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COMMENTARY

Quantifying seabird bycatch: where do we go from here?

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Bycatch of seabirds in offshore commercial fisheries has long been recognized as a serious conservation issue (e.g. Brothers, 1991; Brothers, Cooper & Løkkeborg, 1999), but until recently the problem was principally associated with industrial longline gear. In fact, pelagic seabird bycatch is very much a multi-gear problem. Watkins, Petersen & Ryan (2008) have presented the latest in a string of recent case studies documenting geographically widespread and sometimes severe levels of seabird bycatch in industrial trawl fisheries throughout the Southern Hemisphere (Weimerskirch, Capdeville & Duhamel, 2000; Sullivan, Reid & Bugoni, 2006*a*; Baker *et al*., 2007; Gonzáles-Zevallos, Yorio & Caille, 2007). Substantial seabird bycatch occurs in trawl fleets of the Northern Hemisphere as well (e.g. in Alaskan trawl fisheries for groundfishes; NMFS, 2006). The issue is one of global importance that requires urgent international attention.

National and international fisheries management bodies face several challenges as they move forward to address seabird bycatch within a multi-gear context. One fundamental question is what is the relative and cumulative threat to seabird populations from bycatch in trawl and longline gear? Answering this question depends on having reasonable estimates of mortality from these two gear types across the multitude of international fishing fleets with which particular seabird populations interact (e.g. Baker *et al*., 2007). This will require that new observer programs be established for national trawl fleets that interact with seabirds in their waters, and that international programs currently working to quantify seabird bycatch in high-seas longline fisheries (see Gilman & Moth-Poulsen, 2007) expand to quantify threats posed by trawl fisheries as well.

Trawl gear poses a particularly difficult challenge for seabird bycatch estimation because a large but often unquantified proportion of birds killed by interactions with trawl cables (the dominant cause of mortality in trawl gears) is not hauled onto the vessel and therefore goes unobserved by traditional observer-data collection protocols (e.g. Gonzáles-Zevallos & Yorio, 2006; Sullivan *et al*., 2006*a*). Watkins *et al*. (2008) observed that only two out of the 30 *known* seabird fatalities from cable interaction were eventually hauled aboard, corresponding at best to an overall 0.067 ($\pm$0.046 binomial SE) detection rate for this type of mortality if only haul data had been used to estimated bycatch. This indicates the need to update observer protocols of seabird bycatch monitoring in trawl fisheries, to ensure proper accounting of bird mortalities resulting from cable collisions.

Alternative methods for monitoring seabird bycatch in trawl fisheries should also be explored, as observer programs appropriate for monitoring seabird–trawl cable interactions are labor intensive and therefore expensive. Watkins *et al*. (2008) were only able to observe 0.5% of annual trawl fishing effort for this reason, and even some of the most well-funded fishery observer programs in the world (e.g. several in the United States) are too overstretched financially to meet observer coverage goals (Rossman, 2007). One promising approach is video monitoring (McElderry *et al*., 2004; Ames, Williams & Fitzgerald, 2005), which Watkins *et al*. (2008) used with apparent success during the first part of their study. Another strategy may be to augment traditional observer-data collection protocols, which are based on sampling hauled-in bycatch, over the long term with shorter intensive studies aimed at estimating species composition and non-detection rates for seabirds killed by cable interactions that are not retrieved during hauling of gear. These might then be applied as correction factors to statistically estimate actual seabird bycatch in trawls from data collected using conventional observer protocols. To our knowledge, Watkins *et al*. (2008) were the first to provide some empirical inference about the rate of bycatch non-detection in trawl fisheries and we encourage future studies to report similar data and estimates.

As research and management programs respond to increase collection of trawl bycatch data, it would be helpful to adopt common metrics for reporting trawl bycatch. Watkins *et al*. (2008) reported bycatch per trawl hour, which

makes sense given their protocol of collecting data in $\geq$5-min observation periods during trawling. Other researchers who focused on birds retrieved during hauls have conventionally reported bycatch per haul (or per tow), or per vessel day. Recording bycatch rates at the finest temporal resolution that is practicable would facilitate analyses of correlations between bird interactions and environmental or fisheries characteristics. With auxiliary information such as trawl duration (h) and number of trawls per vessel day, finer-scale metrics can always be scaled to coarser metrics as needed, but the reverse typically is not true. Moreover, some index of gear and vessel size should be agreed upon and recorded. This will facilitate cross-study comparisons of bycatch rates. Otherwise, apparent differences in bycatch rates between different studies may be misleading.

Regarding bycatch rate estimation by Watkins *et al.* (2008), we would like to have seen a clearer description of the temporal distribution of their observation periods during trawls. Validity of their average bycatch rate estimates for each 'dump $\times$ season' stratum requires random (or systematic) allocation of observation-periods throughout the trawl durations within those strata, and that the duration of individual observation periods (which they only specified were $>$5 min in length) were not affected by bird activity. More observer effort allocated to periods of higher bird activity would lead to inflated bycatch-rate estimates; and it is not clear whether they took measures to address this potential sampling issue.

Another challenge for bycatch researchers and managers is to evaluate bycatch estimates, across international fleets and gears, in a more rigorous population context. Watkins *et al.* (2008) assert matter-of-factly that albatross bycatch in South African deep-water trawl fisheries is 'unsustainably high.' Considering the apparent magnitude of bycatch in this fishery and known declines of many seabird populations, this is likely a true statement, at least for some of the affected species. However, increased efforts across bycatch studies to quantitatively evaluate the population-level consequences of bycatch estimates are needed to prioritize conservation efforts and justify management action where it is really needed. Soykan *et al.* (in press) noted that fewer than a quarter of published seabird bycatch studies have attempted to empirically put bycatch estimates in a population context, yet recent studies (e.g. Niel & Lebreton, 2005; Dillingham & Fletcher, 2008; Zador, Punt & Parrish, 2008) have paved the way for doing so even in the absence of complete demographic data.

Watkins *et al.* (2008) have provided important new insight into the problem of seabird bycatch in trawl fisheries, expanding our awareness of the breadth and especially of the potential magnitude of the issue. Researchers, managers, conservation groups and policy makers are now challenged to give equal attention to reducing trawl bycatch as they have in many longline fisheries. A population-based, multi-gear and multi-national framework is required to identify the most significant threats to wide-ranging seabird populations and to prioritize mitigation efforts in the most problematic areas. Fortunately, effective mitigation tools have already been suggested and in some cases are required to reduce seabird bycatch in trawl fisheries (Sullivan *et al.*, 2006*b*; Gilman & Moth-Poulsen, 2007; Gonzáles-Zevallos *et al.*, 2007; Watkins *et al.*, 2008), but additional work is required to refine those methods, and their implementation on a global scale is merely in its infancy.

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