Estimates of Total Seabird Bycatch by Atlantic Pelagic Longline Fisheries from 2003 to 2006

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Introduction

Incidental mortality from fishing has long been recognized as a threat to the long-term viability of vulnerable seabird populations, particularly albatrosses *(Diomedea, Phoebastria, Thalassarche, Phoebetria* spp.*)* (Weimerskirch and Jouventin, 1987; Gales, 1993; Croxall et al., 1998). The International Union for the Conservation of Nature currently lists 17 of 22 species of albatross as Vulnerable, Endangered, or Critically Endangered. Longline fishing has been identified as the primary cause of incidental mortality and population declines for some albatross populations (Weimerskirch et al., 1997).

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*ABSTRACT—Results of recent seabird bycatch studies in the International Commission for the Conservation of Atlantic Tunas Convention Area were combined to estimate total seabird bycatch of pelagic longline fishing in the Atlantic Ocean, and bycatch per selected species. Available studies do not apply to the full spatial and temporal extent of the fishing effort, so assumptions were made to account for missing information. Over the 4 years from 2003 to 2006 the total seabird bycatch estimate was 48,500. Results indicate that about 57% of the pelagic longline seabird bycatch was albatrosses (*Diomedea, Phoebastria, Thalassarche, Phoebetria *spp.). This mortality is at a level to cause concern for the smaller and more vulnerable albatross |populations in the region. Variation in annual seabird bycatch was caused by variation in total fishing effort, and movement of effort away from areas of higher seabird bycatch rates.*

Mortality is mostly caused by the birds taking baits as they float near the surface during line setting (Brothers, 1991), and then becoming hooked and drowning as the line sinks below the water surface. Mitigation measures to reduce incidental seabird mortality have been proposed and sometimes implemented, including using bird scaring lines, using thawed bait that sinks more readily, heavier weights on branch lines, bait throwing devices to throw baits clear of the vessel wash, night setting, spatial or temporal closures, and underwater setting using special bait chutes.

International conservation agreements have been established that recognize the threat of longline fishing to seabird populations, most notably the United Nations (U.N.) Food and Agriculture Organization (FAO) International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries (FAO, 1999) and the Agreement on the Conservation of Albatrosses and Petrels (ACAP[1]). Other agreements regarding the effect of longline fishing on non-target species are also relevant, including the articles within the U.N. Convention on the Law of the Sea, the Convention on Biodiversity, the Convention on Migratory Species, and the U.N. Fish Stocks Agreement.

These agreements establish a legislative framework that encourages monitoring and mitigation of the effects of fishing on vulnerable seabird populations. Some international fisheries have mandated the use of various mitigation measures for longline fishing (Convention on the Conservation of Antarctic Marine Living Resources, Commission for the Conservation of Southern Bluefin Tuna). In 2006, the International Commission for the Conservation of Atlantic Tunas (ICCAT) commenced an assessment of the level of threat from their fisheries to all seabirds that breed or forage within their jurisdiction.

This paper provides estimates of recent total seabird bycatch in the ICCAT Convention Area (the Atlantic Ocean and associated seas from lat. 70°N to lat. 50°S) due to pelagic longline fishing. There are a number of studies that have produced estimates of bycatch over smaller areas and for various national fisheries, and this paper integrates those results.

Various methods have been applied previously to estimate total seabird bycatch from fishing activity (Murray et al., 1993; Klaer and Polacheck, 1997; Baird, 2001; Lewison and Crowder, 2003; Benjamins et al., 2008; Jiménez et al., 2010). These studies used data collected by observers on individual fishing operations, and then scaled the observed catch to the total catch. They provided estimates of seabird bycatch or bycatch rate for individual area/time/fishery strata.

To estimate the total bycatch for broad area/time strata such as the ICCAT Convention Area, a second step is required to extrapolate bycatch estimates to all substrata of interest, and then to aggregate all of the results. This study was concerned with this second stage of extrapolation and aggregation of results, rather than the estimation of bycatch from raw observations. Other studies

[1]Report on a meeting to negotiate an agreement on the conservation of albtrosses and petrels, Cape Town, South Africa, 29 January–2 February 2001. Interim Secretariat for the Agreement on the Conservation of Albatrosses and Petrels, Canberra, Aust.

have also aggregated bycatch estimates from many individual studies, such as the review by Anderson et al. (2011) that estimated global seabird bycatch in longline fisheries.

Other studies (Thomson et al., 2008) are concerned with modeling bird populations and their interactions in space and time with fishing gear to estimate seabird bycatch. The approach here is not to model the underlying processes, but to make assumptions that completely fill gaps in observations to derive total seabird bycatch estimates. These relatively independent methods both provide estimates of total seabird bycatch, and may provide a means for cross-verification.

Methods

This study applies to all seabird species and provides separate bycatch estimates for five priority species where possible. Individual species chosen for study followed the priority list of species developed during planning of the ICCAT seabird assessment (Phillips et al., 2007; Phillips and Small, 2007). Those species were: Cory's shearwater, *Calonectris diomedea*; Tristan albatross, *Diomedea dabbenena*; wandering albatross, *D. exulans*; Atlantic yellow-nosed albatross, *Thalassarche chlororhynchos*; and black-browed albatross, *T. melanophrys*. Observer data used in bycatch studies have not always split these species individually, so two additional groupings were created and identified as albatross species (*Diomedea* and *Thalassarche*) and *Diomedea* spp. (Tristan, wandering, or royal albatross) (Table 1).

Table 1.—Seabird species or groups examined in this study and the codes used.

Common name	Species or group	Code
Albatross spp.	*Diomedea* or *Thalassarche* spp.	ALBSPP
Cory's shearwater	*Calonectris diomedea*	CALDIO
Tristan albatross	*Diomedea dabbenena*	DIODAB
Wandering albatross	*Diomedea exulans*	DIOEXU
Wandering, Tristan, or royal albatross	*Diomedea* spp.	DIOSPP
Atlantic yellow-nosed albatross	*Thalassarche chlororhynchos*	THACHL
Black-browed albatross	*Thalassarche melanophrys*	THAMEL

Data on seabird bycatch were extracted from recent published studies that made estimates based on at-sea observations of pelagic fishing operations. Studies were selected if they were recent pelagic longline seabird bycatch studies that included estimates of bycatch per species. If two or more studies related to the same fishery/area, then the most recent one was selected.

The overall seabird bycatch rate and the percentage contribution of each species or species group were extracted from each available bycatch study (Table 2). The region that the study applied to was related to 5 degree squares as used by ICCAT to compile total fishing effort data. Each study was given a unique reference number, and those numbers were mapped over the distribution of total ICCAT pelagic fishing effort during the years from 2003 to 2006 (Fig. 1: ID numbers shown in larger font). Five degree areas that did not have a corresponding bycatch estimate were allocated estimates based on nearby squares (Fig. 1: ID numbers shown in smaller font). Similarity of distance from land, and also latitude were given the greatest weight when considering the most appropriate estimate to use. This allowed the application of existing bycatch estimates to all five degree areas that contained ICCAT pelagic longline fishing effort.

Within each 5 degree square/year/quarter, the total seabird bycatch was estimated by multiplying total hooks set by the per hook estimate. One existing study (Bugoni et al., 2008) provided bycatch estimates for summer and winter separately, so these rates were applied differentially to quarters 1/4 and 2/3. Bycatch rates from the Uruguay region (Domingo et al., 2009) were split into shelf and high seas areas in summer and winter from a re-aggregation of the raw data (Jiménez[2]). All other studies provided annual estimates only, so there were no quarterly differences. Total seabird bycatch in a 5 degree square/year/quarter was assigned per species according to the corresponding per species percentage contribution in Table 2. Total seabird and per species annual estimates were then made by adding the per 5 degree square/quarter values within each year.

[2] Jiménez, S. Proyecto Albatros y Petreles – Uruguay, Avenuenida Giannattasio Km. 30.500, El Pinar, Canelones, Uruguay. Personal commun., 2009.

Sensitivity of the results to those from individual studies was investigated by doubling the estimates from each study one at a time, and examining the effect on the overall results.

Results

The annual estimates of total seabird bycatch from ICCAT pelagic longline fisheries were 16,568 in 2003, 10,021 in 2004, 9,879 in 2005, and 12,081 in 2006 (Table 3). These annual variations broadly reflected similar variation in total fishing effort. The higher bird bycatch in 2003 was also explained by a greater concentration of fishing effort in that year in areas below about lat. 25°S (Fig. 2). Over the 4 years from 2003 to 2006, the total seabird bycatch estimate was 41,900.

Results indicate that about 57% of the ICCAT pelagic longline seabird bycatch was albatrosses. Based on the available data, estimates of per-species proportions of the total seabird bycatch over the 3 years were 42% other species, 32% black-browed albatross, 17% Atlantic yellow-nosed albatross, 6% albatross species, 1% wandering albatross, 1% Cory's shearwater, and less than 1% Tristan albatross. Remember that these species groupings overlap to some extent, so Tristan albatross, for example, probably forms part of the albatross species group. It is not possible to determine the extent of this overlap without further data.

Sensitivity of the results to a doubling of bycatch rates within the relevant area of each individual study was examined (Table 4). This indicated that a doubling of bycatch rates within the South African and Namibian longline fishery compared with those recorded by Petersen et al. (2007) would have the greatest influence on the total number of seabirds caught. By comparison, the greatest influence on

Table 2.—Studies of pelagic longline in the ICCAT region that contain seabird bycatch estimates per species, total seabird bycatch rate per thousand hooks, and percentage contribution per species.[1]

ID	Source	Start yr	End yr	Quarter	Area	Country	Method
1	Bugoni et al., 2008	2001	2007	2,3		Brazil	Pelagic longline
2				1,4			
3	Fisheries and Oceans Canada, 2007	2001	2001	0		Canada Gulf of St Lawrence	Pelagic longline
4		1986	2001	0		Scotian Shelf, Bay of Fundy	Canadian pelagic longline, assume 2000 hooks per set
5		1989	2001	0		Newfoundland	Faroes pelagic longline, assume 2000 hooks per set
6	Petersen et al., 2007	2000	2005	0		South Africa, Namibia	Pelagic longline
7	Valeiras and Caminas, 2003	1999	2000	0		Spain	Pelagic longline
8	Chang et al., 2007	2002	2005	0		Chinese Taipei	Pelagic longline
9							
10	Domingo et al., 2009	2004	2006	2,3	Shelf	Uruguay	Pelagic longline
11				2,3	H Seas		
12				1,4	Shelf		
13				1,4	H Seas		
14	Hata[2]	2000	2004	0		USA	Pelagic longline

[1]Blank values in the table take existing values from preceding rows (e.g. ID 1 and 2 have the same source). Quarter 0 means that seasonal estimates were unavailable.
[2]text footnote 4.

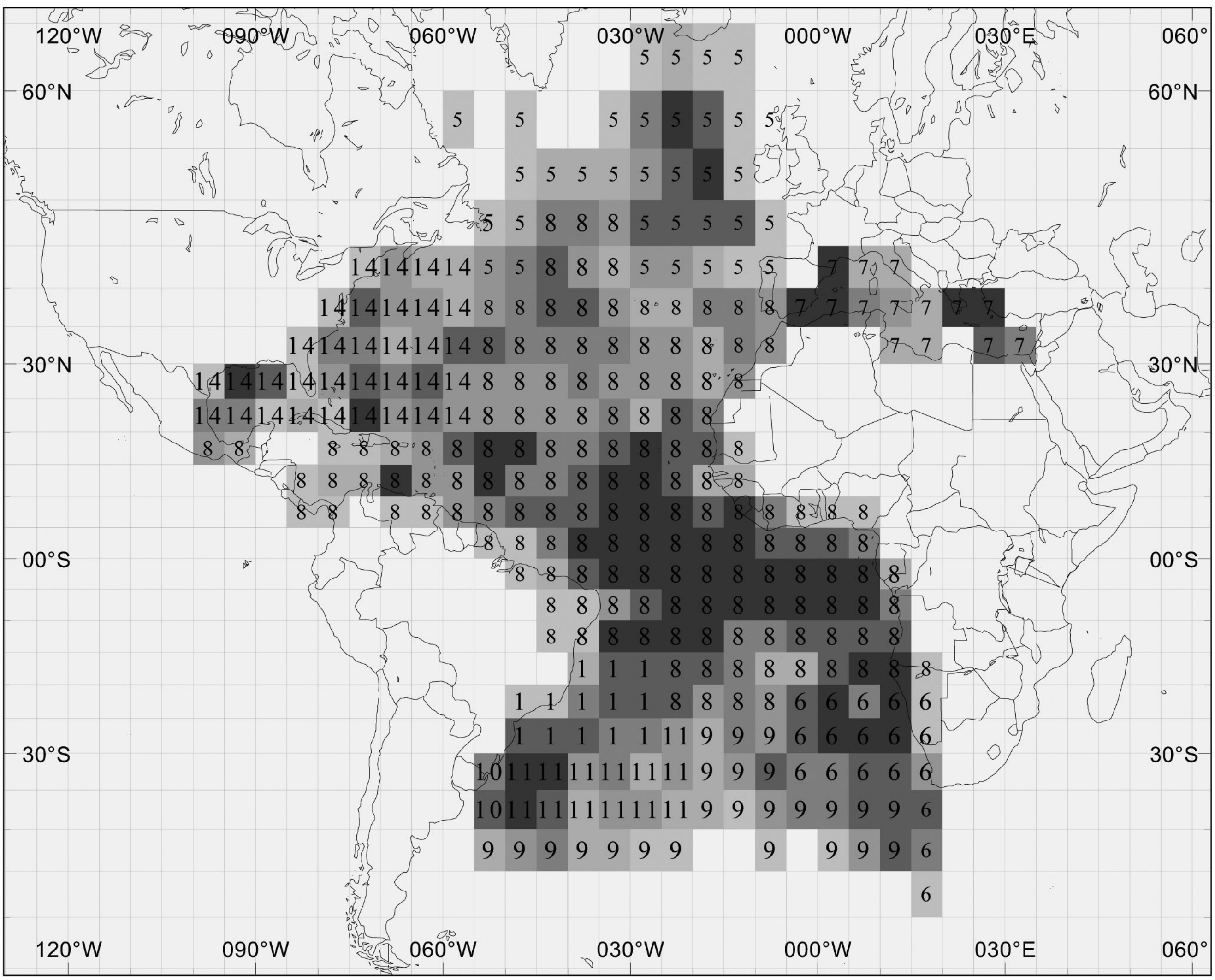

Figure 1.—Total ICCAT fisheries pelagic longline fishing effort 2003–06 overlayed with existing seabird bycatch estimate ID numbers from Table 2. ID numbers for areas where data was extrapolated from adjacent areas are shown in a smaller font. Fishing effort is shown as shades of grey in 5 x 5° squares, with darker grey indicating higher effort.

ICCAT Region	Rate	CV	CALDIO	DIODAB	DIOEXU	DIOSPP	ALBSPP	THACHL	THAMEL	OTHER
55-25W 15–40S	0.2690	0.5	0.00	0.00	0.44	0.00	10.09	4.82	55.26	29.39
	0.1060	0.5	0.00	0.00	0.44	0.00	10.09	4.82	55.26	29.39
55–70W 45–55N	0.0072	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
55–75W 40–45N	0.0229	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
50–55W 45–50N	0.0004	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
5W–20E 35S–20S	0.2000	0.5	0.00	0.00	0.00	0.00	9.14	10.15	19.80	60.91
5W–5E 35N–40N	0.0133	0.5	42.86	0.00	0.00	0.00	0.00	0.00	0.00	57.14
Atlantic N of 25S	0.0006	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Atlantic S of 25S	0.0308	0.5	0.00	0.00	10.50	0.00	14.50	20.00	19.50	35.50
55–50W 40S–30S	0.5460	0.5	0.00	0.00	1.08	0.00	0.00	2.15	78.49	18.28
55–20W 40S–25S	0.3276	0.5	0.00	0.99	0.66	0.00	0.00	44.70	41.72	11.92
55–50W 40S–30S	0.4169	0.5	0.00	0.00	11.11	0.00	0.00	2.78	72.22	13.89
55–20W 40S–25S	0.0120	0.5	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
55–100W 20N–45N	0.0223	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

the number of albatrosses caught would result from a doubling of rates observed by Domingo et al. (2009) within the Uruguayan pelagic longline fishery in high seas areas. Only one of the studies included provided an estimate of bycatch rates of Cory's shearwater, although Browder[3] includes a catch of the species by the U.S. pelagic longline fishery in 2005.

Table 3.—Estimated total seabird catch by pelagic longline from the ICCAT Convention Area using rates from Table 3 and distribution from Figure 1.

Year	Thousand hooks	Birds	CALDIO	DIODAB	DIOEXU	ALBSPP	THACHL	THAMEL	Other
2003	430,582	16,568	162	49	283	844	3,126	5,992	6,110
2004	435,447	10,021	135	22	67	618	1,629	2,822	4,730
2005	352,330	9,879	162	24	94	555	1,670	3,162	4,210
2006	372,634	12,081	203	25	152	743	1,935	3,723	5,301
Total	1,590,993	48,549	662	120	596	2,760	8,360	15,699	20,351

Table 4.—Percentage change in total estimated seabird bycatch caused by doubling bycatch rates from individual sources.[1]

Reference	Source	Birds	Cory's shearwater	Albatrosses
1	Bugoni et al., 2008	15.19	0.00	18.91
2				
3	Fisheries and Oceans, 2007	0.00	0.00	0.00
4		0.00	0.00	0.00
5		0.08	0.00	0.00
6	Petersen et al., 2007	40.00	0.00	27.57
7	Valeiras and Caminas, 2003	3.18	100.00	0.00
8	Chang et al., 2007	1.35	0.00	0.00
9		3.43	0.00	3.90
10	Domingo et al., 2009 Shelf	6.70	0.00	10.09
11	High seas	25.40	0.00	39.52
12				
13				
14	Hata[2]	4.66	0.00	0.00

[1]Blank values in the table take existing values from preceeding rows (e.g., ID 1 and 2 have the same source).
[2]Text footnote 4.

Discussion

The current approach updates preliminary estimates given in Klaer et al. (2008). In general, the estimates here are higher than those made previously, mostly due to updated estimates of pelagic longline effort by area. Several of the studies that provided bycatch rate estimates by area/time/fishery have been updated, an additional study by Hata[4] was included, and estimates by Domingo et al. (2009) were split by season and area.

The major assumptions in the calculations were that bycatch rates per species were similar across 5 degree squares within major regions, across years from 2003 to 2006, across fisheries within major regions, and across seasons or months within years (except Bugoni et al., 2008, which provided summer and winter estimates). These assumptions were not met to various degrees, but it is not possible to quantify this source of uncertainty without more detailed information.

This study can be used to help define regions for which existing studies need to be found, or new ones proposed (Phillips et al., 2007). The method used here to estimate total seabird bycatch per species for ICCAT pelagic longline would work very well if each 5 degree square in each quarter in recent years had a well estimated bycatch rate and species composition. However, the current available information was far from that ideal. There were large areas where significant amounts of fishing effort was placed where there were no bycatch estimates at all (ID numbers in smaller font; Fig. 1)—in particular, the Caribbean Sea, Northwest Africa, Eastern Mediterranean, and Mid North Atlantic.

The method used to allocate regions to individual studies may require refinement. For example, the Domingo

[3] Browder, J. A. 2009. The U.S. national plan of action for reducing the incidental catch of seabirds in longline fisheries (NPOA): its implementation in the U.S. Atlantic tuna, swordfish, and shark longline fisheries. Appendix 2.8.8 to U.S. National Report to ICCAT, 2008. U.S. Dep Commer., NOAA, NMFS, Oct. 2009.

[4] Hata, D. N. 2006. Incidental captures of seabirds in the U.S. Atlantic pelagic longline fishery, 1986–2005. Report prepared as part of the Project Seabirds in the Western North Atlantic and Interactions with Fisheries. NOAA, NMFS, Miami, Florida PRD-05/06-13.

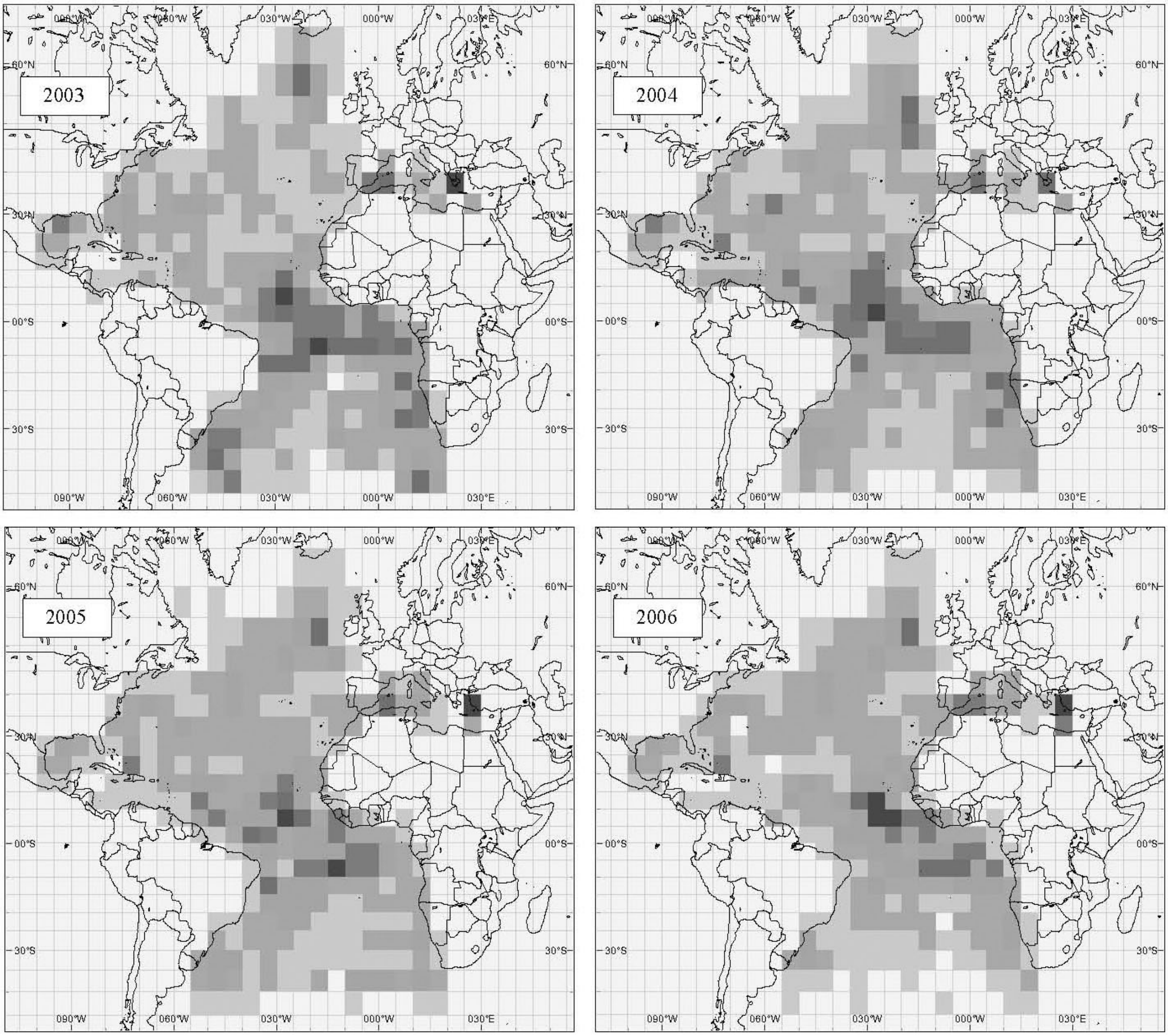

Figure 2.—Total ICCAT fisheries pelagic longline fishing effort annually 2003–06. Fishing effort is shown as shades of grey in 5×5° squares, with darker grey indicating higher effort.

et al. (2009) study has been assigned to regions as far east as long. 20°W (ID = 10, Fig. 1), but the majority of the data in that study applies to about long. 45°W.

Results from single studies have been used to generate bycatch rates over very large areas. In particular, Chang et al. (2007) was used for much of the Atlantic high seas, both north and south of the equator. Only an overall estimate of the species composition was available from this study, even though total seabird bycatch rates were separated north and south of lat. 25°S. It was assumed that catches north of lat. 25°S did not take albatrosses. It would be very useful if actual species composition was available from this study at finer spatial resolution than that published.

Available information on pelagic longline seabird bycatch rates per species in recent years, although used in this study, was severely limiting in many ways. For example, it was assumed that demersal longline seabird bycatch per species in a 5 degree square/quarter was the same regardless of the origin of the fishing fleet. We know that fishing practices, such as the implementation of seabird bycatch mitigation measures, probably vary across fleets. Most studies were applied equally across a large number of 5 degree squares, and the time period and level of observer coverage varies considerably across studies. In particular, national fleets with considerable effort levels in ICCAT regions and no bycatch estimates included here were Japan and China.

In some cases, studies overlapped in their spatial extent. A decision was then made as to which study would apply to each 5 degree square block. Studies with ID 1 and 10 in Figure 1 overlapped, and they were assigned to each side of the lat. 30°S line because this latitude line roughly separates Brazil and Uruguay on the map. Studies with ID 8 and 9 were assigned last where no previous study applied.

The years in which the ICCAT pelagic longline studies applied ranged from 1998 to 2007, and some did not overlap in study time range at all. It is recognized that seabird bycatch rates change from year to year because of changes in fishing practices and distribution of fishing effort, and it would therefore be preferable to use studies that apply to the same time periods.

Variations in the estimated annual seabird bycatch from 2003 to 2006 were simply due to variation in fishing effort and changes in effort distribution. Actual bycatch rates used for each year were the same.

Error values have not been estimated. Coefficient of variation (CV) values of 0.5 are given in Table 2 simply to indicate that the values would necessarily be large. Even if the individual study provided a CV value, if that study was applied to a wider region, then it would not be appropriate to apply that CV to the additional area. At this stage it is simply recognized that the estimate errors would be large. If individual studies are independent, then a combined CV can be calculated by adding the individual study variances (variance = $(CV * mean)^2$).

However, the individual studies are not independent as they often measure the same species populations, and are subject to the same variations in oceanographic conditions or changes in fishing effort distributions. When studies are not independent, the covariance amongst studies should be considered. Calculation of the covariance, per species in particular, is likely to be impossible given the available data.

Results for individual species were combined into several categories in the results, so it was not possible to calculate the absolute catch rate for an individual species or population. For example, it was estimated that 597 wandering albatross were caught from 2003 to 2006. It is unknown what proportion of the combined albatross species category may include wandering albatross. However, if the albatross species category was assumed to contain the same ratio of albatross species that were individually identified, then the total number of wandering albatross caught from 2003 to 2006 was estimated to be 663 (597 + 2.4% x 2,760). Given that the number of breeding pairs in the South Georgia population in that period was estimated to be in the order of 1,500 pairs (Thomson et al., 2009), this level of mortality from pelagic longlines is of concern.

Fisheries other than ICCAT pelagic longline that also operate in the Atlantic are likely to have significant seabird bycatch. Preliminary analyses suggest that demersal longline has a much greater seabird bycatch in the region than pelagic longline (Klaer et al., 2008). The majority of the bycatch, in terms of numbers of birds, was from Namibia, Spain (Gran Sol), Norway, Iceland, and Faroes demersal fisheries. However, when evaluating the impact of these fisheries on seabird populations individual species impacts should be considered. Gran Sol fishery data show bycatch predominantly of great shearwaters and fulmars, which are not threatened. Results here indicate the potential for pelagic longline fishing in the Atlantic to pose a threat to albatrosses in particular.

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