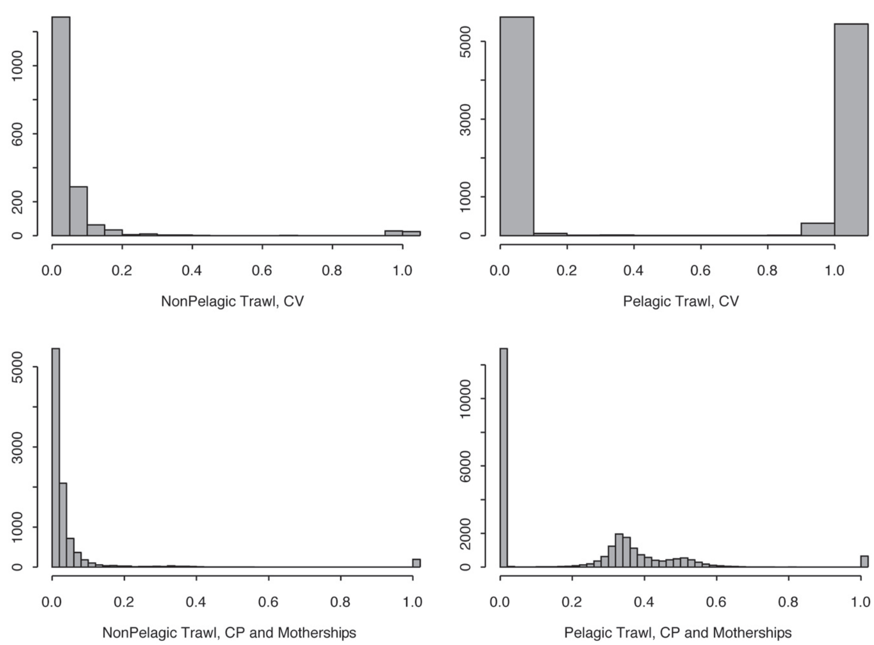

Figure 4. Frequency histogram of sampling fractions achieved on trawl vessels depicting the number of hauls (y-axis) sampled at each sampling fraction (x-axis); 2006 data. Data are presented for catcher-processors (CP) and motherships and catcher-vessels (CV).

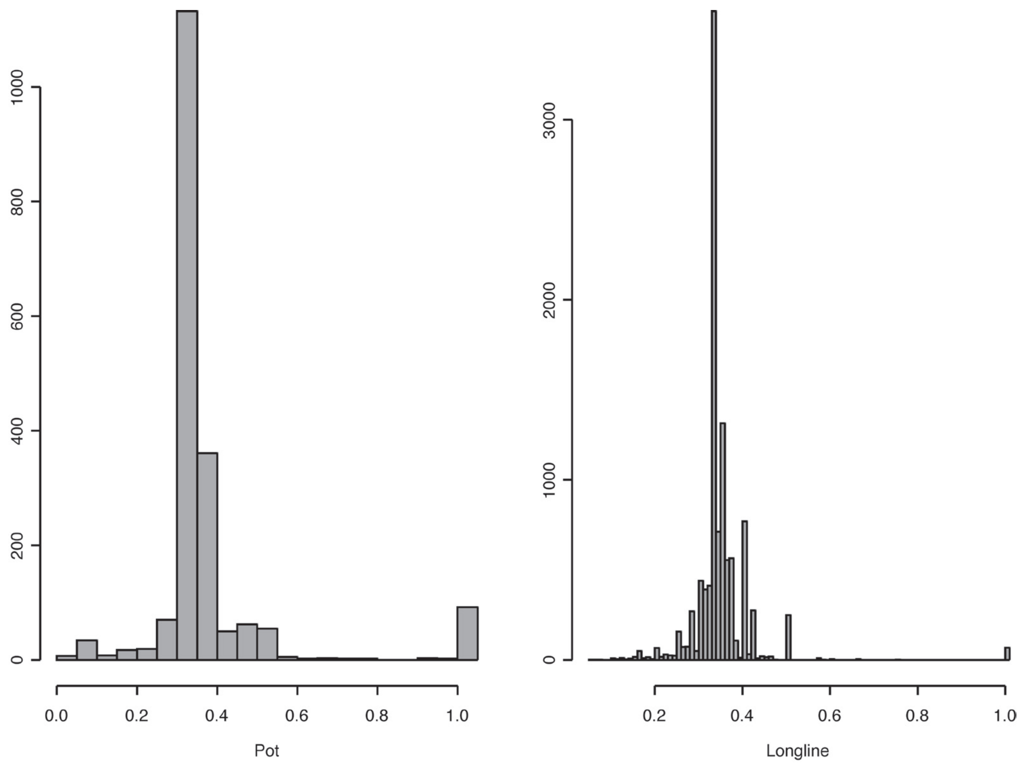

Figure 5: Frequency histogram of sampling fractions achieved on vessels using pot and longline gear depicting the number of hauls (y-axis) sampled at each sampling fraction (x-axis); 2006 data. Data are presented for catcher-processors, motherships, and catcher-vessels.

Sampling Manual. Vessels offloading their catch at these plants are catcher vessels and may be offloading sorted or unsorted catch. Observers assigned to catcher vessels harvesting walleye pollock are required to monitor the delivery at the plant to determine the total number and weight of prohibited species in the catch. For these deliveries, the entire offload must be monitored, which can take between 1 and 24 hours. The numbers and weights of prohibited species in the delivery include those that were recorded as part of an observer's at-sea sample, so that delivery includes the total weight and/or number of prohibited species caught during the trip. This allows the FMA Division to provide fishery managers with a total prohibited species catch for each trip.

Data Storage

All information collected by observers is confidential under the Magnuson-Stevens Fishery Conservation and Management Act so detailed information can be shared only with authorized persons. Observer information aggregated for public release is available on the AFSC website at http://www.afsc.noaa.gov/FMA.

Observer data is stored in an Oracle database housed at the AFSC in Seattle. The AFSC system provides for permanent storage of this important information resource. Data contained in this database encompasses all data collected by observers. The data tables are generally nested and configured to complement the observer sampling methods. Data are organized in the database to reflect, as best possible, where and how the data are collected. A more detailed description of the tables and variables can be found in the NORPAC Data Dictionary, available on the FMA website at http://www.afsc.noaa.gov/FMA/fma_database.htm.

Summary

The improvements made to the sampling methods and databases used by the FMA Division have required tremendous effort from staff. These changes will allow us to provide better data to the end-users and facilitate analyses of fisheries-dependent data from the North Pacific. Although we have attempted to simplify the databases and make the sample methods more robust, we anticipate that these changes will affect many of the scientists who use this data. FMA staff are available to answer questions about the sampling we conduct or the databases that house the data collected by NPGOP observers.