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 U.S. longline fishery, which includes Hawaii & California-based longline vessels, is the largest (Table 1). This fishery catches marlins incidentally 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.

U.S. Longline Fisheries

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 vessels in the U.S. longline fishery have 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 by the U.S. longline fishery peaked at 145 active vessels in 2017 (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 U.S. longline fishery ranged from the equator to 45^{o} N latitude and from 125^{o} W to 175^{o}W longitude in 2017. 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 U.S. longline fishery was a record 54.6 million hooks set in 2017. The record effort was due to more hooks set by the deep-set sector of the longline fishery which accounted for 98% of the total number of hooks set and an expansion of longline fishing outside of the U.S. EEZ in 2017.

Longline catch of striped marlin rose rapidly from 272 t in 1987, peaked at 664 t in 1995 and decreased slowly to a low of 167 t in 2002. There has since been considerable variability in striped marlin catch with 411 t in 2017, up 6% from the previous year. Blue marlin catch increased from 1987, increased significantly in the two subsequent years, remained relatively stable through 1999, then declined through 2002. Blue marlin catch have been on an increasing trend peaking at 684 t in 2017, an increase of 23% from 2016.

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 150^{o} W. U.S. longline catch of striped marlin by stock boundary show 85% of the catch originating from the area at or west of 150^{o} W during 2010-2017 (Table 4). Striped marlin caught east of 150^{o} W and undisclosed areas were highest in 2015 and represented 16% of the catch by the longline fishery. The deep-set sector of the longline fishery was responsible for 96% of

the striped marlin catch. There was substantial variation in catch ranging from 167 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 north-northeast of the main Hawaiian Islands while the highest blue marlin catches occurred south-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 0.23 in 2017 (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 increased slightly through 2017.

The weight-frequency histogram for striped marlin caught by the U.S. 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 2017 (Fig. 6A). The mean weight for striped marlin was 30.8 kg. The blue marlin weight-frequency distribution was unimodal with a peak at the 51-60 and 61-70 kg weight intervals in 2017 (Fig. 6B). The mean weight for blue marlin was 80.8 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 ranged from 1,704 in 1988 to 2,367 in 1999 with 1,720 fishers in 2017. Eighty-one percent of the troll fishers were from Hawaii, 18 % from Guam and less than 1% from CNMI in 2017. 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 was the predominant component of troll marlin catch. Blue marlin catch peaked at 434 t in 1996, declined to a record low 128 t in 2007, and was 153 t in 2017

(Table 5). Striped marlin and other marlin species represented only a small proportion of the marlin catch at 19 t in 2017. Blue marlin and striped marlin catch 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 487 handline fishers in 2017. 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 caught relatively small amounts of striped and blue marlins when compared to the longline and troll fisheries. There have been no striped marlin catch by the handline fishery from 2005. The highest striped marlin catch was 2 t in 2001 (Table 6). Handline catch of blue marlin were higher in the earlier years, peaked at 9 t in 1997 and was 4 t in 2017.

The weight-frequency histogram for striped marlin caught on troll and handline gear exhibited a peak at the 16-20 kg interval (Figure 8A). The mean weight for striped marlin was 34.6 kg in 2017. The blue marlin weight-frequency distribution was unimodal with a mean weight of 90.4 kg in 2017 (Figure 8B). The weight-frequency distribution of 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 catches 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 U.S. longline fishery catch was 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 U.S. 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 catch* (metric tons) from the North Pacific Ocean by gear type, 1987-2017.

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	868	243	4	1,115
2005	1,069	220	3	1,292
2006	1,187	193	3	1,383
2007	698	153	1	852
2008	1,016	208	1	1,225
2009	745	197	1	943
2010	604	179	2	785
2011	987	233	2	1,222
2012	754	164	2	920
2013	1,032	160	3	1,195
2014	1,198	184	4	1,386
2015	1,400	224	3	1,627
2016	1,300	193	2	1,495
2017	1,415	172	4	1,591

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

Table 2.--Annual U.S. commercial fisheries marlin catch* (metric tons) from the North Pacific Ocean by species, 1987-2017.

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	420	471	186	38	1,115
2005	536	525	207	24	1,292
2006	625	570	161	27	1,383
2007	291	390	147	24	852
2008	443	529	226	27	1,225
2009	271	540	113	19	943
2010	186	456	118	25	785
2011	381	574	234	33	1,222
2012	293	441	163	23	920
2013	407	545	213	29	1,195
2014	438	699	218	32	1,386
2015	501	830	263	34	1,627
2016	398	717	340	41	1,495
2017	417	841	303	30	1,591

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

Table 3.—U.S. longline commercial marlin catch* (metric tons) from the North Pacific Ocean, 1987-2017.

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	385	283	186	14	868
2005	516	337	207	9	1,069
2006	604	409	161	13	1,187
2007	278	261	147	12	698
2008	429	348	226	13	1,016
2009	261	360	113	11	745
2010	167	306	118	13	604
2011	365	373	234	15	987
2012	282	298	163	11	754
2013	399	406	213	13	1,032
2014	426	535	218	20	1,198
2015	490	631	263	17	1,400
2016	386	554	340	21	1,300
2017	411	684	303	17	1,415

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

Table 4.—U.S. deep- and shallow-set longline commercial striped marlin catch (metric tons) by stock boundary in the North Pacific Ocean, 2010-2017.

	Deep-set				Shallow-set				Fleet			
Year	≥150° W	<150° W	No longitude	Total	≥150° W	<150° W	No longitude	Total	≥150° W	<150° W	No longitude	Total
2010	129.3	24.8	0.9	155.0	10.6	1.7	0.0	12.3	139.9	26.5	0.9	167.3
2011	315.8	27.6	1.7	345.1	17.7	1.9	0.0	19.6	333.5	29.5	1.7	364.7
2012	254.1	15.6	0.9	270.6	11.3	0.4	0.1	11.8	265.4	16.0	1.0	282.4
2013	313.6	65.8	3.9	383.3	15.5	0.2	0.1	15.8	329.1	66.0	4.0	399.1
2014	343.4	65.4	3.0	411.8	13.5	0.2	0.2	13.9	356.9	65.6	3.2	425.7
2015	401.2	75.7	2.2	479.1	9.9	0.9	0.0	10.8	411.1	76.6	2.2	489.9
2016	315.4	58.8	2.6	376.8	12.0	0.7	0.3	13.0	327.4	59.5	2.9	389.8
2017	318.9	71.8	4.6	395.3	15.2	0.0	0.4	15.6	334.1	71.8	5.0	410.9
Mean	**298.96**	**50.69**	**2.48**	**352.13**	**13.21**	**0.75**	**0.14**	**14.10**	**312.18**	**51.44**	**2.61**	**366.23**

Table 5.—U.S. troll fishery marlin catch* (metric tons) from the North Pacific Ocean, 1987-2017.

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	16	160
2014	12	160	0	12	184
2015	11	196	0	17	224
2016	12	161	0	20	193
2017	6	153	0	13	172

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

Table 6.—The U.S. handline fishery marlin catch* (metric tons) from the North Pacific Ocean, 1987-2017.

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
2015	0	3	0	0	3
2016	0	2	0	0	2
2017	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.—Catch of blue marlin by U.S. commercial fisheries in the North Pacific Ocean, 1987-2017.

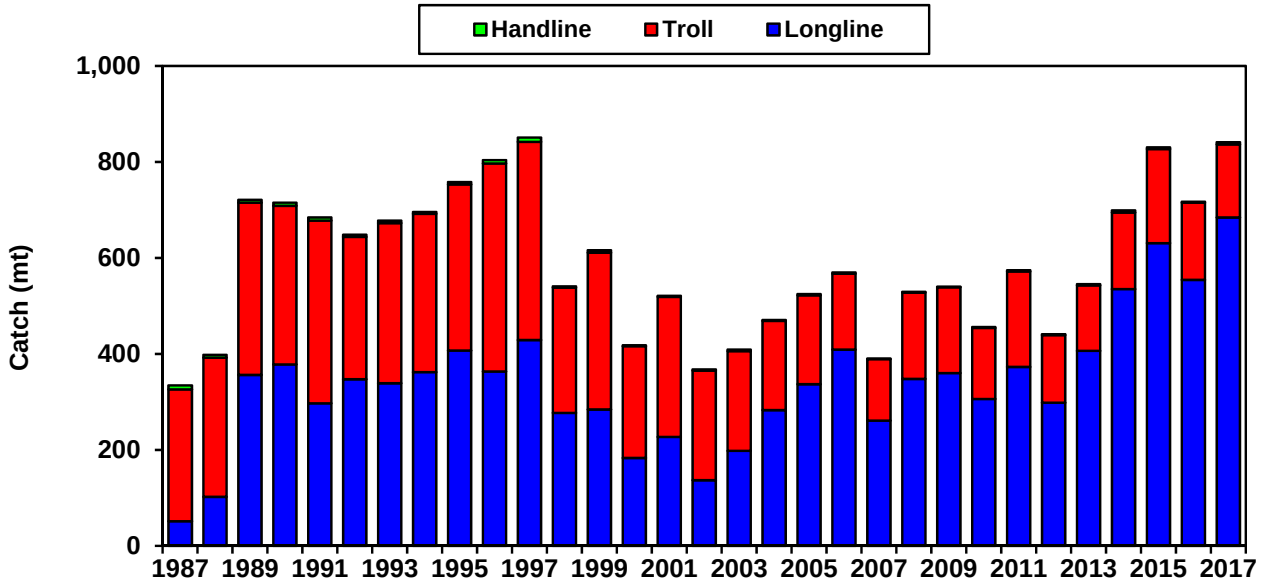


Figure 2.–Catch of striped marlin by U.S. commercial fisheries in the North Pacific Ocean, 1987-2017.

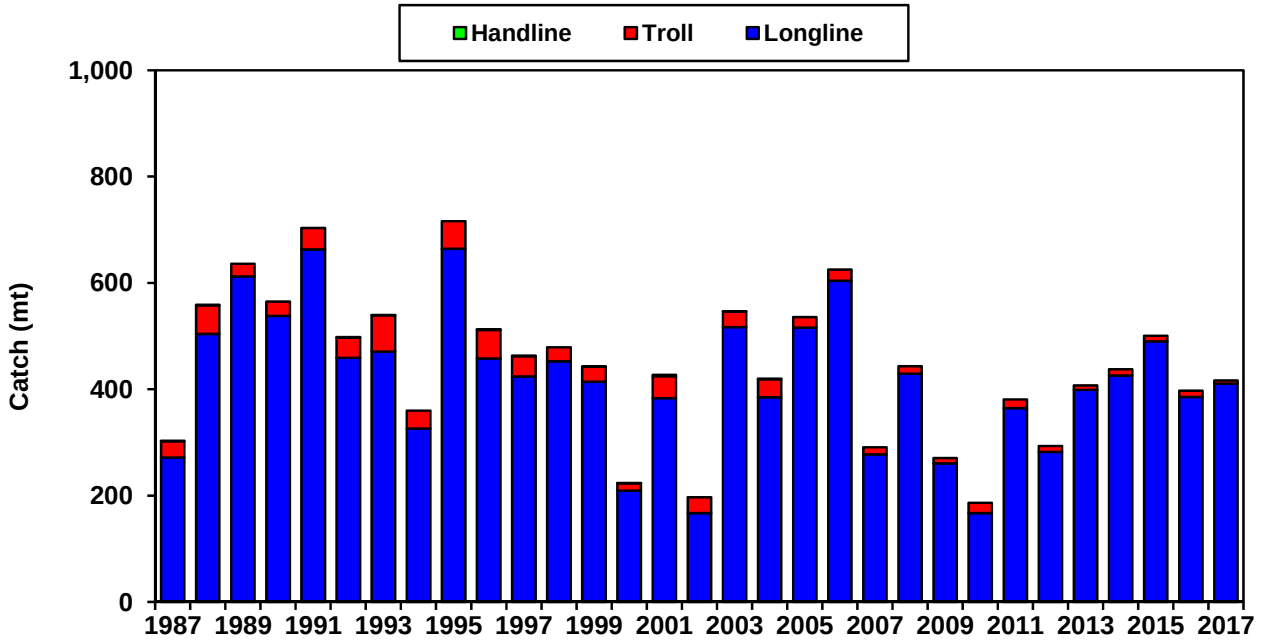


Figure 3.—U.S. longline striped marlin catch (numbers of fish) by area, 2017.

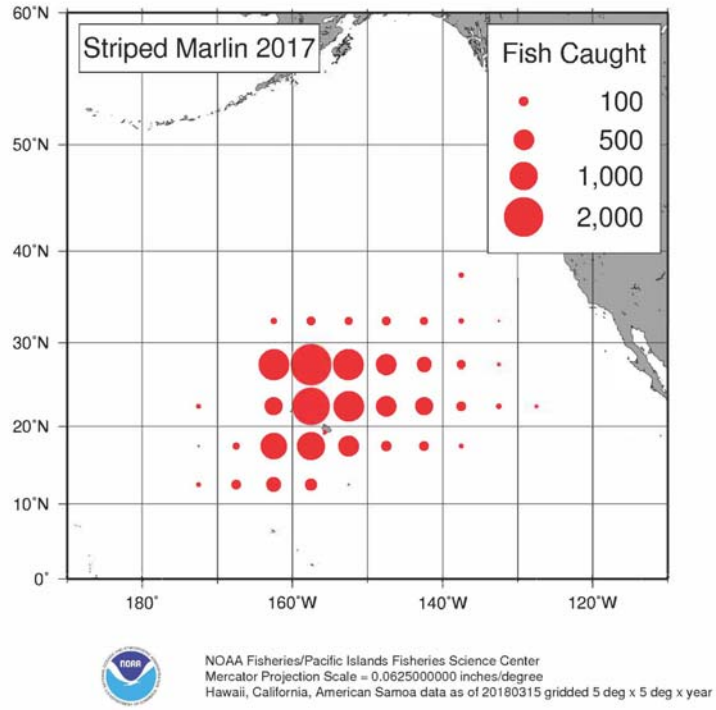


Figure 4.—U.S. longline blue marlin catch (numbers of fish) by area, 2017.

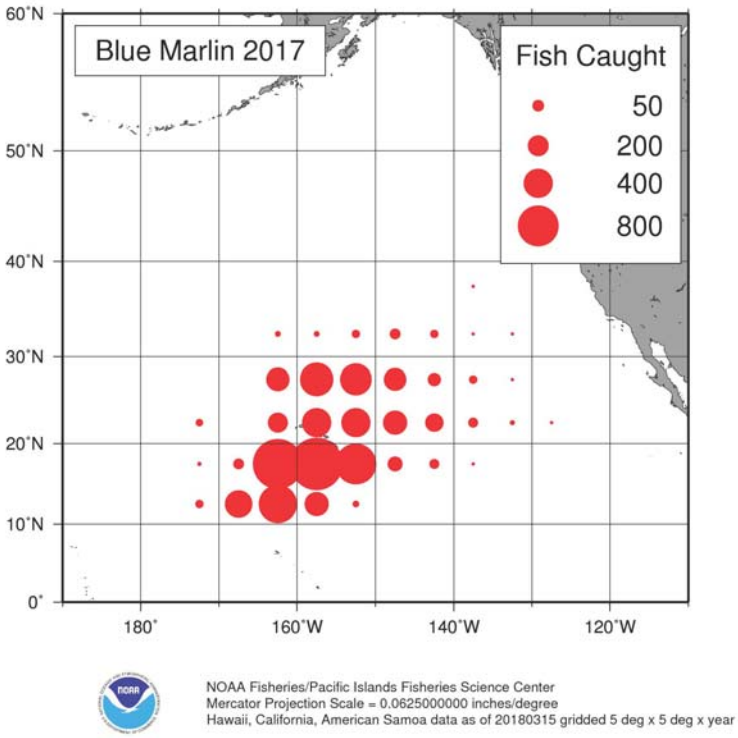


Figure 5.—U.S. longline striped marlin and blue marlin nominal CPUE on tuna-targeted deep sets, 1991-2017.

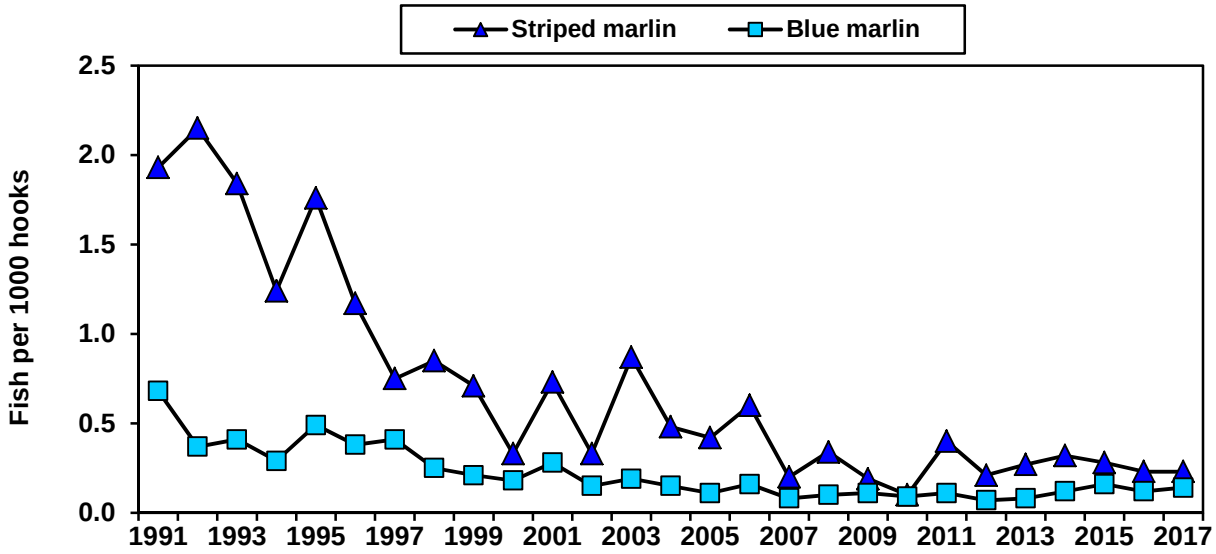
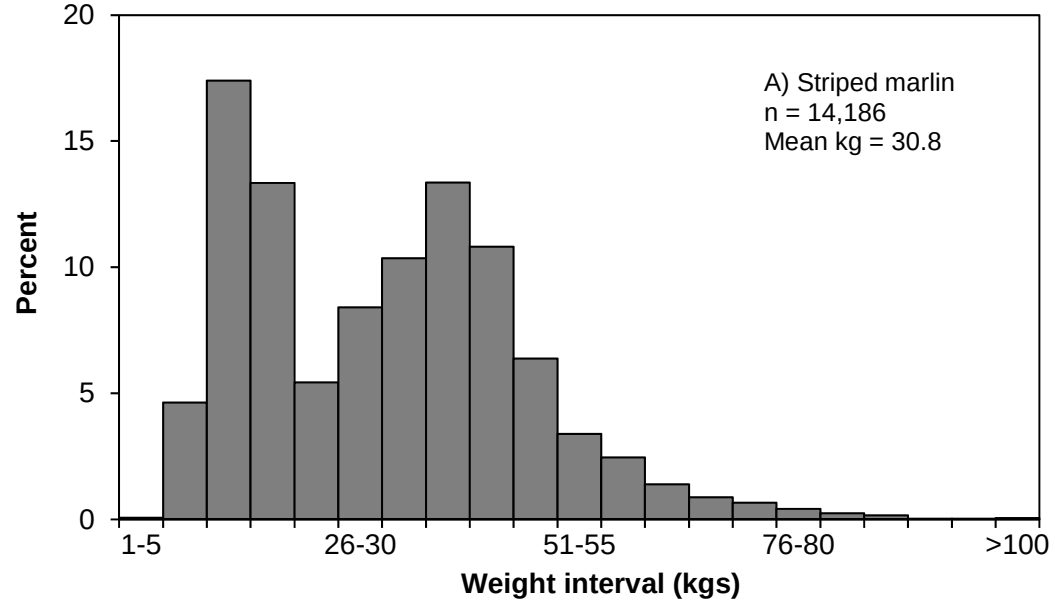


Figure 6.—U.S. longline A) striped marlin and B) blue marlin weight-frequencies, 2017.



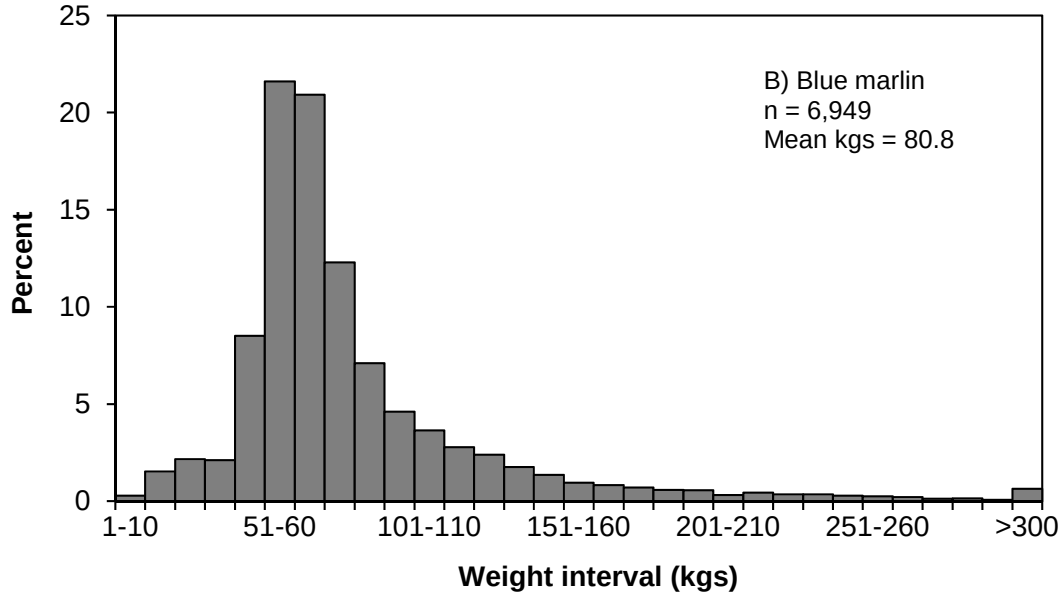


Figure 7.—Hawaii troll striped marlin and blue marlin nominal CPUE, 1991-2017.

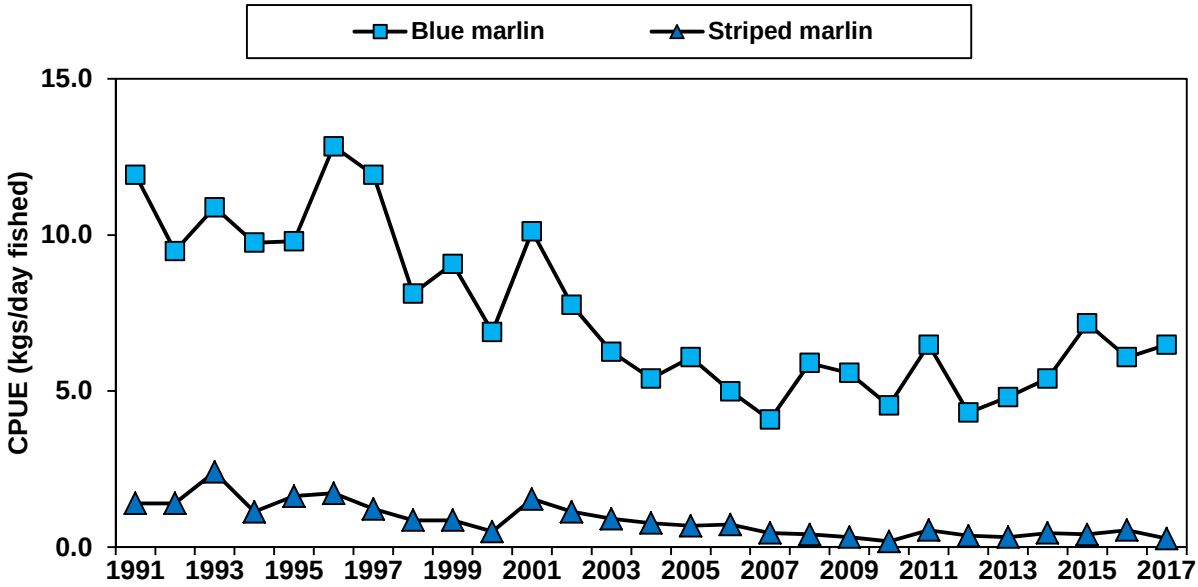
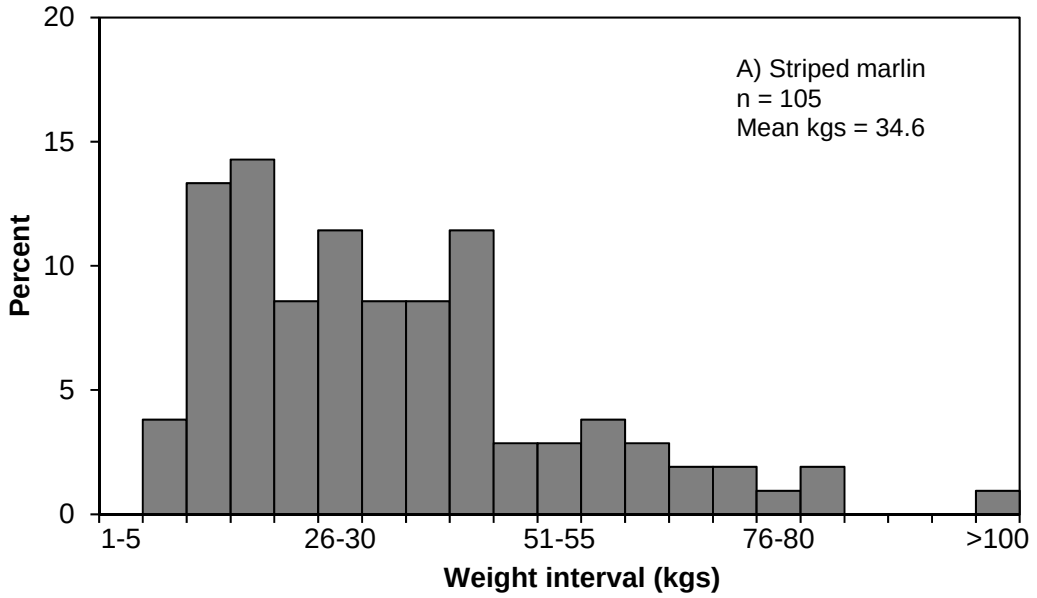


Figure 8.—Hawaii troll and handline A) striped marlin and B) blue marlin weight-frequencies, 2017.



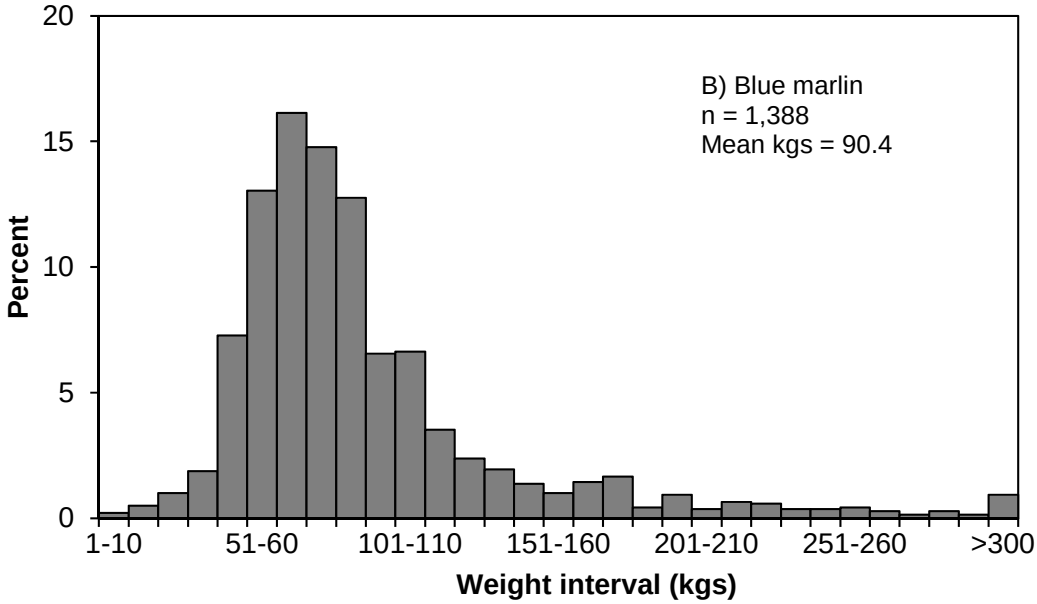
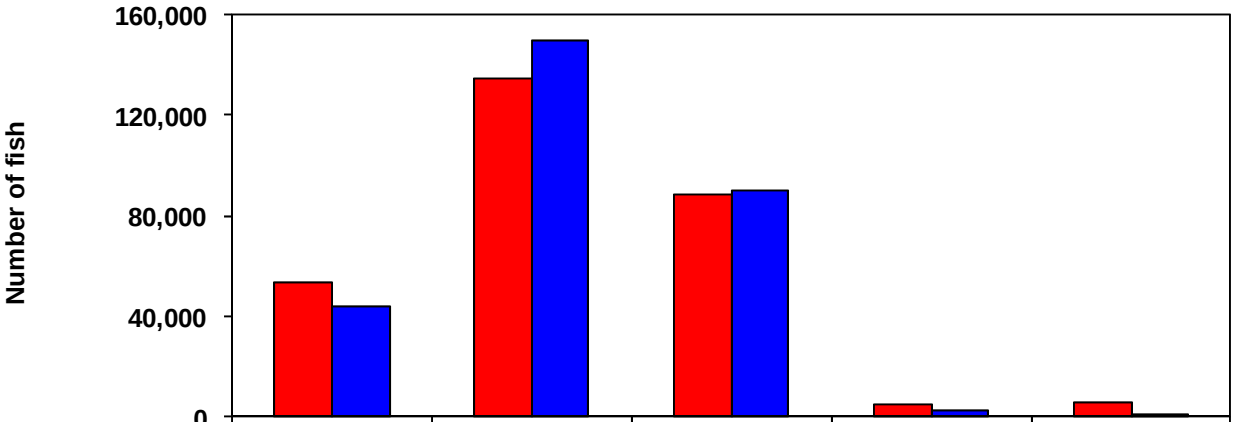


Figure 9. Nominal and corrected marlin catches for the Hawaii-based longline fishery, 1995-2003. Source: Walsh et al. 2007, Table B1.



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