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Purse-seine vessels as platforms for monitoring the population status of dolphin species in the eastern tropical Pacific Ocean

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ABSTRACT

In the eastern tropical Pacific Ocean, yellowfin tuna (*Thunnus albacares*) are often found in association with spotted (*Stenella attenuata*) and spinner (*Stenella longirostris*) dolphins. Purse-seine vessels use this co-occurrence to locate the tuna by searching for dolphins and associated birds. Data collected by onboard observers since the late 1970s were used to develop indices of relative abundance for dolphins, based on line-transect methodology, when the primary method of detection of dolphin herds was with binoculars. However, trend estimation was subsequently discontinued in 2000 due to concerns about changes in reporting rates of dolphin herd detections with increased use of helicopter and radar search. At present, as a result of a hiatus in fishery-independent surveys since 2006, fisheries observer data are the only source of information with which to monitor the status of eastern tropical Pacific Ocean dolphin populations. In this paper, trend estimation with the onboard observer data is revisited using a sightings-per-unit-effort approach. Despite different assumptions and model structure, the results indicate a lack of independence between the distribution of search effort and the search methods used, and the abundance of dolphin herds associated with tunas, on several spatial and temporal scales. This lack of independence poses a considerable challenge to the development of a reliable index of relative abundance for dolphins with these data. Given these results, alternatives for dolphin abundance estimation are discussed. One alternative is the use of purse-seine vessels for line-transect surveys during fishery closure periods. Another alternative is the use of purse-seine vessels during normal fishing operations as platforms for the collection of mark-recapture data (*e.g.*, passive integrated transponder tags or genetics sampling). Life-history data collection, as a supplement to the collection of other data types, is also discussed. Further research and development is needed to assess whether these alternative methods will be useful.

1. Introduction

Mortality of dolphins in the eastern tropical Pacific Ocean (ETP) purse-seine tuna fishery is an iconic conservation issue. In the ETP, yellowfin tuna (*Thunnus albacares*) are often found in association with spotted (*Stenella attenuata*) and spinner (*Stenella longirostris*) dolphins (National Research Council, 1992). Since at least the 1960s, purse-seine vessels have used this co-occurrence to locate the tuna by searching for dolphins, and associated birds, with high-power binoculars, and more recently, high-resolution radar and helicopters (National Research Council, 1992; Lennert-Cody et al., 2001). Historically, this fishing method resulted in significant bycatch of dolphins, which has since been greatly reduced through fishermen's ingenuity and implementation of management measures (MMPA, 2007; Lo and Smith, 1986; National Research Council, 1992; Joseph, 1994; Wade, 1995; Hall, 1998; IATTC, 2013).

Population dynamics modeling of dolphins in the ETP has historically been one of the primary means of evaluating the efficacy

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of bycatch reduction measures for these species (Gerrodette and Forcada, 2005; Reilly et al., 2005; IATTC, 2006; Wade et al., 2007; Gerrodette et al., 2008). Dolphin population assessments require an index of either relative or absolute abundance from which inferences are made about trends in population size through time. Indices of dolphin abundance have been developed from both fishery-dependent and fishery-independent data. In the case of fishery-dependent data, information on dolphin herd sightings is available because fishermen in the ETP use the presence of dolphins, as well as birds and splashes, to locate tunas (National Research Council, 1992). In the early years of the fishery, fishermen would search for these cues primarily using high-powered binoculars. Observers aboard the tuna vessels recorded information about dolphin herd encounters and position information for the purse-seine vessel. Indices of relative abundance were developed from these data in the 1980s based on line-transect methodology (Buckland and Anganuzzi, 1988; Anganuzzi and Buckland, 1989; Buckland et al., 1992). However, trend estimation was discontinued in 2000 due to concerns about changes in reporting rates of dolphin herd detections with the increased use of helicopter and radar, in addition to binoculars, to search for dolphins and tunas (Lennert-Cody et al., 2001). Additional concerns have been raised about potential issues associated with herd size estimation (Ward, 2005). Between 1979 and 2006, the US National Marine Fisheries Service (NMFS) conducted periodic fishery-independent surveys in the ETP for the purpose of estimating dolphin absolute abundance (Gerrodette et al., 2008; and references therein). While such surveys can have the advantage of avoiding time-varying biases due to changes in fishing behavior, they are costly and, as a result, obtaining adequate coverage and precision for monitoring widely distributed marine species is difficult.

One of the advantages of data collection by observers during normal fishing operations onboard tuna purse-seine vessels is that large amounts of data are obtained, with generally good spatial and temporal coverage. However, fishery-dependent data come with the potential for biases when used to develop indices of relative abundance (Maunder et al., 2006). At present, as a result of a hiatus in fishery-independent surveys since 2006, purse-seine observer data are the only source of information with which to monitor ETP dolphin population status. In the first part of this paper, the challenge of estimating dolphin trends with the purse-seine observer data for the offshore spotted dolphin is revisited and the reliability of estimates computed from these data are discussed. To address problems related to sighting data quality and biases caused by changes in the use of different search methods through time (Lennert-Cody et al., 2001), a catch-per-unit-effort-type approach to trend estimation was adopted based on generalized additive models. This methodology for trend estimation does not require sighting bearing and distance information, and can be used to control for covariate effects, such as changes in searching behavior. In the second part of this paper, other options for obtaining dolphin abundance indices from different data types that may be collected aboard purse-seine vessels are discussed. Issues associated with herd size estimation, such as those raised by Ward (2005) and Buckland and Anganuzzi (1988), are not addressed.

2. Trends from fishery-dependent data

2.1. Data

During the course of daily fishing operations, observers of the Inter-American Tropical Tuna Commission (IATTC) aboard large[1] purse-seine vessels recorded data on vessel activities (*e.g.*, running, searching, drifting, setting), fishing operations, and dolphin sightings. These data were used to obtain estimates of distance travelled while searching, species and number of dolphins in each dolphin herd sighted, and information on other factors that may affect dolphin herd sighting rates and herd size (*e.g.*, fishing location and season).

Purse-seine vessel searching behavior is complex and not all details of searching activities were recorded by onboard observers. Large purse-seine vessels that fish for tunas associated with dolphins use three methods to search for the dolphins and tunas: binoculars (typically 25X mounted binoculars, from one or several locations on the vessel), radar, and helicopter. The radar is operated by the crew from the bridge of the vessel. The helicopter is piloted by a special crew member, and due to space constraints and safety concerns, observers are not allowed in the helicopter. Unfortunately, observers did not record which search methods were in use during each searching event, and thus, it is not possible to assign periods of search to particular search methods. Moreover, the helicopter may have searched well away from the purse-seine vessel and its position information was not available to the observer. Therefore, it is only possible to compute a rough measure of searching effort from time and position data for the purse-seine vessel itself.

Observers recorded all dolphin sightings of which they were aware. An initial estimate of dolphin herd size and species composition was recorded by the observer as soon as he became aware of the sighting. This may have been a crew member's initial estimate, or the observer's own initial estimate, if he was able to see the dolphins. A dolphin herd sighting may have begun with the visual cue of the mammal themselves or it may have begun with other cues, such as splashes or birds associated with the dolphins. The association of birds with dolphins enables sightings to be made at much greater distances from the vessel because birds can be visible over the horizon. If the dolphin herd was later involved in a purse-seine set, the observer would have continued to revise his estimate of herd size and species composition, producing a 'best estimate'. This best estimate is the observer's estimate of the size of the entire herd, and includes an estimate of the number of dolphins that were in the original herd but evaded encirclement with the purse-seine net or were intentionally cut-out of the encircled portion of the herd (National Research Council, 1992; Lennert-Cody and Scott, 2005). With possible exception of evasion, a dolphin herd sighting leading to a purse-seine set is similar to a survey vessel entering 'closing mode' in a fishery-independent line-transect survey (*e.g.*, Strindberg and Buckland, 2004). Additional information recorded for each sighting includes the distance and bearing to the sighting from the vessel.

For this analysis, to try to standardize searching practices among vessels and trips through time, data were limited by the following criteria:

1. To ensure homogeneity of searching techniques, data collected prior to 1990 were excluded, because information on radar use did not become available until the late 1980s (Lennert-Cody et al., 2001).
2. To ensure that vessel crew were actively searching for dolphins, and that the vessel was not switching fishing modes, depending on availability of tunas as free schools or as schools associated with dolphins, trips making fewer than 50% of their sets on tunas associated with dolphins were excluded (but see Section 2.5).
3. Days when the vessel was not actively searching with the observer on duty, days without at least two valid positions, days where the vessel was at or near full fish-carrying capacity (≥90% capacity; to remove periods of lower-intensity search), and days

[1] Defined as those vessels with carrying capacities greater than 363 metric tons (IATTC Class 6), all of which are required to carry observers.