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July 7, 2023

Mr. Eric Sklar, President
California Fish and Game Commission
P.O. Box, 944209
Sacramento, CA 94244-2090

RE: Marine Resources Committee Agenda Item 3: Set Gillnet Bycatch Evaluation

Dear President Sklar and Members of the Commission,

California recently made strong international commitments to be a leader in biodiversity conservation at the United Nations Biodiversity Conference (COP 15).[1] The Marine Life Management Act (MLMA) was intended to be one of the most progressive, ecosystem-based fishery management laws in existence. This Commission, the California legislature, and California voters have all taken decisive action over recent decades to restrict or end the use of destructive, unselective fishing practices off our coast including gillnets, bottom trawls, and pelagic longlines. All around the world, set gillnets are recognized as harmful to marine ecosystems, biodiversity, and vulnerable species. Most recently, Australia[2] and Belize[3] took action to phase out set gillnets from their waters.

Despite the previous bans and current set of regulations, the multi-species California set gillnet fishery continues to have a wide suite of major bycatch concerns that threaten biodiversity, sustainability, other fisheries, and marine ecosystems throughout Southern California. Although there are uncertainties and data gaps, the best available scientific data indicates that new management measures are warranted to ensure the types and amounts of bycatch are reduced to acceptable levels.

Following the Commission's prioritization process that identified the set gillnet fisheries targeting California halibut, white seabass, and Pacific angel shark as 3 of the top 4 highest priorities of all commercial finfish fisheries based on its Ecological Risk Assessment,[4] we appreciate the Department's work on the bycatch analysis and the attention spent by the Marine Resource Committee (MRC) in reviewing set gillnet bycatch over the last two years. However, we are concerned the Department has submitted to the Commission a fundamentally flawed bycatch analysis that downplays serious bycatch concerns and could set a harmful precedent as the first application of the bycatch inquiry in the MLMA Master Plan for Fisheries. Its approach, criteria, and conclusions directly contradict the requirements and precautionary approach of the MLMA. To remedy this problem, we ask the Commission to use the full suite of data before you -- including available data from the federal government as well as analysis provided by other interested parties -- to craft a robust, comprehensive management package to minimize bycatch to acceptable types and amounts.

This letter 1) outlines our concerns with the CDFW Bycatch Evaluation, 2) presents the case for identifying specific types and amounts of bycatch as unacceptable under MLMA criteria, and 3) proposes three alternative suites of management options for reducing bycatch to acceptable levels as required by the MLMA Section 7085.

[1] CNRA 2022. California takes action to protect biodiversity at U.N. negotiations. https://resources.ca.gov/Newsroom/Page-Content/News-List/California-Action-Protect-Biodiversity-UN
[2] https://www.theguardian.com/environment/2023/jun/05/conservationists-welcome-gillnet-fishing-ban-in-great-barrier-reef-world-heritage-area
[3] https://www.pressoffice.gov.bz/statutory-instrument-signed-into-law-to-ban-gill-nets-from-marine-waters/
[4] https://wildlife.ca.gov/Conservation/Marine/MLMA/Master-Plan/Prioritizing-Management-Efforts/Results-of-Fisheries-Prioritization

1. Concerns with CDFW Bycatch Evaluation

The introduction of the report summarizes the MLMA and its innovative features, including "shift[ing] the burden of proof toward demonstrating that fisheries and other activities are sustainable, rather than assuming that exploitation should continue until damage has become clear."[5] Given the history of set gillnets in California and this legal framework, the presumption under uncertainty must be that set gillnet bycatch is unacceptable unless evidence demonstrates it is not.

Our overarching concerns with the bycatch report are:

- Requiring proof that bycatch is causing harmful impacts rather than placing the burden on demonstrating sustainability as required by the MLMA
- Broadly concluding there is low to moderate impact that is justified in a detailed appendix primarily composed of opinions rather than data or analysis
- Ignoring and failing to use the best available science
- Omitting critical information needed to assess the amounts of bycatch, such as cumulative discard and discard mortality rates from the federal fishery observer data
- Not estimating total fishing effort, catch and discard amounts based on the available data, in direct conflict with the MLMA which requires information and analysis of the type and amount of bycatch (FGC 7085(a) and (b)
- Ignoring whale entanglements in California set gillnets
- Declaring all bycatch issues "low, moderate, or unknown." and setting an impossible threshold for "high" risk
- Failing to consider or recommend management measures that would meaningfully reduce bycatch, such as limits to soak times, hard caps on bycatch, catch limits, or area closures
- Failing to clearly identify target, incidental, and bycatch species as per Step 2 of the MLMA Master Plan's Bycatch Inquiry
- Disregarding the need to address or manage the retained "incidental catch" of dozens of species that are part of this multi-species fishery
- Failing to assess cumulative impacts of bycatch on marine ecosystems
- Analyzing 12 of the 125 species caught in set gillnets, excluding key vulnerable species such as soupfin (tope) shark, which is a depleted species with high discard mortality that is a candidate for federal Endangered Species Act listing
- Ignoring the component of the fishery targeting white seabass, even though it is managed under the same permit
- Failing to provide data or estimates of post-release mortality for all species evaluated, and failing to recognize that mortality rates from the observer data are the minimum mortality rates for each species evaluated

Specific concerns with the bycatch evaluation report:

- The analysis and conclusion of the report take the opposite of a precautionary approach, repeatedly arguing that there is no proof of threats to sustainability. The report concludes that bycatch risks from this fishery are low to moderate, while having no estimates of total fishing effort or total catch, a small sample of observer data, and population status information for only a handful of the over one hundred species caught in this fishery. Example statements from the report:
    - p. 20: "There is a lack of scientific evidence that concludes the amount of bycatch mortality is significantly impacting the role that each bycatch species is serving in the ecosystem."

[5] California Marine Life Management Act. https://wildlife.ca.gov/Conservation/Marine/MLMA

- p. A1-40: "No humpback whale has been documented as bycatch in the halibut set gill net fishery in California."
- p. A1-5: For brown smoothhound sharks, the report concludes there is a "Low… probability of mortality exceeding levels that have been scientifically determined to be necessary for the continued viability of the species" with the rationale that "There is no directed fishery for brown smoothhound and 8.5" halibut gillnet mesh has low risk of entanglement as indicated by observer data. The species is fast growing, matures early, and has a relatively large number of pups compared to other shark species. Fishbase.org lists brown smoothhound as having a high vulnerability to fishing." Yet the report also states "There is no status estimate or stock assessment", and the observer data indicates brown smoothhound has the highest number dead discards of all sharks, rays, or skates with discard mortality of 47%. A Productivity Susceptibility Analysis ranked brown smoothhound the second most vulnerable state-managed finfish behind Pacific angel shark (Swasey et al. 2016).[6]
- P. A1-2: The report states there are management measures to ensure sustainability for Pacific angel shark and "The Pacific angel shark is largely protected from fishing pressure. Therefore, it is presumed that the population remains relatively stable in California (ESR)." Yet it also states: "Department PSA completed in 2019 indicated angel shark ranked first in vulnerability among 36 fish and invertebrate species analyzed" and CDFW ranked the set gillnet fishery for Pacific angel shark as the number one priority of all state finfish fisheries in the Ecological Risk Assessment prioritization.[7]

- The analysis and conclusions are not supported by quantitative analysis of available data. Instead, the meat of the report is a series of appendices outlining the opinions of agency staff. Quantitative analysis needs to be included in the report to support the conclusions of low to moderate risk, and any conclusions of low to moderate impact require strong data on catch estimates and stock health. The bycatch evaluation is based on ancillary information and professional opinions, without significant acknowledgment or discussion of potential impacts due to the many unknowns. Step 2 of the bycatch inquiry in the MLMA requires the distinguishing of target and bycatch species. Incidental species under the MLMA must be accounted for and managed as either target species under the sustainability standard outlined in Chapter 5 or as bycatch. The Report does not distinguish between which species will be addressed and managed as target or bycatch species, or any plan for managing target species other than California halibut caught in this fishery. Species that are retained at high rates or landed in high frequency with California halibut should be considered for additional management to ensure sustainable harvest.
- The Humpback whale evaluation (Appendix1I. on page A1-40) concludes that no humpback whales have ever been documented as entangled in this fishery, despite the current Marine Mammal Protection Act listing of this fishery as a Category II fishery driven by the take/serious injury of a humpback whale in 2007. There is ample publicly available data in NMFS reports on whale entanglements on the West Coast, which include an unidentified "gillnet" category. An unknown portion of these records are likely to be the Southern California set gillnet fishery, but this data is not presented or discussed as a potential conservation issue. The report denies that California set gillnets entangle humpback whales, contradicting NMFS conclusion in its Marine Mammal Protection Act Category II listing that the fishery entangles humpback whales. The report completely ignores the federally listed endangered humpback whale Central American Distinct Population Segment that feeds primarily in California and Oregon and contradicts the Department's and NMFS's precautionary whale-safe fisheries policy

[6] Swasey et al. 2016. Productivity and Susceptibility Analysis for Selected California Fisheries. https://www.oceansciencetrust.org/wp-content/uploads/2017/07/CDFW-PSA-Report-on-Select-CA-Fisheries_Final-.pdf
[7] https://wildlife.ca.gov/Conservation/Marine/MLMA/Master-Plan/Prioritizing-Management-Efforts/Results-of-Fisheries-Prioritization

for attributing unidentified entanglements. However, in its draft Conservation Plan for the Dungeness Crab Fishery, CDFW recognizes that the Central American DPS feeds primarily in California and Oregon.[8]

- The report attempts to separate sets targeting halibut vs. white seabass in the federal observer data (the observer program tracks the set gillnet fishery as a single fishery, whereas the report analyzes the data in a halibut-centric way), and fails to provide the total number of observed sets when speaking to number of discarded animals/mortality rates in these halibut-targeting sets. While separating these sets may show minor differences in species compositions of bycatch, ultimately the management required to reduce bycatch in either fishery would have to apply to both the white seabass and halibut fishery, as there is only a general gillnet permit issued for both and the main issue with both fisheries is the high rate of bycatch and mortality. Separating these sets ultimately proved to cause further issues and confusion with the limited data, made it impossible to extrapolate observer data into estimates of total catch for the fleet, and minimized the evaluation of the cumulative impacts of the set gillnet fishery on the marine ecosystem throughout this evaluation process.
- The report does not include an evaluation of cumulative impacts, and omits fundamental data for evaluating bycatch such as the cumulative discard rate and discard mortality for the fishery. The report does not present data on the total number and types of species caught and discarded in the fishery. Cumulative impacts are important to evaluate for the ecosystem-based management approach and sustainability standards of the MLMA.
- The management options recommended in the report have promise, however stronger options that directly reduce bycatch and bycatch mortality per the MLMA are not presented. In the list of 3 options proposed, the only measure that would potentially minimize bycatch is the restriction of transferability of the permits to reduce effort over time, which the report suggests could be a short-term option (3-5 years) or a longer-term option that would eventually sunset the permits over time. The short-term option would ultimately not reduce bycatch. The report is equivocal on the question of whether legislation is necessary to implement this option. In the case with non-selective gear-types such as gillnets, reducing fishing effort may be the simplest avenue towards reducing overall bycatch rate.
- The report sets a nearly impossible and inappropriate bar, as few bycatch concerns would ever warrant a “high” risk rating except for an endangered species with a known decreasing population. Extinction is not the standard for high risk. This is the opposite of precautionary.
- The report incorrectly states “there is an FMP for brown smoothhound” (p. A1-5). No such FMP exists.

2. Identification of Unacceptable Types and Amounts of Bycatch in Set Gillnets

In previous submissions to the Commission, we have identified unacceptable types and amounts of bycatch in the set gillnet fishery based on the four MLMA criteria. Attached to this letter, we provide a detailed analysis of available data to provide supporting evidence.

The following table summarizes the types and amounts of bycatch that are unacceptable in the California set gillnet fishery, identifying which MLMA unacceptability criteria each one meets:

[8] CDFW. Draft Conservation Plan for the California Dungeness Crab Fishery. 2021. p. 35 https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=195798&inline “The Central America DPS breeds along the Pacific coasts of Costa Rica, Panama, Guatemala, El Salvador, Honduras, and Nicaragua and feeds almost exclusively off California and Oregon (81 FR 62260).”

Type and/or Amount of Bycatch	Legality	Sustainability	Other Fisheries	Ecosystem
Take of humpback whales	X	X		
Take of gray whales		X		
Cumulative discard rate of 64% and discard mortality rate of 54%		X		X
Minimum of 125 species taken as bycatch		X		X
Discard mortality of sharks, rays, skates, chimeras (spotted ratfish, brown smoothhound shark, bat ray, soupfin shark, leopard shark, California skate, Pacific angel shark, sevengill shark, gray smoothhound shark, Pacific electric ray, white shark)		X		X
Take and discard mortality of minimum of 150 California sea lions per year		X		X
Discard mortality of California halibut (12% discard rate with 40% mortality rate) and white seabass (91% mortality rate)		X	X	
Discard mortality of Rock Crab and Pacific mackerel			X	
Incidental catch of giant sea bass		X	X	
Incidental catch of juvenile white sharks (25 per year)		X		X
Discard mortality of barred sand bass			X	
Take and Discard mortality of cormorants		X		
Discard and discard mortality of lingcod, cabezon, sheephead, boccacio rockfish, barracuda, kelp bass, white croaker, yellowfin croaker, ocean whitefish, king salmon, Humboldt squid, spiny dogfish)			X	
Incidental catch of species without management measures to ensure sustainability (bat ray, spider crab, common thresher shark, California skate, longnose skate, shovelnose guitarfish, soupfin shark)		X		
Catch of federally managed species that is not accounted for in or subject to federal annual catch limits (Pacific mackerel, leopard shark, longnose skate, California scorpionfish, big skate, boccacio rockfish, copper rockfish, cowcod rockfish, king salmon)	X	X		
Discard mortality of crustaceans (rock crab, spider crab, pointer crab, red rock crab, unidentified crabs and crustaceans)		X		
Lost gear (ghost fishing and marine debris)		X		X

3. Management Recommendations

The lack of at-sea monitoring programs in state fisheries to assess bycatch and integrate data into population and stock models seriously impedes the ability to ensure species are being managed to the sustainability requirements of the MLMA. Where evidence for significant or potentially harmful discards exists, a risk-averse and adaptive management approach is required under the MLMA. Fish and Game Code Section 7085(c) states: “In the case of unacceptable amounts or types of bycatch, conservation and management measures that, in the following priority, do the following: (1) Minimize bycatch. (2) Minimize mortality of discards that cannot be avoided.”

We are concerned with approaches that focus only on improved data collection with a plan to revisit the fishery bycatch data at a future date. Our organization has requested additional management measures in the set gillnet fishery since 2012 and have engaged through the Bycatch Work Group, MLMA Master Plan Revision, Fishery Prioritization, Scaled Management Process for California Halibut, and the Bycatch Evaluation. Given the number of fishery priorities requiring attention and resource constraints at the Department and Commission, we have low confidence that such a re-evaluation will occur, or that any meaningful management would result. There is ample evidence before you to act and we strongly urge additional management measures be put in place now to minimize bycatch in this fishery.

To meet the MLMA requirement to minimize bycatch to acceptable types and amounts, we see three alternative pathways forward. The sheer number of species and bycatch concerns in the fishery means that comprehensive and

intensive management is necessary if the fishery is going to continue. Option 1 is to implement a comprehensive suite of management measures to bring the fishery into the 21st century and ensure sustainability as per the MLMA. Option 2 is to initiate a near-term phase out of the fishery, which would be the simplest solution and minimize management costs. Option 3 is a hybrid approach that phases out the fishery in the long-term, while putting in reasonable measures to control bycatch. We request the Commission analyze and consider each of these options. The following table summarizes the elements of each approach, and each element is described below.

	Option 1: Comprehensive management to MLMA sustainability requirements	**Option 2: Near-term phase out and transition program**	**Option 3: Long-term phase-out with bycatch reduction measures**
Active measures to reduce bycatch and/or bycatch mortality	• 24-hour soak time • Bycatch hard caps • Sustainability measures for incidental species • Prohibition on landings of giant seabass and white shark (with an exception for donating dead white sharks for research)	• Permits expire in 5 years	• Permits fully non-transferable • Retire latent permits • 24-hour soak time • Prohibition on landings of giant seabass and white shark (with an exception for donating dead white sharks for research)
Data collection and monitoring	• 100% Bycatch monitoring (observers and/or video) • Gear marking • Electronic logbooks • Electronic vessel tracking • Data-limited assessments for priority species • Assess gear loss rates	• EFPs to identify new low-bycatch methods	• Pilot observer program with partial, random coverage • Gear marking • Electronic logbooks • Assess lost gear rates • EFPs to identify new low-bycatch methods
Legal Requirements	• Secure Incidental Take Permit for ESA-listed humpback whales	• N/A	• Secure Incidental Take Permit for ESA-listed humpback whales

Fishing Effort Reduction through Permit Phase out.

Gillnets, due to their non-selective design and use in areas of high biodiversity, necessitate complex management due to their high rates of bycatch and use in multispecies fisheries. If such management is not practical due to resource constraints, it may be necessary to phase out permits. In 2018, the Commission supported this approach for the drift gillnet swordfish fishery through the passage of Senate Bill 1017 which established a drift gillnet transition program. This program phased out all state permits over a five-year period, established a transition fund, and collected drift gillnets for recycling. In 2022, with support of this Commission, President Biden signed federal legislation to phase out the remaining federal permits for swordfish drift gillnets.

Alternatively, a longer-term phase out of fishing effort over time would reduce bycatch and discard mortality. Retiring latent permits would ensure the fishery does not increase in size. Prohibiting the transfer of permits for the currently active permit holders of the fishery would slowly decrease effort over the long-term, eventually sunsetting the fishery. However, unlike a near-term phase out, a longer-term approach must be accompanied with additional bycatch reduction and measures and monitoring. This would over-time reduce fishing effort and therefore reduce bycatch impacts; and allow for the natural transition to a cleaner gear-type to supply California halibut.

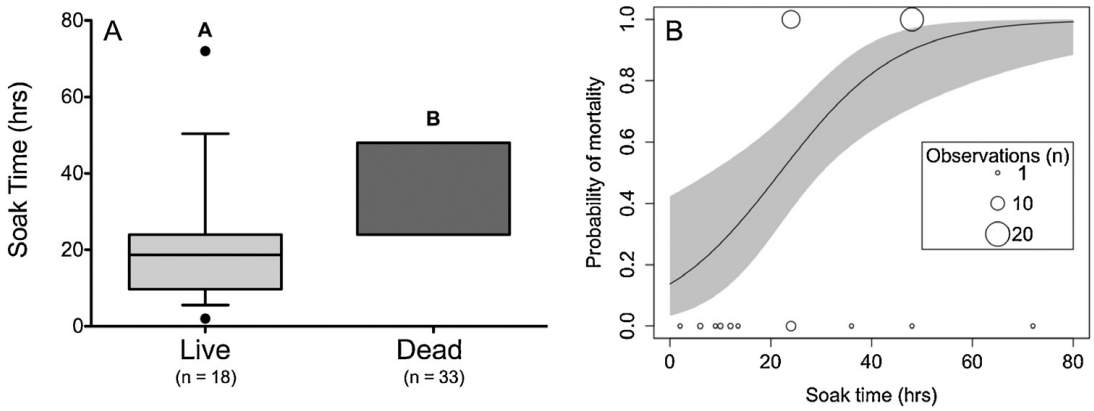
We have heard concerns that phasing out set gillnets would harm fishing communities and result in increased importation of seafood from other countries that may have higher bycatch and/or less regulation. However, there is no evidence to substantiate any of these claims from the experience with the previous bans on set gillnets in state waters in 1994 or off Central California in 2002.

Developing New Methods to Reduce Bycatch

Hook and line gear is already a profitable and viable method for selectively catching California halibut, white seabass, and many other species caught with set gillnets. It has far lower bycatch and lower discard mortality, limiting bycatch to acceptable types and amounts. Many commercial halibut fishermen and all recreational halibut and white seabass fishermen already use hook and line gear. However, we see value in building on this successful method by exploring the potential to scale up the catch rates and volumes of this sustainable gear. For example, in the Pacific halibut fishery in the Pacific northwest, British Columbia, and Alaska, the primary gear type is bottom longlines (trawls and set gillnets are prohibited). In our discussions with current hook and line California halibut fishermen, we have learned that there may be potential to examine this gear type to evaluate whether it can catch California halibut at higher catch rates while minimizing bycatch. The Commission should encourage interested fishermen to develop and test new low-bycatch methods to catch California halibut and white seabass at higher volumes through experimental fishing permits.

24-hour maximum soak time

Reducing the amount of time gear is set underwater can reduce the stress, injury and mortality impacts on more sensitive species. Reducing soak time could also reduce depredation impacts on target and bycatch species, and marine mammal and seabird entanglements from opportunistic predators like sea lions and cormorants. There is direct evidence from the Southern California set gillnet fishery supporting a 24-hour limit on set gillnet soak time to reduce fishing mortality. Lyons et al. 2013 analyzed the effect of several factors on mortality rates of juvenile white sharks in California set gillnets. They concluded soak time was the most important factor determining mortality rates, with statistical significance (See Lyons et al. 2013 Fig. 8). Data provided by the Department on soak times reported in set gillnet fishery logbooks from 2007 to 2022 indicated that 72% of sets are less than 24 hours, while the remaining 28% of sets are greater than 24 hours. Based on these numbers and the significant difference in mortality rates, we estimate that the overall juvenile mortality rate would decrease by approximately 50% if soak times were limited to 24 hours or less (see Table). Arguably this finding would be applicable to other species. For example, other sensitive species with high discard mortality such as the Soupfin shark (64% discard mortality from the Federal observer data)[9] may also benefit from reduced soak durations. Similar to gear tending requirements in other fisheries, there would be an exception during extreme weather events.



Lyons et al. 2013. Fig. 8. The effect of gillnet soak time (all fisheries combined) on juvenile white shark bycatch mortality where (A) average gillnet soak times are compared for gillnet-caught white sharks landed live versus dead and (B) the probability of gillnet-caught white shark mortality relative to gillnet soak times. Panel A: Whiskers represent 10–90th percent quartiles; however, soak times for deceased sharks were only reported as either 24 or 48 h. Letters above bars indicate a significant difference at $p < 0.001$. Panel B: The probability of mortality increased significantly with increases in soak time ($n = 51$; $p = 0.00153$; shaded areas represent 95% confidence intervals).

[9] NMFS. CA Set Gillnet Observer program, observed catch 2007 – 2017. Available :. Accessed June 2023.

	Soak Time	>24 hrs	<24 hrs	Overall mortality rate
Current management	% of sets	2%	72%	40%
	Mortality Rate	90%	20%	
24 hour max soak time	% of sets	0%	100%	20%
	Mortality Rate	90%	20%	

Table. Example calculations based on Lyons et al. 2013[10] white shark mortality rates by soak time and CDFW soak time data from fishery logbooks for California set gillnets targeting California and white seabass 2007-2022.[11] Mortality estimates are approximate. Columns refer to cumulative soak times greater than or less than 24 hours.

Bycatch monitoring by fishery observers and electronic video monitoring

To address the data collection needs for managing this fishery, some version of bycatch monitoring is needed. Bycatch monitoring could be accomplished through a pilot state-run observer program that would document catch and discards of marine animals, as well as information on mesh size, panel length, soak duration, and number of observed sets. Alternatively, the state could work with the existing NMFS West Coast Gillnet Observer Program to increase federal observer coverage and improve data collection protocols. Electronic video monitoring could eventually also be used to collect this data, or a combination of both EM and state observers could be used. 100% observer coverage is necessary to detect and obtain accurate estimates of rare event bycatch of species such as leatherback sea turtles, loggerhead sea turtles, and white sharks.[12]

Bycatch Hard Caps

In the absence of a permit phase-out, hard caps on the bycatch of priority and sensitive species are an essential tool ensure that bycatch in the fishery does not exceed specified levels to ensure sustainability and acceptable types and amounts of bycatch. Hard caps can be set at the fleetwide or vessel level and require 100% bycatch monitoring using human observers and/or electronic video monitoring. There is strong precedent for this approach in fisheries with bycatch concerns. The federal west coast groundfish bottom fishery requires 100% observer coverage or electronic video monitoring to enforce individual quotas ("catch shares") by species for each vessel. The Hawaii shallow-set pelagic longline fishery requires 100% observer coverage to enforce hard caps on endangered leatherback and loggerhead sea turtle interactions. Species for which hard caps should apply in the set gillnet fishery include humpback whales, gray whales, white sharks, sea lions, giant seabass, tope sharks, seabirds, sea turtles, dolphins, and others.

Gear marking

We support the Department report recommendation to require set gillnet gear marking to allow for identification of gillnets involved in wildlife entanglements. The set gillnet fishery operates in Biologically Important Areas for several whale species that migrate and feed on the West Coast, and NMFS has designated the fishery a Category II fishery under

[10] Lyons, K., et al., The degree and result of gillnet fishery interactions with juvenile white sharks in southern California assessed by fishery-independent and -dependent methods. Fish. Res. (2013) http://dx.doi.org/10.1016/j.fishres.2013.07.009
[11] CDFW data request, 2023. Soak Duration in the CA Set Gillnet Fishery, 2007-2022.
[12] Carretta and Curtis paper.

the Marine Mammal Protection Act due to interactions with ESA listed humpback whales.[13] It is currently unlikely to identify gillnet whale entanglements to the California set gillnet fishery due to inadequate gear-marking of the current fisheries and the difficulty of the disentanglement operations to get clear photos of the gear. In addition to current gear-marking requirements, a unique mesh-netting should be selected for the California set gillnet fishery that would distinguish the nets from other gillnet fisheries (such as Mexico's CA halibut set gillnet fishery). A standardized mesh net color, in addition to unique identification numbers or patterns along cork lines and buoys, may help address concerns related to unidentified set gillnets in marine mammal entanglements. Gear-marking improvements should be reviewed by NMFS's entanglement response team to ensure the changes meet their identification needs during whale entanglement operations.

Additional Logbook data requirements

Additional logbook requirements that would support management of the fishery should be implemented. In addition to ensuring current logbook requirements are enforced, logbook reporting should also include the net length, mesh size, and soak duration for each set, as well as the number of sets that occurred during each fishing trip. This data would inform total fleetwide fishing effort estimates, and total catch and bycatch estimates.

Data-limited assessments for priority species

One of the primary focal points of the MLMA Master Plan Revisions was to develop new data-limited tools to assess species sustainability. Priority species should be identified for data-limited assessments, with particular attention on species that are incidentally landed and/or discarded at high rates.

Lost Gear

Set gillnets are collected in the California Lost Fishing Gear Recovery Project. Lost set gillnets, sometimes referred to as "ghost gear" are marine debris that are documented off California to entangle fish, crabs, lobster, and birds.[14] This represents additional bycatch mortality that is not included in fishery observer data estimates of bycatch. The Department needs to monitor gear tags which are required to be placed on each set gillnet and must be returned to CDFW at the end of each 1-2 fishing seasons. Unreturned tags would indicate lost gear.

Incidental Take Permit for ESA-Listed Humpback Whales

The legality of bycatch is one of the four criteria in determining bycatch acceptability under the MLMA. The federal Endangered Species Act prohibits the take of an endangered species without an incidental take permit (ITP). The set gillnet fishery takes humpback whales in California, which include the endangered Central American DPS and the threatened Mexico DPS. Recently, the lack of an ITP for the California Dungeness crab fishery to entangle endangered whales and sea turtles resulted in litigation and a subsequent court settlement. As a result, the Department is currently applying for an ITP and submitting a Conservation Plan to NMFS for that fishery. The Department must also initiate a similar process for the California set gillnet fishery and other fisheries that entangle endangered whales and sea turtles.

[13] NMFS. CA Halibut, White Seabass and Other Species Set Gillnet (>3.5 in mesh) - MMPA List of Fisheries. Available: https://www.fisheries.noaa.gov/national/marine-mammal-protection/ca-halibut-white-seabass-and-other-species-set-gillnet-35-mesh Accessed: June 2023.
[14] UC Davis Lost Gear Retrieval. 2022. Accessed Feb 2023. https://www.ucdavis.edu/climate/news/tons-lost-fishing-gear-recovered-southern-california-coast

Conclusion

A precautionary approach is required under the MLMA where evidence is lacking to demonstrate sustainability. It is clear there need to be management changes to reduce bycatch in the California set gillnet fishery. We remain committed to working through this process with the Department, the Commission, fishery participants, and other stakeholders to find a path forward that minimizes bycatch while promoting robust fishing communities and opportunities. Together, we can build on all the work to date to ensure California remains a leader in biodiversity protection and ecosystem-based fishery management under the MLMA.

Sincerely,

Geoffrey Shester, Ph.D.
California Campaign Director & Senior Scientist

Caitlynn Birch
Pacific Marine Scientist

Attachment: Oceana Bycatch Data Analysis of the California Set Gillnet Fishery by Caitlynn Birch and Geoff Shester

Oceana Bycatch Data Analysis of The California Set Gillnet Fishery

By Caitlynn Birch and Geoffrey Shester, Ph.D.

July 7, 2023

Background

All around the world, set gillnets are recognized as harmful to marine ecosystems, biodiversity, and vulnerable species. [1] Compared to other gear-types, bottom set gillnets continue to pose some of the most complex management and conservation challenges.[2]

Through the state's scaled management process as outlined in the Marine Life Management Act's (MLMA) Master Plan for Fisheries, the California set gillnet fishery rose to the top of the priority list of fisheries in need of updated management due to potential ecosystem risk.

The commercial California set gillnet fishery is a single permit fishery (General Gill/Trammel Net Permit issued by CDFW) that targets and lands multiple species. Under this permit, fishermen may fish with 6.5 inch mesh to target white seabass or 8.5 inch mesh to target California halibut. However, multiple species are retained with both mesh sizes and the fishery is considered a multi-species target fishery. Nets may be up to 6,000 feet long and are anchored to the seafloor at each end. After nearshore and depth restriction closures in Southern and Central California in 1994 and 2002, the current fishery operates in Southern California federal waters (3-200 nautical miles [nm]) south of Point Arguello and in state waters outside of 1nm from the Channel Islands. In 2022, there were 100 set gillnet permit holders, and of these there are 32 active vessels in the set gillnet fishery that have recently landed halibut. This fishery is under jurisdiction of and managed by the state of California through the California Fish and Game Commission (CFGC) and California Department of Fish and Wildlife (CDFW).

This document is intended to support a holistic view of the publicly available information on bycatch and catch compositions in the California set gillnet fishery, and to support the MLMA Master Plan's bycatch inquiry[3] to help inform bycatch acceptability under the MLMA criteria (MLMA Section 7085) as part of the state's ecosystem-based management objectives.

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[3] Marine Life Management Act, Master Plan for Fisheries, Chapter 6. Ecosystem Based Objectives: limiting bycatch to acceptable types and amounts. https://mlmamasterplan.com/6-ecosystem-based-objectives/#limiting

Available Data

Publicly Available Federal Observer Data

We analyzed publicly available federal observer data collected by National Marine Fisheries Service (NMFS), which placed trained independent fishery observers on the commercial California halibut and white seabass set gillnet fishery from 2007 to 2017 for set gillnet vessels operating in southern California.[4] Observer data is available back to 1990, however, the 2007-2017 period reflects the fishery under current regulations. Over this 11-year period, the observer program was active in 6 years: 2007, 2009-2013, and 2017. This data is reported by number of animals caught, kept, and returned. Observers evaluate the mortality of all individual animals returned (discarded) (returned dead, returned alive, returned unknown). The bycatch and catch are not recorded by weight. NMFS observers are placed on vessels for the primary purpose of estimating marine mammal interactions, under the authority of the Marine Mammal Protection Act. However, all species caught are recorded and documented. California halibut and white seabass are targeted via different mesh sizes, however, the observer program aggregates all data from both mesh sizes. NMFS considers the set gillnet fishery a single fishery under their Marine Mammal Protection Act List of Fisheries. The observer program measures fishing effort in number of sets. A set is a single deployment and retrieval of a set gillnet. One or more sets may occur on each fishing trip. Observed sets are aggregated by year, and do not provide spatial information, soak duration (duration net is left underwater to fish), or panel length. In addition, the observer program records the number of sets observed during each year, and estimates the total number of fleetwide sets in 3 of the 6 observed years, but did not estimate fleetwide sets for the last 3 years (2012, 2013, 2017).

Year	Number Sets Observed	Estimated Total Sets	Percentage Observed
2007	248	1,387	17.8%
2010	216	1,724	12.5%
2011	171	2,123	8.1%
2012	250	Not estimated	Unknown
2013	169	Not estimated	Unknown
2017	204	Not estimated	Unknown

Table 1. National Marine Fisheries Service (NMFS) Set Gillnet Observer program 2007 – 2017; number of sets observed each year during that period, and the NMFS estimated total number of fleetwide sets for 2007, 2010, and 2011. NMFS was unable to estimate total number of fleetwide sets for the years 2012, 2013, and 2017. Total sets observed over the 6 years observed are 1,258 sets.

Total Landings Days Data

Total landings days, or trips, were provided by the California Department of Fish and Wildlife for the set gillnet fishery for the period of 2007 – 2021 (Table 2).[5] This data was summarized by year and by mesh size. Since multiple sets may occur on each trip, the number of sets these trips represent is unknown. For 2007 - 2016 the large-mesh and small-mesh set gillnet trips were combined due to logbook reporting at the time. Logbook reporting requirements changed after 2016 and were then separated by mesh-size, although some trips were still reported as combined small and large mesh in the subsequent years after the reporting change. Large mesh (>8in) set gillnet trips are considered California halibut

[4] National Marine Fisheries Service. Accessed 2022. California Set Gillnet Observer Program, Observed Catch 2007-01-01 to 2017-12-31. Available: https://media.fisheries.noaa.gov/2022- 01/setnet-catch-summaries-2007-2010-2013-2017.pdf *observer data is recorded by number of animals
[5] CDFW data request. Total Landing days/trips annually in the CA set gillnet fishery. 2022.

targeting trips and small-mesh (6-7.9in) trips considered white seabass and yellowtail targeting trips. As the publicly available federal observer data does not distinguish between halibut and white seabass targeting trips, both large-mesh and small-mesh trips were combined to produce an estimate of total effort in number of total fleetwide trips per year for the set gillnet fishery.

Year	Set* (small & large)	Large-mesh Set	Small-mesh Set	Total Set Net Trips
2007	1,945			1,945
2008	1,936			1,936
2009	2,131			2,131
2010	1,587			1,587
2011	2,096			2,096
2012	1,752			1,752
2013	1,720			1,720
2014	1,243			1,243
2015	1,076			1,076
2016	1,136	214	115	1,465
2017	112	859	379	1,350
2018	91	1,178	387	1,656
2019		1,395	299	1,694
2020		1,312	284	1,596
2021		1,356	196	1,552

Table 2. Total landing days or trips annually in the California set gillnet fishery. Data were summarized as count of unique date/captain/vessel/gear combinations by year, each indicating one day of landing (i.e. one trip) by a single individual. Provided by CDFW, 2022.

Protected Species Data

In addition to protected species counts and species documented in the federal observer data, we sourced expanded estimates of marine mammal, seabird and white shark take, and whale entanglement records (not expanded) from federal reports.

Marine mammals

We sourced expanded estimates of marine mammal take associated with the set gillnet fishery based on observed interactions from the most recent Stock Assessment Reports for the four marine mammal species in the federal observer data: CA sea lion[6], harbor seal[7], long beaked common dolphin[8], short beaked common dolphin[9].

Whale entanglement records were sourced from the Marine Mammal Protection Act List of Fisheries[10] as well as NOAA Fisheries Whale Entanglement Records on the U.S. West Coast.[11]

[6] NMFS. 2019. Marine Mammal Stock Assessment Reports by Species/Stock: CALIFORNIA SEA LION (Zalophus californianus): U.S. Stock. NOAA Fisheries. https://media.fisheries.noaa.gov/dam-migration/ca_sea_lion_final_2018_sar.pdf. Accessed November 2022. *estimates by fishery located in Table 1.
[7] NMFS. 2014. Marine Mammal Stock Assessment Reports by Species/Stock: HABOR SEAL: California Stock. NOAA Fisheries. https://media.fisheries.noaa.gov/dam-migration/po2014sehr-ca_508.pdf
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[11] NMFS. 2021. Large whale entanglements off the U.S. West Coast, from 1982-2017. Saez, L., D. Lawson, and M. DeAngelis. NOAA Tech. Memo. NMFS-OPR-63A, 50 p. Updated through 2022 by NMFS. 2023. NOAA Fisheries Whale Entanglement Response Program. Official Report. L. Saez,. Jan 2023.

Seabirds

In addition to observed seabirds in the federal observer data, we sourced expanded seabird estimates from the National Bycatch Report database, though expanded estimates are only available for two of the six years observed (2011, 2012).[12]

White shark

We sourced expanded estimates of white shark catch from the Status Review of the Northeastern Pacific Population of White Sharks (Carcharodon Carcharias) under the Endangered Species Act, which estimated total juvenile white shark catch from fishery logbooks.[13] Data from this report was sourced from Table 4.3, and expanded estimates are only available through 2011. We requested updated data from CDFW, however, data since 2011 were not released due to asserted confidentially concerns.

Methods

Catch Compositions

To calculate catch compositions from the federal fishery observer data we analyzed the species groups present in the catch, examined the composition of catch that is kept versus discarded, and evaluated discard mortality across species and species groups.

Species Groups

We categorized the observer data into several species groups for different purposes: taxonomic or ecological similarities and management considerations. Taxonomic groups included marine mammals, seabirds, bony fish, Chondrichthyes (sharks, skates, rays, chimeras), and invertebrates. Management consideration categories differed depending on the purpose of analysis. Under the MLMA, incidentally caught species must be managed as either bycatch or as target species. For this purpose we identified incidentally caught and landed species that should be considered for management as "target species" due to their high catch volume and retainment rate. For catch composition analyses, incidentally caught and retained individuals were separated from incidentally caught and discarded individuals.

Composition of Catch Kept vs. Discarded

The observer data was used to determine the composition of the catch that is kept by the fishers versus the portion that is discarded. Kept catch refers to the species that are retained for sale or consumption, while discarded catch includes species that are discarded at sea due to various reasons, such as regulatory requirements, market preferences, damaged individuals, or undersized individuals. To understand the portion of retained catch that is considered "target" species catch versus "incidental" species catch, we also separated the retained catch by target and non-target species in some cases.

Discard Rate and Mortality Rate

We calculated discard rate by species, by species group, and in aggregate as the number of individuals discarded divided by the total number of individuals caught.

Discard mortality rate is available for all species in the federal observer dataset, defined as the number of individuals discarded dead divided by the total number of individuals discarded. Discard mortality rate can be achieved through observer programs which document the mortality of the animal as it is discarded. Post-release mortality is additional mortality that occurs after the species is released alive, caused by injury, stress or predation. Post-release mortality is

[12] NMFS. National Bycatch Report Database, Seabird Bycatch by Fishery 2011, 2012, Update 2. https://appsst.fisheries.noaa.gov/stapex/f?p=243:101:29602220642274: Accessed August 2022

[13] Dewar et al. 2013. Status Review of the Northeastern Pacific Population of White Sharks (Carcharodon Carcharias) under the Endangered Species Act, 2013. https://repository.library.noaa.gov/view/noaa/17705. Table 4.3 Average estimated catches from U.S. west coast set nets 2001-2011.

generally not known and requires species and fishing-gear specific studies conducted in labs, with tracking devices, or tanks on vessels. However, post-release discard mortality can be a significant source of additional mortality. In the absence of post-release mortality information, the discard mortality rate must be understood as the minimum mortality rate for the species discarded.

We calculated discard mortality rate for the total observer dataset across all species combined, across species groups, and for individual species.

Catch Composition Across Species

Calculating catch composition across different species involves analyzing the observer data to determine the relative proportions of each species within the overall catch. By aggregating the data annually or across total observed years, we generated catch composition estimates for different species. These estimates can be expressed as proportions or percentages of the total catch, providing insights into the species' relative contribution to the overall catch.

By analyzing catch compositions across species groups, the composition of catch kept versus discarded, and across different species, valuable information is obtained for fisheries management, conservation, and scientific assessments. These simple calculations aid in understanding the species interactions, identifying bycatch concerns, evaluating the impact of fishing practices, and can inform effective management strategies.

Spatial and Soak Time Data

We requested data on soak durations of the CA set gillnet fishery from CDFW which was provided as a range of soak times and frequency reported in logbooks for sets occurring in the California set gillnet fishery (CA halibut and white seabass) from 2007 to 2022.[14] This was analyzed to understand the proportion of sets with soak times under 25 hours already occurring in the set gillnet fishery.

Spatial extent of the fishery was estimated using GIS from known depth restrictions for the gear, and current regulations. CDFW also provided a map of fishing effort by block and halibut landings for comparison.[15]

Total Effort and Total Catch Estimates

A management challenge with the California set gillnet fishery and the available data is estimating total fishing effort in consistent metrics with observed effort. The Bycatch Inquiry of the MLMA states that the "types and amounts" of bycatch must be evaluated to determine the acceptability of the bycatch. To achieve accurate "amounts" of bycatch the available observer data must be extrapolated to estimate total fleetwide catch and discarded catch using estimates of total effort.

Estimating total fishing effort can be done in several different approaches depending on the gear type and availability of data. For gillnets for which net length and soak duration are variable for each set, the best estimate of standardized fishing effort is net soak hours and net length per unit set, which could be extrapolated to the total fleetwide sets deployed during a given period.

The publicly available observer data collected from 2007 – 2017 is recorded by number of sets observed, and does not include soak duration or net length. Additionally, the observer program only estimated total number of fishing sets per year for 3 of the 6 years observed, and both CDFW and NMFS analysts have indicated those estimates of total sets are highly uncertain.

[14] CDFW data request, 2023. Soak Duration in the CA Set Gillnet Fishery, 2007-2022.

[15] CDFW, pers. comms. 2023. Set gillnet fishing effort associated with CA halibut landings 2007 – 2017.

Further complicating total effort estimates, The California Department of Fish and Wildlife (CDFW) has been tracking total effort of the fishery in number of trips, or number of times a vessel lands catch. In 1 trip, multiple sets may be occurring depending on where the fisher is fishing, how many times the nets were deployed and retrieved, weather conditions and success of fishing effort.

Due to data gaps in fishing effort, accurate catch per unit effort (CPUE), a standard metric in fishery management used to achieve both target and non-target total catch in a given fishery, is difficult to achieve for the set gillnet fishery.

Based on the limits in available data, one approach is to use the CDFW annual trip counts to develop a minimum, lower-bound estimate of total effort that can be used to generate minimum, lower-bound estimates of total catch and discards. Following this approach, we assumed that 1 trip is equivalent to 1 set, and used the CDFW provided total number of fishing trips per year as an estimate of total fishing sets per year. From this, we calculated the annual mean number of sets that occurred over that period. We multiplied the annual mean effort by the previously calculated CPUE based upon observer data, and were able to estimate total annual fleetwide catch. These estimates should be considered minimum estimates with the understanding that one trip can represent multiple sets. This method for developing minimum total catch estimates based on assuming 1 trip = 1 set was recommended as a viable approach in consultations with Department and Commission data analysts and a NMFS bycatch data analysist. They should not be viewed as central or absolute estimates.

In the future management of this fishery, fishery managers should consider better data collection efforts to estimate total fleetwide fishing effort. Total fishing effort is a standard tool of fishery management to assess impacts on both target species and bycatch species, as well as inform better stock assessments and more informed management decisions.

Spatial Extent of Fishing Effort

The California set gillnet fishery operates in Southern California federal waters (3-200nm offshore) and outside of 1nm of the Channel Islands. Depths deeper than 60 fathoms are typically too deep to fish using set gillnets.

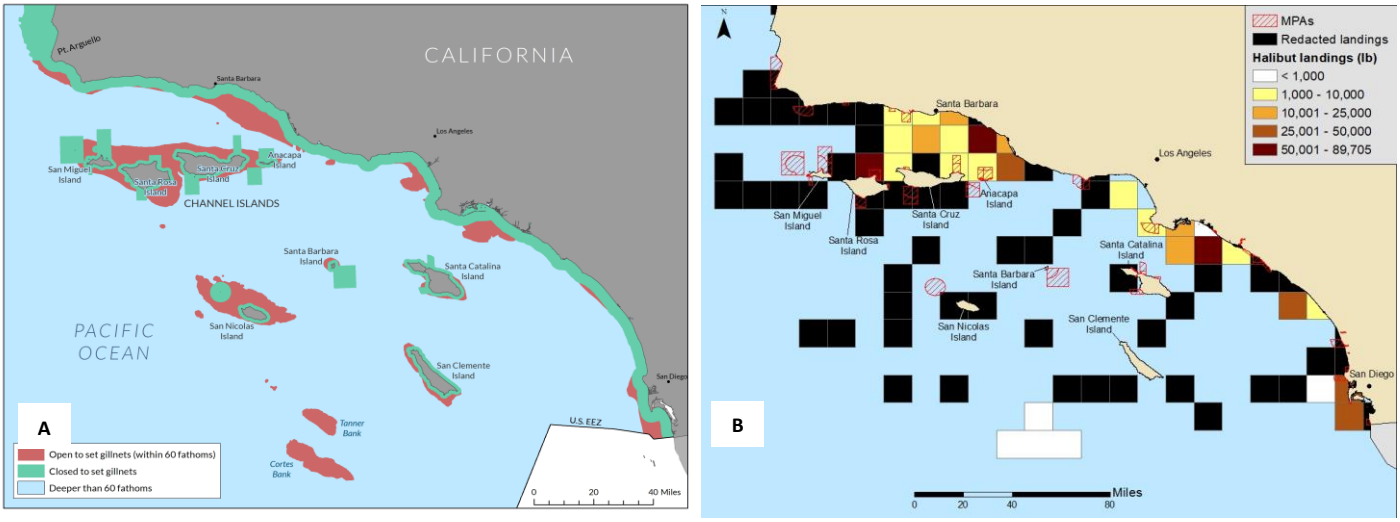

Figure 1. Map (A) produced by Oceana depicts a spatial approximates of areas of potential set gillnet fishing (for both CA halibut and white seabass) in Southern California based on depths (shallower than 60 fathoms) and current regulations. Areas in red are areas open to set gillnet fishing and shallower than 60 fathoms. Map (B) produced by the California Department of Fish and Wildlife shows fishing effort in California halibut landings by spatial block for the CA halibut set gillnet fishery (CDFW, 2023).[16] Black blocks indicate areas where set gillnet effort occurred, but do not show landings for confidentiality purposes.

[16] CDFW, pers. comms. 2023. Set gillnet fishing effort associated with CA halibut landings 2007 – 2017.

Results and Discussion

Soak Time

The duration that nets are set and left underwater can have an impact on mortality of the catch. From available soak time data, approximately 73% of sets occurring in the fishery are less than 25 hours in length, 26% of sets are between 26-50 hours in length, and 6% of sets are left to soak for more than 50 hours.

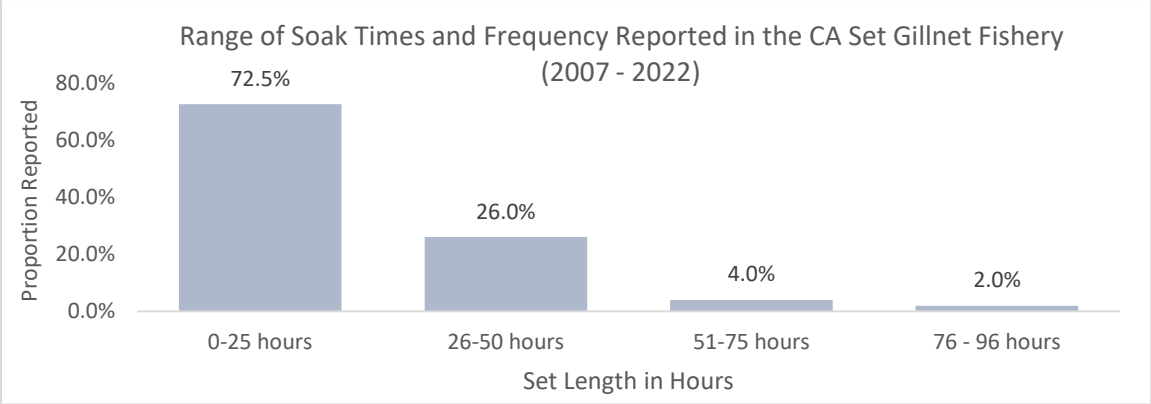

Figure 2. Range of soak times and frequency reported for sets occurring in the California set gillnet fishery (CA halibut and white seabass) from 2007 to 2022 (CDFW, 2023)[17]. Reported soak times may be subject to inaccuracies as they are based on self-reported data from gillnet logbooks. In cases where data were provided as <1%, we assumed 0.5%.

Catch and Bycatch Compositions from Raw Observer data

Federal observer data was used to understand general catch and bycatch compositions, discard mortality, and trends in which species are generally kept or discarded.

Over the 6 years of available data, 1,258 sets were observed in the CA set gillnet fishery, or an average of 210 sets per year observed. Over these 1,258 sets, 18,255 animals were caught, 6,530 were retained, and 11,725 were discarded. Of the 11,725 animals discarded, 6,359 were discarded dead, 5,127 were alive at the time of discard, and 239 had an unknown mortality status upon discarding (Table 9, Appendix).

Discard rate, or the proportion of total catch that is not retained, is generally used as a measure of waste or ecological impact, allowing for comparisons across fisheries.[18] From federal observer data of the set gillnet fishery, the aggregate discard rate across all species ranges from 51% to 72% over the 6 years observed, and retention rates range from 28% to 49% (Table 3).

Year	% Discarded	% Retained	% Discard mortality
2007	65	35	50
2010	70	30	71
2011	51	49	57
2012	63	37	36
2013	72	28	43
2017	61	39	56
Total across all years	**64**	**36**	**54**

Table 3. Annual discard rate and percent discard mortality rate aggregated for all catch for each year observed based on federal observer data of the CA set gillnet fishery.

[17] CDFW data request, 2023. Soak Duration in the CA Set Gillnet Fishery, 2007-2022.
[18] U.S. National Bycatch Report. Corporate Author(s): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; Published Date: 2011; Series: NOAA technical memorandum NMFS-F/ SPO; 117E.

Aggregated over the 6 years, 64% of all catch has been discarded and 36% retained. Of the total percent retained for all years, 21% is made up of California halibut and white seabass, the primary target species, and 15% consists of other incidentally retained species (Figure 3.)

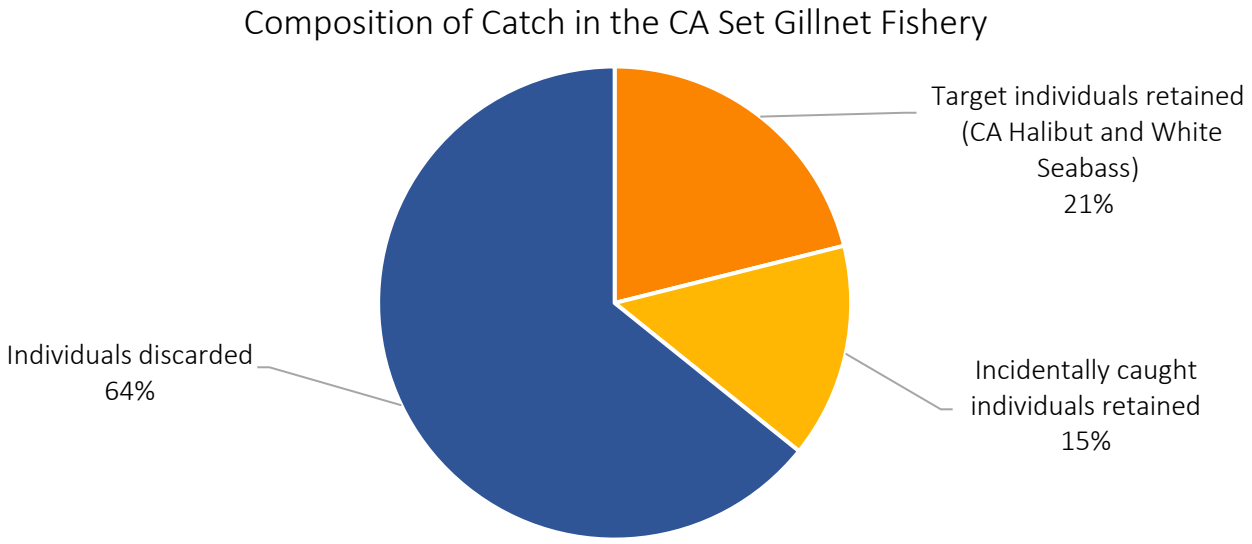

Figure 3. Catch composition of observed catch by number of animals, separated into three categories: retained CA halibut and white seabass, retained incidental individuals, and discarded individuals. Based upon 6 years of federal observer data 2007 – 2017.[19]

Of the total discarded catch by number of animals, the majority (41%) is made up of invertebrate species, followed by cartilaginous fish (Chondrichthyes) species (29%) and bony fish species (29%). Marine mammal and seabirds, from the observer data, make up 1% of total discarded catch by number of animals (Figure 4).

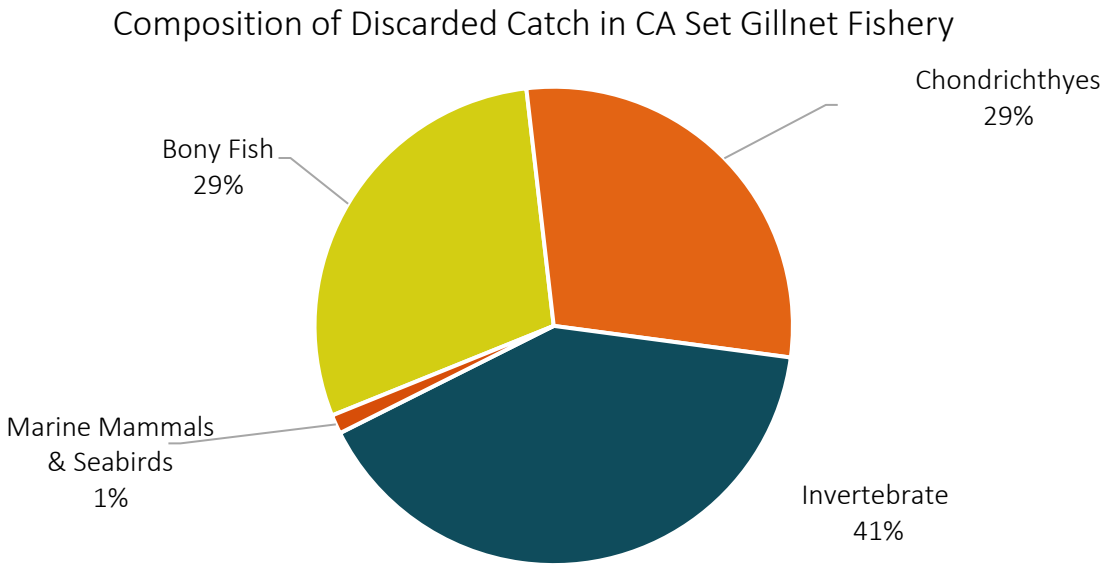

Figure 4. Composition of discarded catch in the CA set gillnet fishery based upon federal observer data 2007 – 2017.[15] *Categories of catch include bony fish, marine mammals and seabirds, Chondrichthyes, and invertebrates.*

[19] National Marine Fisheries Service. Accessed 2022. California Set Gillnet Observer Program, Observed Catch 2007-01-01 to 2017-12-31. Available: https://media.fisheries.noaa.gov/2022- 01/setnet-catch-summaries-2007-2010-2013-2017.pdf *observer data is recorded by number of animals

Of the top most frequently discarded species in the observer data, 9 are Chondrichthyes species (sharks, skates, rays and chimeras), 8 are invertebrate species (crab, squid, sea stars, and sea snails), and 3 are bony fish species (P. mackerel, Scorpionfish, and California halibut).

Top Discarded Species	Observed Discarded (over 1,258 sets)	Discard Mortality Rate
1. Pacific Mackerel	2126	98.7%
2. Rock Crab	1280	56.4%
3. Jumbo (Humboldt) Squid	847	88.9%
4. Spider Crab	845	49.8%
5. Swell Shark	731	2.1%
6. Pointer Crab	646	81.4%
7. California Skate	391	8.7%
8. Sea Star	382	0.3%
9. Bat Ray	376	20.5%
10. Spiny Dogfish	336	35.7%
11. Longnose Skate	307	23.1%
12. Brown Smoothhound Shark	284	47.2%
13. Whelk	240	2.1%
14. Pacific Angel Shark	216	13.9%
15. Spotted Ratfish	199	67.3%
16. Red Rock Crab	179	92.2%
17. Yellow Crab	137	58.4%
18. California Halibut	121	39.7%
19. California Scorpionfish	119	41.2%
20. Leopard Shark	108	45.4%

Table 4. Top 20 discarded species ranked by number of animals discarded in the federal observer data.[20]

Discard Mortality

For this fishery based on observer data, total discard mortality rate across all six years for all species discarded is 54.2%, meaning that of all sets observed, over half of the animals thrown back were considered dead by the observer upon discarding. These do not include any estimates or assumptions of post-release mortality. The discard mortality rate varies across years however, and ranges from as low as 36% and up to 71% in certain years. The overall discard mortality rate can be driven by certain species that are caught and discarded in high numbers and have high mortality rates.

Discard mortality rate varies greatly across species groups and for individual species (Figure 5 & Table 5). Marine mammals and seabirds had the highest observed discard morality rate at 97%. Bony fish species across the 1,258 sets observed had a 78% discard mortality rate; invertebrate species had a discard mortality rate of 62%, and Chondrichthyes had a discard mortality rate of 22%.

[20] National Marine Fisheries Service. Accessed 2022. California Set Gillnet Observer Program, Observed Catch 2007-01-01 to 2017-12-31. Available: https://media.fisheries.noaa.gov/2022- 01/setnet-catch-summaries-2007-2010-2013-2017.pdf *observer data is recorded by number of animals

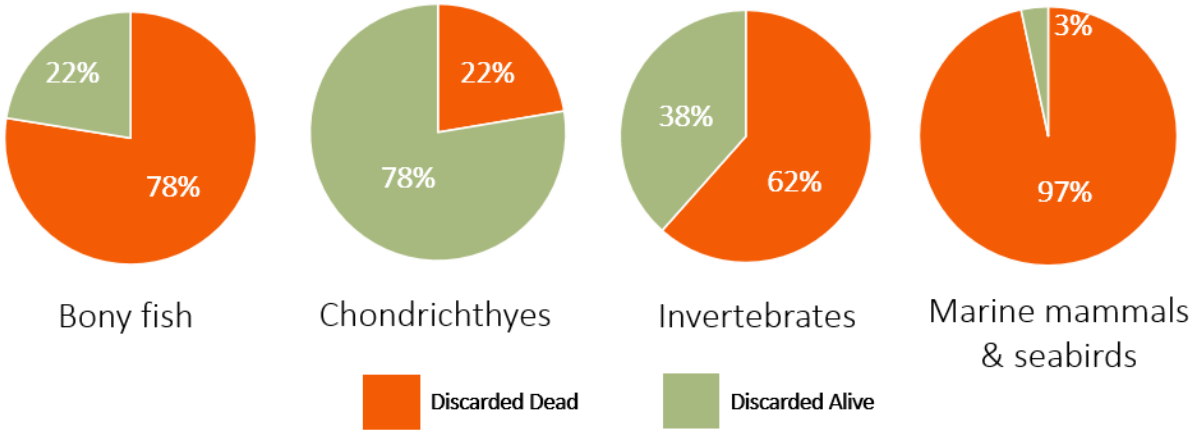

Figure 5. Discard mortality rate based on federal observer data across species groups: Bony fish, Chondrichthyes, Invertebrates, and Marine Mammals and Seabirds.[21]

The high discard mortality rate among the observed bony fish is likely being driven by Pacific mackerel, which have a high discard mortality rate (98.7%) and are caught in high numbers in some observed years. Conversely, the low discard mortality rate across all Chondrichthyes species caught is likely being driven by the high rate of survival of the most caught and discarded sharks species, the swell shark, which has a discard mortality rate of 2%. Other shark and ray species have much higher discard mortality rates, such as the Soupfin shark (64% discard mortality rate) and the Leopard shark (45% discard mortality rate), but are caught less frequently. Lyons et al. 2013 found that the discard mortality rate of juvenile white sharks is significantly related to soak time, with higher discard mortality rates in longer soaks.[22]

Example Species	Higher Discard Mortality Rate	Example Species	Lower Discard Mortality Rate
Pacific Mackerel	98%	Thornback Ray	3%
Rock Crab	56%	Whelk	2%
CA Halibut	40%	Swell Shark	2%
Giant seabass	50%	Spiny Lobster	4%
Brown Smoothhound Shark	47%	Cabezon	11%
Leopard Shark	45%	Pacific Angel Shark	14%
Spotted Ratfish	67%	Sea Cucumber	7%
Soupfin Shark	64%	California Skate	9%

Table 5. Example species with high discard mortality rates and lower discard mortality rates from the federal observer data. Discard mortality rates are aggregated across all years of available data.[17]

A chart of all observed species and their discard mortality rate can be found in the Appendix (Table 9).

Post-release Mortality

Few studies exist on post-release mortality for species caught in the CA set gillnet fishery. There is a post-release mortality study examining spiny dogfish (S. acanthias) mortality in gillnets, a species also caught in the CA set gillnets. Rulifson (2007) caught S. acanthias by commercial otter trawl and gillnet, with sampled fish left on deck for 10–15 min (to simulate fishing processes) before being categorized as live or dead. Sub-samples (n=480 for each gear type) were then placed in sea pens that were anchored for 48 hours.[23] The direct capture mortality was 0% for trawl (0.5–1.5 h tow

[21] National Marine Fisheries Service. Accessed 2022. California Set Gillnet Observer Program, Observed Catch 2007-01-01 to 2017-12-31. Available: https://media.fisheries.noaa.gov/2022- 01/setnet-catch-summaries-2007-2010-2013-2017.pdf *observer data is recorded by number of animals
[22] Lyons, K., et al., The degree and result of gillnet fishery interactions with juvenile white sharks in southern California assessed by fishery-independent and -dependent methods. Fish. Res. (2013), http://dx.doi.org/10.1016/j.fishres.2013.07.009
[23] Rulifson, R. A. (2007). Spiny dogfish mortality induced by gill-net and trawl capture and tag and release. North American Journal of Fisheries Management 27, 279–285.

duration) and 17.5% for gillnet (19.5–23.5 h soak time). After 48 hours in the sea pens, there was no further mortality of trawl-caught S. acanthias, whereas there was a further 33% mortality for those caught by gillnet.

A study estimating post-release mortality of a shark species (M. antarcticus) in the same family (Triakidae) as many of the shark species caught in the set gillnet fishery may give an approximate indication of additional mortality in the fishery for closely related species. Lyle et al. (2014) conducted a study in the Tasmanian gillnet fisheries, where post-release survival for the M. antarcticus shark was estimated to be 58.7%, indicating an additional post-release morality of 41.3%.[24] Species in the California set gillnet fishery most closely related to M. antarcticus are the smoothhound shark species, such as the brown smoothhound and gray smoothhound. Other shark species that are in the same Triakidae family are the leopard shark and soupfin (tope) shark. Several studies indicate variable survival of this family in fisheries, and note post-release mortality is an important source of overall mortality associated with fishing.[20,25,26]

Hyatt et al. (2012) looked at the blood chemistry of carcharhiniform sharks caught in experimental gillnets and longlines, with higher lactate concentrations and a greater pH in gillnet-caught sharks, underlining the greater physiological effect of capture in gillnets.[27]

While a proportion of fish can survive capture and release from gillnets, some individuals escaping from this gear may retain monofilament netting around parts of the body,[28,29] but it is uncertain as to how frequent this is and the subsequent effects of these events.

Studies conducted on post-release mortality in gillnet fisheries suggest potential bycatch mitigation measures to reduce overall mortality in gillnet fisheries could include spatial and temporal restrictions, restrictions on net lengths, limiting soak times, changes to mesh size, hanging ratio and height of the net and modifications to the thickness and color of the netting.[30,31]

Incidentally Retained Species

The CA set gillnet fishery is considered a multi-species fishery and many species that are legal and marketable are retained in addition to the primary target species CA halibut and white seabass. There are several species from the observer data that appear to be clear secondary targets -- caught in high numbers relative to other species and high rates of retainment. These species are yellowtail, CA barracuda, and common thresher shark. These three species are retained over 75% of the time and make up a significant proportion of non-target species retained.

There are many species in the observer data frequently caught and retained, but a significant proportion of the catch of these species is also discarded. This may be due to differing fisher preferences or availability of markets for certain species. Many of these species are Chondrichthyes, and include the bat ray (44% retained), pacific angel shark (37% retained), and California skate (22% retained) among others. Many species in the dataset are caught and discarded more often than they are retained, with a small number of individuals retained over the 6 years of data. A full table of the top retained species (ranked by observed number retained) can be found in Table 6. From observer data, incidentally retained catch (excluding California halibut and white seabass) comprises 15% of the total catch of the set gillnet fishery

[24] Lyle, J. M., Bell, J. D., Chuwen, B. M., Barrett, N., Tracey, S. R. & Buxton, C. D. (2014). Assessing the impacts of gillnetting in Tasmania: implications for by-catch and biodiversity. Institute for Marine and Antarctic Studies, University of Tasmania. Fisheries Research and Development Corporation (FRDC) Project No. 2010/016. Available at http://dpipwe.tas.gov.au/Documents/Gillnetting_Impacts_Tas_Bycatch_Biodiversity_ FRDC2010.pdf/

[25] Frick, L. H., Reina, R. D. & Walker, T. I. (2010a). Stress related changes and post-release survival of Port Jackson sharks (Heterodontus portusjacksoni) and gummy sharks (Mustelus antarcticus) following gill-net and longline capture in captivity. Journal of Experimental Marine Biology and Ecology 385, 29–37.

[26] Frick, L. H., Walker, T. I. & Reina, R. D. (2012). Immediate and delayed effects of gill-net capture on acid–base balance and intramuscular lactate concentration of gummy sharks, Mustelus antarcticus. Comparative Biochemistry and Physiology A 162, 88–93.

[27] Hyatt, M. W., Anderson, P. A., O'Donnell, P. M. & Berzins, I. K. (2012). Assessment of acid–base derangements among bonnethead (Sphyrna tiburo), bull (Carcharhinus leucas) and lemon (Negaprion brevirostris) sharks from gillnet and longline capture and handling methods. Comparative Biochemistry and Physiology A 162, 113–120.

[28] Schwartz, F. J. (1984). A blacknose shark from North Carolina deformed by encircling monofilament line. Florida Scientist 47, 62–64

[29] Seitz, J. C. & Poulakis, G. R. (2006). Anthropogenic effects on the smalltooth sawfish (Pristis pectinata) in the United States. Marine Pollution Bulletin 52, 1533–1540.

[30] Thorpe, T. & Frierson, D. (2009). Bycatch mitigation assessment for sharks caught in coastal anchored gillnets. Fisheries Research 98, 102–112

[31] Baeta, F., Batista, M., Maia, A., Costa, M. J. & Cabral, H. (2010). Elasmobranch by-catch in a trammel net fishery in the Portuguese west coast. Fisheries Research 102, 123–129.

and contributes 41.6% of the total retained catch for the fishery. For each top retained species, we evaluated whether there are management measures in the set gillnet fishery to ensure sustainability, such as size limits, catch limits, or closed seasons. Some species managed under federal Fishery Management Plans (FMP) have annual catch limits when targeted in federal fisheries, but those limits do not apply to the set gillnet fishery and set gillnet catch is not applied to those federal limits. Those species include Pacific mackerel, leopard shark, longnose skate and California scorpionfish.

Species	FMP	Assessed	Management measures for sustainability	ESR	Observed Retained	Observed Discarded	Discard Mortality Rate	Percent Retained
Seabass, White (target)	Yes (State FMP)	Yes (2016)	Size limit	Yes	2975	74	91%	98%
Halibut, California (target)	No	Yes (2011)	Size limit	Yes	878	121	40%	88%
Crab, Spider	No	No	None	No	321	845	50%	28%
Ray, Bat	No	No	None	No	296	376	20%	44%
Mackerel, Pacific	Yes (CPS FMP)	Yes (2021)	None *	No	228	2126	99%	10%
Crab, Rock	No	No	None	Yes	221	1280	56%	15%
Yellowtail	No	No	Size limit	Yes	192	4	100%	98%
Whelk	No	No	None	No	137	240	2%	36%
Barracuda, California	No	No	Size limit	Yes	134	43	98%	76%
Shark, Common Thresher	Yes (HMS FMP)	Yes	None	No	130	14	29%	90%
Shark, Pacific Angel	No	No	Size limit	Yes	125	216	14%	37%
Skate, California	No	No	None	No	110	391	9%	22%
Shark, Leopard	Yes (G FMP)	No	None*	No	106	108	45%	50%
Skate, Longnose	Yes (G FMP)	Yes	None*	No	78	307	23%	20%
Guitarfish, Shovelnose	No	No	None	No	68	28	4%	71%
Shark, Brown Smoothhound	No	No	Size limit	Yes	55	284	47%	16%
Scorpionfish, California	Yes (G FMP)	Yes (2017)	Size limit	No	55	119	41%	32%
Crab, Pointer	No	No	None	No	54	646	81%	8%
Shark, Swell	No	No	None	No	52	731	2%	7%
Shark, Soupfin	Ecosystem Component Species GFMP	No	None	No	40	86	64%	32%
Squid, Jumbo (Humboldt)	No	No	None	No	27	847	89%	3%
Bass, Giant Sea	No	No	1 per trip in set nets (closed fishery)	No	26	8	50%	76%

*Table 6. Top incidentally retained species, ranked by number of observed animals retained.[32] Percent retained and discard mortality rate is included to better understand total mortality of each species, along with relevant management information for each species. * Species has a federal Annual Catch Limit, but set gillnet catch is not counted toward or subject to such limit.*

Many species caught in this fishery as bycatch or as incidentally landed species (that are not target species) do not have stock assessments or other indicators of stock status, or basic management for sustainability in place under guidelines of the MLMA. The CA set gillnet fishery is considered a multi-species fishery, which can be difficult in terms of management under the Marine Life Management Act, which manages species in fisheries as either "targets" or "bycatch". The MLMA states this in terms of incidental fisheries catch:

> "Incidental catch is defined as fish caught incidentally during the pursuit of the primary target species, but legal and desirable to be sold or kept for consumption. Some may define these species as secondary targets or retained bycatch. For purposes of FMP development these species should be accounted for and must be managed either as target species under the sustainability standards outlined in Chapter 5, or as bycatch under the bycatch standard described below." (MLMA Master Plan for Fisheries, Chapter 6)[33]

[32] National Marine Fisheries Service. Accessed 2022. California Set Gillnet Observer Program, Observed Catch 2007-01-01 to 2017-12-31. Available: https://media.fisheries.noaa.gov/2022- 01/setnet-catch-summaries-2007-2010-2013-2017.pdf *observer data is recorded by number of animals

[33] Marine Life Management Act Master Plan for Fisheries, Chapter 6: Ecosystem-based Objectives. https://mlmamasterplan.com/6-ecosystem-based-objectives/

Many species retained incidentally are also discarded, making their total mortality (retained + discard mortality) potentially significant, and should be considered for additional management to ensure sustainable harvest.

Target species

California halibut and white seabass are considered the primary targets of this multispecies gillnet fishery, and combined, both target species landed out of the total catch of the fishery comprise 21% of the total catch. California halibut caught makes up 5.5% of the total catch by number of animals in the observer data. Retained CA halibut comprises 4.8% of the total catch of the fishery, and comprises 13.4% of total retained catch. California halibut has a discard rate of 12%, and a discard mortality of 39.7%. White seabass comprises 16.7% of the total catch by number of animals in the observer data. Retained white seabass comprises 16.3% of total animals caught, and makes up 45.6% of total retained catch of the fishery. White seabass has a discard rate of 2.4% and discard mortality rate of 90.5%.

California halibut does not have a current stock assessment (last assessment in 2011), and is not yet managed under a Fishery Management Plan (FMP) with catch quotas, though the state is currently working on a state FMP and updated stock assessment. The California halibut stock in Southern California is depleted, and efforts in all fishing sectors should be explored to reduce bycatch impacts on such a commercially important species in California. From observer data, 12% of halibut caught are discarded, which have a discard mortality rate of 39.7%. Discard mortality does not consider depredation that may be occurring of this resource while the nets are soaking by sea lions and other natural predators, nor does it consider post-release mortality.

White seabass is managed under a state FMP and has a 2016 stock assessment. The most recent stock assessment for white seabass estimates the stock is at 27% of its unfished biomass, indicating depletion, though not “overfished” as defined by the Pacific Fishery Management Council as below 25% of a stock’s unfished biomass.

Protected Species

Marine Mammals

This fishery is a Category II fishery under the Marine Mammal Protection Act (MMPA) for its interactions with protected marine mammals. The primary rational for the Category II listing is the take of ESA-listed humpback whales.[34] The observer program that monitors this fishery has authority under the MMPA.

Marine mammals this fishery has interacted with historically include the southern sea otter, northern elephant seal, and harbor porpoise. In the current observer data (2007 – 2017) there are 4 identified species of marine mammals the fishery has interacted with during this period: CA sea lion (n= 90), harbor seal (n = 9), long-beaked common dolphin (n = 2), and the short-beaked common dolphin (n = 2). From observer data, all marine mammals caught are discarded and have a near 100 percent discard mortality rate (99%). These numbers are observed marine mammal interactions and are not expanded. An unknown number of marine mammals breakaway with portions of netting still entangled around their body, and additional mortality and injury of these marine mammal stocks should be considered.

NMFS provides expanded estimates of marine mammal fishery related death and injury in their Stock Assessment Reports for marine mammals.[35] From these reports an estimated 150 CA sea lions are killed each year in the CA set gillnet fishery, out of a total 197 estimated fishery related mortalities from observed fisheries.[36] An estimated 23 harbor seals are killed annually in the CA set gillnet fishery, though the California Harbor seal stock has not been evaluated since

[34] NOAA Fisheries. MMPA List of Fisheries: CA Halibut, White Seabass and Other Species Set Gillnet (>3.5in mesh). Available: https://www.fisheries.noaa.gov/national/marine-mammalprotection/ca-halibut-white-seabass-and-other-species-setgillnet-35-mesh. Accessed 2023

[35] NMFS. Marine Mammal Stock Assessment Reports by Species/ Stock. https://www.fisheries.noaa.gov/national/marinemammal-protection/marine-mammal-stock-assessmentreports-species-stock

[36] NMFS. 2019. Marine Mammal Stock Assessment Reports by Species/Stock: CALIFORNIA SEA LION (Zalophus californianus): U.S. Stock. NOAA Fisheries. https://media.fisheries.noaa. gov/dammigration/ca_sea_lion_final_2018_sar.pdf. Accessed November 2022. *estimates “by fishery” located in Table 1.

2013. An estimated ≥1.6 Long beaked common dolphins, and ≥ 3 short beaked common dolphins are killed annually in the fishery.

The NMFS West Coast Entanglement program has identified the take of a humpback whale in 2007, and a gray whale in 2020, to the Southern California set gillnet fishery.[37] Large whale entanglements are an ongoing problem on the U.S. West Coast and have become more common over the last decade, but due to a lack of unique gear marking requirements for the CA set gillnet fishery and other fisheries, most whale entanglements remain unidentified to the fishery-level. Efforts to implement better gear-marking and identification protocols in many fishing sectors in California and other states are ongoing. From known records of whale entanglements on the West Coast 2001 – 2022, 22 gray whales, 12 humpbacks, and 1 unidentified whale have been entangled in unidentified gillnets.[38] Unidentified gillnets are commercial gillnets that could not be identified down to the fishery level, and could be set gillnet entanglements from the Southern California fishery, among a number of other gillnet fisheries on the West Coast and Mexico. In this analysis, any identified drift gillnet or Tribal gillnet is excluded.

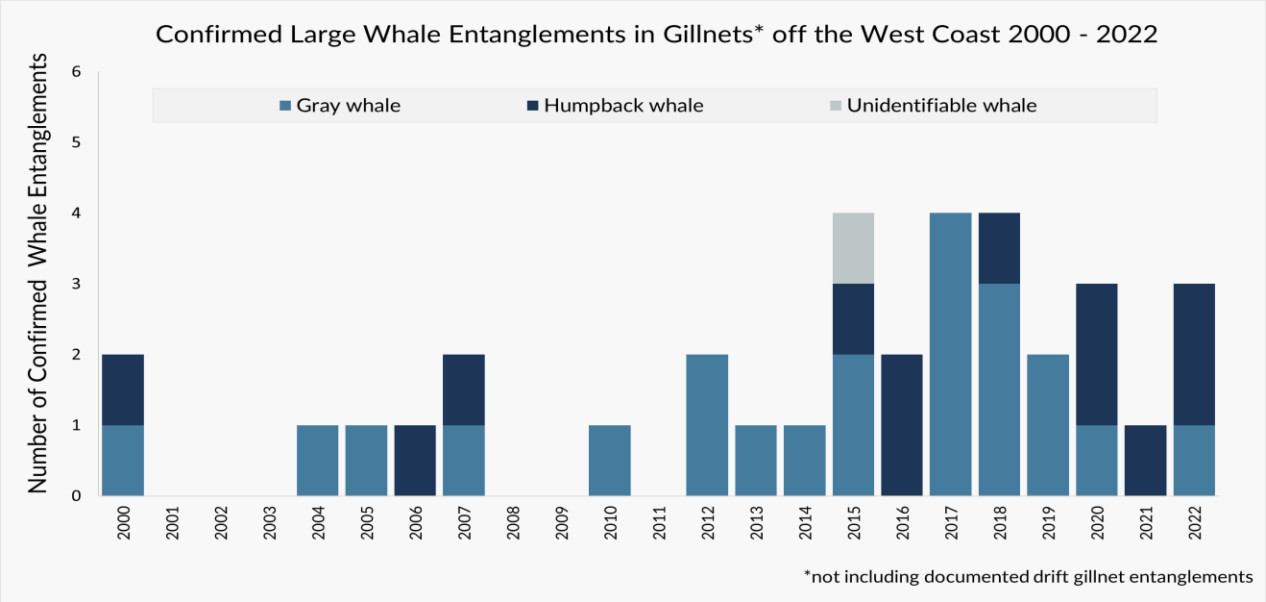

Figure 6. Confirmed Large Whale Entanglements in Gillnets off the West Coast 2000 – 2022. Entanglement records were only included if the entanglement could reasonably be attributed to the California set gillnet (CA halibut and white seabass) fishery. We have included all the "Gillnet" records, excluding any that are drift gillnet, tribal gillnet, or where the "Gear set location code" is OR, WA, Central California and Northern California. Gear-set location filters are set only to "unknown", "California unknown" or "Southern California".

[37] NOAA Fisheries. MMPA List of Fisheries: CA Halibut, White Seabass and Other Species Set Gillnet (>3.5in mesh). Available: https://www.fisheries.noaa.gov/national/marine-mammalprotection/ca-halibut-white-seabass-and-other-species-setgillnet-35-mesh. Accessed 2023

[38] NMFS. 2021. Large whale entanglements off the U.S. West Coast, from 1982-2017. Saez, L., D. Lawson, and M. DeAngelis. NOAA Tech. Memo. NMFS-OPR-63A, 50 p. Updated through 2022 by NMFS. 2023. NOAA Fisheries Whale Entanglement Response Program. Official Report. L. Saez, Personal communication. Jan 2023.

Seabirds

From observer data, there are 4 identified seabird species caught by the fishery and 3 unidentified seabird species. These include the Brandt's Cormorant (n=11), the Common Murre (n=3), the Double-crested Cormorant (n= 1) and the Pelagic Cormorant (n= 1). Unidentified species in the observer data are the unidentified Gull (n=2), unidentified Cormorant (n = 23) and unidentified seabird (n =3). Total seabirds caught from the observer data 2007 - 2017 are 44 birds.

The National Bycatch Report Update 2 database[39] provides expanded estimates for seabirds catch in the set gillnet fishery for 2011 and 2012. In 2011, an estimated 247 seabirds were caught in the set gillnet fishery (49 Brandt's Cormorants and 198 unidentified seabirds); a total of 458 estimated seabirds were caught in 2011 in all observed West Coast fisheries (7 fisheries), indicating set gillnets caught 54% of the estimated seabird catch in 2011 (Table 7). However, the Coefficient of Variance (CV) for the estimates in the set gillnet fishery are high, indicating uncertainty in the extrapolations. In 2012, an estimated 72 seabirds were caught in the set gillnet fishery (18 Pelagic Cormorants and 54 unidentified seabirds); a total of 439 estimated seabirds were caught in 2012 in all observed West Coast fisheries (7 fisheries), indicating set gillnets caught 16% of the estimated seabird catch in 2012 (Table 8). Again, the Coefficient of Variance (CV) for estimates in the set gillnet fishery is high, indicating uncertainty in the extrapolations.

California Halibut/White Seabass and Other Species Set Gillnet (>3.5 in Mesh):						
Common Name	Scientific Name	Year	Bycatch	Unit	CV	Footnote(s)
Brandt's cormorant	Phalacrocorax penicillatus	2011	49.00	INDIVIDUAL	0.61	
Seabirds (unidentified)	Laridae	2011	198.00	INDIVIDUAL	1.03	
Fishery total			**247.00**			

Table 7. National Bycatch Report Update 2: 2011, expanded estimates of seabird bycatch by fishery; estimated seabird bycatch for the CA halibut/white seabass and other species set gillnet fishery for 2011.

California Halibut/White Seabass and Other Species Set Gillnet (>3.5 in Mesh):						
Common Name	Scientific Name	Year	Bycatch	Unit	CV	Footnote(s)
Pelagic cormorant - Pacific	Phalacrocorax pelagicus	2012	18.00	INDIVIDUAL	0.98	
Seabirds (unidentified)	Laridae	2012	54.00	INDIVIDUAL	0.72	
Fishery total			**72.00**			

Table 8. National Bycatch Report Update 2: 2012, expanded estimates of seabird bycatch by fishery; estimated seabird bycatch for the CA halibut/white seabass and other species set gillnet fishery for 2012.

White Sharks

The NMFS status report of the Northeastern white shark population estimates an average of 25 white sharks were caught annually in the CA set gillnet fishery from 2001 – 2011, representing the most recent estimate of annual white shark catch. [40] Most white sharks reported in logbooks over the data period (1982 – 2012) were young of year. White shark mortality increases with soak duration of the nets.[41] This take of white sharks represents 93% of all white shark catch estimated in observed West Coast fisheries.

[39] NMFS. National Bycatch Report Database, Seabird Bycatch by Fishery 2011, 2012, Update 2. https://appsst.fisheries.noaa.gov/stapex/f?p=243:101:29602220642274:::::. Accessed July 2023

[40] Dewar et al. 2013. Status Review of the Northeastern Pacific Population of White Sharks (Carcharodon Carcharias) under the Endangered Species Act, 2013. https://repository.library.noaa.gov/view/noaa/17705. Table 4.3 Average estimated catches from U.S. west coast set nets 2001-2011.

[41] Lyons, K., et al., The degree and result of gillnet fishery interactions with juvenile white sharks in southern California assessed by fishery-independent and -dependent methods. Fish. Res. (2013), http://dx.doi.org/10.1016/j.fishres.2013.07.009

Data and Management Gaps

The lack of comprehensive monitoring programs in state fisheries to assess bycatch and integrate data into population and stock models seriously impedes a full understanding of bycatch consequences and impacts on target and incidentally retained species. However, where evidence for significant bycatch exists, a risk-averse and adaptive management approach is clearly warranted.

In addition to identified sustainability concerns and ecosystem risk, this analysis highlights several key areas of uncertainty that warrant improved data collection. These include:

- Gear marking to enable positive and negative attribution of gillnet wildlife entanglements to the California set gillnet fishery.
- Consistent and regular observer coverage and/or electronic video monitoring to increase sample sizes.
- Collection of data on the number and duration of sets, the set location, and length of each net for each set to enable total effort calculations and accurate estimates of total catch and discards.
- Stock assessments or data-limited assessments for incidentally caught and retained species as well as discards.
- Differentiating observer coverage based on set gillnet mesh sizes to compare catch compositions in halibut-targeting vs. white seabass-targeting sets.
- Evaluating the effects of soak time on discard mortality.

Despite these uncertainties and data gaps, the publicly available data on bycatch in the California set gillnet fishery indicates a wide suite of conservation concerns across the MLMA Criteria for determining acceptable levels of bycatch. The high number of species caught in the fishery suggests that significant management improvements are necessary to ensure sustainability and keep bycatch to acceptable types and amounts under the MLMA.

Appendix

Table 9. NMFS Set Gillnet Observer Data;[42] totals have been compiled over the 6 years of available data 2007 – 2017 over 1,258 sets observed. Included in the table is the Discard Mortality Rate based on observer data, Percent Retained based on observer data, and total extrapolated estimates for 2007 – 2021 based upon the 1set:1trip ratio explained in the *total effort methods* section above. Total extrapolated estimates of catch, discard, and discard mortality are based upon an estimated 24,699 sets from 2007 – 2021. Average annual estimated sets over this period are 1,653.

Species	Total Observed Catch (2007 - 2017)	Observed Retained	Observed Discarded	Observed Returned Dead	Observed Returned Alive	Observed Returned Unknown	Discard Rate (Total discarded/total caught)	Discard Mortality Rate (total discarded dead/ total discarded)	Rate Retained (total retained/ total caught)	Min Catch Estimate (2007 - 2021)	Min Discard Estimate (2007 - 2021)	Min Discard Mortality Estimate (2007 - 2021)
Seabass, White	3049	2975	74	67	6	1	2.4%	90.5%	97.6%	60,105	1,459	1,321
Mackerel, Pacific	2354	228	2126	2098	28	0	90.3%	98.7%	9.7%	46,404	41,910	41,358
Crab, Rock	1501	221	1280	722	546	12	85.3%	56.4%	14.7%	29,589	25,233	14,233
Crab, Spider	1166	321	845	421	409	15	72.5%	49.8%	27.5%	22,985	16,658	8,299
Halibut, California	999	878	121	48	73	0	12.1%	39.7%	87.9%	19,693	2,385	946
Squid, Jumbo (Humboldt)	874	27	847	753	32	62	96.9%	88.9%	3.1%	17,229	16,697	14,844
Shark, Swell	783	52	731	15	713	3	93.4%	2.1%	6.6%	15,435	14,410	296
Crab, Pointer	700	54	646	526	120	0	92.3%	81.4%	7.7%	13,799	12,735	10,369
Ray, Bat	672	296	376	77	295	4	56.0%	20.5%	44.0%	13,247	7,412	1,518
Skate, California	501	110	391	34	357	0	78.0%	8.7%	22.0%	9,876	7,708	670
Skate, Longnose	385	78	307	71	231	5	79.7%	23.1%	20.3%	7,590	6,052	1,400
Sea Star	382	0	382	1	376	5	100.0%	0.3%	0.0%	7,530	7,530	20
Whelk	377	137	240	5	223	12	63.7%	2.1%	36.3%	7,432	4,731	99
Dogfish, Spiny	357	21	336	120	210	6	94.1%	35.7%	5.9%	7,038	6,624	2,366
Shark, Pacific Angel	341	125	216	30	186	0	63.3%	13.9%	36.7%	6,722	4,258	591
Shark, Brown Smoothhound	339	55	284	134	150	0	83.8%	47.2%	16.2%	6,683	5,599	2,642
Shark, Leopard	214	106	108	49	57	2	50.5%	45.4%	49.5%	4,219	2,129	966
Ratfish, Spotted	201	2	199	134	65	0	99.0%	67.3%	1.0%	3,962	3,923	2,642
Yellowtail	196	192	4	4	0	0	2.0%	100.0%	98.0%	3,864	79	79
Crab, Red Rock	180	1	179	165	11	3	99.4%	92.2%	0.6%	3,548	3,529	3,253
Barracuda, California	177	134	43	42	1	0	24.3%	97.7%	75.7%	3,489	848	828
Scorpionfish, California	174	55	119	49	69	1	68.4%	41.2%	31.6%	3,430	2,346	966
Shark, Common Thresher	144	130	14	4	8	2	9.7%	28.6%	90.3%	2,839	276	79
Crab, Yellow	139	2	137	80	55	2	98.6%	58.4%	1.4%	2,740	2,701	1,577
Shark, Soupfin	126	40	86	55	31	0	68.3%	64.0%	31.7%	2,484	1,695	1,084
Crab, Unidentified	107	0	107	95	12	0	100.0%	88.8%	0.0%	2,109	2,109	1,873
Lobster, California Spiny	103	2	101	4	97	0	98.1%	4.0%	1.9%	2,030	1,991	79
Bass, Barred Sand	101	3	98	36	62	0	97.0%	36.7%	3.0%	1,991	1,932	710
Thornback	99	1	98	3	95	0	99.0%	3.1%	1.0%	1,952	1,932	59

[42] National Marine Fisheries Service. Accessed 2022. California Set Gillnet Observer Program, Observed Catch 2007-01-01 to 2017-12-31. Available: https://media.fisheries.noaa.gov/2022- 01/setnet-catch-summaries-2007-2010-2013-2017.pdf *observer data is recorded by number of animals

Guitarfish, Shovelnose	96	68	28	1	27	0	29.2%	3.6%	70.8%	1,892	552	20
California Sea Lion	90	0	90	89	1	0	100.0%	98.9%	0.0%	1,774	1,774	1,754
Sea Cucumber	88	16	72	5	29	38	81.8%	6.9%	18.2%	1,735	1,419	99
Cabezon	77	14	63	7	55	1	81.8%	11.1%	18.2%	1,518	1,242	138
Lingcod	68	5	63	30	33	0	92.6%	47.6%	7.4%	1,340	1,242	591
Skate, Big	65	3	62	0	62	0	95.4%	0.0%	4.6%	1,281	1,222	0
Invertebrate, Unid.	47	9	38	8	4	26	80.9%	21.1%	19.1%	927	749	158
Tunicates, Pelagic	45	0	45	20	0	25	100.0%	44.4%	0.0%	887	887	394
Crustacean, Unidentified	43	6	37	25	12	0	86.0%	67.6%	14.0%	848	729	493
Bass, Giant Sea	34	26	8	4	4	0	23.5%	50.0%	76.5%	670	158	79
Rockfish, Bocaccio	31	0	31	18	10	3	100.0%	58.1%	0.0%	611	611	355
Sheephead, California	28	9	19	7	12	0	67.9%	36.8%	32.1%	552	375	138
Hake, Pacific	27	0	27	27	0	0	100.0%	100.0%	0.0%	532	532	532
Sardine, Pacific	27	0	27	27	0	0	100.0%	100.0%	0.0%	532	532	532
Shark, Horn	26	4	22	1	21	0	84.6%	4.5%	15.4%	513	434	20
Sea Urchin	26	2	24	3	19	2	92.3%	12.5%	7.7%	513	473	59
Butterfish, Pacific	25	12	13	8	5	0	52.0%	61.5%	48.0%	493	256	158
Sole, English	25	2	23	3	20	0	92.0%	13.0%	8.0%	493	453	59
Sole, Fantail	21	6	15	3	12	0	71.4%	20.0%	28.6%	414	296	59
Sanddab, Pacific	21	1	20	7	13	0	95.2%	35.0%	4.8%	414	394	138
Shark, Gray Smoothhound	20	8	12	3	9	0	60.0%	25.0%	40.0%	394	237	59
Cormorant, Unidentified	20	0	20	16	4	0	100.0%	80.0%	0.0%	394	394	315
Sole, Slender	19	2	17	8	9	0	89.5%	47.1%	10.5%	375	335	158
Whitefish, Ocean	19	2	17	4	13	0	89.5%	23.5%	10.5%	375	335	79
Octopus, Unidentified	19	1	18	1	17	0	94.7%	5.6%	5.3%	375	355	20
Crab, Marble	19	0	19	17	2	0	100.0%	89.5%	0.0%	375	375	335
Skate, Starry	19	0	19	2	16	1	100.0%	10.5%	0.0%	375	375	39
Shark, Shortfin Mako	17	17	0	0	0	0	0.0%	retained	100.0%	335	0	0
Stingray, Round	17	3	14	1	13	0	82.4%	7.1%	17.6%	335	276	20
Sculpin, Unidentified	17	1	16	3	13	0	94.1%	18.8%	5.9%	335	315	59
Crab, Dungeness	16	0	16	8	8	0	100.0%	50.0%	0.0%	315	315	158
Crab, California King	14	11	3	0	3	0	21.4%	0.0%	78.6%	276	59	0
Rockfish, Vermilion	14	1	13	9	4	0	92.9%	69.2%	7.1%	276	256	177
Croaker, White	14	0	14	11	3	0	100.0%	78.6%	0.0%	276	276	217
Flatfish, Unidentified	13	3	10	2	8	0	76.9%	20.0%	23.1%	256	197	39
Turbot, Hornyhead	12	4	8	3	5	0	66.7%	37.5%	33.3%	237	158	59
Bass, Kelp	12	0	12	2	9	1	100.0%	16.7%	0.0%	237	237	39
Rockfish, Copper	12	0	12	8	3	1	100.0%	66.7%	0.0%	237	237	158
Bonito, Pacific	11	10	1	1	0	0	9.1%	100.0%	90.9%	217	20	20
Cormorant, Brandt's	11	0	11	11	0	0	100.0%	100.0%	0.0%	217	217	217
Croaker, Yellowfin	9	3	6	1	5	0	66.7%	16.7%	33.3%	177	118	20

Sanddab, Longfin	9	3	6	6	0	0	66.7%	100.0%	33.3%	177	118	118
Crab, Decorator	9	0	9	4	5	0	100.0%	44.4%	0.0%	177	177	79
Salmon, King	9	0	9	8	1	0	100.0%	88.9%	0.0%	177	177	158
Turbot, Diamond	9	0	9	0	9	0	100.0%	0.0%	0.0%	177	177	0
Harbor Seal	9	0	9	9	0	0	100.0%	100.0%	0.0%	177	177	177
Octopus	8	0	8	0	8	0	100.0%	0.0%	0.0%	158	158	0
Ray, California Butterfly	8	0	8	1	7	0	100.0%	12.5%	0.0%	158	158	20
Shark, Prickly	8	0	8	0	8	0	100.0%	0.0%	0.0%	158	158	0
Snail, Unidentified	8	0	8	0	8	0	100.0%	0.0%	0.0%	158	158	0
Sole, Rock	7	6	1	0	1	0	14.3%	0.0%	85.7%	138	20	0
Lizardfish, California	7	2	5	4	1	0	71.4%	80.0%	28.6%	138	99	79
Skate, Unidentified	7	0	7	1	5	1	100.0%	14.3%	0.0%	138	138	20
Flounder, Starry	6	5	1	1	0	0	16.7%	100.0%	83.3%	118	20	20
Shad, American	6	4	2	2	0	0	33.3%	100.0%	66.7%	118	39	39
Crab, Opossum	6	1	5	2	3	0	83.3%	40.0%	16.7%	118	99	39
Shark, Sevengill	6	1	5	3	2	0	83.3%	60.0%	16.7%	118	99	59
Turbot, Curlfin	6	0	6	3	3	0	100.0%	50.0%	0.0%	118	118	59
Sole, Sand	5	1	4	2	2	0	80.0%	50.0%	20.0%	99	79	39
Fish, Unidentified	5	0	5	5	0	0	100.0%	100.0%	0.0%	99	99	99
Mackerel, Bullet	5	0	5	5	0	0	100.0%	100.0%	0.0%	99	99	99
Ray, Pacific Electric	5	0	5	2	3	0	100.0%	40.0%	0.0%	99	99	39
Rockfish, Canary	5	0	5	1	3	1	100.0%	20.0%	0.0%	99	99	20
Sole, Petrale	4	3	1	1	0	0	25.0%	100.0%	75.0%	79	20	20
Anchovy, Northern	4	0	4	4	0	0	100.0%	100.0%	0.0%	79	79	79
Crab, Sand	4	0	4	2	2	0	100.0%	50.0%	0.0%	79	79	39
Mackerel, Jack	4	0	4	2	1	1	100.0%	50.0%	0.0%	79	79	39
Midshipman, Specklefin	4	0	4	0	4	0	100.0%	0.0%	0.0%	79	79	0
Rockfish, Cowcod	4	0	4	0	4	0	100.0%	0.0%	0.0%	79	79	0
Rockfish, Unidentified	4	0	4	3	1	0	100.0%	75.0%	0.0%	79	79	59
Shark, Unidentified	4	0	4	2	2	0	100.0%	50.0%	0.0%	79	79	39
Sole, Bigmouth	4	0	4	1	3	0	100.0%	25.0%	0.0%	79	79	20
Turbot, C-O	4	0	4	1	3	0	100.0%	25.0%	0.0%	79	79	20
Tuna, Yellowfin	3	3	0	0	0	0	0.0%	retained	100.0%	59	0	0
Fish, Other Identified	3	2	1	0	1	0	33.3%	0.0%	66.7%	59	20	0
Turbot, Spotted	3	1	2	0	2	0	66.7%	0.0%	33.3%	59	39	0
Bird, Unidentified	3	0	3	3	0	0	100.0%	100.0%	0.0%	59	59	59
Crab, Hermit	3	0	3	0	3	0	100.0%	0.0%	0.0%	59	59	0
Crab, Northern Kelp	3	0	3	2	1	0	100.0%	66.7%	0.0%	59	59	39
Mollusk, Unidentified	3	0	3	0	3	0	100.0%	0.0%	0.0%	59	59	0
Murre, Common	3	0	3	3	0	0	100.0%	100.0%	0.0%	59	59	59
Rockfish, Gopher	3	0	3	2	1	0	100.0%	66.7%	0.0%	59	59	39

Rockfish, Treefish	3	0	3	1	2	0	100.0%	33.3%	0.0%	59	59	20
Shark, Blue	3	0	3	0	3	0	100.0%	0.0%	0.0%	59	59	0
Skate, Other Identified	3	0	3	0	3	0	100.0%	0.0%	0.0%	59	59	0
Unidentified Cormorant	3	0	3	3	0	0	100.0%	100.0%	0.0%	59	59	59
Rockfish, Grass	2	2	0	0	0	0	0.0%	retained	100.0%	39	0	0
Halfmoon	2	0	2	2	0	0	100.0%	100.0%	0.0%	39	39	39
Mola, Common	2	0	2	0	2	0	100.0%	0.0%	0.0%	39	39	0
Needlefish, California	2	0	2	0	2	0	100.0%	0.0%	0.0%	39	39	0
Rockfish, Bank	2	0	2	0	1	1	100.0%	0.0%	0.0%	39	39	0
Rockfish, Brown	2	0	2	0	2	0	100.0%	0.0%	0.0%	39	39	0
Sablefish	2	0	2	1	1	0	100.0%	50.0%	0.0%	39	39	20
Short Beak Common Dolphin	2	0	2	2	0	0	100.0%	100.0%	0.0%	39	39	39
Surfperch, Other Ident.	2	0	2	2	0	0	100.0%	100.0%	0.0%	39	39	39
Surfperch, Pink	2	0	2	2	0	0	100.0%	100.0%	0.0%	39	39	39
Surfperch, Rubberlip	2	0	2	2	0	0	100.0%	100.0%	0.0%	39	39	39
Long Beak Common Dolphin	2	0	2	2	0	0	100.0%	100.0%	0.0%	39	39	39
Shark, White	1	1	0	0	0	0	0.0%	retained	100.0%	20	0	0
Cormorant, Double-crested	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Croaker, Spotfin	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Echinoderm, Unidentified	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Fringehead, Sarcastic	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Garibaldi	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Guitarfish, Banded	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Gull, Unidentified	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Hagfish, Pacific	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Pelagic Cormorant	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Pinniped, Unidentified	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Pipefish, Bay	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Rockfish, Bronzespotted	1	0	1	0	0	1	100.0%	0.0%	0.0%	20	20	0
Rockfish, Kelp	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Rockfish, Rosy	1	0	1	0	0	1	100.0%	0.0%	0.0%	20	20	0
Salmon, Other Identified	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Sanddab, Speckled	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Sanddab, Unidentified	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Searobin, Lumptail	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Shark, Sixgill	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Sole, Rex	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Triggerfish, Finescale	1	0	1	0	1	0	100.0%	0.0%	0.0%	20	20	0
Unidentified Gull	1	0	1	1	0	0	100.0%	100.0%	0.0%	20	20	20
Total	**18254**	**6530**	**11724**	**6358**	**5127**	**239**	**64.2%**	**54.2%**	**35.8%**	**359,842**	**231,116**	**125,335**

Table 10. Chondrichthyes species recorded in the observer data including any current management, stock assessments, and general information from the observer data.

Chondrichthyes Species	Enhanced status report	PSA Vulnerability Score (Degrees of vulnerability, as follows: lowest, V < 1.8; medium, 1.8 < V < 2.0; high, 2.0 < V < 2.2; and highest, V > 2.2)	Fishery Management Plan (FMP)	Stock Assessment (in the last 10 years)	Stock Status	Discard Mortality Rate	Observed Discarded Dead	Observed Retained	Observed total catch
Spotted Ratfish	No		Ecosystem Component Species GFMP	No	None	67%	134	2	201
Brown Smoothhound Shark	Enhanced Status Report	1.77	No FMP	No	None	47%	134	55	339
Spiny Dogfish	No		"In the fishery" of the GFMP	Spiny Dogfish Stock Assessment	42% of unexploited levels	36%	120	21	357
Bat Ray	No		No FMP	No	None	21%	77	296	672
Longnose Skate	No		"In the fishery" of the GFMP	Longnose Skate (CA, OR, WA) Stock Status	57% unexploited levels	24%	71	78	385
Soupfin Shark	No		Ecosystem Component Species GFMP	No	None	64%	55	40	126
Leopard Shark	No		"In the fishery" of the GFMP	No	None	46%	49	106	214
California Skate	No		Ecosystem Component Species GFMP	No	None	9%	34	110	501
Pacific Angel Shark	Enhanced Status Report	2.02	No FMP	No	None	14%	30	125	341
Swell Shark	No		No FMP	No	None	2%	15	52	783
Common Thresher Shark	No		"In the fishery" of the HMS FMP	Common Thresher Stock Assessment	Not overfished or subject to overfishing	33%	4	130	144
Sevengill shark	No		No FMP	No	None	60%	3	1	6
Gray Smoothhound Shark	No		No FMP	No	None	25%	3	8	20
Thornback	No		No FMP	No	None	3%	3	1	99
Pacific Electric Ray	No		No FMP	No	None	40%	2	0	5
Starry Skate	No		No FMP	No	None	11%	2	0	19
California Butterfly Ray	No		No FMP	No	None	13%	1	0	8
Round Stingray	No		No FMP	No	None	7%	1	3	17
Horn Shark	No		No FMP	No	None	5%	1	4	26
Shovelnose Guitarfish	No		No FMP	No	None	4%	1	68	96
Banded Guitarfish	No		No FMP	No	None	NA	0	0	1

Prickly Shark	No		No FMP	No	None	NA	0	0	8
Sixgill Shark	No		No FMP	No	None	NA	0	0	1
White Shark	No		No FMP	Central Coast Abundance estimates	286 adults/subadults	NA	0	1	1
Shortfin Mako	No		"In the fishery" of the HMS FMP	Shortfin Mako North Pacific Stock Assessment through 2016	# of mature females 36% higher # of mature females at MSY	0%	0	17	17
Blue Shark	No		"In the fishery" of the HMS FMP	Blue Shark Stock Assessment NPO	Not in an overfished state	0%	0	0	3
Big Skate	No		"In the fishery" of the GFMP	Stock status of big skate US Pacific Coast	79.2% of Unfished spawning biomass	0%	0	3	65

Table 11. Example species and information pertinent to the MLML Bycatch Inquiry for assessing sustainability and acceptability of bycatch.

Bycatch Inquiry Factor	**Soupfin (Tope) Shark**	**Brown Smoothhound**	**Bat Ray**
Ecosystem Importance	Sharks are apex predators, maintaining healthy and balanced ecosystems through predator top-down control. Depletion of shark populations is known to limit ecosystem function and resilience.	Sharks are apex predators, maintaining healthy and balanced ecosystems through predator top-down control. Depletion of shark populations is known to limit ecosystem function and resilience.	As predatory species, skates play pivotal roles in the regulation of lower trophic level organisms and, therefore, of marine ecosystems, especially after the decline of the largest top predators such as large pelagic sharks (Shepherd and Myers, 2005, Myers et al., 2007, Baum and Worm, 2009)
Population Status	No population assessment ESA candidate species IUCN Critically Endangered Population crashed in 1940s (Vitamin A fishery) Remains depleted	No population assessment.	No population assessment. Status of California rays and skates highly uncertain
Inherent Vulnerability	Triennial reproductive cycle (reproduces once every 3 years) Southern California nursery grounds (females and juveniles caught in SoCal) Late sexual maturity Fishbase: Very high vulnerability (76 of 100)	A Productivity Susceptibility Analysis ranked brown smoothhound the second most vulnerable state-managed finfish behind Pacific angel shark (Swasey et al. 2016). Fishbase: High Vulnerability (58 of 100)	Late onset maturity, low fecundity, and slow growth. Fishbase: Very high vulnerability (75 of 100)
Impacts from Set Gillnet Fishery	Minimum estimate of 1,695 sharks discarded from 2007 – 2021 (based on 1 set to 1 trip extrapolation) High discard mortality rate (64%) Historic regional depletions in Southern CA due to set net impacts	47% discard mortality Most discarded dead of all Chondrichthyes by number of animals	21% discard mortality Minimum of ~7,400 discarded 2007 – 2021 (based on 1 set to 1 trip extrapolation) Caught and landed at high rates with no catch limits (present in ~13% of set gillnet sets targeting CA halibut; not including white seabass targeting sets) (Chris Free Bycatch Report 2022)