ISC/16/SHARKWG-1/15

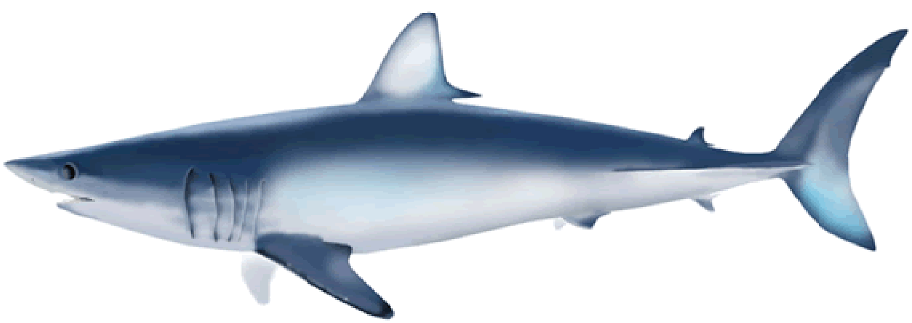
Catch and Size of Blue Sharks Caught in U.S. Fisheries in the North Pacific[1]

Suzanne Kohin[2], *Tim Sippel*[2], *Felipe Carvalho*[3]

[2]*NOAA Southwest Fisheries Science Center*
8901 La Jolla Shores Dr.
La Jolla, CA 92037-1509 U.S.A.

[3]*NOAA Pacific Islands Fisheries Science Center*
1845 Wasp Boulevard, Building 176
Honolulu, Hawaii 96818 U.S.A.

suzanne.kohin@noaa.gov



[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

Document not to be cited without author's permission.

ABSTRACT

The objective of this working paper is to describe blue shark catch and size time series for U.S. fisheries in Hawaii and along the U.S. West Coast (California, Oregon, and Washington) and provide updates of blue shark catch estimates (i.e., dead removals) for the period 1971-2015 for use in the upcoming ISC north Pacific blue shark stock assessment. Fisheries are characterized as commercial (longline, drift gillnet, troll), recreational (private or rental vessels, and commercial passenger fishing vessels), and research. Two fisheries for which blue shark catch was not previously estimated are included herein: a troll/pole-and-line fishery targeting albacore that operates primarily out of Oregon and Washington, and a recreational charter boat fishery in Oregon and Washington. Blue shark size/sex data, collected through observer programs and during research surveys, are also described. Some relatively minor changes to catch estimation methodology for some fleets have been made. Estimates of U.S. north Pacific blue shark dead removals average 361 mt annually over the recent 10 years, down from a peak in 1993 of 4007 mt. The estimate of U.S. dead removals of north Pacific blue shark derived with improved methodologies and including some previously undescribed catch is approximately 14% higher than estimated for the previous assessment (1971-2011). The most significant change results from applying a post-release mortality estimate of 9.8% to blue sharks released live from the Hawaii-based longline fisheries. Observers and researchers measured 17420 blue sharks between 1990-2015. The size data show that west coast fisheries catch predominately juvenile blue sharks while the Hawaii-based fisheries tend to catch larger sharks in the central North Pacific, and some juveniles in the transition zone. These data update previous catch estimates and provide size/sex data for use in the assessment and for examination of the population dynamics of blue sharks in the North Pacific.

INTRODUCTION

The blue shark is a ubiquitous pelagic shark species in temperate and subtropical waters worldwide. In the North Pacific, they overlap with a number of commercially important fish species including tunas and swordfish. The U.S. does not have a market for blue sharks, therefore there are no directed fisheries for them. However, they are caught incidentally in commercial tuna and swordfish fisheries and by recreational anglers. Because of low retentions, landings data do not represent fishery impacts and catch must be estimated from a variety of data sources. This paper provides catch estimates for U.S. fisheries interacting with blue sharks for use in the upcoming ISC north Pacific blue shark stock assessment.

The U.S. fishery with the highest blue shark catch in the North Pacific is the pelagic longline fishery based in Hawaii and operating in the central and eastern North Pacific Ocean. The fishery has been operating since the mid 1970s and has two sectors: one targeting tunas in central Pacific waters around Hawaii with deep-set gear; and the second using shallow-set gear to target swordfish in transition zone waters to the north of Hawaii (Walsh et al. 2009, Walsh and Teo 2012, 2013).

---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

Document not to be cited without author's permission.

Vessels based in California joined the Hawaii-based vessels in the swordfish and tuna longline fishery around 1991 (Vojkovich and Barsky 1998), but since 2005, shallow-set swordfish longlining has not been permitted for vessels operating with a U.S. West Coast HMS permit. A California-based deep-set longline fishery, currently with only one vessel participating, targets bigeye tuna in the eastern North Pacific (Walsh and Teo 2012, 2013). Two experimental longline fisheries that targeted pelagic sharks (shortfin mako and blue) operated briefly in southern California waters, but those fisheries were closed due to the lack of market for blue shark and concerns over the high number of juvenile sharks caught (O'Brien and Sunada 1994, Teo 2013).

Another fishery that has historically caught large numbers of blue sharks is the large mesh drift gillnet (DGN) fishery targeting swordfish in the U.S. West Coast EEZ. This fishery emerged in the late 1970s as a fishery to target thresher sharks. However, after several years of high levels of effort, thresher shark catch declined and the fishery switched to targeting more abundant and higher value swordfish (Hanan et al. 1993). The fishery is subject to heavy regulation imposed to limit marine mammal and turtle interactions. Effort, which peaked in the mid 1980s, has been steadily declining (in terms of number of vessels and trips) since 2001. Additional information about the operations of this fishery was also described in Lee et al. (2014).

Recreational angling for pelagic sharks and other large pelagic fish is popular off the U.S. West Coast, particularly in southern California (Holts et al. 1998). Anglers fishing for tunas, mako sharks, or thresher sharks also catch blue sharks, although in recent years most are released alive. Recreational anglers fish from small private vessels as well as charter boats along the West Coast, including in Mexican waters. Commercial troll and pole-and-line fishers targeting albacore also occasionally catch blue sharks. Blue shark catch is rare or undocumented in other U.S. fisheries in the North Pacific.

MATERIALS AND METHODS

Catch

Commercial fisheries

Longline

Catch estimates from pelagic longline fisheries in Hawaii were updated using the methods described in Walsh and Teo (2013). One modification for updating the HI longline catch was made. Once the retained and discarded dead blue shark catch was calculated, a post-release mortality rate of 9.8% was applied to the live discards based on a recent study in the Atlantic (Campana et al. 2016). The prior estimates for HI were a minimum mortality estimate that only accounted for landings (or finned) sharks and dead discards. The post-release mortality was applied to the entire time series once an estimate for live discards was derived, thus changing the time series of HI longline dead removals. As in Walsh and Teo

---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

(2013), the average weight of 40.93 kg for blue sharks caught in this fishery was used to convert catch in numbers to catch in weight.

The California-based pelagic longline fleet has been represented by a single vessel targeting tunas since 2005. Prior estimates of dead removals for this fishery (1991-2010) were estimated by Walsh and Teo (2013) and are not updated here. Recent observer coverage in the CA-based fishery is nearly 100% (96% of trips since 2005), thus, blue shark catch estimates for 2011-2014 were derived directly from observer records. Nearly all blue sharks caught were discarded. Annual total dead removals in numbers of sharks was calculated as the sum of retained sharks, those reported as discarded dead, and the number of sharks reported as discarded alive multiplied by the post-release mortality factor of 9.8% (Campana et al. 2016). For those years when not all trips were observed, the estimates of dead removals were divided by the observer coverage rate to scale up the total catch. As in Walsh and Teo (2013), the average weight of 19.7 kg for blue sharks caught in this fishery was used to convert catch in numbers to catch in weight.

Catch estimates from two experimental longline fisheries referred to as the “Saltonstall-Kennedy” fishery (1979-1980) and “California Fish and Game Commission” (1988-1991) were developed by Teo (2013). Those fisheries targeted juvenile sharks in Southern California as part of a short-lived effort to develop a market for blue shark, but they are currently out of operation.

Drift gillnet (DGN)

Catch estimates from the U.S. DGN fishery were previously developed by Teo et al. (2012). The methods of Teo et al. (2012) were used to update catches through 2015. Briefly, blue shark catch in numbers was estimated as a multiple of annual nominal CPUE from observer records and total effort from logbook data. Post-release survivorship was assumed to be zero to derive precautionary estimates, and catch in numbers was multiplied by the average annual size of blue sharks measured by observers.

Albacore troll/pole-and-line fishery

A logbook program for the albacore troll/pole and line fishery has been in place since 1961, first voluntarily and as a mandatory program since 2005 (Teo et al. 2010). Blue shark bycatch has been recorded in the logs since 1998. Logbook reporting was assumed to be only 7% as a precautionary estimate given that coverage varied between 7% and 75% through 2005 (McDaniel et al. 2006). A catch time series for 1998-2015 was estimated from the logbook data. Annual total dead removals in numbers of fish was calculated as the sum of retained sharks and the number discarded multiplied by a post-release mortality factor of 6.3% (Musyl et al. 2011) and then divided by the logbook coverage rate. The post-release mortality rate is assumed lower than the one applied to the longline fishery because these sharks are likely all caught on pole-and-line right at the vessel and survivorship is expected to be high. A mean weight of 13.1 kg obtained from the U.S. DGN observer database during 1998-2014 was applied to convert catch in numbers to mt.

---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

Recreational fisheries

Estimation of catch from recreational fisheries on the U.S. West Coast, both private vessels and commercial passenger fishing vessels (CPFV), was described previously (Sippel and Kohin, 2013). Catches for these fisheries were estimated from 'RecFIN', which maintains dockside and phone survey-based recreational fishery data and the California Commercial Passenger Fishing Vessel (CA-CPFV) logbook database.

Private and rental boats

Although the angler surveys and sampling programs underlying the catch estimates have not changed, the data within RecFIN have undergone changes, and recreational catch estimates have been updated since blue shark catch was last tabulated. For private and rental boats in California, Oregon, and Washington, it is not clear if the current difference from what was previously estimated for 1971-2011 resulted from updates to the underlying data used by the Pacific States Marine Fisheries Commission (PSMFC) to estimate catches, or if the PSMFC changed their estimation formulas. As previously, blue shark catch estimates for private and rental boats were extracted directly from the RecFIN database as the sum of the number of sharks kept or reported released dead, plus the number of blue sharks reported released alive multiplied by the post-release mortality rate of 6.3%. The post-release mortality rate assumed is based on the study of Musyl et al. (2011) as survivorship of blue shark is assumed to be high from this pole-and-line fishery. Despite database changes since 2013, the resulting updated estimates are not substantially different.

Commercial passenger fishing vessels (CPFV)

Catches from the CPFV fleets (also known as charter or party boats) were derived from two databases. California maintains its own database of CPFV logbooks (referred to here as CA-CPFV), described previously in Sippel and Kohin (2013) and Hill and Schneider (1999). Some minor updates to the data within this database have occurred since catches were tabulated for the last assessment. The catch time series from 1980-2015 was estimated here using the updated CA-CPFV database and the methods of Sippel and Kohin (2013), but data from 1971-1979 were not impacted by the database updates and are unchanged from previous estimates.

Estimates for the CPFV fleets from Oregon and Washington were extracted from the RecFIN database as well. RecFIN estimates are provided by sampling programs unique to each state. The Oregon Recreational Boat Survey (ORBS) uses a stratified sampling design to derive catches from all recreational fisheries, including CPFV vessels. CPFV offices are contacted weekly to get effort data (i.e., number of vessels and days). The program also conducts random interviews with vessel crews to gauge number of anglers and catch per boat, and applies catch rates to the effort data to derive catch (Schindler et al. 2012). The state of Washington uses a two stage effort sampling approach (stage 1: randomly selected days, stage 2: randomly selected boats on a given day to count angler effort and catch rate) and expands survey results to total catch (WDFW 2008). In both Oregon and Washington, CPFV fleets generally target

---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

groundfish or salmon, and their blue shark catches are very small. A time-series from 1981-2015 was estimated for CPFV vessels in Oregon and Washington.

A mean weight of 12.9 kg (updated from 10.6 kg) from the DGN observer database (1990-2014) was used to convert numbers to weight for all recreational fisheries. The post-release mortality rate of 6.3% from Musyl et al. (2011) was applied to blue sharks discarded alive to add to reported or observed landed and reported dead discards for all recreational fisheries.

Size/Sex sampling

Commercial Fisheries

Longline

Observers aboard trips originating in Hawaii are instructed to measure every third fish brought onboard. Observer coverage in the Hawaii-based longline fisheries was roughly 3.5-5.6% per year through 1999, increased in 2000, and from 2001 forward has been roughly 20% of deep-set trips and 20% of shallow-set trips through 2002, when the fishery closed due to concerns over sea turtle interactions (Walsh and Teo 2013, Sippel et al. 2014). In 2004, the shallow-set longline fishery reopened with mandatory 100% observer coverage. Observer coverage during the period before the observer program expanded (pre-2000) was not representative of the full range of the fishery (Sippel et al. 2014). Nevertheless, a large number of blue sharks were measured and their sex recorded. Total length (TL) in cm was measured more often than fork length (FL). To standardize length measurements to precaudal length (PCL) for the assessment, the following equations agreed upon by the SHARKWG were used:

$PCL=0.894*FL+2.547$,

$PCL=0.748*TL+1.063$,

$PCL=2.463*AL+12.798$

where AL is the length from the origin of the first dorsal fin to the origin of the second dorsal fin. The size and sex data for blue sharks in this fishery have been previously described in Walsh and Teo (2013).

Size data for the CA-based commercial longline fishery and the two CA-based experimental fisheries are too scant to be considered representative and are not provided for use in the current stock assessment.

DGN

Between 1980-1989, the California Department of Fish and Game had a port sampling program and measured samples of pelagic sharks landed for markets (Childers and Halko 1994). However, due to the low retention of blue sharks, few were landed during that period and those data are not considered representative of the fishery catch.

---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

Beginning in 1990, a federal observer program has been in place for the drift gillnet fishery due to the concern over protected species interactions. The goal has been to observe 20% of the effort, with observers instructed to measure all landed sharks. Fork length is measured for most sharks, however, in some cases total length or alternate length is the only measurement available. All sizes were converted to PCL using the equations listed above. The size and sex data for blue sharks in this fishery have been previously described by Teo et al. (2012).

Research

Juvenile Shark Survey

The NOAA Southwest Fisheries Science Center conducted an annual longline research cruise for juvenile blue and mako sharks in the Southern California Bight between 1993-2015 (with the exception of 1998 and 1999). The objectives of the cruise were to conduct a fishery-independent abundance survey for juvenile sharks on their nursery area and collect life history and biological information. Figure 1 shows the area of operation of the survey and data collection; the survey methodologies and results were recently described in Runcie et al. (2016). Each shark caught was brought onboard, the sex determined, and either FL or TL recorded. Nearly all sharks survived the capture and were released after data collection. In a few cases the sharks escaped before being brought onboard and the sizes of those sharks were estimated. For use by the SHARKWG, data for only those blue sharks that were measured are included here. As above, FL or TL was converted to PCL before summarizing and for use in the assessment. Size data for blue sharks caught in the research survey have been previously described by Wells and Kohin (2011).

Results and Discussion

Catch

Longline

Longline catch estimates are shown in Table 1. Catch estimates since 2005 cannot be reported here due to data confidentiality for the single California-based vessel. The data will be provided to the ISC Shark Working Group for use in the 2017 stock assessment. New estimates for 2011 -2015 were derived using the methodologies reviewed for prior assessments. There has been little change in the magnitude of catch in the U.S. longline fisheries since 2004 with an average estimate of annual total dead removals of less than 150 mt (Figure 2). Higher estimates of removals occurred prior to 2000 before a ban on shark finning was imposed. Subsequent to the finning ban, nearly 100% of blue sharks caught have been discarded.

Other Fisheries

Catch estimates for the west coast-based DGN, albacore troll and recreational fisheries are shown in Table 2. For the DGN fishery, effort, and thus catch, have continued to decline. Estimates for the troll fishery were not included in past assessments, and although very low,

---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

the catch data time series is now more complete. The recreational catch time series includes new estimates for charter boats operating out of Oregon and Washington ports. Even with the additional catch, the west coast recreational fisheries result in very low estimated mortality on blue sharks. The combined estimated dead removals for these miscellaneous fisheries since 2004 has averaged less than 10 mt annually. For the stock assessment, given the very low removals for the troll fishery, we recommend aggregating them with the recreational catch.

Figure 2 shows the combined catch estimates of north Pacific blue shark for all U.S. fisheries. The Hawaii-based longline fishery has more blue shark dead removals than any other U.S. fishery in the North Pacific.

Size Compositions

Longline

Hawaii longline fishery observers recorded length and sex of 9082 blue sharks between 1994-2014. The overall size frequency distributions for the deep-set and shallow-set sectors is shown in Figure 3. There are a few patterns to note in the overall size compositions. For example, in both sectors of the fishery the largest sharks tend to be males, which is consistent with reported differences in growth; Fujinami et al. (2016) and others have shown that male blue sharks reach a greater asymptotic size than females. In addition, in both sectors there appears to be a skewed sex ratio with more males caught than females. Another pattern is that the smallest sharks are caught in the shallow-set sector of the fishery which tends to operate in higher latitudes of the central North Pacific, an area hypothesized to be a blue shark pupping area.

DGN

Fishery observers for the west coast-based DGN fishery recorded length and sex of 12274 blue sharks between 1990-2014. The overall size frequency distributions are shown in Figure 4A. This fishery operates within the US EEZ close to the continental margin. As with the longline fishery, there appears to be a skewed sex ratio with more males caught than females. In general, sharks caught in this fishery are smaller than those caught in the central Pacific longline fisheries, with fewer sharks caught above the approximate size at maturity (145 cm PCL).

Survey

Research scientists measured and recorded the sex of 5146 blue sharks caught during the fishery-independent longline survey from 1993-2015 (Figure 4B). This survey operates in a nursery area for several shark species including blue, shortfin mako, white, and thresher sharks. As such, blue sharks caught in the survey were small, many likely young-of-the-year. Unlike for other U.S. fisheries, the sex ratio for the survey catch is near 1:1, which is consistent with information on the sex ratio at birth from other blue shark studies. While these data are from a fishery-independent survey in which there is almost no mortality, these sizes cannot be directly assigned to a fishing fleet for the blue shark assessment. However, given that the nursery area

---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

is believed to extend into Mexican waters to San Vizcaino Bay, it is possible these size data could represent size compositions for the coastal artisanal pelagic shark longline fisheries off Baja California.

All these catch estimates and size data are provided to the SHARKWG for use in the 2017 stock assessment and for other analyses such as those reported in Sippel et al. (2016) and Carvalho and Sippel (2016).

References

Campana, S.E., Joyce, W., Fowler, M., Showell, M., 2016. Discards, hooking, and post-release mortality of porbeagle (Lamna nasus), shortfin mako (Isurus oxyrinchus), and blue shark (Prionace glauca) in the Canadian pelagic longline fishery. ICES Journal of Marine Science, 73(2): 520-528. doi:10.1093/icesjms/fsv234.

Carvalho, F., Sippel, T., 2016. Direct Estimates of Gear Selectivity for the North Pacific Blue Shark Using Catch-at-Length Data: implications for stock assessment. Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Busan Republic of Korea. ISC/16/SHARKWG-1/13.

Childers, J., Halko, L., 1994. Length-frequency database description: California Department of Fish and Game Gillnet Market Samples. NMFS - Southwest Fisheries Science Center, Administrative Report LJ-94-01, 46 pp.

Fujinami, Y., Semba, Y., Ijima, H., Tanaka, S., 2016. Age and growth estimation of the blue shark, Prionace glauca, in the western North Pacific Ocean. Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Busan Republic of Korea. ISC/16/SHARKWG-1/02.

Hanan, D.A., Holts, D.B., Coan, A.L., 1993. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91 (Vol. 175). State of California, Resources Agency, Department of Fish and Game.

Hill, K.T., Schneider, N., 1999. Historical Logbook Databases from California's Commercial Passenger Fishing Vessel (Partyboat) Fishery, 1936-1997. Scripps Institution of Oceanography Reference Series 99–19.

Holts, D.B., Julian, A., Sosa-Nishizaki, O., Bartoo, N.W., 1998. Pelagic shark fisheries along the west coast of the United States and Baja California, Mexico. Fisheries Research, 39(2): 115-125.

Lee, H., Piner, K., Teo, S., Kohin, S., 2014. Standardized catch rates of shortfin mako shark in the U.S. West Coast drift gillnet fishery (http://isc.fra.go.jp/pdf/SHARK/ISC14_SHARK_3/09-Lee-DGN%20CPUE_final%20with%20abstract.pdf No. ISC/14/SHARKWG-3/09).

McDaniel, J. D., Crone, P. R., and Dorval, E., 2006. Critical evaluation of important time series associated with albacore fisheries (United States, Canada, and Mexico) of the Eastern North Pacific Ocean (2006). ISC/06/ALBWG/09.

Musyl, M.K., Brill, R.W., Curran, D.S., Fragoso, N.M., McNaughton, L.M., Nielsen, A., Kikkawa, B.S., Moyes, C.D., 2011. Post-release survival, vertical and horizontal movements, and

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

Document not to be cited without author's permission.

thermal habitats of five species of pelagic sharks in the central Pacific Ocean. Fishery Bulletin 109, 341–368.

O'Brien, J.W., Sunada, J.S., 1994. A review of the southern California experimental drift longline fishery for sharks, 1988–1991. CalCOFI Rep. 35: 222-229.

Runcie, R., Holts, D., Wraith, J., Xu, Y., Ramon, D., Rasmussen, R., Kohin, S., 2016. A fishery-independent survey of juvenile shortfin mako (Isurus oxyrinchus) and blue (Prionace glauca) sharks in the Southern California Bight, 1994–2013. Fisheries Research 183: 233-243.

Schindler, E., Freeman, M., Wright, B., 2012. Sampling Design of the Oregon Department of Fish and Wildlife's Ocean Recreational Boat Survey (ORBS) (http://www.recfin.org/sites/default/files/documents/ORBS_Design_03142012.pdf). Oregon Department of Fish and Wildlife - Marine Resources Program.

Sippel, T., Kohin, S., 2013. Catches of blue sharks from US West Coast recreational fisheries during 1971-2011. ISC/13/SHARKWG-2/01.

Sippel, T., Semba, Y., Shiozaki, K., Carvalho, F., Catillo-Geniz, J. L., Tsai, W.-P., Liu, K.-M., Kwon, Y., Chen, Y., Kohin, S., 2016. Size and sex structure of blue sharks in the North Pacific Ocean. Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Busan Republic of Korea. ISC/16/SHARKWG-1/14.

Teo, S., 2013. Preliminary catch estimates of north Pacific blue shark from California experimental shark longline fisheries (http://isc.fra.go.jp/pdf/SHARK/ISC13_SHARK_1/02-Teo-CA_expt_LL_timeseries.pdf No. ISC/13/SHARKWG-1/02).

Teo, S., Lee, H., Kohin, S., 2010. Time series associated with albacore fisheries based in the Northeast Pacific Ocean (http://isc.fra.go.jp/pdf/ALB/ISC10_ALB_3/ISC-10-ALBWG-3-WP02.pdf No. ISC/10-3/ALBWG/02).

Teo, S., Sippel, T., Wells, D., Kohin, S., 2012. Preliminary time series for the north Pacific blue and shortfin mako sharks from the US West Coast drift gillnet fishery (http://isc.fra.go.jp/pdf/SHARK/ISC12_SHARK_1/03-Teo%20et%20al%20-%20DGN_timeseries.pdf No. ISC/12/SHARKWG-1/03).

Vojkovich, M., Barsky, K., 1998. The California-based longline fishery for swordfish, Xiphias gladius, beyond the US exclusive economic zone. US Nat. Mar. Fish. Serv., NOAA Tech. Rep. NMFS, 142, pp.147-152.

Walsh, W.A., Bigelow, K.A., Sender, K.L., 2009. Decreases in shark catches and mortality in the Hawaii-based longline fishery as documented by fishery observers. Marine and coastal fisheries: Dynamics, management, and ecosystem science, 1(1): 270-282.

Walsh, W., Teo, S., 2012. Catch Statistics, Length Data and Standardized CPUE for Blue Shark Prionace glauca taken by Longline Fisheries based in Hawaii and California. (http://isc.fra.go.jp/pdf/SHARK/ISC12_SHARK_1/02-Walsh&Teo-US%20longline-final.pdf No. ISC/12/SHARKWG-1/02).

Walsh, W., Teo, S., 2013. Catch statistics, length data and standardized CPUE for blue shark Prionace glauca taken by longline fisheries based in Hawaii and California. ISC/13/SHARKWG-1/05. Working document submitted to the ISC Shark Working Group Workshop, 7-14 Jan 2013, La Jolla CA USA.

WDFW (Washington Department of Fish and Wildlife) 2008. Washington State Department of Fish and Wildlife Ocean Sampling Program Overview (http://www.recfin.org/sites/default/files/documents/WA_OSP_methods_10_2008_0.pdf).

Wells, D., Kohin, S., 2011. Length frequencies of the blue shark (Prionace glauca) in the eastern Pacific Ocean. ISC/11/SHARKWG-2/08. Working document submitted to the ISC Shark Working Group Workshop, 28 November – 3 December, NOAA Southwest Fisheries Science Center La Jolla, California U.S.A.

---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

Tables

Table 1. Estimated catch and dead removals of blue sharks taken by Hawaii- and California-based longline fisheries in 1976–2015. Due to data confidentiality policies, California and total estimates beginning in 1995 are not shown.

Year	HI Total Catch (#)	HI Dead Removals (#)	HI Dead Removals (mt)	CA Commercial Total Catch (mt)	CA Commercial Dead Removals (mt)	CA Experimental Dead Removals (mt)	HI and CA Dead Removals (mt)
1976	4093	2558.698	104.7				104.7
1977	8186	5117.396	209.5				209.5
1978	12279	7675.192	314.2				314.2
1979	16372	10233.89	418.9			36.6	418.9
1980	20465	12791.686	523.6			99.2	523.6
1981	24558	15350.384	628.3				628.3
1982	28651	17909.082	733				733
1983	32744	20466.878	837.7				837.7
1984	36837	23025.576	942.5				942.5
1985	40930	25584.274	1047.2				1047.2
1986	45023	28142.972	1151.9				1151.9
1987	49116	30700.768	1256.6				1256.6
1988	53209	33259.466	1361.4			39.7	1361.4
1989	57302	35817.262	1466.1			9.3	1466.1
1990	61395	38375.96	1570.8			23.8	1570.8
1991	65481	40930.364	1675.3	3.978068	1.582573	4.5	1676.9
1992	89292	55813.368	2284.5	26.37711	10.49346		2295
1993	150216	93895.12	3843.3	5.63004	2.239768		3845.5
1994	110187	68874.498	2819.1	17.77907	7.072952		2826.2
1995	110462	53071.348	2172.3	94.24909	37.4946		2209.8
1996	97591	62292.132	2549.7	207.7992	82.66763		2632.4
1997	89962	70649.278	2891.8	224.439	89.28732		2981.1
1998	105079	73706.538	3016.9	276.3272	109.9297		3126.8
1999	92818	69125.166	2829.4	407.1838	161.9877		2991.4
2000	78521	31422.168	1286.2	600.0445	238.7124		1524.9
2001	40947	7022.78	287.5	537.2362	213.7257		501.2
2002	41535	6636.62	271.6	350.2374	139.333		410.9
2003	64073	9082.57	371.8	321.4694	127.8884		499.7
2004	66970	9492.756	388.6	136.0636	54.12945		442.7

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

2005	68516	9711.914	397.5	NA	NA		NA
2006	60362	8556.532	350.2	NA	NA		NA
2007	66540	9431.674	386.1	NA	NA		NA
2008	53952	7647.83	313	NA	NA		NA
2009	49041	6950.974	284.5	NA	NA		NA
2010	59825	8480.454	347.1	NA	NA		NA
2011	56825	8054.762	329.7	NA	NA		NA
2012	13.77531	6725.21	275.3	NA	NA		NA
2013	5.221284	6450.694	264	NA	NA		NA
2014	3.369334	9539.332	390.5	NA	NA		NA
2015	3.108721	11444.164	468.4	NA	NA		NA

Table 2. Estimated dead removals (mt) of blue sharks taken in drift gillnet, albacore troll, and recreational fisheries along the U.S. West Coast, 1971–2015.

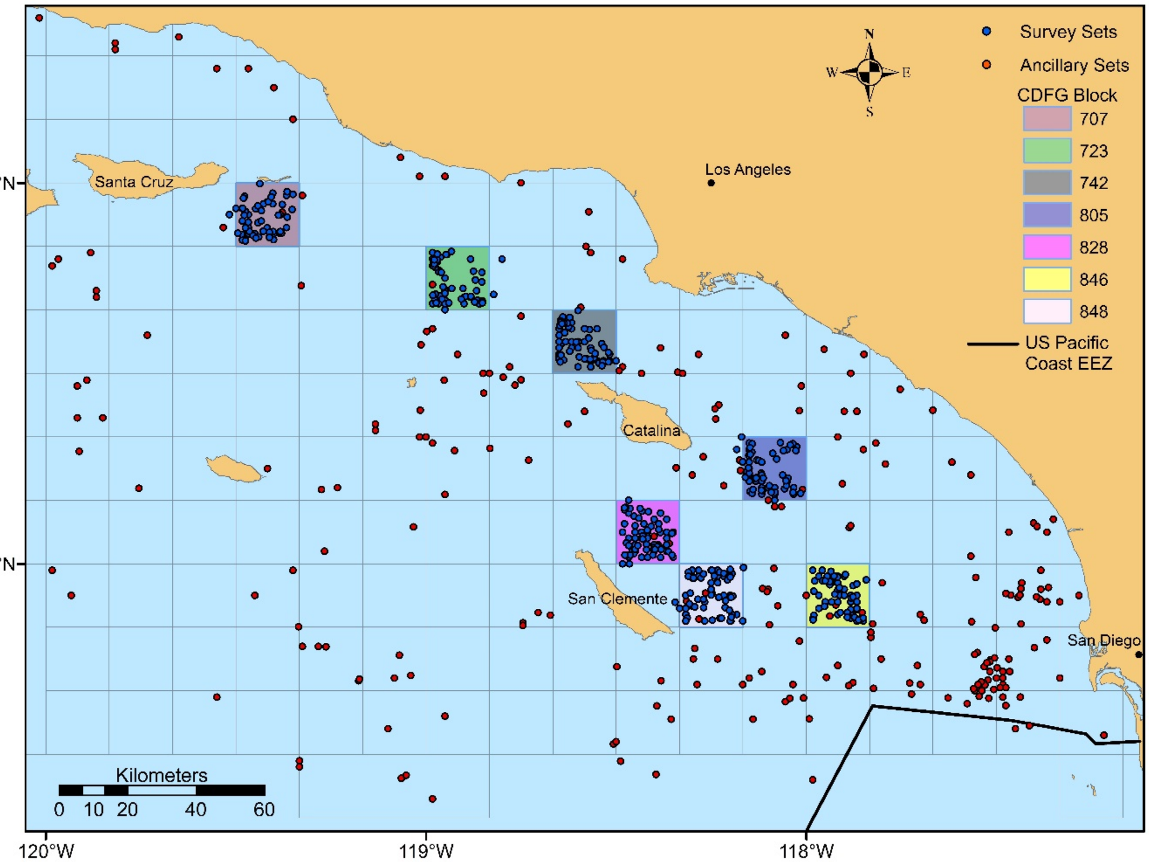
			Recreational Fisheries		
Year	Drift Gillnet	Albacore Troll	Private Sport	CA Charter Boat	OR & WA Charter Boat
1971	0.00		35.2	0.8	
1972	0.00		35.2	0.7	
1973	0.27		35.2	1.0	
1974	0.49		35.2	1.5	
1975	0.40		35.2	4.3	
1976	0.04		35.2	1.7	
1977	0.39		35.2	0.4	
1978	2.04		35.2	4.1	
1979	4.52		35.2	3.9	
1980	11.79		35.2	0.3	
1981	55.08		32.3	1.3	0.0
1982	84.23		17.4	1.1	1.2
1983	124.83		56.0	0.4	0.0
1984	135.33		117.4	0.5	0.0
1985	118.70		235.4	0.3	0.0
1986	376.08		49.8	2.8	0.0
1987	152.15		213.3	8.4	0.0
1988	125.13		411.2	12.2	0.0
1989	128.06		63.4	57.7	0.0
1990	295.88		49.6	34.5	0.0
1991	92.42		49.6	74.8	0.0
1992	132.87		49.6	14.3	0.0
1993	101.47		49.1	9.0	0.1
1994	33.39		46.3	6.5	0.0

1995	157.95		53.4	7.4	0.2
1996	80.56		24.6	6.8	0.3
1997	59.78		67.6	7.7	0.2
1998	96.79	0.01	11.4	3.0	0.7
1999	53.22	0.07	21.1	3.3	0.2
2000	26.66	0.25	40.1	3.4	0.3
2001	17.78	0.09	13.1	3.3	0.4
2002	11.27	0.02	6.2	0.3	0.3
2003	15.16	0.02	13.1	0.7	1.4
2004	10.02	0.04	4.8	0.5	0.9
2005	2.32	0.06	3.6	0.4	0.3
2006	3.31	0.17	4.3	0.5	0.2
2007	27.13	0.05	6.4	0.4	1.5
2008	13.78	0.45	3.2	1.2	0.3
2009	5.22	0.64	2.9	0.4	1.3
2010	3.37	0.62	1.1	2.1	0.1
2011	3.11	0.25	0.7	0.2	0.0
2012	4.97	0.07	2.0	0.3	0.1
2013	2.55	0.05	0.7	0.2	0.3
2014	2.30	0.81	0.7	0.1	0.0
2015	1.08	0.33	0.7	0.2	0.6

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea
Document not to be cited without author's permission.

Figures

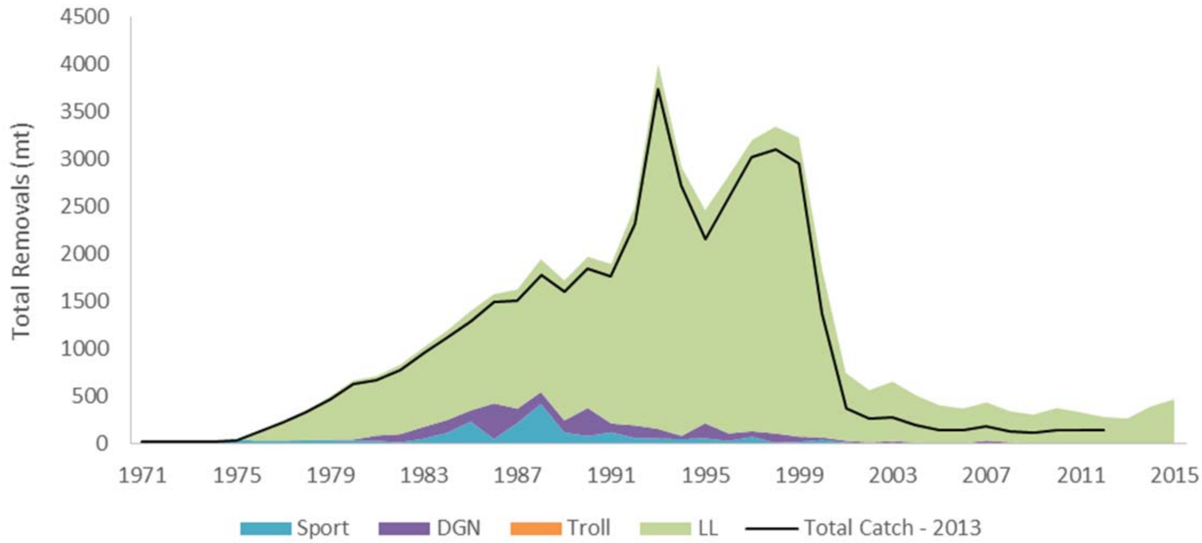
Figure 1. Area of operation for the NOAA Juvenile Shark Survey (from Runcie et al. 2016).



[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

Document not to be cited without author's permission.

Figure 2. Combined estimated U.S. west coast total dead removals (mt) of blue sharks by fishery.



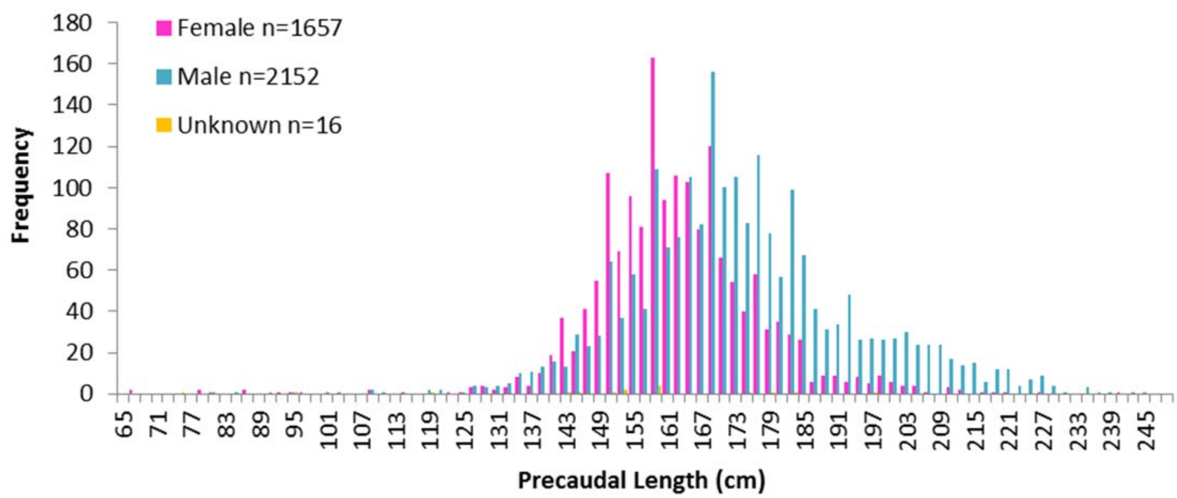
---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

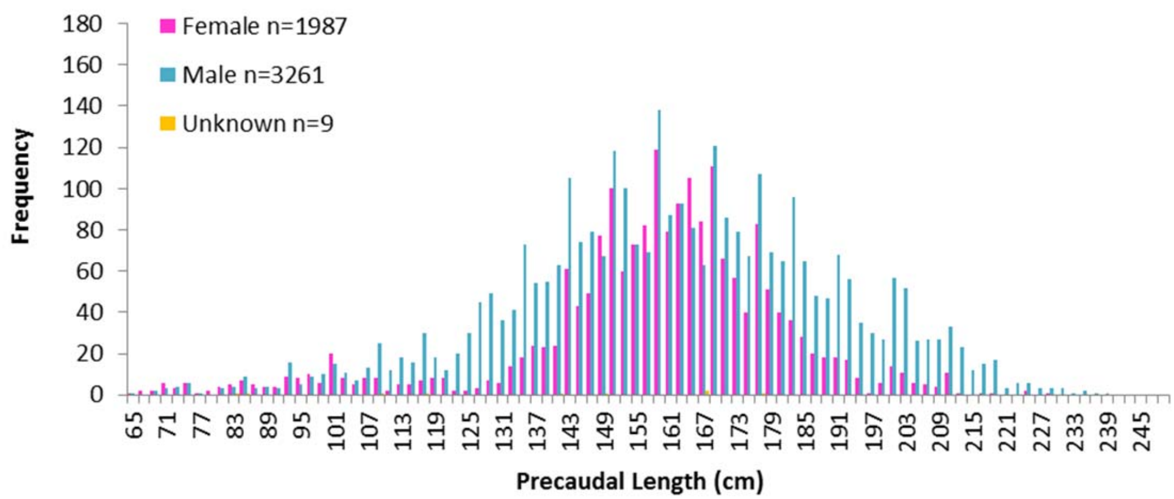
Document not to be cited without author's permission.

Figure 3. Size compositions of blue sharks caught in the Hawaii longline fisheries, 1994-2014.

A) Deep-set



B) Shallow-set

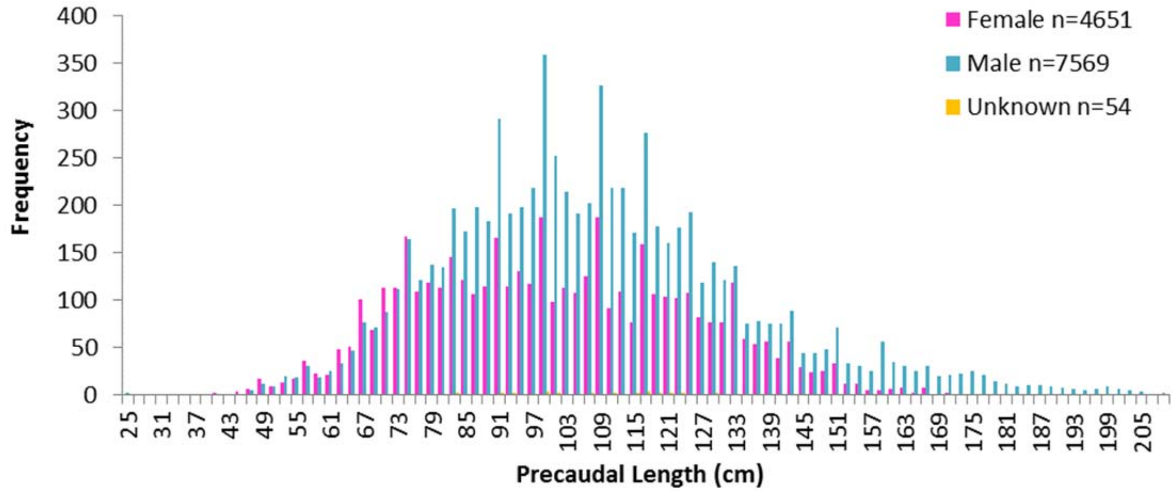


[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

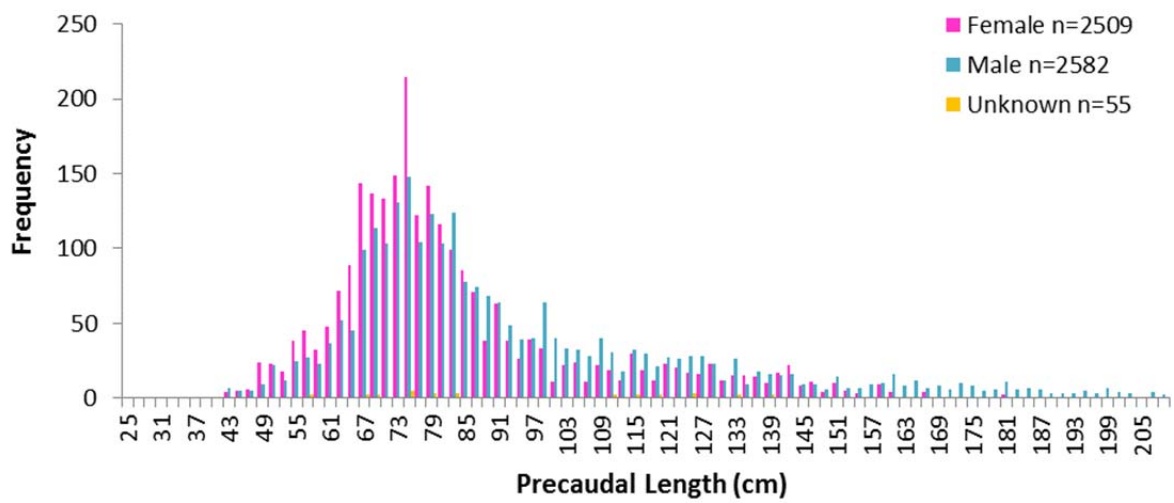
Document not to be cited without author's permission.

Figure 4. Size compositions of blue sharks caught in the drift gillnet fishery (1990-2014) and NOAA juvenile shark survey (1993-2015). Note that the sizes on the x-axis are shifted by 40 cm to smaller values than in Figure 3.

A) Drift gillnet



B) Juvenile shark survey



---

[1]Working document submitted to the ISC Shark Working Group Workshop, 14-21 November 2016, Haeundae Grand Hotel, Haeundae-gu, Busan, South Korea

Document not to be cited without author's permission.