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RECORDING SEABIRD BYCATCH IN LONGLINE OBSERVER PROGRAMS

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Summary
This paper discusses best practice for collecting seabird bycatch data in pelagic longline observer programs.

The paper recognizes that key challenges for WCPFC include:
- The levels of observer coverage needed for recording and monitoring bycatch of non-target species such as seabirds, which typically have high variability in CPUE
- The need to divide observer time between a range of tasks
- The standardization of data collection across existing programs, and establishing a protocol with a sufficient level of detail to ensure consistency
- The importance of high quality observer training in relation to recording bycatch data

Recommendations are:
- Effective monitoring of bycatch rates of non-target species will require high observer coverage. These levels may have to be achieved progressively. Coefficients of variation of seabird CPUE should be regularly reviewed to assess the effectiveness of observer coverage in monitoring bycatch rates.
- Specific time should be allocated for observers to spend observing hooks as they are hauled aboard. Sampling protocols should be made explicit.
- Seabird bycatch rates must be reported based on hooks observed from the hauling deck itself
- The protocol for recording seabird bycatch data should be specified in as much detail as possible, to ensure consistency. Crucial data to record are time/date of setting, a description of the configuration/ characteristics of gear, a detailed description of mitigation measures and their level of adoption, seabird identification, number of seabirds caught and status
- It is highly desirable to collect seabird carcasses and return to port for identification. If this is not feasible then photographs of the upper and lower body and bill may be sufficient.
- Currently, few seabird bycatch data are reported standardized by seabird abundance, but this would make comparisons between bycatch rates more meaningful.
- The experience of BirdLife International is that high quality observer training, including the provision of targeted materials is crucial in order to obtain reliable bycatch data

Introduction

At-sea observer programs are accepted as the only reliable and accurate source of many of the data needed for fisheries management, including verification of fishing effort and CPUE data, and collection of data on discards and on interactions with non-target species.

The WCPFC Convention establishes that the WCPFC regional observer program will '*collect verified catch data, other scientific data and additional information related to the fishery from the Convention Area and to monitor the implementation of the conservation and management measures adopted by the Commission'* (Article 28).

The second regular session of the WCPFC Scientific Committee (WCPFC 2006) recommended the following five high-priority objectives for the regional observer program:

a. *To record the species, fate (retained or discarded) and condition at capture and release (e.g. alive, barely alive, dead etc) of the catch of target and non-target species; depredation effects; and interactions with other non-target species including species of special interest (i.e. sharks, marine reptiles, marine mammals and seabirds);*
b. *To collect data to allow the standardisation of fishing effort, such as gear and vessel attributes, fishing strategies, the depths of longline hooks, FAD use and setting activities of purse seiners, and other factors affecting fishing power;*
c. *To sample the length and other relevant measurements of target and non-target species;*
d. *To sample other biological parameters, such as gender, stomach contents, hard parts (e.g. otoliths, first dorsal bone), tissue samples and collect data to determine relationships between length and weight, and processed weight and whole weight;*
e. *To record information on mitigation measures utilised and their effectiveness.*

The existing longline observer programs in the WCPFC area have been reviewed by Lawson (2006). From 1994 to 2003, the average percentage of longline hooks observed throughout the region was 0.77%.

Clearly, significant challenges lie ahead for WCPFC members in order to establish an effective observer program that meets the above aims. Key challenges include:

- Levels of observer coverage
- Division of observer time between a range of tasks
- Standardization of data collection
- Observer training

Responses to these four challenges are outlined below in relation to meeting objectives on recording data on non-target bycatch, particularly seabird bycatch. Discussion is also added on the use of observer data to meet WCPFC objectives on estimating total seabird bycatch within WCPFC fisheries (paragraph 11, WCPFC Conservation Measure 2006-02)

1. Level of Observer Coverage

It is well-recognized that increasing WCPFC observer coverage to a level that will deliver the data necessary for effective fisheries management is a major challenge (WCPFC 2006). The coverage must also extend across the geographical and seasonal range of the fishery, in order to be able to confidently extrapolate to the whole fishery.

Sufficient observer coverage is a particular challenge for the accurate monitoring of the highly variable bycatch events that are typical of vulnerable non-target species of seabirds, marine mammals and sea turtles. Rare species are likely to have low bycatch rates per unit effort, yet this catch rate may be significant in population terms.

A distinction also needs to be drawn between sufficient observer coverage to detect that bycatch is occurring, and sufficient observer coverage to monitor the effectiveness of Conservation and Management measures to reduce it (Article 28 of the WCPFC Convention). While detection of bycatch of non-target species may be achieved at relatively low levels of observer coverage, reliable estimates of CPUE for these species (required for monitoring) require much higher coverage, even complete observer coverage (Lawson 2006). The levels of coverage needed can be determined by the coefficients of variation in data collected. Within the WCPFC area, a high level of coverage could be focused in areas in which the bycatch of vulnerable non-target species is known to occur (WCPFC 2006). In the case of seabirds, the high risk area has initially been identified as south of 30ºS and north of 23ºN (WCPFC Conservation Measure 2006-02). Complete (100%) observer coverage, such as used in CCAMLR fisheries (Box 1), has additional benefits of being able to monitor aspects of compliance, and in eliminating the risk of observers introducing bias to vessel behavior (WWF 2006).

Box 1. The Commission for the Conservation of Antarctic Marine Living Resources

To date, no other Regional Fisheries Management Organisation (RFMO) has an observer program with the scope and coverage of CCAMLR and their program is therefore a good example of what can be achieved. A comprehensive review of the CCAMLR observer scheme can be found in Sabourenkov and Appleyard (2005). The CCAMLR observer program was established in 1992 and was originally focused on monitoring seabird mortality. Subsequently, the program has expanded to also monitor the sustainable exploitation of fisheries. Observers have proved to be an indispensable source of fisheries data, including data describing fishing operations, catch, biological characteristics of target and bycatch species and interactions of seabirds and marine mammals with fishing operations.

Key elements of the program are the independence of observers, and high coverage rates (100% in longline fisheries). Independent observers are achieved by placing observers from one member state on vessels registered in a different member state.

Clear objectives and observer protocols are provided within the comprehensive CCAMLR observer manual (http://www.ccamlr.org/pu/e/e_pubs/om/toc.htm). Objectives are regularly reviewed in order to ensure the data collected is relevant to the management issues of highest priority.

Since its inception, one of the key objectives of the program has been to minimise seabird and marine mammal mortalities. Observers often provide advice to fishers on the operational implementation of conservation and mitigation measures and observer data is used to evaluate the effectiveness of mitigation measures, along with providing real time biological and catch data for stock assessments. Within Subarea 48.3, seabird bycatch rates have dropped from over 0.5 birds per 1,000 hooks in the early 1990s to zero in 2006 (SC-CCAMLR 2006).

In summary, four fundamental steps have been instrumental in providing effective management of seabird bycatch in CCAMLR fisheries. These are: quantifying the scale of seabird bycatch, identifying and assessing the risks to seabirds, the implementation of management measures to address risks, and continual monitoring and reviewing of procedures. All these steps rely on high quality data from the observer program.

However, although coverage should be set with data requirements in mind, the true level is likely to be limited due to other factors such as cost and the logistics of deploying observers. Lawson (2006) identifies that a 20% observer coverage typically reduces the coefficient of variation of estimates of CPUE to about 10% (i.e. a 95% confidence interval of +/- 20%). Where observer coverage is below 20% there is an exponential increase in the coefficient of variation (uncertainty in the estimate), whereas coverage above 20% results in smaller increments of reduction of the coefficient of variation.

Ashford (2002) predicted that 25% coverage should be sufficient to record seabird bycatch rates in the region of 0.2 birds/1,000 hooks; although to record seabird bycatch at a species level would require higher levels of coverage. In order to estimate CPUE and coefficients of variation for seabird bycatch, BirdLife believe that in the initial phase the WCPFC should aim to achieve a minimum level of 25-30% observer coverage across their fleets. This level can then be adjusted progressively based on the co-efficients of variation and the stated objectives of the programme. As discussed above, in order to develop a robust bycatch estimate the level of observer coverage may need to be markedly increased in certain areas, and conversely, it may be possible to reduce levels in others areas.

In addition, when determining the optimal level of observer coverage, a distinction must be made between within-fleet coverage and within-trip coverage. True coverage will depend on the proportion of effort observed on each vessel within each trip. For accurate recording of seabird bycatch, these hooks must be observed at the hauling station, not from the bridge or a separate fish processing area. Within-trip coverage for bycatch data will therefore depend on the priority given to the various objectives of the observer program. A coverage of 20% hooks observed may equate to observers being on board 30-40% vessels (see below).

2. Sampling strategy

Another challenge is the fact that there are many tasks for observers to undertake, and observer work time must be divided into a realistic and effective workload. On small boats, where only 1000 hooks are hauled per day, and where the hauling station and fish processing area are not separated, then an observer may be able to monitor 100% of the hooks during both setting and hauling.

However, on larger vessels the crew often work in shifts allowing fishing operations to continue 24 hours a day. This will limit the maximum potential of the observer to monitor about 50% of hooks hauled. Also, where more detailed examination and sampling of fish are required to determine age, diet or the relationship between processed and whole weight, the potential for observing hooks as they are hauled will be significantly less. As such, a system of sampling becomes a necessity, and the protocol for sampling needs to be defined.

Broadly speaking, there are two strategies for obtaining a random sample during hauling. The choice is between sampling random sections of longline (gear-based) or sampling randomly throughout the duration of line hauling (time-based). The gear-based method involves dividing the line into sections containing an equal number of hooks and taking a random sample from these sections, whereas the time-based sample consists of a randomly selected time slots, based on the expected time spent hauling each day. For example, if a vessel is predicted to be hauling for 12 hours per day and the target is to monitor 50% of hauled hooks, divide this period into six, two-hour slots and randomly select three to achieve the desired coverage. The actual number of hooks or time period selected will depend on the targets and objectives set by the observer program and the division of labour between bycatch monitoring and factory sampling. When the number of hooks hauled can be easily monitored from the factory floor or the crew has an accessible means of counting the amount of gear hauled, a gear-based protocol is recommended. If this is not feasible, the time-based method is an effective alternative. Since observer duties involving factory sampling and deck observations are often mutually exclusive it might even be necessary to randomly assign days for factory work and deck observation work to assist observer time management.

3. Protocol for recording seabird bycatch data

A challenge for WCPFC is to achieve standardization of data collection protocols when existing programs already have a variety of protocols and may be reluctant to lose long-term data sets through changing the methods by which data are recorded. The lack of standardization between observer programs is a problem globally, and is not limited to the Pacific, making it difficult to compare results from different fisheries. Careful planning is needed to develop best-practice protocols, recording forms and a database that will accommodate all the necessary information and yet, as far as possible, minimize disruption to existing programs, to allow continuity of data.

The protocol described below focuses on core/critical data needed to monitor seabird bycatch, though mentions additional variables that may also be desirable. It allows for the reality that an observer will have to fit these duties in with other tasks, such as factory sampling.

3.1 Deck observations during hauling

Most seabird bycatch takes place as hooks are set. However, it is normal practice to base seabird bycatch rates on the number of birds recorded caught on hooks during hauling. This should be regarded as a minimum bycatch rate as birds can be lost during the soak period.

Crucial data to record are:

● Spatial and temporal information (time and vessel position at the start and end of the haul)

This information is necessary to evaluate the spatial and temporal extent of seabird bycatch. The collection of this information is standard for all observers and should be freely available from the ship's logbook.

● Number of hooks observed & species caught

Note the start and end time for each observation period so that all observations are related to an approximate position. Find a good vantage point (on deck overlooking the hauling hatch) and count hooks as they are hauled. Record each animal and it's fate (alive / dead, retained / discarded, sampled) as it is hauled aboard. Hooks can be recorded individually giving the distribution of catch along the line and relating this to the distribution of floats, light-sticks and other bycatch.

It has been shown experimentally that as much as 95% of the seabird bycatch returned to the vessel can go unrecorded when an observer's primary role is fish sampling (Gales *et al*. 1998). This occurs because crew can cut birds from the line before they come aboard. Research of this kind emphasizes the importance of having dedicated seabird/bycatch observers and the importance of only recording as 'observed' those hooks that are actually witnessed being hauled aboard. The mere presence of an observer on board a vessel does not ensure that all bycatch is recorded. Any error in the collection of raw bycatch data is magnified when extrapolated for the fleet as a whole.

● Seabird samples

It is highly desirable that all seabird carcasses (or at least the head and one leg) should be returned ashore for identification and an autopsy examination by appropriate experts. This information can be used to determine the sex, age, breeding status and general health of the bird and samples can be used for genetic analysis. Baker et al (2007) gives an example of the analysis that is possible when the provenance of seabird bycatch can be determined. If the collection of carcasses is not possible, several photographs of the head and underwing should be enough to identify the bird. Samples and photographs should be accompanied by details of vessel ID, date and if possible time hauled and position. The number of any tags or rings should be noted and collected.

In addition, desirable data to record include:

● Mitigation measures in place during haul

In some cases there may be catches of birds during hauling as they try to take baits returning to the vessel. These birds are usually alive, although injured, and with care can be released. The number of these instances, the species involved and the outcome (released unharmed, badly injured, killed) should be recorded. When presenting data the Bycatch Per Unit Effort (BPUE) of birds caught during setting, returning to the vessel dead, and the BPUE of birds caught during hauling, usually released alive, should be separated. There are a limited number of mitigation measures (e.g. Brickle curtain) designed to deter birds from interacting with baited hooks as they return to the vessel. Combined with discharging offal on the opposite side of the vessel, this problem can be minimized. In cases where seabirds are caught on the haul, data on seabird abundance and environmental conditions may be desirable (see below)

The overall impact of ingesting discarded hooks is unknown but there is evidence that the chronic effect of hook injuries can lead to death (Weimerskirch and Jouventin 1987). Observers should be aware of this issue and attempt to record the proportion of baits and bycatch that are discharged with embedded hooks.

Several fisheries have the compulsory removal of hooks from all discards written into their licence agreement (CCAMLR, Falkland Islands).

3.2 Deck observations during setting

While seabird bycatch data will be based on haul observations, data collected during setting can be of great value since it is during setting that seabirds are caught and drowned

Attempts should be made to observe all sets made during daylight, and a pre-defined sub-sample of night-time sets. Dependent on the phase of the moon, it may be impractical to observe night-time sets.

Crucial data to record are:

● Spatial and temporal information (time and vessel position at the start and end of the set).

This information is necessary to evaluate the spatial and temporal extent of seabird bycatch. The collection of this information is standard for all observers and should be freely available from the ship's logbook. However, independent verification from the observer by means of a handheld GPS is desirable. This information enables the stratification of data on an area and seasonal basis.

● Mitigation measures (which measures are used and how are they deployed).

Recording which measures are used for each fishing operation, their configuration and deployment strategy, will help to evaluate which methods are most efficient and fine tune their use. Observers should be provided with clear definitions and the performance criteria for the possible range of mitigation measures to remove subjectivity from the evaluation of performance.

● Fishing gear characteristics (number of hooks, number, spacing and type of floats, light-stick spacing, snood weights, bait type and condition).

Generally, the gear specifications will remain the same throughout the trip but the number of hooks and spacing of floats will vary according to the target species. Subtle differences in fishing gear can have dramatic consequences for seabird and turtle bycatch. The addition of light-sticks, bait type, bait condition and the addition of snood weights will all affect hook sink rate and therefore have implications for seabird bycatch. Diagrams clearly showing the gear configuration and dimensions should be included within the observer's report.

In addition, desirable data are:

● Seabird abundance

Of all the factors that lead to seabird bycatch, seabird abundance at setting is likely to be one of the most important. Gilman *et al.* (2003) found a significant linear correlation between albatross abundance and seabird interaction rates and concluded that seabird abundance should be used to normalize bycatch rates when comparing mitigation measures. This will lead to a standardized estimate of seabird bycatch and help make meaningful comparisons between seasons, vessels and fisheries. Reid and Sullivan (2004) also found seabird abundance to be a significant factor in the level of seabird mortality. Currently, however, few programs record these data, and most seabird bycatch data are not normalized by seabird abundance.

A protocol for recording seabird abundance is as follows: at the start and end of setting, and at regular intervals throughout setting (every 30mins), count the birds, by species, present within a 500 by 500m 'box' astern of the vessel (i.e. 250m to port and starboard and 500m astern). During night-time sets, when visibility is reduced, it is not possible to record much more than the presence or absence of species. It is notoriously difficult to judge distances at-sea, and one of two methods should be used to estimate the size of the 'box'. Heinemann (1981) describes the process of constructing a simple range finder or by using the principle that a vessel traveling at a set speed will travel 500m in a set time. For example, a vessel traveling at 10 knots will travel 500m in 100 seconds (8 knots = 125 seconds). Simply, time the vessels progress from the deployment of buoys or any other fixed object to estimate the size of the 'box'.

● Environmental data.
Environmental factors that have an influence on seabird mortality are wind speed and direction relative to the vessel's course, sea state, wave and swell height, cloud cover, (extent/degree of) visibility and moon-phase. Reid and Sullivan (2004) identified a range of environmental (wind speed and direction) and operational variables (daylight period, use of mitigation measures) that along with area and season effects had significant influence on black-browed albatross (*Thalassarche melanophrys*) mortality. Data concerning all these variables can only be recorded during line setting and will lead to better modeling of the interactions between seabirds and longline fisheries.

● Seabird behavior.
It should be possible to record some aspects of seabird behavior during line setting. Attempts should be made to record the number of baits taken by birds and the number of definite hookups. This information can be related to the mitigation measures in place and help to identify the most effective measures under a range of environmental conditions. Bait loss during setting also has considerable economic implications for fishermen, in terms of bait costs and lost fishing potential.

Crucial and desirable data for recording seabird bycatch are also listed in Dietrich et al (2007).

4. Observer recruitment and training
Experience within BirdLife International programs have highlighted the importance of observer selection and observer training in achieving reliable data collection: observers must be convinced of the relevance and importance of their data collection.

● Recruitment
Recruitment of the right people is crucial as it is difficult to find observers who have the skills and experience to undertake both fish and non-fish data duties equally proficiently. Some fisheries deploy two observers, one for the fish work and one to monitor bycatch. There is considerable evidence that dedicated seabird observers collect more rigorous bycatch data than a generalist observer. This is a result of observer's interests and passions and is also related to workload. Whoever is employed, they have to be self-motivated, willing to work independently under conditions of physical and mental hardship while maintaining a sense of humor. A schedule of regular radio, e-mail or satellite phone communications should be established with the observer co-ordinator and other observers. This enables the exchange of data, helps to find solutions to any problems regarding work and is generally good for morale.

● Training
Experience has revealed the importance of the quality of the training program in relation to quality of data recorded by observers. For bycatch species, this requires background information on the importance of the bycatch data that the observers are being asked to collect. Training on species identification will take time, as well explanation of the importance of observations at the hauling deck as well as in the fish processing area. Background information on the fishery including bycatch issues should be included in the training.

● Observer manuals
A number of examples exist worldwide of good seabird bycatch sections within observer manuals (e.g. from CCAMLR, NOAA Hawaii longline, South Africa). The manuals contain detailed descriptions of all the sampling protocols, species identification keys, copies of all the data forms required and instructions for inputting the data into a database.

● Debriefing
Following the completion of a trip, a debrief session has proven particularly valuable in relation to understanding abnormal bycatch events.

5. Using observer data to calculate the total seabird bycatch for the fishery
Seabird bycatch rates are influenced by many environmental, seasonal and spatial factors (Klaer and Polacheck 1998, Brothers *et al.* 1999, Reid and Sullivan 2004). When raw bycatch data comes from a small sample of the overall fishing effort it is a huge assumption to regard this data as representative of the whole fleet. Several models have been used to increase the accuracy of bycatch figures derive from observer data but these are not appropriate for very low levels of observer coverage. Within New Zealand fisheries two models are used, *ratio estimator* and *random effects predictive models* (Baird and Smith 2007, New Zealand Ministry of Fisheries 2007).

The ratio estimator model is used to calculate the total number of seabird captures by multiplying the rate estimator by the total fishing effort. Essentially, the observed number of birds caught is divided by the number of hooks observed, to give the BPUE (ratio estimator), which is expressed as number of birds caught per 1,000 hooks hauled. BPUE is multiplied by the total effort within the fishery to give total bycatch. This model is applied where observer coverage is over 10% of effort and assumes the coverage representatively sampled the areas, seasons and vessel types within the fishery. Coefficients of variance for fisheries modeled in this way range from 12% to over 100%, which is not compatible with the management of interactions between seabirds and marine mammals. High variance is a function of low observer coverage and the patchy nature of capture events in the fishery.

Random effects models have been developed to estimate seabird and marine mammal bycatch in fisheries that have relatively high observer coverage and show relative homogeneity in the fishing fleet. These models are useful to explore factors within the fishery (e.g. vessel type, fishing practice, capture location, mitigation efficacy) that may be affecting the probability of non-fish captures. This approach is recognised as highly computer intensive and requires a considerable amount of data for fitting the models. As a result, it is only used for specific applications where the datasets are adequate.

When comparing these two models, the random effects model tends to produce lower estimates of total bycatch with lower coefficients of variation than the random effects model for areas with low bycatch estimates. In areas with the highest bycatch estimates the random effects model tended to predict fewer captures with lower coefficients of variation than the ratio estimator. The type of model used depends primarily on the quality and availability of data. More intensive accurate methods can be applied where data are representative, high observer coverage has been achieved and where specific questions about fishery performance are being analysed.

Longliners fishing within CCAMLR waters have 100% observer coverage and a simple extrapolation method is used. The total seabird bycatch is estimated for each individual vessel using each vessels observed catch rate multiplied by the total number of hooks set (New Zealand Ministry of Fisheries 2007).

The model used to estimate seabird bycatch will depend on the quality of data available but given the likely observer coverage within WCPFC waters the ratio estimator model will be most applicable. However, bycatch estimates should still be viewed cautiously as the extremely ‘clumpy’ nature of seabird bycatch data and the non-random distribution of observers throughout the fleet lead to biases. Despite the shortcomings of this method, especially when observer coverage is low, this method is widely used to calculate overall bycatch figures for entire fisheries.

In terms of data management, centralized collation and management of observer data by the WCPFC Secretariat will help to maintain consistency in the data collected and better enable the dissemination of fisheries/seabird statistics and the production of annual seabird bycatch reports.

Conclusion

Currently, the observer coverage within the WCPFC (less than 1% of all effort) is very low and key challenges lie ahead for the development of the WCPFC regional observer program. Key recommendations from this paper are:

- Effective monitoring of bycatch rates of non-target species will require high observer coverage. These levels may have to be achieved progressively. Coefficients of variation of seabird CPUE should be regularly reviewed to assess the effectiveness of observer coverage in monitoring bycatch rates.
- Specific time should be allocated for observers to spend observing hooks as they are hauled aboard, as opposed to observers being in the fish processing area
- Seabird bycatch data should be reported based on hooks observed from the hauling deck itself, not from hooks deployed while an observer is on board a vessel
- The protocol for recording seabird bycatch data should be specified in as much detail as possible, to ensure consistency
- Crucial data to record are time/date of setting and hauling, gear characteristics, description and use of mitigation measures, number of seabirds caught and status
- It is highly desirable to collect seabird carcasses and return to port for identification. If this is not feasible then photographs of the upper and lower body and head/bill may be sufficient.
- Currently, few seabird bycatch data are reported standardized by seabird abundance, but this would make comparisons between bycatch rates more meaningful. This would require seabird census counts during setting
- The experience of BirdLife International is that high quality observer training is crucial in order to obtain reliable bycatch data

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