U.S. COMMERCIAL FISHERIES FOR MARLINS IN THE NORTH PACIFIC OCEAN[1]

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INTRODUCTION

This report summarizes historical trends and recent developments for U.S. commercial fisheries taking marlins and related billfish species (Istiophoridae) in the North Pacific Ocean. Five species of marlins are caught by U.S. commercial fisheries in the North Pacific Ocean. These are striped marlin (*Kajikia audax*), blue marlin (*Makaira nigricans*), shortbill spearfish (*Tetrapturus angustirostris*), sailfish (*Istiophorus platypterus*), and black marlin (*Istiompax indica*). The first two species are predominant in the commercial landings. The description of fisheries in this report will serve as background information for stock assessment and standardization models developed in the ISC Billfish Working Group.

1. FISHERIES AND CATCHES

U.S. fisheries for marlins in the North Pacific Ocean can be categorized according to three distinct gear types: longline, troll, and handline. The longline fishery, which for the purposes of this report refers to the Hawaii-based longline fishery, is the largest (Table 1). This fishery takes marlins as incidental catch on sets targeting tuna or swordfish. Troll fisheries in Hawaii, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI) take the second largest catches of marlins. These fisheries opportunistically target marlins on a seasonal basis. The Hawaii handline fishery represents the third category, with small incidental catches of marlin. Blue marlin landings from both longline and troll fisheries (Fig. 1) were typically the largest component of the marlin landings (Table 2), followed by striped marlin, landed primarily by the longline fishery (Fig. 2), and shortbill spearfish ranking third. Marlins are also caught by recreational fisheries but there is no mandatory data collection program for this fishery sector, therefore, only the U.S. commercial fisheries are discussed in this report.

Hawaii-based Longline Fishery

The longline gear consists of a single monofilament mainline about 30 to 80 km in length with floats attached to the mainline to support the gear in the water column. Branchlines with baited hooks are attached to the mainline between the floats. Gear configurations and operational techniques differ according to target species (i.e.,

tunas,*Thunnus* spp., and swordfish, *Xiphias gladius*) (Ito and Machado 2001). Deep-set longline fishing targets tunas. Gear is usually set in the morning and then hauled back in the afternoon; Pacific sauries *Cololabis saira* or sardines (Clupeidae) are used for bait; 15 or more hooks are set between floats; and a line thrower is used (Kawamoto et al. 1989). The latter creates slack in the mainline, which causes the gear to sag between floats as it sinks and results in a "deep-set". In contrast, shallow-set longline fishing used to target swordfish typically sets gear after dusk and hauls it back the following morning, uses mackerel *Scomber japonicus* or mackerel-like bait, attaches chemical lightsticks to the branchlines, and typically sets 4-5 hooks between floats (Ito et al 1994, PIRO 2014). Since the gear and technique for swordfish is fishing relatively shallow, a line thrower is not needed and is referred to as "shallow-set" longline fishing. Striped and blue marlin were the largest components of the longline marlin landings followed by shortbill spearfish (Table 3). The deep-set longline sector accounts for majority of the effort and marlin landings for this fishery.

The Hawaii-based longline fishery has operated under a limited-access program since 1994. This program capped participation at 164 vessels, although the number of active vessels has never reached this limit. Participation in this fishery included 141 active vessels in 2014 (deep- and shallow-set sectors combined).

Two other important characteristics of this fishery are its geographic range and the annual number of hooks set. The Hawaii-based longline fishery ranged from the equator to 40^{o} N latitude and from 130^{o} W to 175^{o}W longitude in 2014. The total range exploited since 1991 extended from 5^{o}S to 50^{o}N latitude and from 125^{o}W to 175^{o}E longitude. Effort by the Hawaii-based longline fishery was a record 52.9 million hooks set in 2014. The record effort was due to more hooks set by the deep-set sector of the longline fishery which accounted for 97% of the total number of hooks set and an expansion of longline fishing outside of the U.S. EEZ in 2014.

Longline landings of striped marlin rose rapidly from 272 t in 1987, peaked at 664 t in 1995 and decreased slowly to a low of 165 t in 2010. There was considerable variability in striped marlin landings with landings increasing to 426 t in 2014, up 7% from the previous year. Blue marlin landings increased from 1987, increased significantly in the two subsequent years, remained relatively stable through 1999, then declined through 2002. Blue marlin landings have been on an increasing trend peaking at 535 t in 2014, an increase of 32% from 2013.

The ISC Billfish Working Group concluded there were two stocks of striped marlin in the North Pacific Ocean (ISC 2010) and the boundary between the Western-central Pacific Ocean (WCPO) and Eastern Pacific Ocean (EPO) stocks was delineated at 140^{o} W (ISC 2011). Hawaii-based longline landings of striped marlin by stock boundary show 98% of the landings originating from the area at or west of 140^{o} W during 2010-2014 (Table 4). Although striped marlin landings caught east of 140^{o}W and undisclosed areas were highest

in 2014, these represented only 6% of the landings by the longline fishery. The deep-set sector of the longline fishery was responsible for 97% of the striped marlin landings. There was substantial variation in landings ranging from 165 t in 2010 to 426 t in 2014.

Plots of the geographic distributions of striped marlin catches (in number of fish) show that the highest catches occurred northeast and southwest of the main Hawaiian Islands while the highest blue marlin catches occurred southwest of the main Hawaiian Islands (Figs. 3 & 4).

Catches of marlins exhibited strong seasonal cycles. Striped marlin catches were typically highest in the first and fourth quarters of the year, whereas blue marlin catches were usually highest in the second and third quarters of the year.

Nominal catch per unit effort (CPUE: number of fish per 1000 hooks) for the two marlin species exhibited declines from the early 1990s into the early 2000s. Striped marlin CPUE on deep-set longline fishing peaked at 2.2 fish per 1000 hooks in 1992, exhibited a significant decline through 2000, and remained low thereafter. CPUE continued to decrease further to a record low of 0.10 in 2010 and was slightly higher at 0.29 in 2014 (Fig. 5). Blue marlin deep-set longline CPUE exhibited a peak of 0.68 in 1991, decreased sharply in 1992, declined slowly to a record low 0.07 in 2012, and remained low through 2014.

The weight-frequency histogram for striped marlin caught by the Hawaii-based deep-set longline fishery, derived from records of commercial fish landings (see data sources below), was bi-modal, with peaks in the 11-15 kg and 36-40 kg weight intervals in 2014 (Fig. 6A). The mean weight for striped marlin was 26.4 kg. The blue marlin weight-frequency distribution was unimodal with a peak at the 61-65 kg weight interval in 2014 (Fig. 6B). The mean weight for blue marlin was 87.0 kg.

Hawaii, Guam, and CNMI Troll Fisheries

The troll fisheries in Hawaii, Guam, and CNMI are hook and line fisheries that use fishing gear consisting of fiberglass rods, reels and artificial lures typically made of resin or chrome metal heads dressed with colored rubber skirts (Rizzuto 1977). Live bait bridled to hooks are also used to catch marlins and other pelagic fishes. This fishery targets tunas, marlins and other pelagic species such as mahimahi (*Coryphaena spp.)* and wahoo *(Acanthocybium solandri*). Fishing is conducted from relatively small boats.

The number of troll fishers peaked at 2,367 in 1999, declined to a minimum of 1,837 fishermen in 2005, and has since increased gradually to 2,060 in 2014. Eighty percent of the troll fishers were from Hawaii, 19 % from Guam and 1% from CNMI in 2014. The duration of a typical troll trip is one day. Since this fishery employs small vessels, most trips remain within 50 miles from shore, well inside the 200 mile U.S. EEZ.

Blue marlin landings comprised 88% of the troll marlin landings. Blue marlin landings peaked at 434 t in 1996, declined to a record low 128 t in 2007, and were 160 t in 2014 (Table 5). Striped marlin made up only 7% of the marlin landings at 12 t in 2014. Blue marlin and striped marlin landings were higher in the earlier years of the time series.

Marlin CPUE for the Hawaii troll fishery was expressed as kgs of fish per day. Blue marlin CPUE was higher than striped marlin CPUE, but both species exhibited similar declining trends as in the Hawaii-based longline fishery (Fig. 7)

Hawaii Handline Fishery

The Hawaii handline fishery, which targets tunas, includes day and night components known as the “palu ahi” and “ika shibi” fisheries, respectively. The daytime handline fishery employs “palu” (chum in Hawaiian) to evoke a feeding frenzy in an aggregation of juvenile “ahi” (tuna in Hawaiian) and hook the catch with a handline. The nighttime handline fishery has two sets of gear, one used to catch the “ika” (squid in Japanese) for bait and the other for catching large “shibi” (tuna in Japanese) (Yuen 1979).

There were 494 handline fishers in 2014. The duration of a handline trip is typically one day for the daytime handline fishery and one night for the nighttime handline fishery. As with the troll fisheries, most handline trips remain within 50 miles from shore, although some handline fishers operate offshore by seamounts and weather buoys on multiple day trips.

Marlins are rarely caught by the handline fishery and represent only a small proportion of its overall catch. This fishery landed relatively small amounts of striped and blue marlins when compared to the longline and troll fisheries. There have been no striped marlin landings by the handline fishery in the past 10 years. The highest striped marlin landings were 2 t in 2001 (Table 6). Handline landings of blue marlin were somewhat higher in the earlier years. The highest blue marlin landings were 9 t in 1997.

The weight-frequency histogram for striped marlin caught on troll and handline gear was bi-modal distribution with its dominant peak at the 11-15 kg interval and a smaller peak at the 31-35 kg interval (Figure 8A). The mean weight for striped marlin was 23.3 kg in 2014. The blue marlin weight-frequency distribution was unimodal with a mean weight of 114.9 kg in 2013 (Figure 8B). The weight-frequency distribution of striped marlin by the troll and handline fisheries were somewhat similar to the longline histogram while the weight-frequency distribution for blue marlin by the troll and handline fisheries were nearly identical to the histogram for the longline fishery.

2. DATA SOURCES

Category I: Annual Catch Data

Category I catch statistics refer only to the quantity of fish kept and landed. Catch that was discarded or released was not included. Several sources of fisheries dependent data for the longline, troll, and handline fisheries are collected by Federal (NOAA Fisheries Service), State (Hawaii), and Pacific Island (Guam and CNMI) agencies and used in combination by staff of the NOAA Pacific Islands Fisheries Science Center (PIFSC). The duration and coverage (i.e., percent of catch reported) varied amongst the different data sources (Table 7).

Estimated landings are reported in this paper as whole weights. Some fish were landed whole while others were processed out at sea, e.g., headed and gutted or gilled and gutted. The recorded weight of individual processed fish was adjusted by applying a conversion factor depending on the degree of processing (Table 8). This step increased the nominal weight of processed catch to an estimate whole weight to account for the weight loss. Likewise, to account for missing market sample days, the sample data were extrapolated to represent full coverage to estimate total landings.

Data sets were combined to estimate annual catch statistics for certain fisheries. For example, the Hawaii-based longline fishery landings were estimated from Federal logbook data, market sample data, and State of Hawaii, Division of Aquatic Resources (Hawaii DAR) Commercial Marine Dealer data. The numbers of fish kept, as recorded in longline logbooks, are multiplied by the mean weights of landed fish, estimated from the PIFSC market sample data or the Hawaii DAR Commercial Marine Dealer data.

Marlin Species Identification Issues

Since blue marlin, striped marlin, and black marlin are similar in appearance, a longstanding problem in monitoring the Hawaii-based longline fishery at the NOAA PIFSC has been the accuracy of species identifications for the istiophorid billfishes. This problem has primarily affected logbook data, but some fishery observers, particularly newly-hired individuals, have also erred in species identifications. A long-term project to correct these problems was completed for the years 1995 through 2003. Its principal output consisted of one paper emphasizing blue marlin that was published in a peer-reviewed scientific journal that dealt with the five istiophorid species (Walsh et al. 2005). A subsequent document showed the overall marlin counts in the Hawaii-based longline logbook data were reasonably accurate but blue marlin was overlogged by 18% while striped marlin was underlogged 11% during the study period (Walsh, W.A. et al. 2007)(Figure 9). The document can be obtained from the PIFSC's website at:

http://www.pifsc.noaa.gov/library/pubs/tech/NOAA_Tech_Memo_PIFSC_13.pdf

The marlin species identification corrections from the project are included in the longline marlin catch tables for the years of these studies. Nominal marlin catches were reported for the years prior to 1995 and after 2003. This Working Paper has been written to

conform to the guidelines adopted by the ISC concerning use of best available scientific information (Brodziak and Dreyfus 2011). The specific guidelines pertaining to this Working Paper are related to the need for accurate species identifications.

Category II: Spatial Catch and Effort Data

Year, area fished, catches and effort are the most important information included in Category II data reporting. The Hawaii-based longline fishery provided Category II data calculated from Federal logbook and Hawaii DAR Commercial Marine Dealer data. The combination of data sets was sufficient to generate area-specific summaries of catch and effort.

Category III: Biological (size composition) Data

Biological measurements were obtained for the Hawaii longline, troll, and handline fisheries. Raising factors were applied to the market sample and Hawaii DAR Commercial Marine Dealer data if the fish was processed to yield an estimated whole weight (Table 7). Weight-frequency distributions for striped marlin and blue marlin were produced from HDAR Commercial Marine Dealer data.

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Table 1.—Annual U.S. commercial fisheries marlin landings* (metric tons) from the North Pacific Ocean by gear type, 1987-2014.

Year	Longline	Troll	Handline	Total
1987	368	324	9	701
1988	675	362	7	1,044
1989	1,100	404	6	1,510
1990	973	373	6	1,352
1991	1,029	444	6	1,479
1992	947	351	5	1,303
1993	910	422	6	1,338
1994	787	385	4	1,176
1995	1,179	424	5	1,608
1996	884	504	8	1,396
1997	944	467	10	1,421
1998	831	305	3	1,139
1999	822	387	6	1,215
2000	464	269	3	736
2001	666	368	4	1,038
2002	367	269	3	639
2003	812	255	4	1,071
2004	867	243	4	1,114
2005	1,064	220	3	1,287
2006	1,188	193	3	1,384
2007	697	153	1	851
2008	1,014	208	1	1,223
2009	742	197	1	940
2010	602	179	2	783
2011	984	233	2	1,219
2012	754	164	2	920
2013	1,031	156	3	1,190
2014	1,200	180	4	1,384

* Based on estimated whole weight and does not include discards.

Table 2.--Annual U.S. commercial fisheries marlin landings* (metric tons) from the North Pacific Ocean by species, 1987-2014.

Year	Striped marlin	Blue marlin	Shortbill spearfish	Other marlins	Total
1987	303	334	43	21	701
1988	559	398	65	22	1,044
1989	636	721	128	25	1,510
1990	565	715	50	22	1,352
1991	703	684	60	32	1,479
1992	498	648	46	111	1,303
1993	540	678	54	66	1,338
1994	360	696	59	61	1,176
1995	716	758	65	69	1,608
1996	513	804	38	41	1,396
1997	463	851	47	60	1,421
1998	479	541	63	56	1,139
1999	443	616	96	60	1,215
2000	224	418	43	51	736
2001	427	521	40	50	1,038
2002	197	368	39	35	639
2003	547	409	80	35	1,071
2004	419	471	186	38	1,114
2005	531	525	207	24	1,287
2006	626	570	161	27	1,384
2007	290	390	147	24	851
2008	441	529	226	27	1,223
2009	268	540	113	19	940
2010	184	456	118	25	783
2011	378	574	234	33	1,219
2012	293	441	163	23	920
2013	406	545	213	26	1,190
2014	438	699	218	29	1,384

* Based on estimated whole weight and does not include discards.

Table 3.—Hawaii-based longline commercial marlin landings* (metric tons) from the North Pacific Ocean, 1987-2014.

Year	Striped marlin	Blue marlin	Shortbill spearfish	Other marlins	Total
1987	272	51	43	2	368
1988	504	102	65	4	675
1989	612	356	128	4	1,100
1990	538	378	50	7	973
1991	663	297	60	9	1,029
1992	459	347	46	95	947
1993	471	339	54	46	910
1994	326	362	59	40	787
1995	664	407	65	43	1,179
1996	458	363	38	25	884
1997	424	429	47	44	944
1998	453	277	63	38	831
1999	414	284	96	28	822
2000	209	183	43	29	464
2001	383	227	40	16	666
2002	167	137	39	24	367
2003	517	198	80	17	812
2004	384	283	186	14	867
2005	511	337	207	9	1,064
2006	605	409	161	13	1,188
2007	277	261	147	12	697
2008	427	348	226	13	1,014
2009	258	360	113	11	742
2010	165	306	118	13	602
2011	362	373	234	15	984
2012	282	298	163	11	754
2013	398	406	213	14	1,031
2014	426	535	218	21	1,200

* Based on estimated whole weight and does not include discards.

Table 4.—Hawaii-based deep- and shallow-set longline commercial striped marlin landings (metric tons) by stock boundary in the North Pacific Ocean, 2010-2014.

	Deep-set				Shallow-set				Fleet			
Year	≤140° W	>140° W	No longitude	Total	<140° W	>140° W	No longitude	Total	<140° W	>140° W	No longitude	Total
2010	152	0	1	153	12	0	0	12	164	0	1	165
2011	341	1	2	343	19	0	0	19	360	1	2	362
2012	269	0	1	270	11	0	0	11	281	0	1	282
2013	361	7	14	382	13	0	3	16	374	7	17	398
2014	387	10	15	412	10	0	4	14	396	10	20	426
Mean	280.7	2.0	4.4	287.1	13.8	0.0	0.8	14.6	294.5	2.0	5.2	301.7

Table 5.—U.S. troll fishery marlin landings* (metric tons) from the North Pacific Ocean, 1987-2014.

Year	Striped marlin	Blue marlin	Shortbill spearfish	Other marlins	Total
1987	30	275	0	19	324
1988	54	290	0	18	362
1989	24	359	0	21	404
1990	27	331	0	15	373
1991	40	381	0	23	444
1992	38	297	0	16	351
1993	68	334	0	20	422
1994	34	330	0	21	385
1995	52	346	0	26	424
1996	54	434	0	16	504
1997	38	413	0	16	467
1998	26	261	0	18	305
1999	28	327	0	32	387
2000	14	233	0	22	269
2001	42	292	0	34	368
2002	30	228	0	11	269
2003	29	208	0	18	255
2004	34	186	0	23	243
2005	20	185	0	15	220
2006	21	158	0	14	193
2007	13	128	0	12	153
2008	14	180	0	14	208
2009	10	179	0	8	197
2010	19	148	0	12	179
2011	16	199	0	18	233
2012	11	141	0	12	164
2013	8	136	0	12	156
2014	12	160	0	8	180

* Based on estimated whole weight and does not include discards.

Table 6.—The U.S. handline fishery marlin landings* (metric tons) from the North Pacific Ocean, 1987-2014.

Year	Striped marlin	Blue marlin	Shortbill spearfish	Other marlins	Total catch
1987	1	8	0	0	9
1988	1	6	0	0	7
1989	0	6	0	0	6
1990	0	6	0	0	6
1991	0	6	0	0	6
1992	1	4	0	0	5
1993	1	5	0	0	6
1994	0	4	0	0	4
1995	0	5	0	0	5
1996	1	7	0	0	8
1997	1	9	0	0	10
1998	0	3	0	0	3
1999	1	5	0	0	6
2000	1	2	0	0	3
2001	2	2	0	0	4
2002	0	3	0	0	3
2003	1	3	0	0	4
2004	1	2	0	1	4
2005	0	3	0	0	3
2006	0	3	0	0	3
2007	0	1	0	0	1
2008	0	1	0	0	1
2009	0	1	0	0	1
2010	0	2	0	0	2
2011	0	2	0	0	2
2012	0	2	0	0	2
2013	0	3	0	0	3
2014	0	4	0	0	4

* Based on estimated whole weight and does not include discards.

Table 7.—Data sources and rates of coverage for the longline, troll, and handline fisheries by category.

	Hawaii-based longline	Hawaii troll	Guam troll	CNMI troll	Hawaii handline
Category I: Annual catch data					
Market sample	~33-90%	+++	---	---	+++
Fish dealer	~50-100%	+++	---	+++	+++
Logbook	~100%	---	---	---	---
Fish catch report	---	+++	---	---	+++
Creel survey	---	---	+++	---	---
Observer	NA	NA	NA	NA	NA
Category II: Spatial catch and effort data					
Market sample	NA	NA	NA	NA	NA
Fish dealer	NA	NA	NA	NA	NA
Logbook	~100%	---	---	---	---
Fish catch report	---	+++	---	---	+++
Creel survey	NA	NA	NA	NA	NA
Observer					
Category III: Biological (size composition) data					
Market sample	~33-90%	+++	---	---	+++
Fish dealer	~50-100%	+++	---	+++	+++
Logbook	NA	NA	NA	NA	NA
Fish catch report	NA	NA	NA	NA	NA
Creel survey	---	---	+++	---	---
Observer	3-25%	---	---	---	---

*NA - not applicable, +++ - available but coverage unknown, --- - not collected

Table 8.—Conversion factors for processed fish.

Species	Condition of fish	Raising factor
Blue marlin	Shark bitten	1.11
	Gutted	1.15
	Gilled & gutted	1.25
	No head	1.28
	No head & guts	1.47
	No head, guts & tail	1.54
Striped marlin	Shark bitten	1.11
	Gutted	1.15
	Gilled & gutted	1.23
	No head	1.25
	No head & guts	1.37
	No head, guts & tail	1.41

Figure 1.—Landings of blue marlin by U.S. commercial fisheries in the North Pacific Ocean, 1987-2014.

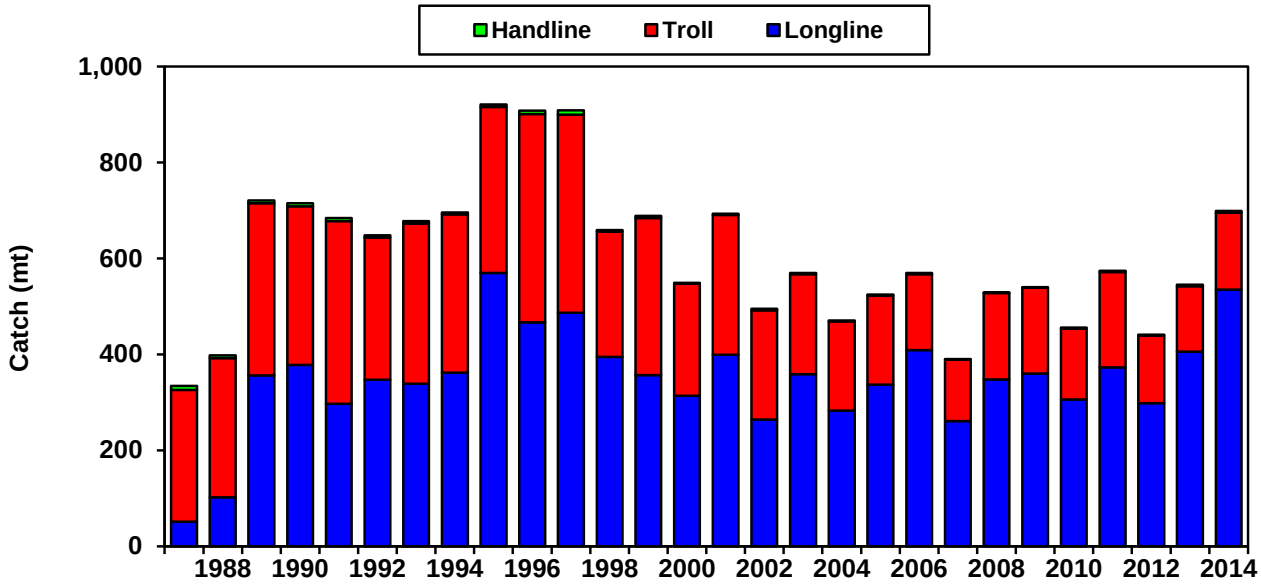

Figure 2.–Landings of striped marlin by U.S. commercial fisheries in the North Pacific Ocean, 1987-2014.

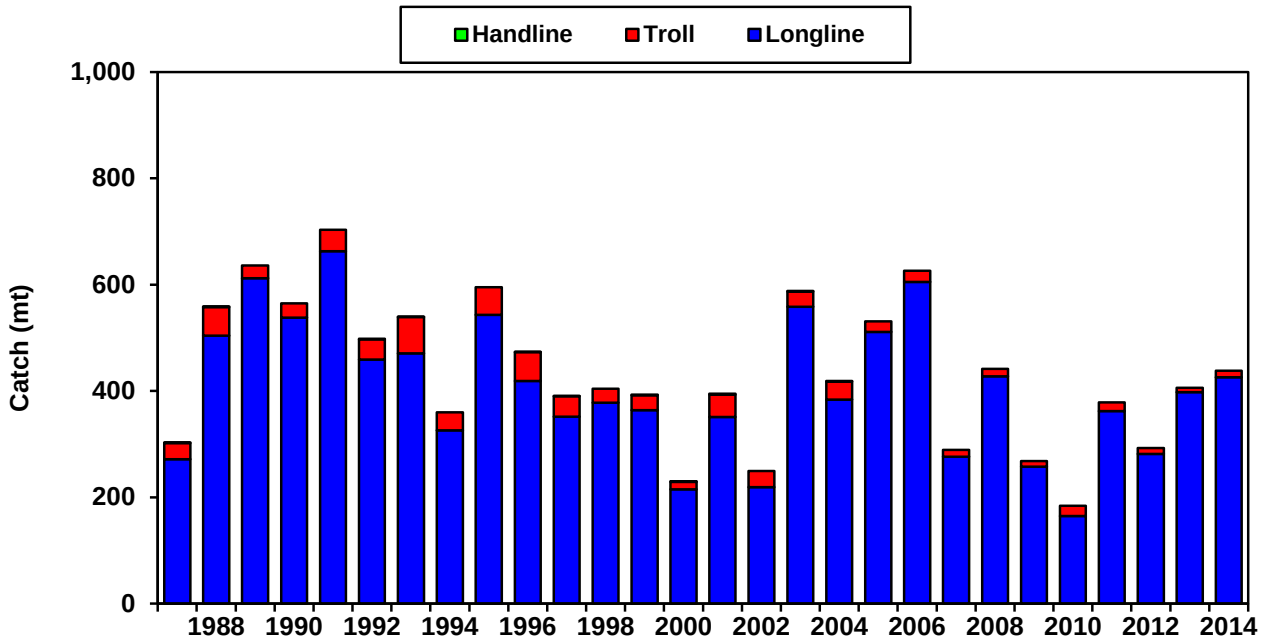

Figure 3.—Hawaii-based longline striped marlin catch (numbers of fish) by area, 2014.

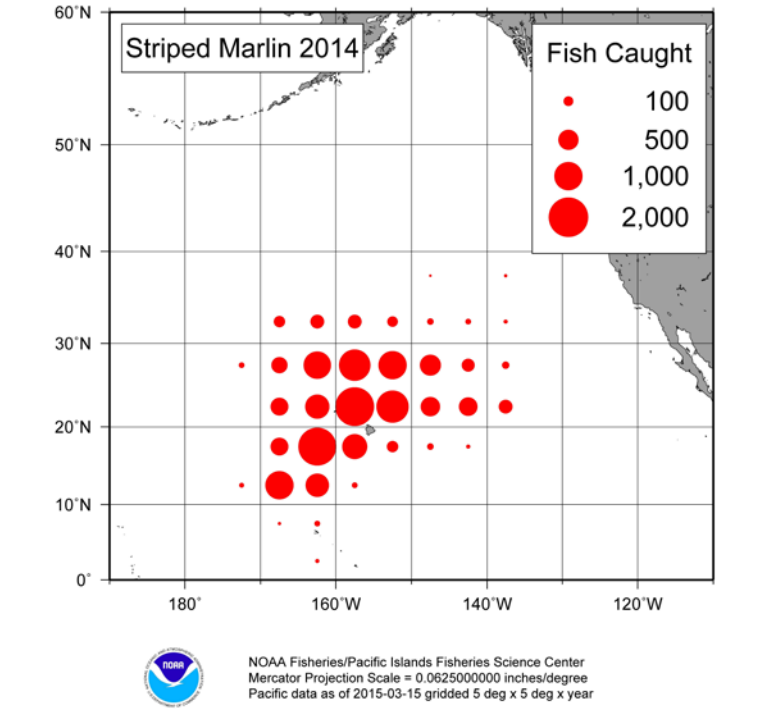

Figure 4.—Hawaii-based longline blue marlin catch (numbers of fish) by area, 2014.

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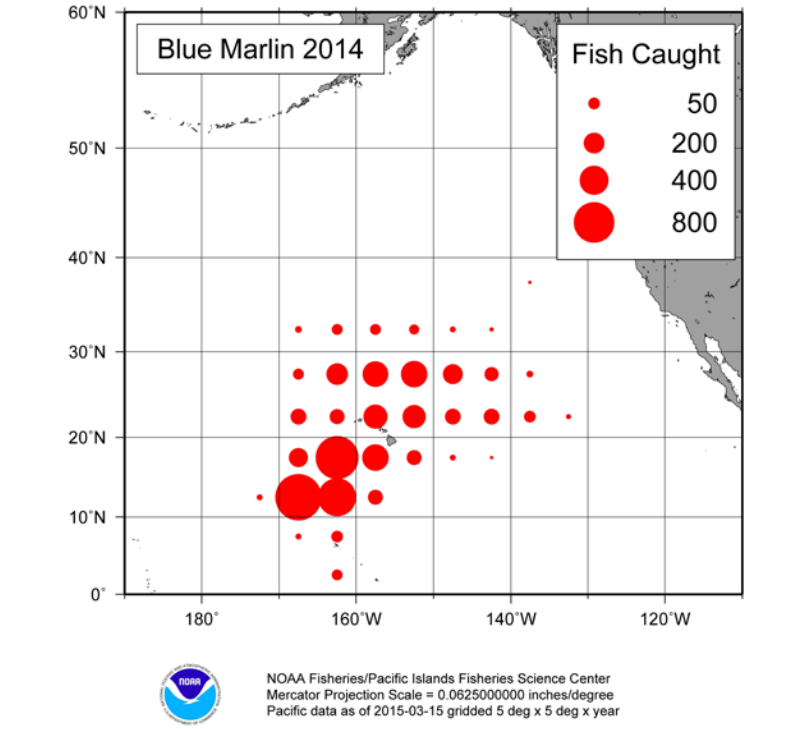


Figure 5.—Hawaii-based longline striped marlin and blue marlin nominal CPUE on tuna-targeted deep sets, 1991-2014.

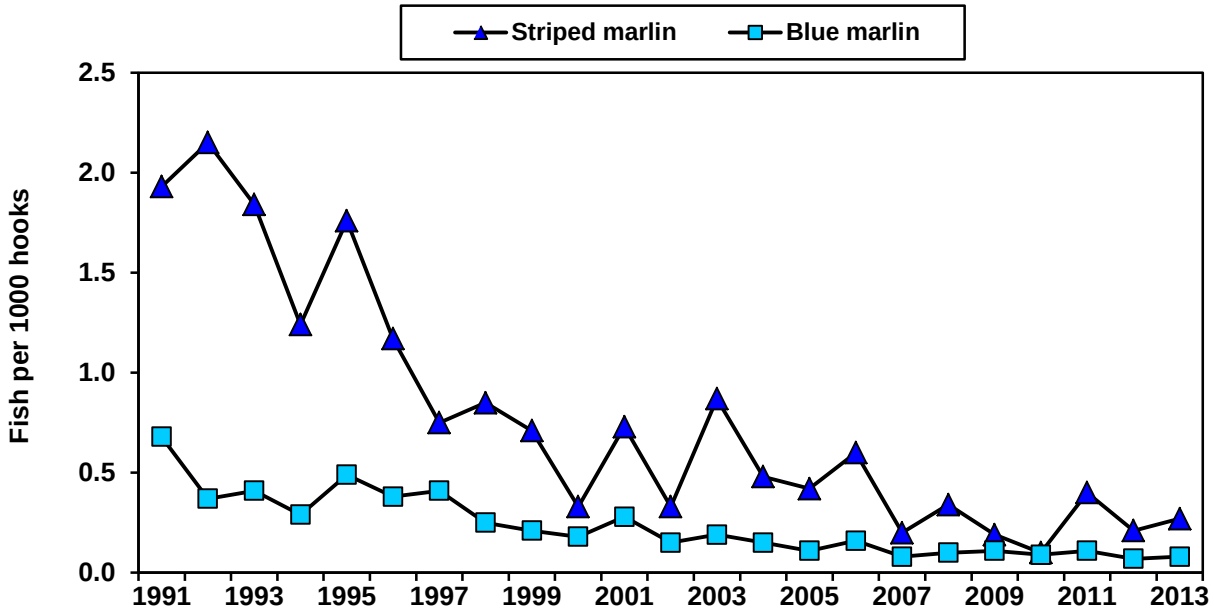
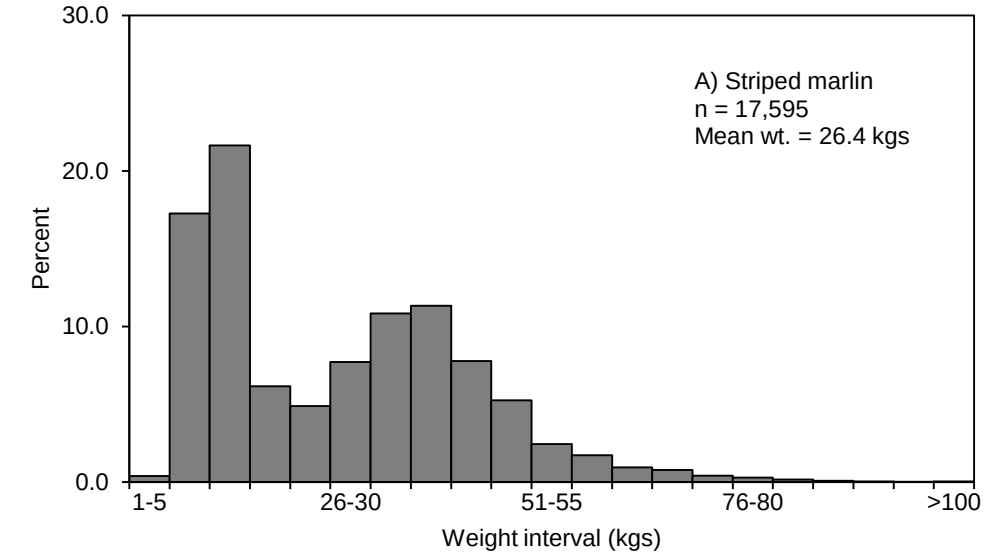


Figure 6.--Hawaii deep-set longline A) striped marlin and B) blue marlin weight-frequencies, 2014.



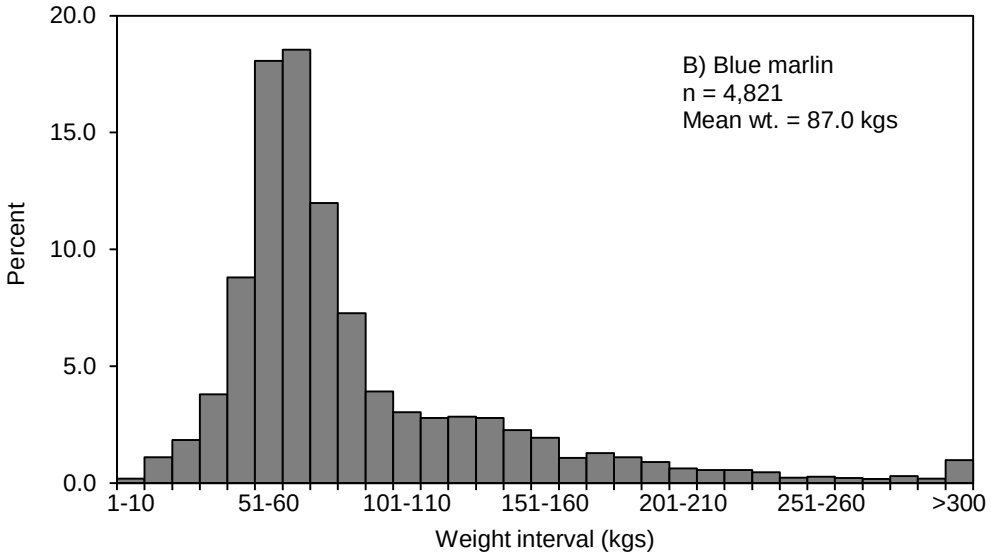


Figure 7.—Hawaii troll striped marlin and blue marlin nominal CPUE, 1991-2014.

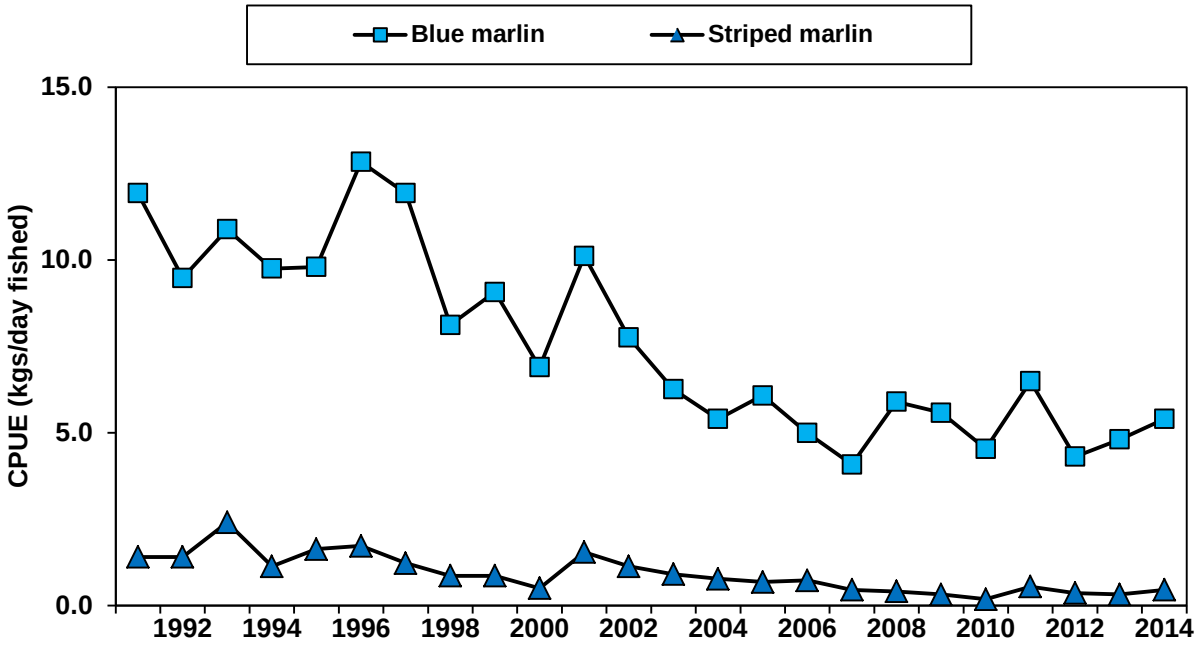
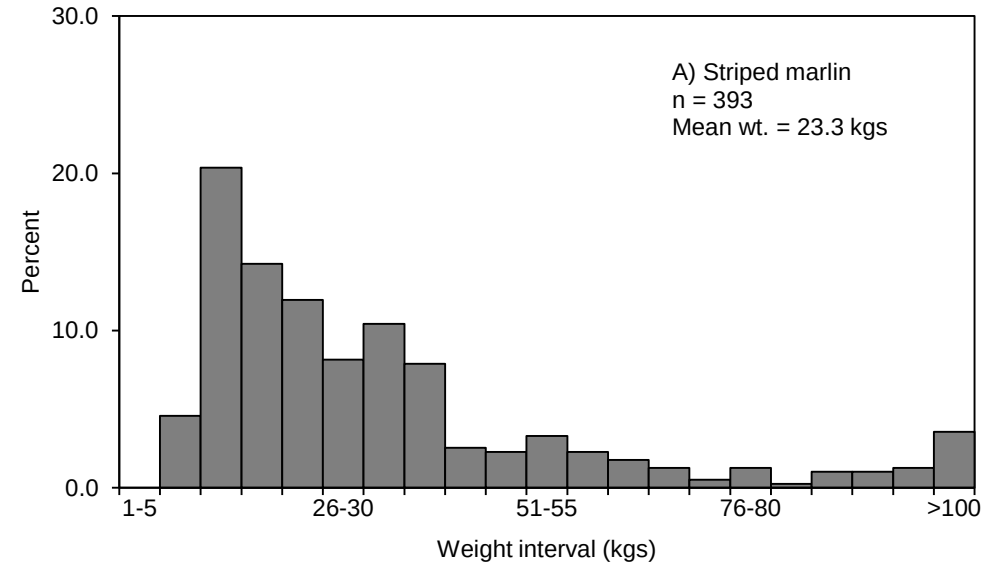


Figure 8.—Hawaii troll and handline A) striped marlin and B) blue marlin weight-frequencies, 2014.



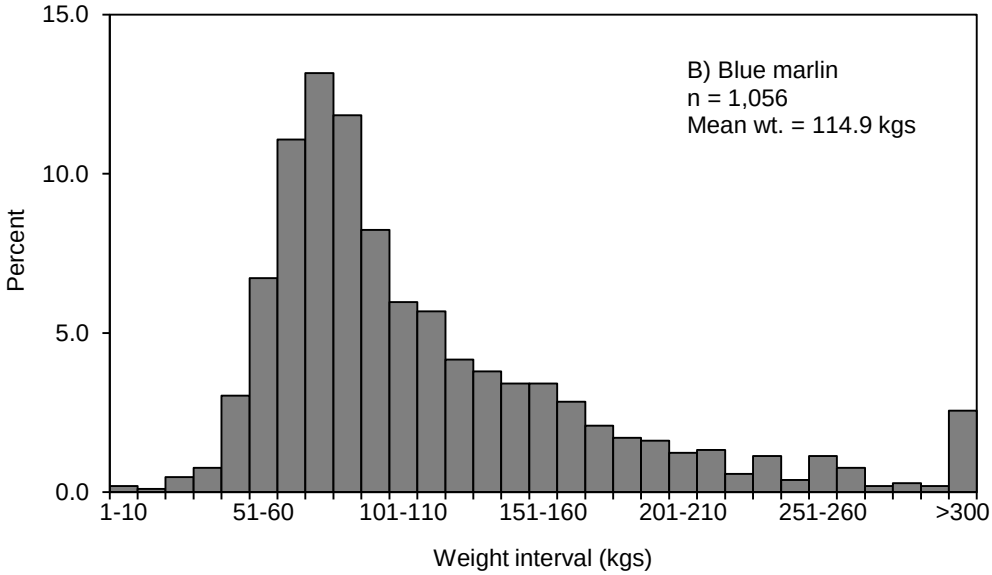
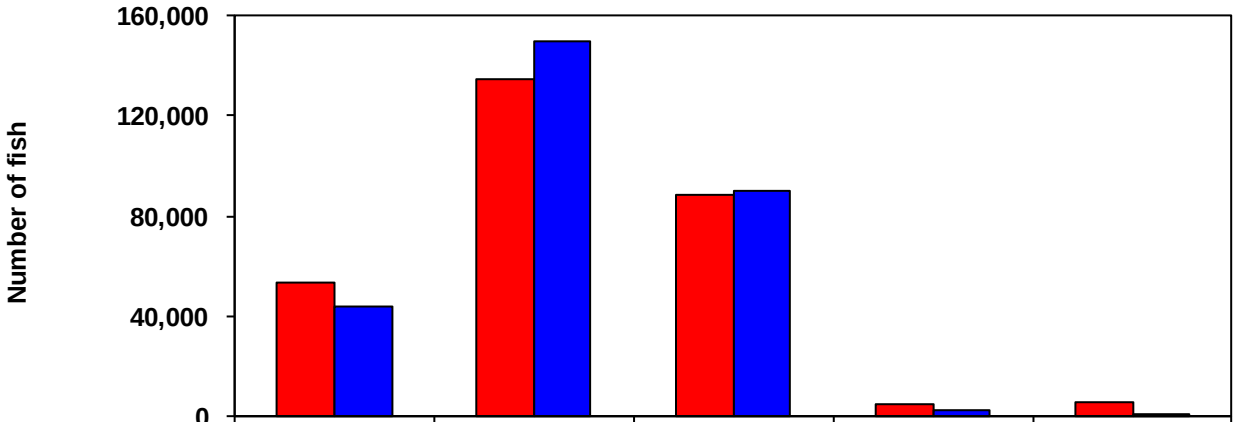


Figure 9. Nominal and corrected marlin catches for the Hawaii-based longline fishery, 1995-2003. Source: Walsh et al. 2007, Table B1.



	Blue marlin	Striped marlin	Shortbill spearfish	Sailfish	Black marlin
Nominal catch	53480	134319	88210	4638	5778
Corrected	43772	149381	89569	2749	689