**Title**
An Analysis of Fish Bycatch in the California Large Mesh Drift Gillnet Fishery



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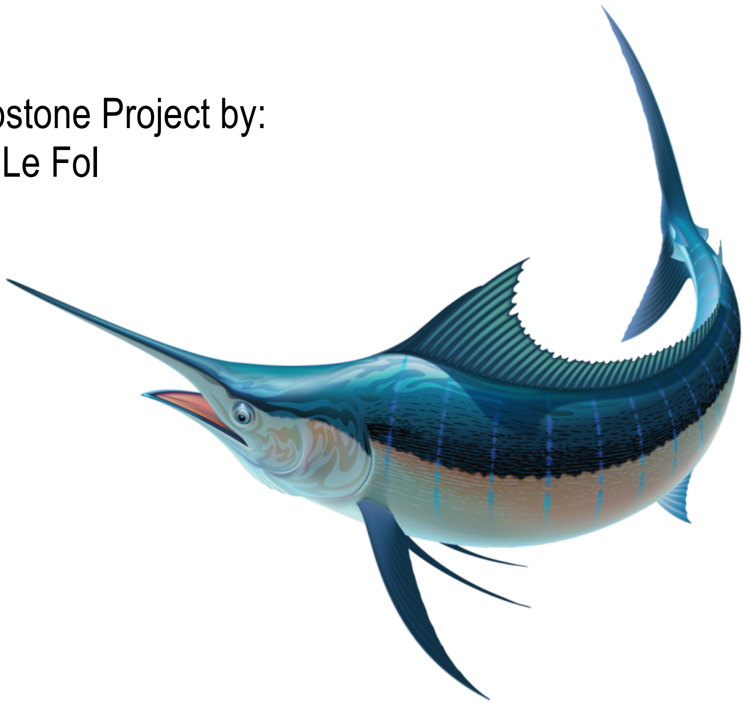
# AN ANALYSIS OF FISH BYCATCH IN THE CALIFORNIA LARGE MESH DRIFT GILLNET FISHERY



2016 Capstone Project by:
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## Table of Acronyms

| Acronym | Definition |
|---|---|
| **CA** | California |
| **CDFW** | California Department of Fish and Wildlife |
| **CPUE** | Catch Per Unit Effort |
| **DGN** | Drift Gill Net |
| **EEZ** | Exclusive Economic Zone |
| **ESA** | Endangered Species Act |
| **FMP** | Fisheries Management Plan |
| **HMS** | Highly Migratory Species |
| **MMPA** | Marine Mammal Protection Act |
| **NGO** | Non-Governmental Organization |
| **NMFS** | National Marine Fisheries Service |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **PFMC** | Pacific Fisheries Management Council |
| **POCTRP** | Pacific Offshore Cetacean Take Reduction Plan |
| **PLCA** | Pacific Leatherback Conservation Area |
| **SFA** | Sustainable Fisheries Act |
| **SIO** | Scripps Institution of Oceanography |

## Introduction

The California Large Mesh Drift Gillnet fishery (CA DGN fishery) has targeted swordfish (*Xiphias gladius*) within the exclusive economic zone (EEZ) off the West Coast of the United States since the late 1970s. Since its inception a number of regulatory changes have been implemented to reduce the take of non-target species. Concerns over marine mammal interactions led to the implementation of the Federal Fisheries Observer Program in 1990 to support compliance with the Marine Mammal Protection Act (MMPA). Observer information is used by the National Marine Fisheries Service (NMFS) to inform stock assessments, help construct fishery management plan regulations, develop bycatch reduction devices, and identify the need for protective regulations for protected species[1]. The implementation of gillnet extenders in 1998 under the Pacific Offshore Cetacean Take Reduction Plan (POCTRP) and the establishment of the Pacific Leatherback Conservation Area (PCLA) in 2001 have since contributed to reducing marine mammal and sea turtle interactions for this fishery into compliance with the MMPA and Endangered Species Act (ESA). The tremendous dataset collected by fisheries observers since 1990 is rich with information on finfish catch and discards in the CA DGN fishery. This component of the fishery remains largely under-studied in the context of the gear modifications and spatial closures that were originally intended to benefit marine mammals, sea turtles and sharks. This research project therefore aims to explore the fish catch and discard characteristics and disposition of fish species in the CA DGN fishery, using an approach based on biomass wherever possible. In addition, catch trends of various species will be described graphically in order to begin drawing a picture of the fishery's impact on the major species that constitute its catch. The overall aim of this project is to provide an overview of catch and bycatch composition in the CA DGN fishery.

## Background

Drift gillnets are set at dusk and allowed to drift during the night, with the fishing vessel attached at one end of the net (NOAA-NMFS) (see Figure 1 below for a representation of the drift gillnet fishing gear).

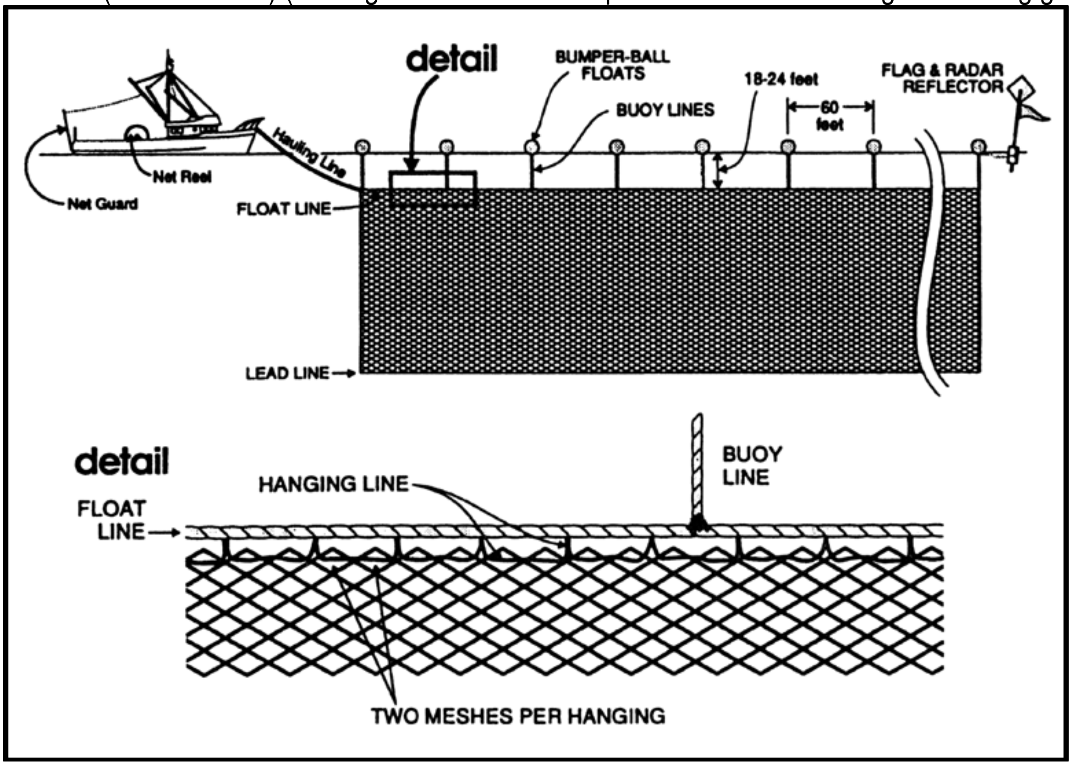


**Figure 1: Typical California drift gillnet. Source: California Department of Fish and Wildlife**

[1] Brooke S.G. Federal Fisheries Observer Programs in the United States: Over 40 Years of Independent Data Collection. Marine Fisheries Review

The California Large Mesh Drift Gillnet fishery (CA DGN fishery) originally targeted common thresher sharks (*Alopias vulpinus*) offshore of the West Coast of the USA. In the late 1970s, in part due to increasing conservation concerns regarding shark populations and a higher economic value[2] of swordfish (*Xiphias gladius*) compared to thresher shark[3], this fishery underwent a rapid reconversion towards targeting swordfish.

Since the 1980s, conservation regulations of the DGN fishery have become increasingly restrictive (see Figure 2 below) with the implementation of various administrative and technical requirements (logbooks, quotas, a limited entry program in 1982, an observer program in 1990) and by 1998 the required use of net extenders as part of the Pacific Offshore Cetacean Take Reduction Plan (POCTRP).

"An extender is a line that attaches a buoy (float) to a drift gillnet's floatline. The floatline is attached to the top of the drift gillnet. All extenders (buoy lines) must be at least 6 fathoms (36 ft; 10.9 m) in length during all sets. Accordingly, all floatlines must be fished at a minimum of 36 feet (10.9 m) below the surface of the water" (cited from: Pacific Offshore Cetacean Take Reduction Plan. | US Law | LII / Legal Information Institute, 2015) in order to minimize impacts on marine species such as cetaceans that are vulnerable to entanglement when at the surface (for breathing for example). The use of pingers (a device that transmits short high-pitched signals at brief intervals for purposes of detection, measurement, or identification) is also enforced as a component of the POCTRP. These regulations have been in effect over the subsequent years along with several time-area closures intended to reduce interactions with marine mammals, sharks and sea turtles. The Pacific Leatherback Conservation Area (PLCA) implemented in 2001 closes over 160 000 square nautical miles to Drift Gillnet fishing during 3 months of the year, when leatherback turtles come into the area to feed on jellyfish, mainly the brown sea nettle (*Chrysaora fuscescens*). El Niño years typically see the arrival of loggerhead turtles earlier in the summer; therefore an additional closure is implemented in June through August during those years.

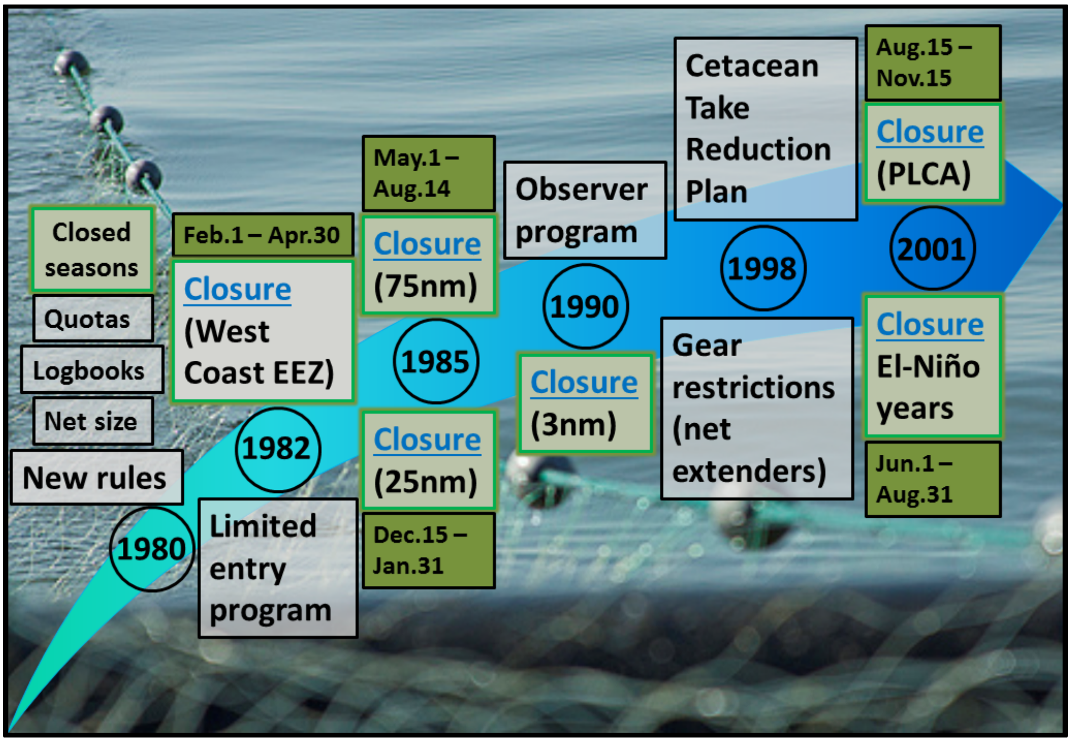


Figure 2: Regulations of the CA DGN fishery since 1980. Source: author's own

[2] Hanan D.A., Hoks D.B., and Coan L.A., 1993. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91. State of California, The Resources Agency Department Of fish and Game

[3] Urbisci L.C., Stohs S.M., and Piner K.R., 2015. From sunrise to sunset in the California drift gillnet fishery: An examination of the effects of time and area closures on the catch and catch rates of pelagic species (SWFSC Working Paper). NOAA-SWFSC

As Figure 4 below further illustrates, it is clear that the Pacific Leatherback Conservation Area (PLCA) and surrounding time/area closures represent a formidable refuge for all marine species that interact with, or are bycaught in the CA DGN fishery, as the drift gillnet fishing effort in these zones is reduced to zero during a large part of the year.

Overall, these measures aimed to reduce interactions with marine mammals, sharks and sea turtles, many of which are considered priority or charismatic species and are listed under the Endangered Species Act and/or subject to management by Take Reduction Teams under the Marine Mammal Protection Act.
In order to supply crucial data for scientific research and in turn to inform management, the California large mesh drift gillnet fishery has been observed at varying levels since 1990. Observer coverage varies yearly, with a low of 4.5% in 1990 and a high of 34.5% in 2013, while the average level of observation was 17% of fishing trips between 1990 and 2013 (see figure 3 below for more detail).

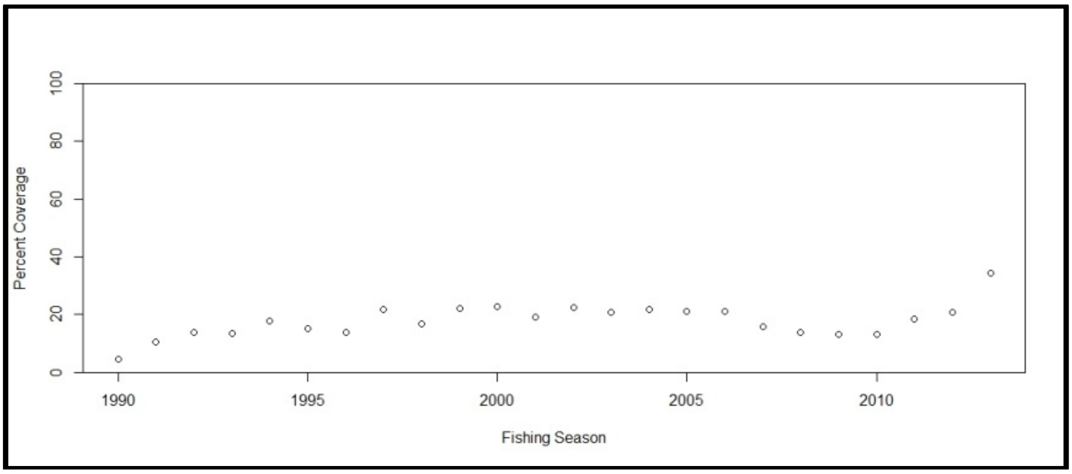


**Figure 3: Observer coverage in CA DGN fishery between 1990 and 2013. Source: author's own**

While the observer coverage value has generally increased since the start of the observer program, this is due in part to a reduction in the number of active vessels (see Table 1 below) and the related decrease in fishing effort (see figure 4 on page 8, which describes expanded number of fishing sets per year in the CA DGN fishery).

**Table 1: Landings (mt) and number of vessels CA DGN fishery (2001-2012). Source: D'Angelo (2014). 2012 total landings are from PFMC (2013).**

| Year | Swordfish landings (mt) | Total landings (mt) | Number of vessels |
|---|---|---|---|
| 2001 | 371 | 757 | 68 |
| 2002 | 301 | 592 | 54 |
| 2003 | 216 | 583 | 46 |
| 2004 | 182 | 373 | 37 |
| 2005 | 220 | 465 | 39 |
| 2006 | 444 | 701 | 39 |
| 2007 | 490 | 835 | 40 |
| 2008 | 405 | 664 | 39 |
| 2009 | 253 | 456 | 37 |
| 2010 | 61 | 214 | 28 |
| 2011 | 119 | 271 | 23 |
| 2012 | 118 | 200 | 17 |

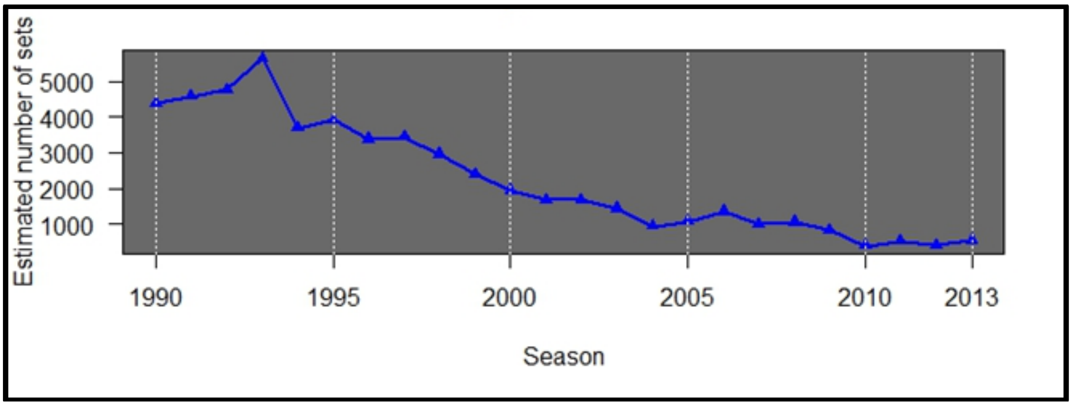


**Figure 4: Effort in the CA DGN fishery, 1990 to 2013, expanded number of sets per year. Source: author's own**

In going out to catch swordfish or other marketable catch[4], fishermen catch other species which are not retained and end up being discarded at sea. Available data has mainly been analyzed in terms of interactions with turtles and marine mammals, many of which are considered priority or charismatic species and are listed under the Endangered Species Act and Marine Mammal Protection Act. In fact, the conservation measures presented in Figure 2 above and Figure 5 below aim to protect sharks, sea turtles and marine mammals only, and do not address the issue of fish bycatch.

The Magnuson–Stevens Act is the primary law governing marine fisheries conservation and management in United States federal waters. Under the National Standard 9, bycatch is defined as all fish discards (whole fish at sea or elsewhere, including economic discards and regulatory discards, and fishing mortality due to an encounter with fishing gear that does not result in capture of fish). Bycaught fish are therefore harvested in a fishery, but not sold or kept for personal use. The priority under this Standard is to minimize bycatch and bycatch mortality first by avoiding bycatch to the extent practicable. The Standard also requires each management measure that is implemented to be assessed in terms of its effects on the amount and type of bycatch and bycatch mortality in the fishery. For the purposes of this project, bycatch is simply defined as fish discards at sea.

Catches, or "takes", of sea turtles and marine mammals are referred to here as "interactions" to clearly differentiate them from the catches or bycatches of fish species that are the topic of this report.

[4] The DGN can technically be regarded as a multispecies fishery which (legally) catches and sells numerous other species of fish besides swordfish, including tunas and highly migratory sharks which are managed under the Pacific Fishery Management Council's HMS (Highly Migratory Species) Fishery Management Plan.

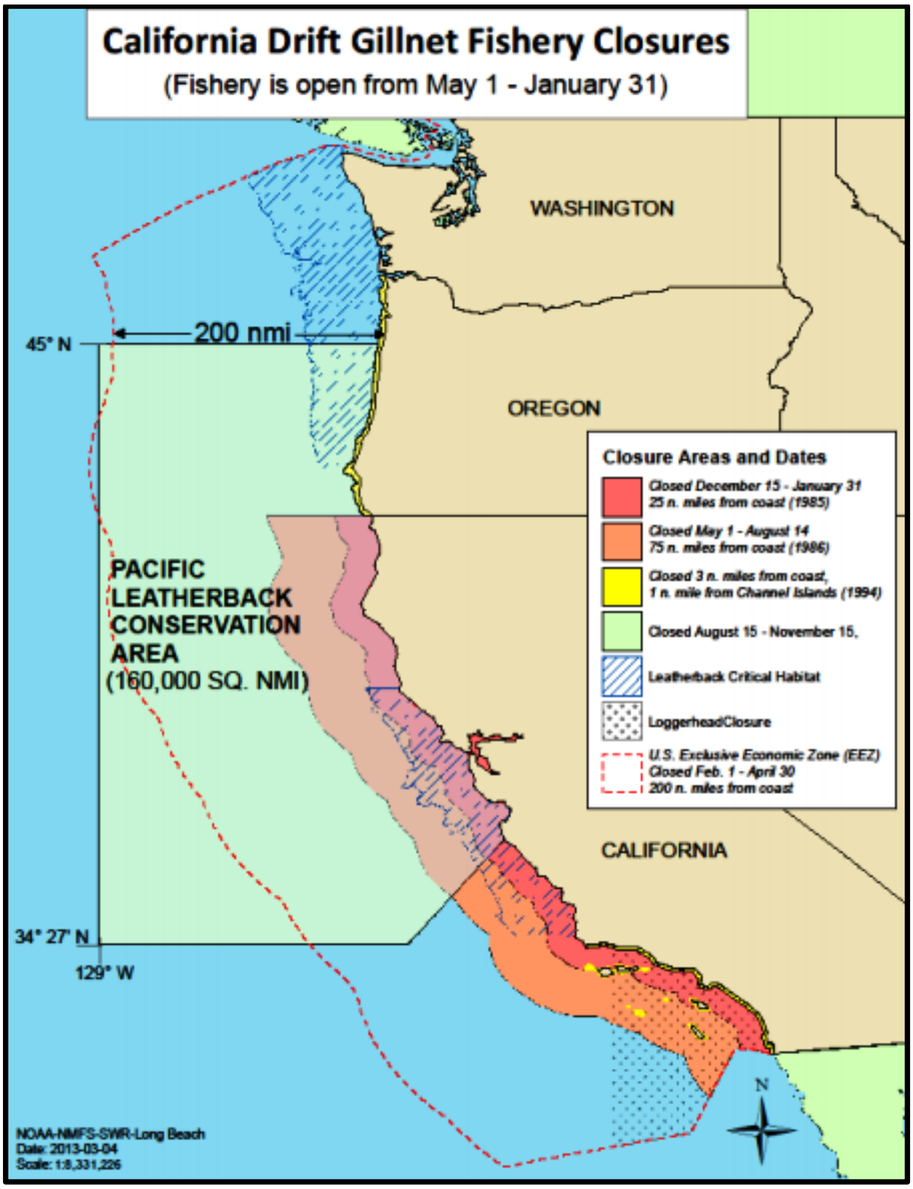


Figure 5: California-Oregon-Washington drift gillnet closures. Source: NOAA-NMFS-SWR-Long Beach

## Purpose

While time, spatial and technical regulations alone represent a strong deterrent to any potential new fisherman wanting to enter this fishery, non-renewable permits also ensure that fishing effort in terms of the number of participating boats will never again increase. Dwindling participation in the fishery since a peak of 251 permits in 1985, as well as the implementation of a moratorium on new permits in 1986, has led to a reduction in the yearly number of active permits to less than 50 over the past ten years. This has resulted in a huge decrease in effort in the California drift gillnet fishery (see Figure 4).

This drastic reduction in effort, coupled with effective, well-enforced and actively managed conservation measures have been successful in reducing marine mammal interactions. Since 2000, leatherback turtle interactions have been reduced by 90 % (2 leatherback turtles caught and returned alive), loggerhead turtle interactions have been reduced by 85 % (2 loggerhead turtles caught and returned alive) and there have been no observed interactions with green or olive Ridley turtles or with fin whales, humpback whales or sperm whales (NOAA, 2012),.

It is clear that the impacts of this fishery on the populations of numerous marine species have been greatly reduced over the years, yet it is still regularly used as a poster child for destructive fishing gears with no acknowledgment of decreasing impacts over time. The CA DGN fishery has even been dubbed the "Wall of Death[5]" by one U.S. Non-Governmental Organization (NGO) and has in recent years served as a scape-goat for the impacts of Pacific fisheries as a whole. As this fishery is often portrayed as "dirty"[6][7], it is interesting to look at the numbers in an objective way, by using fisheries-dependent data such as the observer data set produced by the Observer Program since 1990. In addition, by issuing statements such as "These drift gillnets discard, on average, over 60 percent of their catch (Oceana, 2015)", so-called conservationists seem to intentionally overlook the disposition of discards, which is a crucial factor in assessing the impact of a fishery on marine ecosystems. As high quality data on the disposition of all catch in the observer record exists to support an analysis, this important variable will be considered in this research project.

Section 303 of the 1996 Sustainable Fisheries Act (SFA) requires all Fisheries Management Plans (FMP) to "establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery" and include conservation and management measures that meet the above-mentioned National Standard 9[8].

This research project therefore fits into the broader objectives of the Pacific Fisheries Management Council (PFMC) and NOAA to develop better metrics in order to characterize the fisheries that they manage. This, in part, will serve to monitor and analyze the effects of the conservation measures implemented on bycatch trends, in terms of volume, specific composition and discard disposition (alive or dead). It was hypothesized at the onset that the 1998 POCTRP and 2001 PLCA are likely to have had effects on the catches of species beyond their scope, and thus may have had effects, positive or negative, on the levels and composition of bycatch in the CA DGN fishery since their respective implementations.

Whereas fisheries have often been characterized by numbers caught and discarded (alive or dead), this is problematic where multi-species fisheries are concerned, as the comparison between species of significantly different sizes may be misleading. Firstly, this research project will aim to characterize bycatch in the CA DGN fishery on the basis of biomass caught and discarded in order to gain a new perspective compared to the traditional approach using numbers of fish caught and discarded. Secondly, this project aims determine whether trends can be identified in bycatch in relation to the implementation of the POCRTP and the PLCA.

## Project Origin

This project was initially conceived in a meeting with Brian Stock (SIO, PhD. Candidate) and Josh Steward (SIO, PhD. Candidate) at a MAS-MBC ice-breaker/mixer event, in early July 2015. It immediately became obvious that our interests converged on fisheries, and conversations lead to Brian introducing me to James Wraith (NOAA-SWFSC) soon after. After providing some elements of my background, professional experience and interests to James, he directed me to SWFSC biologist Dr. Heidi Dewar (NOAA-SWFSC) and a meeting was set-up in early August to meet her and her Fisheries Resources Division colleague, Dr. Stephen Stohs (NOAA-SWFSC), about a potential Capstone Project idea.

In addition to being experts in their respective fields (Heidi is a Marine Biologist and Stephen is an Economist), Heidi and Stephen have a thorough knowledge of all aspects of the CA DGN fishery. They are actively involved in research projects related to swordfish, which is the target species for this fishery, and on the CA DGN fishery as a whole. They have recently produced an analysis to compare protected species interactions to economic performance across U.S. fisheries targeting or retaining

[5] Oceana, 2013. URL: http://oceana.org/reports/end-walls-death-replace-devastating-drift-gillnets-california-cleaner-fishing-gear

[6] Oceana, 2015. URL: http://oceana.org/press-center/press-releases/el-ni%C3%B1o-triggers-temporary-drift-gillnet-fishery-closure-southern

[7] Oceana, 2014. URL: http://oceana.org/sites/default/files/reports/exposing_california_drift_gillnet_secret-4.15.pdf

[8] SFA National Standard 9: "Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch."

swordfish, focusing on a list of high priority protected species which are subject to special regulatory measures under the ESA or MMPA. As such, Stephen and Heidi were interested in a related project to analyze CA DGN observer data with respect to fish species bycatch and suggested that this could make for an interesting, and useful Capstone Project. By the beginning of September, my Capstone Committee was therefore formed, comprised of Dr. Stephen Stohs, Dr. Heidi Dewar and PhD. Candidate Brian Stock. At a later stage, during the Winter Quarter, Dr. Stuart Sandin kindly accepted an invitation to join my Committee as full-time SIO faculty member and expert in Ecology and Statistics. Meetings were held regularly throughout the project to help steer research efforts and ensure the coherence of findings.

# Methodology

## The data

Data for the large mesh drift gillnet fishery was provided by SWFSC staff from the California Gillnet Observer Database after signature of a non-disclosure agreement. This dataset remains the property of SWFSC and cannot be disclosed in non-summarized form due to confidentiality requirements. Anyone wishing to pursue work on this dataset can reach out to SWFSC staff to explore possible collaborations. The original dataset that was provided contains 53 356 rows of 21 variables. These variables are: Fake vessel ID, Trip number, Set number within each trip, date when pull for the set began, Year when pull for the set began, Month when pull for the set began, Day when pull for the set began, Longitude at beginning of the set, Latitude at beginning of the set, Temperature at beginning of the set, Species Code[9], Common Name, Scientific Name, Number Kept, Number Returned Alive, Number Returned Dead, Number Returned in Unknown Condition, Net Type ("drift" in this case), Mesh size stretched to the nearest ½ inch (which ranges from 14 to 31 inches), Depth of the net (which ranges from 14 to 200), and Length of the mesh panel in fathoms.
For the specific purposes of this Capstone project, each row of the dataset was assigned a season number from 1990 to 2013, included. This season identifier was on the California drift gillnet fishing season dates (May 1st to January 31st of the following year) and the Year, Month and Day attributes of the dataset. This was a relatively simple step which went a long way towards producing temporal analyses of catches as well as looking at trends related to the 1998 and 2001 conservation measures.
The dataset lists 90 different species codes, which include a code for completely unknown species and several codes for unknown marine organisms that have not been identified to the genus level (Unidentified Mackerel, Unidentified Billfish, Unidentified Hammerhead shark, Unidentified Ray, Unidentified Skate, Unidentified Rockfish, Unidentified Fish, Unidentified Octopus, Unidentified Mollusk, Unidentified Crustacean, Unidentified Shark, Unidentified Thresher shark, and Unidentified Invertebrate). Unidentified invertebrates, crustaceans, octopi and mollusks, as well as data on pelagic tunicates were removed from the dataset for analysis as they are not relevant to a study on finfish bycatch. 74 species of fish remained, caught over 8 568 observed fishing sets between 1990 and 2013.

**CAVEAT:** Although extremely comprehensive and valuable in describing observed catches since 1990, the dataset does not account for fish that were caught on unobserved vessels. Freak occurrences of certain rare species cannot therefore be ruled out, and the dataset can only be regarded as a close approximation of reality.

Data on observer coverage was procured thanks to Elizabeth Hellmers of the California Department of Fish and Wildlife. Elizabeth Hellmers had previously carried out her own analyses of the observer data and kindly gave me some of her time early on in the project to walk me through some of the main aspects of this data. As part of her work for CDFW, Elizabeth Hellmers had kept track of the observer coverage per year and provided me with that data, which I would later use to produce expansion expansions of total catch and discard values from observed catch and discard values based on a fraction of all effort in a season. Observer coverage percentages were also used to calculate an expansion estimate of effort for full seasons from observed effort (Figure 4).

In order to calculate expansions of biomass for certain species that I will later choose to focus on, I obtained measurements of fish lengths from SWFSC, thanks to Heidi Dewar. The original data that was made available to me contained a combination of 51 756 fork lengths, total lengths and disc widths describing 30 different species. These measurements were collected by fisheries observers on CA DGN vessels and reflect fish sizes caught by this fishery. As measurements include bycatch species (species systematically discarded, displaying very low levels of retention), and not only the species retained, it is safe to assume that the data is representative of the entire catch, both retained and discarded.

Large amounts of literature exist on length-weight relationships and growth patterns of fish species of major commercial importance or potential for aquaculture. However, this is much less common for most of the other species that are caught regularly or exceptionally by the CA DGN fishery. Allometry refers to biological scaling relationships in general (Shingleton A., 2010), length-weight being one example. The general allometry equation used here is:

$$Weight = a \times Length^b$$

Where:

$$a = Initial\ Growth\ Index$$
$$b = Scaling\ Exponent$$

Table 2 below presents the Initial Growth Index and Scaling Exponent that were used for each species for which a calculation of biomass was conducted:

**Table 2: Allometry coefficients used in biomass calculations. Source: author's own**

| Species Scientific Name | Species (Author R code) | Initial Growth Index | Scaling Exponent | Source |
|---|---|---|---|---|
| *Mola mola* | MOLA | 52.96 | 2.96 | NOAA/SWFSC |
| *Prionace glauca* | BLUESHARK | 3.18E-06 | 3.1313 | NOAA/NEFSC |
| *Thunnus alalunga* | ALBACORE | 3.17E-05 | 2.88938 | NOAA/PIFSC |
| *Xiphias gladius* | BROADBILLSWO | 2.11E-05 | 2.961 | NOAA/SWFSC |
| *Isurus oxyrinchus* | SHORTFINMAKO | 5.24E-06 | 3.1407 | NOAA/NEFSC |
| *Katsuwonus pelamis* | SKIPJACK | 7.65E-06 | 3.24281 | NOAA/PIFSC |
| *Scomber japonicus* | PACMACKEREL | 1.17E-06 | 3.48 | NOAA/SWFSC |
| *Alopias vulpinus* | COMMONTHRESHER | 1.88E-04 | 2.5188 | NOAA/NEFSC |
| *Lampris guttatus* | OPAH | 9.449E-05 | 2.8247 | NOAA/SWFSC |
| *Thunnus orientalis* | BLUEFIN | 0.0001139 | 2.6767 | Watanabe & Sato |
| *Auxis rochei* | BULLETMACKEREL | 7.65E-06 | 3.24281 | Used Skipjack coefficients |
| *Sarda chiliensis* | BONITO | 7.65E-06 | 3.24281 | Used Skipjack coefficients |
| *Alopias superciliosus* | BIGEYETHRESHER | 9.107E-06 | 3.0802 | NOAA/NEFSC |
| *Thunnus albacares* | YELLOWFIN | 3.17E-05 | 2.88938 | NOAA/PIFSC |
| *Tetrapturus audax* | STRMARLIN | 1.33E-06 | 3.41344 | NOAA/PIFSC |
| *Pteroplatytrygon violacea* | PELAGICSTINGRAY | 48.4 | 3.471 | Mollet et al. (2002) |

**CAVEAT:** Allometry coefficients should be used with caution as many different estimates exist for the same species. It seems that distinct parties from research institutions and the aquaculture industry all calculate their own allometry coefficients and these can vary significantly with environmental conditions in which the fishes are grown as well as density and the kind of feed that they are given. The allometric coefficients used here were selected because they were calculated for Pacific Ocean fishes, from studies as close to California as possible, and wherever possible, from NOAA or trusted NOAA-affiliated sources.

**CAVEAT 2:** The fish length measurements that were used in calculating fish length averages for the DGN fishery were measured by observers on the DGN fishery as a whole and may therefore be representative in part of fish lengths caught by Small Mesh DGN in addition to the Large Mesh DGN that is the focus of this report. Although this may have an influence on the final average fish lengths and therefore average weights that were calculated, this uncertainty does not undermine the concept that is tested here, that is, exploring an alternative metric for quantifying fish bycatch in the Large Mesh California DGN fishery.

## Analysis using R

Using R to conduct my analysis provided me with a very powerful way to organize and manipulate the data, and display results.
In order to remove the influence of fluctuating observer coverage levels on catch trends I calculated expanded catch values using yearly observer coverage, as follows:

$$Expanded\ Catches = Observed\ Catches \times \frac{100}{Observer\ Coverage\ (\%)}$$

When looking at the potential effects of conservation measures I also wanted to remove the effect of decreasing effort in the fishery and produce graphs of Catch Per Unit Effort (CPUE); I therefore produced expansion estimates of numbers of sets in each year, calculated as follows:

$$Expanded\ Sets = Observed\ Sets \times \frac{100}{Observer\ Coverage\ (\%)}$$

The observer coverage was coded in R as a dataframe, which would then be applied to any other dataframe object with the same dimensions, thus enabling the expansion of the observed data to an expanded total value caught, retained and discarded.
For each species that I chose to address in this project, I was able to calculate an average length as being representative of the average length of each species caught by the CA DGN fisheries. From this average value of length, and by using the allometry relationship described above, it was possible to calculate an average weight for each of the species caught by the CA DGN fishery that I chose to address.
These average weights were then combined with expanded number of catches for a selection of species to calculate an expanded biomass caught, retained and/or discarded, using the formula below:

$$Expanded\ Catches\ Biomass = Expanded\ Catches \times Estimated\ Weight$$

I was able to categorize the data according to individual species according to numbers of retained catch, number of discarded fish and expanded biomass over selected time periods, and this provided me with the necessary building blocks to analyze the specific composition of bycatch in the CA DGN fishery.

**CAVEAT:** In order to be able to compare live and dead discards more directly, discards whose disposition was unknown were omitted from the figures included in today's presentation. Unknown discards account for 1.5% of overall catch numbers between 1990 and 2013.

Some of the steps undertaken and objects created in R are as follows:

1) Creation of a dataframe of observer coverage to use throughout (observer coverage per season)
2) The main dataset was sub-set by fishing season (24 subsets from 1990 to 2013) by matching the season identifier. R was able to recognize all observed catches made during each season and create dataframes for each season, with cumulative observed catch numbers overall:
3) Using the species code as identifier, total catches for each species were calculated.
4) For each species, a dataframe of observed catches retained and discarded alive, dead or unknown was created by matching the season identifier and species code, asking R to sum-up all observed catches that matched these criteria:
5) More detail was extracted by calculating observed catches according to their fate (retained/discarded) discarded disposition (alive/dead/unknown)
6) Yearly observed catch dataframes were created for each species, enabling the visualization of catch trends over the time frame of the dataset or any other time frame that is of interest
7) Using the observer coverage dataframe, all observed catches were expanded to their corresponding values assuming theoretical observer coverage of 100 %. This allows the removal of the effect introduced by varying yearly observer coverage.
8) For determined time periods, the total number of species caught was divided by the total observed number of fishes caught during that same time period. This produced a ranking of each species according to its significance in terms of numbers, relative to the fishery as a whole. The time periods explored are 1990-1997 (included, as the POCTRP was effective during the 1998 fishing season) – pre-CTRP, 1998-2000 (included) – between POCTRP and PLCA and 2001-2013 (included, as the PLCA was effective during the 2001 fishing season) – post-PLCA.

This variety of objects that were created laid the basis for drawing a picture of fish bycatch in the California drift gillnet fishery. The results of this project are described in the following section.

# Findings

## Bycatch ranks

As was described above, the CA DGN observer dataset was partitioned into three time periods in order to produce a visualization of the effects of the 1998 POCTRP and 2001 PLCA on the bycatch of fish species. For each of these time periods, the species comprising 99 % of the total catch by numbers were retained and are displayed in the following tables (Tables 1, 2, and 3). This target of 99 % came about because of the high number of species that were caught at one time or another by this fishery, but only account for a very small fraction of all catches. In order to be able to conduct a meaningful analysis it was necessary to operate a selection. 99 % was deemed to be a good target, and this allowed a reduction in the number of species to address, leaving the most caught species only. The entire list of species caught for each time period and ranked by percentage of total catch is available for each time period in Annexes B, C, and D. For each of these tables, species managed under the Highly Migratory Species Fisheries Management Plan are highlighted in purple. These species are:

**Tunas:** North Pacific albacore (*Thunnus alalunga*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), skipjack tuna (*Katsuwonus pelamis*), Northern bluefin tuna (*Thunnus thynnus*).

**Sharks:** common thresher shark (*Alopias vulpinus*), pelagic thresher shark, (*Alopias pelagicus*), bigeye thresher shark (*Alopias superciliosus*), shortfin mako shark (*Isurus oxyrinchus*), Blue shark (*Prionace glauca*).

**Billfish/Swordfish:** striped marlin (*Tetrapturus audax*), swordfish (*Xiphias gladius*).

**Other:** dorado or dolphinfish (*Coryphaena hippurus*).

Of note: The Billfish Conservation Act of 2012 was signed into law on October 2012 and prohibits the sale, and possession for purposes of sale, of all billfish (excluding swordfish)[10].

### 1990-1997 (included):

The full ranking of all 58 species observed caught during that time period is given in Annex B.

The POCTRP was implemented during the 1998 fishing season, and therefore the best image of the CA DGN fishery prior to this ensemble of conservation measures can be derived from the period prior to that.

Table 3 below provides a ranking of species that account for the top 99.82 % of catches by number between 1990 and 1997. The category UNIDFISH (Unidentified fish) accounts for 0.67 % of overall catches during that same time period. As the objective here is to characterize the top identified fishes caught by the CA DGN fishery, this unidentified category has been ignored, and replaced instead by those species that previously fell outside of the 99 % mark and represent 0.68 % of overall catches when combined. Therefore, it is fair to say that Table 3 characterizes 99.15 % of all identified catches that were made during the fishing seasons from 1990 to 1997 (included), or 99.82 % of all catches, including unknown species.

[10] Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species Compliance Guide March 3, 2015.

**Table 3: Fish ranks in CA DGN fishery, fishing seasons 1990-1997 (included), 99 % of catches. Source: author's own.**

| Species (Author R Code) | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes (number of fish caught) | Expanded Total Retained (number of fish retained) | Percentage of Total Finfish Catch | Cumulative Percentage of Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| MOLA | 0.1 | 90.0 | 4.1 | 234699 | 306 | **27.85** | 27.85 |
| BLUESHARK | 0.7 | 27.5 | 65.1 | 130448 | 1261 | **16.21** | 44.07 |
| BROADBILLSWO | 99.1 | 0.0 | 0.7 | 93962 | 93059 | **11.50** | 55.57 |
| ALBACORE | 86.5 | 0.0 | 13.2 | 71467 | 61593 | **9.48** | 65.05 |
| SKIPJACK | 45.2 | 0.1 | 54.6 | 46923 | 21389 | **6.59** | 71.64 |
| PACMACKEREL | 31.7 | 1.5 | 66.3 | 41624 | 13848 | **5.58** | 77.22 |
| SHORTFINMAKO | 97.1 | 1.7 | 1.0 | 40041 | 38984 | **4.92** | 82.14 |
| COMMONTHRESHER | 99.6 | 0.0 | 0.3 | 37606 | 37455 | **4.42** | 86.56 |
| BULLETMACKEREL | 34.7 | 0.2 | 60.5 | 24439 | 9990 | **3.37** | 89.94 |
| OPAH | 97.6 | 0.1 | 2.1 | 24872 | 24337 | **3.19** | 93.12 |
| BLUEFIN | 91.6 | 0.0 | 7.9 | 19447 | 17604 | **2.76** | 95.88 |
| **UNIDFISH** | **7.3** | **13.5** | **75.0** | **5222** | **551** | **0.67** | 96.55 |
| LOUVAR | 88.6 | 0.2 | 10.6 | 3979 | 3543 | **0.49** | 97.04 |
| BIGEYETHRESHER | 93.2 | 0.4 | 5.8 | 3692 | 3407 | **0.46** | 97.50 |
| STRMARLIN | 18.5 | 1.7 | 75.8 | 2627 | 530 | **0.33** | 97.83 |
| PACPOMFRET | 55.3 | 0.9 | 42.6 | 2214 | 1127 | **0.30** | 98.13 |
| PACIFICHAKE | 3.0 | 6.7 | 89.9 | 2363 | 64 | **0.30** | 98.43 |
| BONITO | 56.8 | 0.0 | 37.5 | 2971 | 1876 | **0.29** | 98.72 |
| YELLOWFIN | 89.9 | 0.0 | 9.2 | 1546 | 1375 | **0.22** | 98.94 |
| PELAGICSTINGRAY | 0.4 | 67.7 | 26.0 | 1461 | 8 | **0.20** | 99.15 |
| PELAGICTHRESHER | 98.0 | 0.0 | 2.0 | 725 | 710 | **0.14** | 99.28 |
| REMORA | 0.0 | 93.5 | 4.9 | 784 | 0 | **0.11** | 99.40 |
| JACKMACKEREL | 54.6 | 2.5 | 42.9 | 826 | 512 | **0.11** | 99.51 |
| UNIDMACKEREL | 27.1 | 0.0 | 72.9 | 322 | 88 | **0.06** | 99.57 |
| SMOOTHHAMMERHEAD | 33.3 | 0.0 | 66.7 | 427 | 143 | **0.06** | 99.63 |
| PACSARDINE | 18.6 | 0.0 | 81.4 | 368 | 72 | **0.05** | 99.68 |
| YELLOWTAIL | 95.6 | 0.0 | 2.2 | 346 | 318 | **0.04** | 99.72 |
| CABARRACUDA | 59.0 | 10.3 | 30.8 | 205 | 132 | **0.04** | 99.76 |
| BLUEMARLIN | 8.3 | 0.0 | 91.7 | 228 | 22 | **0.03** | 99.79 |
| BIGEYETUNA | 100.0 | 0.0 | 0.0 | 226 | 226 | **0.03** | 99.82 |

**Key:**

| | |
|---|---|
| BROADBILLSWO | Target species |
| SPECIES | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) |
| SPECIES | Bycatch species (with very low level of retention) |
| UNIDFISH | This category comprises all finfish species that observers were not able to identify. This category is removed from the 99 % of identified species caught by the CA DGN fishery. |
| SPECIES | These species were included in the 99 % of identified species caught by the CA DGN fishery to substitute for the removal of unidentified fishes. |

## 1998-2000 (included):

The full ranking of all 51 species observed caught during that time period is given in Annex C.

Table 4: Fish ranks in CA DGN fishery, fishing seasons 1998-2000 (included), 99 % of catches. Source: author's own.

| Species (Author R Code) | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes (number of fish caught) | Expanded Total Retained (number of fish retained) | Percentage of Total Finfish Catch | Cumulative Percentage of Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| MOLA | 0.6 | 97.1 | 1.9 | 104016 | 529 | **32.19** | 32.19 |
| ALBACORE | 81.5 | 0.2 | 18.3 | 56780 | 46479 | **18.17** | 50.36 |
| BLUESHARK | 0.1 | 40.6 | 58.1 | 56834 | 61 | **17.78** | 68.14 |
| BROADBILLSWO | 98.4 | 0.0 | 1.6 | 28531 | 28073 | **9.06** | 77.20 |
| SKIPJACK | 28.3 | 0.1 | 71.7 | 16716 | 4643 | **4.45** | 81.65 |
| SHORTFINMAKO | 95.1 | 2.2 | 2.7 | 10902 | 10387 | **3.54** | 85.19 |
| BLUEFIN | 92.0 | 0.0 | 8.0 | 10496 | 9631 | **3.29** | 88.47 |
| COMMONTHRESHER | 99.5 | 0.4 | 0.0 | 8711 | 8669 | **2.66** | 91.13 |
| OPAH | 94.2 | 0.5 | 5.3 | 7647 | 7217 | **2.42** | 93.55 |
| PACMACKEREL | 17.2 | 1.8 | 80.8 | 6035 | 1111 | **2.09** | 95.64 |
| BULLETMACKEREL | 19.5 | 0.0 | 80.5 | 4201 | 822 | **1.16** | 96.80 |
| LOUVAR | 80.0 | 0.5 | 19.5 | 1778 | 1421 | **0.57** | 97.38 |
| PACPOMFRET | 75.5 | 0.8 | 22.8 | 1642 | 1237 | **0.56** | 97.94 |
| SALMONSHARK | 10.2 | 0.0 | 89.8 | 800 | 81 | **0.28** | 98.21 |
| PELAGICSTINGRAY | 0.6 | 81.0 | 16.7 | 805 | 5 | **0.26** | 98.48 |
| UNIDFISH | 3.9 | 7.9 | 87.5 | 813 | 36 | **0.24** | 98.72 |
| BONITO | 75.2 | 1.3 | 23.5 | 854 | 638 | **0.23** | 98.95 |
| YELLOWFIN | 79.2 | 0.0 | 20.8 | 592 | 468 | **0.20** | 99.15 |
| BIGEYETHRESHER | 94.4 | 0.0 | 5.6 | 360 | 339 | **0.11** | 99.26 |
| UNIDMACKEREL | 0.0 | 0.0 | 100.0 | 302 | 0 | **0.11** | 99.37 |
| JACKMACKEREL | 95.4 | 0.0 | 4.6 | 287 | 273 | **0.10** | 99.47 |
| **Key:** | | | | | | | |
| BROADBILLSWO | Target species | | | | | | |
| SPECIES | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) | | | | | | |
| SPECIES | Bycatch species (with very low level of retention) | | | | | | |
| UNIDFISH | This category comprises all finfish species that observers were not able to identify. This category is removed from the 99 % of identified species caught by the CA DGN fishery. | | | | | | |
| SPECIES | These species were included in the 99 % of identified species caught by the CA DGN fishery to substitute for the removal of unidentified fishes. | | | | | | |

## 2001-2013 (included):

The full ranking of all identified species and 6 unidentified species observed caught during that time period is given in Annex C.

49 species were caught during that period, some of which very rarely, and some others haven't been observed in well over 10 years. A choice had to be made. Table 5 below represents the selection of most caught species caught during the period post-PLCA (2001-2013, included) and is the basis of further analysis as I deem it to be most representative of recent years (it includes all prior conservation measures).
Table 5 provides an overview of catches in the fishery, focusing on the species that comprise 99.23 % of the catch. It can be noticed immediately that the fishery has gotten increasingly more selective when compared to the other two time periods considered above. As is demonstrated by the lower number of different species that comprise 99 % of the overall catch (18 species, as opposed to 20 between 1998-2000 and 30 between 1990-2000), the impact of this fishery has been considerably narrowed on fewer species over the years and certainly since the implementation of the PLCA.

**Table 5: Fish ranks in CA DGN fishery, fishing seasons 2001-2013 (included), 99 % of catches. Source: author's own.**

| Species (Author R Code) | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes (number of fish caught) | Expanded Total Retained (number of fish retained) | Percentage of Total Finfish Catch | Cumulative Percentage of Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| MOLA | 0.1 | 94.8 | 4.3 | 220500 | 284 | **44.01** | 44.01 |
| BROADBILLSWO | 97.4 | 0.4 | 2.2 | 49647 | 48343 | **10.35** | 54.36 |
| ALBACORE | 91.5 | 0.0 | 8.4 | 36769 | 33641 | **7.80** | 62.16 |
| SHORTFINMAKO | 93.7 | 2.5 | 3.8 | 33036 | 30909 | **7.15** | 69.31 |
| BLUESHARK | 1.0 | 34.9 | 61.5 | 28362 | 274 | **5.60** | 74.92 |
| OPAH | 96.8 | 0.2 | 3.0 | 25950 | 25159 | **4.79** | 79.70 |
| SKIPJACK | 39.1 | 0.6 | 60.1 | 20505 | 8073 | **4.33** | 84.03 |
| COMMONTHRESHER | 98.2 | 0.8 | 1.0 | 20908 | 20492 | **4.26** | 88.29 |
| PACMACKEREL | 14.0 | 3.9 | 81.8 | 16957 | 2517 | **3.59** | 91.89 |
| BLUEFIN | 93.9 | 0.0 | 6.1 | 8719 | 8183 | **1.87** | 93.76 |
| BONITO | 30.8 | 2.8 | 66.4 | 9076 | 2637 | **1.80** | 95.55 |
| BULLETMACKEREL | 34.8 | 0.3 | 64.6 | 4296 | 1608 | **1.07** | 96.63 |
| YELLOWFIN | 82.8 | 0.0 | 17.2 | 2840 | 2350 | **0.56** | 97.19 |
| LOUVAR | 90.6 | 0.4 | 9.0 | 2649 | 2383 | **0.56** | 97.75 |
| BIGEYETHRESHER | 47.8 | 0.8 | 51.0 | 2628 | 1290 | **0.52** | 98.27 |
| PACPOMFRET | 62.2 | 1.0 | 36.8 | 2588 | 1900 | **0.51** | 98.78 |
| PELAGICSTINGRAY | 2.0 | 81.6 | 12.2 | 1183 | 24 | **0.25** | 99.03 |
| STRMARLIN | 0.0 | 0.0 | 100.0 | 1001 | 0 | **0.20** | 99.23 |

**Key:**

| | |
|---|---|
| BROADBILLSWO | Target species |
| SPECIES | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) |
| SPECIES | Bycatch species (with very low level of retention) |
| SPECIES | Species for which reliable average weight data was not available, and which have been removed from the analysis of discard biomass |
| STRMARLIN | Prohibited species |

## Biomass

I chose to characterize 99% of the fish catch (in numbers) and gather weight information for all of them. The pelagic stingray straddles the 99% mark so technically we are addressing 99.2% of the catch. At this stage, I was unable to obtain reliable estimates of average weight for louvar and Pacific pomfret caught in the CA DGN fishery so have chosen to remove them from the current analysis and concentrate on the rest, which leaves 98.1% Striped marlin was included here as it is a species of interest[11] although with only 194 observed catches during this period it falls just outside of the top 99%. This leaves us with 16 species for roughly 98.3% of the catch. In the top caught species and highlighted in orange we observe 5 species with very low levels of retention, these are our bycatch species. The following slides characterize the species that are listed here only, characterizing 98.3% of the total catch for fish species. As was mentioned above, the dataset as a whole comprised 74 species of fish, some of which are caught in very low numbers, while other haven't been caught in well over ten years.

Because the period since 2001 includes the 1998 POCTRP and 2001 PLCA, it was considered to be most representative of current fishery characteristics such as discard rate and discard disposition. For that reason, catch and discard biomass was calculated for each species of table 5, using average length estimates (calculated using observer measurements) and allometry equations for each species.

**CAVEAT:** Reliable estimates of average lengths for louvar and Pacific pomfret were not available, due to a lack of data. Therefore these species were not included in the calculations of biomass and subsequent analysis of discard rate by weight. These species account for 1.07 % of overall catch numbers between 2001 and 2013. Therefore, the following analyses characterize the remaining species displayed in table 5, that is, 16 species for 98.16 % of total catches during the period from 2001 to 2013.

**CAVEAT 2:** A latitude effect on catches existed prior to the implementation of the PLCA in 2001, which has since caused the fishery as a whole to shift its effort down South of Point Conception. As the fishery's displacement south correlates with the implementation of the PLCA, the true effect of the PLCA is not clear. This will therefore be addressed in later stages of this project, as described in the Future Steps section below.

It is interesting to note that over half of the most caught species in this fishery are managed under the HMS FMP. Data and research is therefore available, and is continually being gathered/carried out to guide the management/monitoring of these species.

# Trends in discards in the CA DGN fishery

## Overall discards

Discard rate has been calculated for the CA DGN fishery in terms of biomass and numbers discarded. The following equation was used to calculate the discard rate:

$$Discard\ Rate = \frac{Discards\ of\ the\ Top\ 16\ Species\ (Numbers\ or\ Biomass)}{Total\ Catch\ of\ the\ Top\ 16\ Species\ (Numbers\ or\ Biomass)}$$

[11] Striped marlin is a prohibited species under the HMS FMP, it also is a valuable species to the recreational fishery and in 2013 the International Scientific Committee for Tuna and Tuna-like Species indicated in their stock assessment of striped marlin in the Western and Central North Pacific Ocean that the North Pacific stock is considered overfished while overfishing is occurring.

Although the analysis has been carried out on the 16 top caught species post-PLCA (black and beige lines in Figure 6), the same analysis of discards was run through R to account for all identified species caught during that same time period. The result is represented by the orange line in Figure 6. The strong similarity between the discard rates for the top 99.16 % of species and the discard rates for all 49 species caught shows that the choice that was made to characterize 99 % of the fishery is coherent.

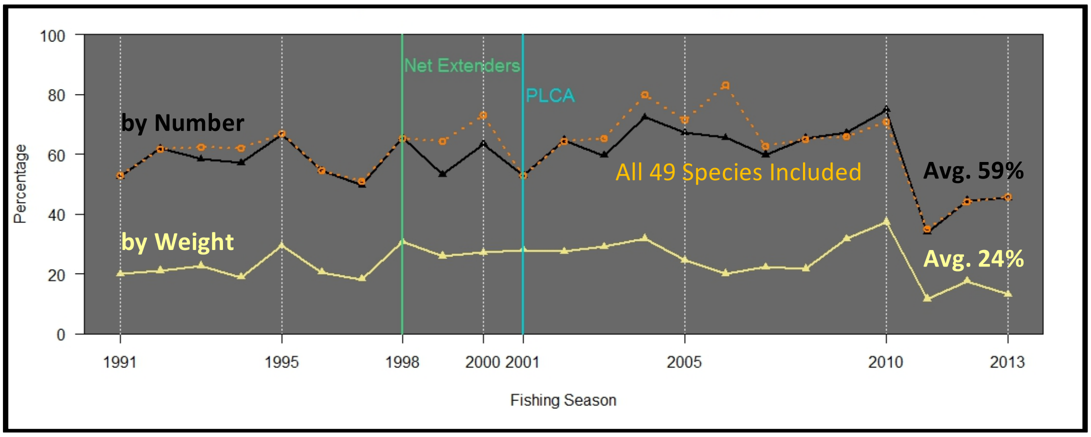


**Figure 6: Discards by number and by weight as a percentage of total catch in the CA DGN fishery (Species accounting for top 98.16 % of catches)**

**CAVEAT:** The methodology that was used to calculate these yearly discard rates is not state-of-the-art. Current best approaches include an estimate of uncertainty that is obtained from pooling together several years and taking into account some measure of variance of the data, which would then be square-rooted and divided by the mean to obtain a, easily understandable coefficient of variance. For the purposes of this project and in the interest of time, a simpler approach was implemented, which consists in calculating a discard rate for each year by using only that year's data. One advantage of the simpler method however is that anomalies such as the decrease in discard rate in 2011 is observable, whereas it may have been lost in the pooling approach.

**CAVEAT 2:** Because effort is decreasing so drastically in the CA DGN fishery (see Figure 4), and because of the very low number of sets observed as a result in recent years, there is an increased uncertainty associated with these calculations. This may not be as important for very common species, but could induce some loss of information with regard to rarer and not as commonly caught species.

The most obvious and significant feature of Figure 6 is the drastic difference between the discard rates when calculated on the basis of numbers or biomass of fishes discarded. The line in black shows a traditional approach by numbers. When assessing discards by numbers of fishes, the average value over 24 seasons is approximatively 59 %. It is easy to recognize here the value that has been widely used by parties opposing this fishery to support their claims and arguments towards a ban of this fishery, as well as others[12]. There are two fundamental flaws in formulating discard assessments using number of fishes caught and discarded. The first is that as fishes very tremendously in size, numbers of fishes do not provide a clear picture of the actual impact on the biomass of a population. Comparing mackerels or even anchovies to sharks or even common molas in this way is unrealistic at best. The second flaw, which is perhaps even more insidious, is that this value of 59 % does not take into account the decrease in discard rates over the past few years. It can clearly be seen from Figure 6 that the 2011 fishing season saw a drastic decrease in discards. It is difficult at this stage to attribute this trend to any specific factor, as several variables could be responsible for this (environmental factors, fishing habits, population dynamics, etc.). This has not been researched further during this project.

[12] http://oceana.org/press-center/press-releases/new-oceana-report-exposes-nine-dirtiest-us-fisheries

After calculating an average weight for each of the species in Table 5, and using expanded catches and discards, a biomass caught and discarded of each species was calculated. This in turn enabled the calculation of a discard rate in terms of biomass, which is represented by the beige line in Figure 6. The discard rate when calculated by biomass is down to 24 %, which sheds an unusual light on this fishery and makes a change from the multitude of blind accusations it is being targeted by.

### Discard disposition

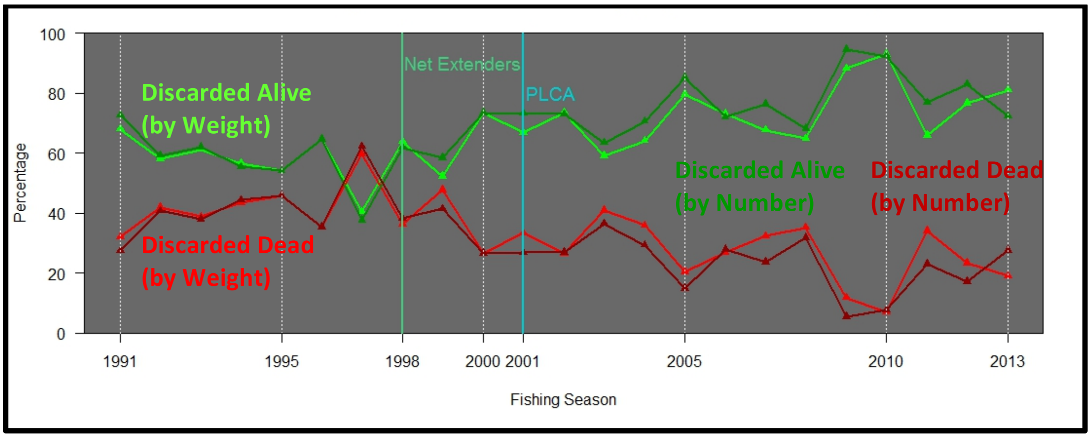


Figure 7: Live and dead disposition of discards by number and by weight as a percentage of total discards in the CA DGN fishery (Species accounting for top 98.16 % of catches)

**CAVEAT 1:** Although live discards far outweigh dead discards in the CA DGN fishery, there is no reliable information on post-release survivorship for the species that are being discarded. Therefore, a live release does not necessarily mean survival for the fish. Certain species such as the common mola are likely to survive due to their sheer bulk and the limited damage that they sustain while interacting with the fishing gear. Other species however are more active and sustain more damage by attempting to free themselves from the net.

**CAVEAT 2:** As the common mola is the most caught fish both in terms of numbers (44.1 % of all catches by number) and biomass (most caught species in numbers, but also one of the heaviest), and as it is released alive at 94.8 % (see Table 5), it is expected that this species alone would account for these remarkably high percentages of live discards overall.

## Discussion

In many ways, the findings of this project contradict the very severe attacks that the CA DGN fishery has sustained over many years. This fishery is a provider of locally caught, documented and managed seafood to the American market, which would otherwise meet demand from any other sources available, including fisheries that do not implement the conservation measures that apply here. It is clear that improvements can always be made on any fishery, but it is also clear that the CA DGN fishery is a much less impactful fishery than what various conservation interests would like us to believe. Conservationists are trying to focus public interest and create a negative sentiment, driving for a total ban of this fishery. It could however be argued that the removal of such a fishery would do more harm than good since swordfish will still have to be procured from fisheries that have a much worse track record than the CA DGN fishery.

One avenue for improvement in terms of bycatch levels in the CA DGN fishery could be the development of new markets for bycaught species, especially in the case of species that are typically dead when discarded.

The catches of blue shark that are observed in the CA DGN observer data represent only a fraction of overall catches in the Pacific Ocean; and despite this fact, the fishery is described by some as being a major destructive force on this species[13]. Figure 8 and 9 below provide some elements of information on the catch of blue shark by the CA DGN fishery.
Figure 8 describes the CPUE for blue shark, showing a steady decrease in catches per set of blue sharks since the implementation of the 1998 POCTRP.

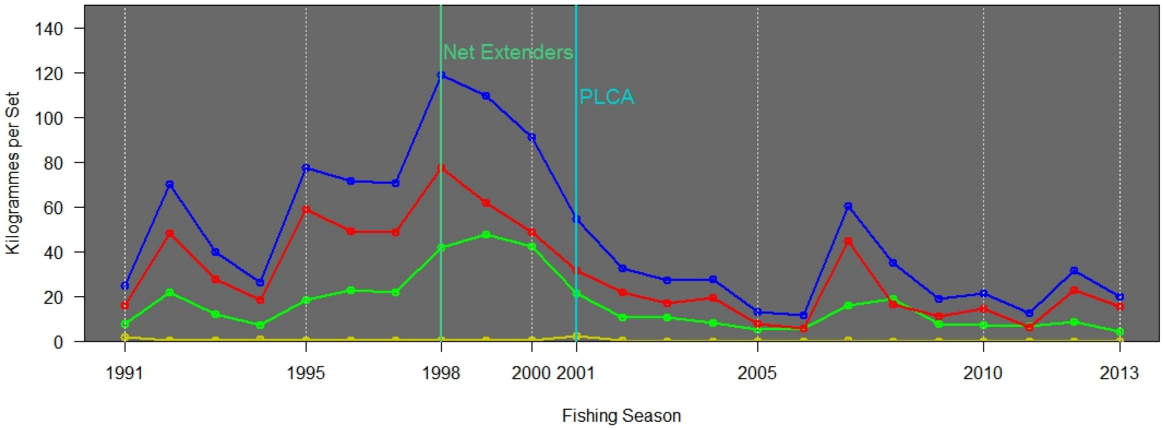


Figure 8: Catches and discards per unit effort of Blue Shark. Source: author’s own

CPUE is a useful metric for assessing the efficiency of a fishery as it removes the variability that is associated with effort. The downwards trend that is displayed in figure 8 is therefore independent of effort, and shows a real decrease in catches of blue shark for eat set that is fished. This of course is in reality further coupled with a decrease in effort, resulting in an impact of the CA DGN fishery on blue sharks that is but a fraction of what it has been in the past. Figure 9 provides an insight into this reduced impact.

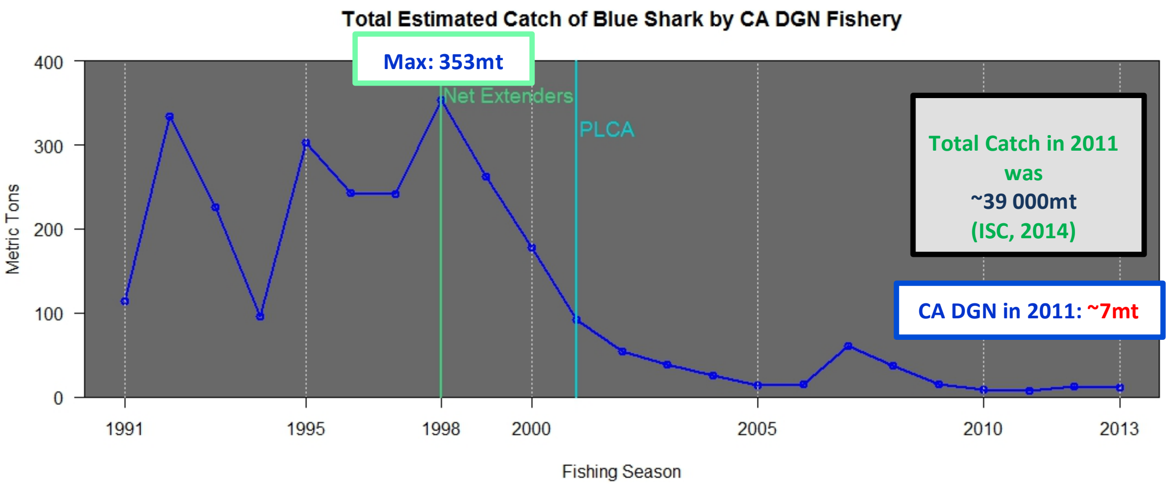


Figure 9: Total catch of Blue Shark in the CA DGN fishery. Source: author's own

Figure 9 illustrates the decrease in catches of blue sharks in the CA DGN fishery since an expanded maximum of 353 metric tons in 1998. In 2011, the share of blue shark catches by CA DGN was 5 500 times less than overall Pacific Ocean catches. The impact is further reduced when considering that 34.9 % of all blue sharks caught in the CA DGN fishery are released alive.

[13] https://seaturtles.org/campaigns/shark-watch/

**CAVEAT:** The decrease in CPUE displayed in Table 8 cannot be attributed to any one factor in particular. Although this could indicate a decrease in abundance and therefore a reduction in stock, the latest ISC stock assessment concludes that blue shark is neither subjected to over-fishing, nor are they over-fished.

**CAVEAT 2:** The biomass caught by the CA DGN fishery in Table 9 was expanded using estimates of average weight for blue shark caught in the CA DGN fishery (calculated as described above) and expanded numbers caught. This is an approximation of reality and should not be taken as absolute image of catch biomass.

## Future steps

The topic covered in this project, as well as the wealth of information that is available to me via the SWFSC, scientific literature, fisheries experts and the datasets from additional fisheries, as well as the very real stakes that are currently at play with regard to the survival of the CA DGN fishery, and the need for more objective methods to assess fisheries bycatch, suggest the project will live on. Several steps will be taken over the next few months in order to refine the analysis, introduce an appropriate degree of statistical analysis and hone in on the most crucial aspects to produce a publishable manuscript. Some of these steps are as follows:

### Bootstrapping

The analysis that was produced lacks a crucial statistical component to provide an analysis of variance and estimates of uncertainty along with the findings.
For this purpose, R will be used to re-sample the observer dataset at the levels of seasons, fishing trips and fishing sets in order to produce a "bootstrap" sample which will be as free as possible from the influence of variations in effort and observer coverage. The same analyses will be conducted from this new "ideal" dataset and comparisons will be made with findings derived from the observed dataset.

### Removing the effect of latitude that already existed pre-PLCA

The data prior to the implementation of the 2001 PLCA has already been partitioned in two components, North and South of Point Conception (34.4486 °N). The catch rankings tables derived from these two components are supplied in Annexes G and H. It seems obvious that the characteristics of the data as exhibited by the pre and post PLCA components will be correlated with those displayed by the N and S components as the fishery was also operating south of Point Conception before the implementation of the PLCA. In order to assess of the 2001 PLCA had any effect on the fishery in terms of catches and discards, it is necessary to remove the influence of these latitude effects.

### Comparison with other fisheries

As was briefly touched on with Figure 9 above, it will be interesting to compare the findings associated with the CA DGN fishery with other US fisheries. The comparisons can be made on the basis of observer data and numbers of fish caught in order to produce rankings of most caught fishes, and biomasses can also be calculated to estimate the discard rates of these fisheries by weight. In addressing conservation concerns that have been raised about the CA DGN fishery, the analysis of other fisheries such as the Longline fisheries for example could provide a useful frame of reference.

### Assess the magnitude of catches in relation to stock biomass

A significant number of species caught in the highest numbers by the CA DGN fishery are being managed to a certain extent, or at least monitored across the Pacific Ocean and certainly in US waters. Refining catch biomass estimates of each of these species in the CA DGN fishery would provide a useful basis for assessment of the removal by the fishery compared to overall Pacific Ocean removals or at least to expanded stock biomass for these species. Indeed, bycatch metrics for a fishery are somewhat meaningless when taken out of context without some kind of population-based standardized measure of impacts. These exist under the Marine Mammal Protection Act in the form of Potential Biological Removal standards for population impacts and comparable population-wide reference points for finfish impacts are under development in the international stock assessment arena.

### Explore the effects of environmental variables

Where variations are observed in catch and discard trends in the CA DGN or any other fishery, it is very important to consider variations in environmental factors as well. All fish stocks are driven to some extent my meteorological and oceanic conditions, and so these influences should be taken into account when assessing increases or decreases in catch.

## Conclusion

Although the CA DGN fishery today is regarded as a “swordfish fishery”, it was not always that way. The large mesh drift gillnet fishing gear was originally designed to target common thresher sharks. In practice however, this is fairly misleading as the fishery should really be regarded more as more of a “multi-species” fishery. Indeed, as was illustrated in Table 5 above, 18 species of fish characterize 99.23 % of overall catches (by number between 2001 and 2013).
Out of these 18 species, One is the target of the fishery (swordfish) and 5 can be considered to be purely “bycatch”, one of which is the result of regulations (it is prohibited to retain striped marlin) and the four others result from the lack of a commercial market for these species. Out of these four non-regulatory bycatch species, the common mola is released alive 94.8 % of the time while the pelagic stingray is also mainly released alive (84.6 %). True bycatch mortality within the top 99.23% is therefore focused on just two species, the blue shark and the Pacific mackerel. The blue shark is assessed by the ISC as not over-fished or subject to over-fishing, while the Pacific mackerel is a short-lived, fast growing forage species that exhibits environmentally driven boom and bust population dynamics (as illustrated by Figure 18 in Annex F).
This leaves us with 12 species of varying commercial importance, that are exploited opportunistically by the fishery on the basis of availability and market demand.
The image portrayed by this analysis is that of a very small-scale fishery (the number of vessels engaged in the fishery is presently less than 17) that is now comparable to various other artisanal fisheries around the world and is very far from having the level of impact that is being portrayed by various conservation parties. The number of fishing sets operated each year is but a minute fraction of what it used to be just twenty years ago and a large portion of the fishes caught is either retained for consumption or released alive. In fact, when considering the biomass of catches, the average rate of retention between 1990 and 2013 is 76 % (see Figure 6), with a significant increase to close to 90 % since 2011 (the discard rate of fish biomass in the CA DGN fishery in 2013 was 13 %).

The impacts of fishing in general are real. There is no denying that major fisheries around the world have become depleted as a result of ruthless and unethical fishing practices. There is no denying either that these practices still exist currently and that harnessing public opinion for conservation purposes is instrumental in driving change. However, it is also obvious that for various reasons and differing interests, conservation outreach can sometimes be misdirected. The public in general has very little idea of how fishing is conducted and how complex fisheries management really is. Public outcries can be easily fueled with effective media campaigns and just a few strong arguments, but the potential consequences of such strategies are also very real. In focusing on a small-scale fishery such as the CA DGN, the impacts of much larger operations are overlooked. In diverting public outreach effort to convince policy makers and donors that the CA DGN fishery is “among most destructive fisheries in the world[14]”, conservationists are doing a dis-service to the environment as a whole because they are removing all elements of context and blowing fisheries statistics out of proportion to fulfill their own agenda. With communication playing such a huge role in the public’s perception of fisheries nowadays, it is sometimes difficult to discern between the arguments of various parties. Conservationists, scientists and managers make battle in a never-ending tug of war, sometimes making use of arguments that are not equally grounded in scientific fact.

14 “The California drift gillnet fishery is among the world’s most destructive […]” - Turtle Island Restoration Network.

# Annexes

## Annex A: Bibliography (cited as well as general sources of information)

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## Annex B: 1990-1997 CA DGN catch rankings

| Species | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes (number of fish caught) | Expanded Total Retained (number of fish retained) | Percentage of Total Finfish Catch | Cumulative Percentageof Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| SPECIES IN PURPLE | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) | | | | | | |
| MOLA | 0.14 | 90.00 | 4.13 | 234699 | 306 | 27.85 | 27.85 |
| BLUESHARK | 0.75 | 27.46 | 65.06 | 130448 | 1261 | 16.21 | 44.07 |
| BROADBILLSWO | 99.15 | 0.00 | 0.73 | 93962 | 93059 | 11.50 | 55.57 |
| ALBACORE | 86.52 | 0.00 | 13.25 | 71467 | 61593 | 9.48 | 65.05 |
| SKIPJACK | 45.20 | 0.07 | 54.64 | 46923 | 21389 | 6.59 | 71.64 |
| PACMACKEREL | 31.70 | 1.53 | 66.26 | 41624 | 13848 | 5.58 | 77.22 |
| SHORTFINMAKO | 97.11 | 1.66 | 0.99 | 40041 | 38984 | 4.92 | 82.14 |
| COMMONTHRESHER | 99.65 | 0.02 | 0.31 | 37606 | 37455 | 4.42 | 86.56 |
| BULLETMACKEREL | 34.66 | 0.22 | 60.55 | 24439 | 9990 | 3.37 | 89.94 |
| OPAH | 97.64 | 0.06 | 2.10 | 24872 | 24337 | 3.19 | 93.12 |
| BLUEFIN | 91.61 | 0.00 | 7.92 | 19447 | 17604 | 2.76 | 95.88 |
| UNIDFISH | 7.28 | 13.46 | 75.00 | 5222 | 551 | 0.67 | 96.55 |
| LOUVAR | 88.64 | 0.19 | 10.61 | 3979 | 3543 | 0.49 | 97.04 |
| BIGEYETHRESHER | 93.19 | 0.40 | 5.81 | 3692 | 3407 | 0.46 | 97.50 |
| STRMARLIN | 18.46 | 1.65 | 75.76 | 2627 | 530 | 0.33 | 97.83 |
| PACPOMFRET | 55.29 | 0.91 | 42.60 | 2214 | 1127 | 0.30 | 98.13 |
| PACIFICHAKE | 3.05 | 6.71 | 89.94 | 2363 | 64 | 0.30 | 98.43 |
| BONITO | 56.83 | 0.00 | 37.46 | 2971 | 1876 | 0.29 | 98.72 |
| YELLOWFIN | 89.92 | 0.00 | 9.24 | 1546 | 1375 | 0.22 | 98.94 |
| PELAGICSTINGRAY | 0.45 | 67.71 | 26.01 | 1461 | 8 | 0.20 | 99.15 |
| PELAGICTHRESHER | 97.99 | 0.00 | 2.01 | 725 | 710 | 0.14 | 99.28 |
| REMORA | 0.00 | 93.50 | 4.88 | 784 | 0 | 0.11 | 99.40 |
| JACKMACKEREL | 54.62 | 2.52 | 42.86 | 826 | 512 | 0.11 | 99.51 |
| UNIDMACKEREL | 27.14 | 0.00 | 72.86 | 322 | 88 | 0.06 | 99.57 |
| SMOOTHHAMMERHEAD | 33.33 | 0.00 | 66.67 | 427 | 143 | 0.06 | 99.63 |
| PACSARDINE | 18.64 | 0.00 | 81.36 | 368 | 72 | 0.05 | 99.68 |
| YELLOWTAIL | 95.56 | 0.00 | 2.22 | 346 | 318 | 0.04 | 99.72 |
| CABARRACUDA | 58.97 | 10.26 | 30.77 | 205 | 132 | 0.04 | 99.76 |
| BLUEMARLIN | 8.33 | 0.00 | 91.67 | 228 | 22 | 0.03 | 99.79 |
| BIGEYETUNA | 100.00 | 0.00 | 0.00 | 226 | 226 | 0.03 | 99.82 |
| SALMONSHARK | 53.33 | 0.00 | 46.67 | 218 | 115 | 0.0 | 99.85 |
| PACELECTRAY | 3.33 | 60.00 | 16.67 | 216 | 6 | 0.0 | 99.88 |
| BLACKMARLIN | 0.00 | 0.00 | 100.00 | 132 | 0 | 0.0 | 99.89 |
| MANTA | 0.00 | 22.22 | 66.67 | 88 | 0 | 0.0 | 99.91 |
| UNIDRAY | 8.33 | 50.00 | 25.00 | 109 | 8 | 0.0 | 99.92 |
| BATRAY | 0.00 | 90.91 | 0.00 | 86 | 0 | 0.0 | 99.93 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MOBULA | 60.00 | 40.00 | 0.00 | 49 | 28 | 0.0 | 99.94 |
| OARFISH | 11.11 | 0.00 | 88.89 | 55 | 8 | 0.0 | 99.95 |
| NORTHANCHOVY | 0.00 | 12.50 | 87.50 | 52 | 0 | 0.0 | 99.96 |
| WHITESHARK | 60.00 | 0.00 | 40.00 | 29 | 19 | 0.0 | 99.96 |
| WHITESEABASS | 80.00 | 0.00 | 20.00 | 34 | 27 | 0.0 | 99.97 |
| SAILFISH | 0.00 | 0.00 | 100.00 | 23 | 0 | 0.0 | 99.97 |
| SOUPFINSHARK | 100.00 | 0.00 | 0.00 | 24 | 24 | 0.0 | 99.97 |
| PACANGELSHARK | 0.00 | 25.00 | 0.00 | 39 | 0 | 0.0 | 99.98 |
| RNDSTINGRAY | 0.00 | 75.00 | 25.00 | 21 | 0 | 0.0 | 99.98 |
| BAYPIPEFISH | 0.00 | 0.00 | 66.67 | 37 | 0 | 0.0 | 99.98 |
| PRICKLYSHARK | 0.00 | 100.00 | 0.00 | 18 | 0 | 0.0 | 99.99 |
| PACHERRING | 100.00 | 0.00 | 0.00 | 20 | 20 | 0.0 | 99.99 |
| BASKINGSHARK | 0.00 | 0.00 | 100.00 | 15 | 0 | 0.0 | 99.99 |
| DOLPHINFISH | 100.00 | 0.00 | 0.00 | 10 | 10 | 0.0 | 99.99 |
| UNIDSHARK | 0.00 | 0.00 | 50.00 | 17 | 0 | 0.0 | 99.99 |
| SHORTSPEAR | 100.00 | 0.00 | 0.00 | 8 | 8 | 0.0 | 99.99 |
| UNIDHAMMERHEAD | 100.00 | 0.00 | 0.00 | 8 | 8 | 0.0 | 100.00 |
| SEVENGILLSHARK | 100.00 | 0.00 | 0.00 | 6 | 6 | 0.0 | 100.00 |
| UNIDSKATE | 0.00 | 100.00 | 0.00 | 10 | 0 | 0.0 | 100.00 |
| BIGSKATE | 0.00 | 100.00 | 0.00 | 6 | 0 | 0.0 | 100.00 |
| PACIFICHAGFISH | 0.00 | 0.00 | 100.00 | 6 | 0 | 0.0 | 100.00 |
| KINGOFSALMON | 100.00 | 0.00 | 0.00 | 10 | 10 | 0.0 | 100.00 |

## Annex C: 1998-2000 CA DGN catch rankings

| Species | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes (number of fish caught) | Expanded Total Retained (number of fish retained) | Percentage of Total Finfish Catch | Cumulative Percentageof Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| SPECIES IN PURPLE | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) | | | | | | |
| MOLA | 0.58 | 97.14 | 1.93 | 104016 | 529 | 32.19 | 32.19 |
| ALBACORE | 81.47 | 0.23 | 18.30 | 56780 | 46479 | 18.17 | 50.36 |
| BLUESHARK | 0.12 | 40.60 | 58.09 | 56834 | 61 | 17.78 | 68.14 |
| BROADBILLSWO | 98.40 | 0.00 | 1.60 | 28531 | 28073 | 9.06 | 77.20 |
| SKIPJACK | 28.26 | 0.07 | 71.67 | 16716 | 4643 | 4.45 | 81.65 |
| SHORTFINMAKO | 95.11 | 2.22 | 2.67 | 10902 | 10387 | 3.54 | 85.19 |
| BLUEFIN | 92.00 | 0.00 | 8.00 | 10496 | 9631 | 3.29 | 88.47 |
| COMMONTHRESHER | 99.53 | 0.41 | 0.00 | 8711 | 8669 | 2.66 | 91.13 |
| OPAH | 94.20 | 0.46 | 5.35 | 7647 | 7217 | 2.42 | 93.55 |
| PACMACKEREL | 17.22 | 1.80 | 80.83 | 6035 | 1111 | 2.09 | 95.64 |
| BULLETMACKEREL | 19.54 | 0.00 | 80.46 | 4201 | 822 | 1.16 | 96.80 |
| LOUVAR | 80.00 | 0.55 | 19.45 | 1778 | 1421 | 0.57 | 97.38 |
| PACPOMFRET | 75.49 | 0.85 | 22.82 | 1642 | 1237 | 0.56 | 97.94 |
| SALMONSHARK | 10.17 | 0.00 | 89.83 | 800 | 81 | 0.28 | 98.21 |
| PELAGICSTINGRAY | 0.60 | 80.95 | 16.67 | 805 | 5 | 0.26 | 98.48 |
| UNIDFISH | 3.95 | 7.89 | 87.50 | 813 | 36 | 0.24 | 98.72 |
| BONITO | 75.17 | 1.34 | 23.49 | 854 | 638 | 0.23 | 98.95 |
| YELLOWFIN | 79.20 | 0.00 | 20.80 | 592 | 468 | 0.20 | 99.15 |
| BIGEYETHRESHER | 94.44 | 0.00 | 5.56 | 360 | 339 | 0.11 | 99.26 |
| UNIDMACKEREL | 0.00 | 0.00 | 100.00 | 302 | 0 | 0.11 | 99.37 |
| JACKMACKEREL | 95.38 | 0.00 | 4.62 | 287 | 273 | 0.10 | 99.47 |
| YELLOWTAIL | 100.00 | 0.00 | 0.00 | 289 | 289 | 0.091339 | 99.5622 |
| PACIFICHAKE | 0.00 | 0.00 | 100.00 | 248 | 0 | 0.085039 | 99.64724 |
| STRMARLIN | 0.00 | 0.00 | 100.00 | 206 | 0 | 0.070866 | 99.71811 |
| REMORA | 5.88 | 85.29 | 0.00 | 164 | 9 | 0.053543 | 99.77165 |
| PACELECTRAY | 0.00 | 54.84 | 19.35 | 143 | 0 | 0.048819 | 99.82047 |
| SMOOTHHAMMERHEA D | 0.00 | 0.00 | 100.00 | 100 | 0 | 0.034646 | 99.85512 |
| CABARRACUDA | 100.00 | 0.00 | 0.00 | 66 | 66 | 0.017323 | 99.87244 |
| MANTA | 0.00 | 25.00 | 75.00 | 48 | 0 | 0.012598 | 99.88504 |
| BLUEMARLIN | 0.00 | 0.00 | 100.00 | 32 | 0 | 0.011024 | 99.89606 |
| NORTHANCHOVY | 28.57 | 14.29 | 57.14 | 38 | 9 | 0.011024 | 99.90709 |
| SPINYDOGFISHSHARK | 0.00 | 42.86 | 57.14 | 38 | 0 | 0.011024 | 99.91811 |
| UNIDSHARK | 0.00 | 0.00 | 33.33 | 30 | 0 | 0.009449 | 99.92756 |
| SOUPFINSHARK | 40.00 | 0.00 | 60.00 | 26 | 12 | 0.007874 | 99.93543 |
| PACANGELSHARK | 0.00 | 100.00 | 0.00 | 18 | 0 | 0.006299 | 99.94173 |
| UNIDRAY | 0.00 | 0.00 | 100.00 | 18 | 0 | 0.006299 | 99.94803 |
| RNDSTINGRAY | 0.00 | 100.00 | 0.00 | 20 | 0 | 0.006299 | 99.95433 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| UNIDSKATE | 0.00 | 0.00 | 100.00 | 18 | 0 | 0.006299 | 99.96063 |
| SIXGILLSHARK | 0.00 | 100.00 | 0.00 | 14 | 0 | 0.004724 | 99.96535 |
| WHITESEABASS | 100.00 | 0.00 | 0.00 | 14 | 14 | 0.004724 | 99.97008 |
| CANEEDLEFISH | 0.00 | 66.67 | 33.33 | 18 | 0 | 0.004724 | 99.9748 |
| PELAGICTHRESHER | 100.00 | 0.00 | 0.00 | 12 | 12 | 0.00315 | 99.97795 |
| BATRAY | 0.00 | 100.00 | 0.00 | 12 | 0 | 0.00315 | 99.9811 |
| MEGAMOUTHSHARK | 0.00 | 100.00 | 0.00 | 9 | 0 | 0.00315 | 99.98425 |
| UNIDROCKFISH | 0.00 | 50.00 | 50.00 | 12 | 0 | 0.00315 | 99.9874 |
| POMFRET | 0.00 | 0.00 | 100.00 | 9 | 0 | 0.00315 | 99.99055 |
| DOLPHINFISH | 100.00 | 0.00 | 0.00 | 9 | 9 | 0.00315 | 99.9937 |
| PACSARDINE | 0.00 | 0.00 | 100.00 | 5 | 0 | 0.001575 | 99.99528 |
| BIGSKATE | 0.00 | 100.00 | 0.00 | 5 | 0 | 0.001575 | 99.99685 |
| BLACKSMITH | 0.00 | 100.00 | 0.00 | 6 | 0 | 0.001575 | 99.99843 |
| PRICKLYSHARK | 0.00 | 0.00 | 100.00 | 5 | 0 | 0.001575 | 100 |

## Annex D: 2001-2013 CA DGN catch rankings

| Species | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes (number of fish caught) | Expanded Total Retained (number of fish retained) | Percentage of Total Finfish Catch | Cumulative Percentage of Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| SPECIES IN PURPLE | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) | | | | | | |
| MOLA | 0.14 | 94.82 | 4.28 | 220500 | 284 | 44.01 | 44.01 |
| BROADBILLSWO | 97.40 | 0.38 | 2.22 | 49647 | 48343 | 10.35 | 54.36 |
| ALBACORE | 91.54 | 0.00 | 8.37 | 36769 | 33641 | 7.80 | 62.16 |
| SHORTFINMAKO | 93.69 | 2.52 | 3.75 | 33036 | 30909 | 7.15 | 69.31 |
| BLUESHARK | 0.98 | 34.91 | 61.51 | 28362 | 274 | 5.60 | 74.92 |
| OPAH | 96.83 | 0.15 | 2.98 | 25950 | 25159 | 4.79 | 79.70 |
| SKIPJACK | 39.09 | 0.60 | 60.14 | 20505 | 8073 | 4.33 | 84.03 |
| COMMONTHRESHER | 98.23 | 0.75 | 1.02 | 20908 | 20492 | 4.26 | 88.29 |
| PACMACKEREL | 13.99 | 3.94 | 81.84 | 16957 | 2517 | 3.59 | 91.89 |
| BLUEFIN | 93.87 | 0.00 | 6.13 | 8719 | 8183 | 1.87 | 93.76 |
| BONITO | 30.83 | 2.76 | 66.42 | 9076 | 2637 | 1.80 | 95.55 |
| BULLETMACKEREL | 34.81 | 0.29 | 64.62 | 4296 | 1608 | 1.07 | 96.63 |
| YELLOWFIN | 82.75 | 0.00 | 17.25 | 2840 | 2350 | 0.56 | 97.19 |
| LOUVAR | 90.59 | 0.37 | 9.04 | 2649 | 2383 | 0.56 | 97.75 |
| BIGEYETHRESHER | 47.82 | 0.79 | 50.99 | 2628 | 1290 | 0.52 | 98.27 |
| PACPOMFRET | 62.22 | 1.01 | 36.77 | 2588 | 1900 | 0.51 | 98.78 |
| PELAGICSTINGRAY | 2.04 | 81.63 | 12.24 | 1183 | 24 | 0.25 | 99.03 |
| STRMARLIN | 0.00 | 0.00 | 100.00 | 1001 | 0 | 0.20 | 99.23 |
| SCOMBRID | 5.29 | 0.00 | 94.71 | 812.0 | 44.0 | 0.18 | 99.41 |
| SALMONSHARK | 9.80 | 9.80 | 80.39 | 535.0 | 50.0 | 0.11 | 99.51 |
| YELLOWTAIL | 100.00 | 0.00 | 0.00 | 398.0 | 398.0 | 0.08 | 99.60 |
| UNIDFISH | 11.29 | 27.42 | 56.45 | 310.0 | 36.0 | 0.06 | 99.66 |
| JACKMACKEREL | 62.71 | 6.78 | 30.51 | 305.0 | 195.0 | 0.06 | 99.72 |
| REMORA | 0.00 | 97.30 | 0.00 | 196.0 | 0.0 | 0.04 | 99.76 |
| PACSARDINE | 58.33 | 2.78 | 22.22 | 230.0 | 151.0 | 0.04 | 99.80 |
| PACELECTRAY | 0.00 | 62.96 | 29.63 | 136.0 | 0.0 | 0.03 | 99.82 |
| BLUEMARLIN | 0.00 | 0.00 | 100.00 | 117.0 | 0.0 | 0.02 | 99.85 |
| BATRAY | 0.00 | 95.65 | 4.35 | 109.0 | 0.0 | 0.02 | 99.87 |
| OILFISH | 11.76 | 23.53 | 64.71 | 73.0 | 10.0 | 0.02 | 99.89 |
| LONGFINMAKO | 100.00 | 0.00 | 0.00 | 99.0 | 99.0 | 0.01 | 99.90 |
| SMOOTHHAMMERHEAD | 41.67 | 0.00 | 58.33 | 60.0 | 24.0 | 0.01 | 99.92 |
| UNIDBILLFISH | 0.00 | 0.00 | 100.00 | 56.0 | 0.0 | 0.01 | 99.93 |
| MEGAMOUTHSHARK | 0.00 | 100.00 | 0.00 | 36.0 | 0.0 | 0.01 | 99.93 |
| LONGNOSELANCETFISH | 0.00 | 100.00 | 0.00 | 32.0 | 0.0 | 0.01 | 99.94 |
| ESCOLAR | 66.67 | 0.00 | 33.33 | 35.0 | 26.0 | 0.01 | 99.95 |
| UNIDROCKFISH | 0.00 | 100.00 | 0.00 | 32.0 | 0.0 | 0.01 | 99.95 |
| MOBULA | 0.00 | 20.00 | 80.00 | 24.0 | 0.0 | 0.01 | 99.96 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PACIFICHAKE | 0.00 | 0.00 | 100.00 | 24.0 | 0.0 | 0.01 | 99.96 |
| BASKINGSHARK | 0.00 | 50.00 | 50.00 | 19.0 | 0.0 | 0.00 | 99.97 |
| UNIDMACKEREL | 0.00 | 0.00 | 100.00 | 14.0 | 0.0 | 0.00 | 99.97 |
| SPINYDOGFISHSHARK | 66.67 | 33.33 | 0.00 | 18.0 | 10.0 | 0.00 | 99.97 |
| CASKATE | 0.00 | 100.00 | 0.00 | 14.0 | 0.0 | 0.00 | 99.98 |
| WHITESEABASS | 66.67 | 0.00 | 33.33 | 14.0 | 9.0 | 0.00 | 99.98 |
| PRICKLYSHARK | 0.00 | 33.33 | 66.67 | 15.0 | 0.0 | 0.00 | 99.98 |
| MANTA | 0.00 | 0.00 | 100.00 | 10.0 | 0.0 | 0.00 | 99.99 |
| UNIDHAMMERHEAD | 0.00 | 0.00 | 100.00 | 16.0 | 0.0 | 0.00 | 99.99 |
| SOUPFINSHARK | 100.00 | 0.00 | 0.00 | 11.0 | 11.0 | 0.00 | 99.99 |
| RNDSTINGRAY | 0.00 | 100.00 | 0.00 | 11.0 | 0.0 | 0.00 | 99.99 |
| KINGOFSALMON | 100.00 | 0.00 | 0.00 | 10.0 | 10.0 | 0.00 | 99.99 |
| BAYPIPEFISH | 0.00 | 100.00 | 0.00 | 6.0 | 0.0 | 0.00 | 99.99 |
| PELAGICTHRESHER | 100.00 | 0.00 | 0.00 | 8.0 | 8.0 | 0.00 | 100.00 |
| SEVENGILLSHARK | 0.00 | 100.00 | 0.00 | 6.0 | 0.0 | 0.00 | 100.00 |
| CRESTFISH | 100.00 | 0.00 | 0.00 | 8.0 | 8.0 | 0.00 | 100.00 |
| OARFISH | 0.00 | 0.00 | 100.00 | 6.0 | 0.0 | 0.00 | 100.00 |
| UNIDTHRESHER | 100.00 | 0.00 | 0.00 | 5.0 | 5.0 | 0.00 | 100.00 |

## Annex E: 1990-2013 CA DGN catch rankings

| Species | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes (number of fish caught) | Expanded Total Retained (number of fish retained) | Percentage of Total Finfish Catch | Cumulative Percentage of Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| SPECIES IN PURPLE | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) | | | | | | |
| MOLA | 0.23 | 93.77 | 3.72 | 560540 | 1118 | 34.55 | 34.55 |
| BLUESHARK | 0.57 | 32.86 | 62.33 | 217110 | 1594 | 12.79 | 47.35 |
| ALBACORE | 85.83 | 0.09 | 13.98 | 165222 | 141891 | 10.87 | 58.22 |
| BROADBILLSWO | 98.32 | 0.13 | 1.50 | 174250 | 171475 | 10.61 | 68.82 |
| SHORTFINMAKO | 95.20 | 2.14 | 2.55 | 84493 | 80790 | 5.40 | 74.22 |
| SKIPJACK | 40.04 | 0.23 | 59.64 | 84230 | 34150 | 5.24 | 79.46 |
| PACMACKEREL | 24.37 | 2.32 | 72.93 | 64808 | 17577 | 4.03 | 83.49 |
| COMMONTHRESHER | 99.08 | 0.37 | 0.54 | 67358 | 66749 | 3.93 | 87.42 |
| OPAH | 96.68 | 0.16 | 3.06 | 59352 | 57559 | 3.63 | 91.05 |
| BLUEFIN | 92.23 | 0.00 | 7.57 | 38753 | 35473 | 2.55 | 93.60 |
| BULLETMACKEREL | 32.90 | 0.19 | 63.90 | 34067 | 12855 | 2.10 | 95.70 |
| BONITO | 37.59 | 2.26 | 59.33 | 12910 | 5160 | 0.81 | 96.52 |
| LOUVAR | 86.97 | 0.34 | 12.47 | 8478 | 7396 | 0.54 | 97.05 |
| PACPOMFRET | 64.27 | 0.93 | 34.21 | 6443 | 4264 | 0.44 | 97.49 |
| BIGEYETHRESHER | 72.00 | 0.56 | 26.98 | 6679 | 5035 | 0.40 | 97.89 |
| UNIDFISH | 6.92 | 13.52 | 75.89 | 6399 | 622 | 0.35 | 98.24 |
| YELLOWFIN | 84.19 | 0.00 | 15.59 | 5018 | 4229 | 0.34 | 98.58 |
| STRMARLIN | 10.09 | 0.90 | 86.75 | 4118 | 530 | 0.24 | 98.82 |
| PELAGICSTINGRAY | 1.08 | 76.23 | 18.67 | 3504 | 36 | 0.24 | 99.06 |
| PACIFICHAKE | 2.58 | 5.68 | 91.47 | 2633 | 64 | 0.14 | 99.20 |
| SALMONSHARK | 14.24 | 3.24 | 82.52 | 1552 | 245 | 0.11 | 99.32 |
| JACKMACKEREL | 67.49 | 2.88 | 29.63 | 1416 | 979 | 0.09 | 99.41 |
| REMORA | 1.02 | 92.86 | 3.06 | 1153 | 9 | 0.07 | 99.48 |
| YELLOWTAIL | 98.90 | 0.00 | 0.55 | 1031 | 1004 | 0.07 | 99.54 |
| SCOMBRID | 5.29 | 0.00 | 94.71 | 812 | 44 | 0.06 | 99.61 |
| PELAGICTHRESHER | 98.03 | 0.00 | 1.97 | 744 | 729 | 0.06 | 99.66 |
| UNIDMACKEREL | 13.38 | 0.00 | 86.62 | 647 | 88 | 0.05 | 99.72 |
| SMOOTHHAMMERHEAD | 26.80 | 0.00 | 73.20 | 586 | 167 | 0.04 | 99.75 |
| PACSARDINE | 33.33 | 1.04 | 59.38 | 602 | 222 | 0.04 | 99.79 |
| PACELECTRAY | 1.14 | 59.09 | 21.59 | 495 | 6 | 0.03 | 99.82 |
| BLUEMARLIN | 3.95 | 0.00 | 94.74 | 422 | 22 | 0.03 | 99.85 |
| CABARRACUDA | 68.00 | 8.00 | 24.00 | 271 | 198 | 0.02 | 99.87 |
| BATRAY | 0.00 | 94.44 | 2.78 | 207 | 0 | 0.01 | 99.88 |
| BIGEYETUNA | 100.00 | 0.00 | 0.00 | 226 | 226 | 0.01 | 99.89 |
| MANTA | 0.00 | 21.43 | 71.43 | 146 | 0 | 0.01 | 99.90 |
| BLACKMARLIN | 0.00 | 0.00 | 100.00 | 132 | 0 | 0.01 | 99.91 |
| OILFISH | 11.76 | 23.53 | 64.71 | 73 | 10 | 0.01 | 99.91 |
| UNIDRAY | 6.25 | 37.50 | 43.75 | 127 | 8 | 0.01 | 99.92 |
| NORTHANCHOVY | 13.33 | 13.33 | 73.33 | 90 | 9 | 0.01 | 99.93 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MOBULA | 40.00 | 33.33 | 26.67 | 73 | 28 | 0.01 | 99.93 |
| LONGFINMAKO | 100.00 | 0.00 | 0.00 | 99 | 99 | 0.00 | 99.94 |
| SOUPFINSHARK | 72.73 | 0.00 | 27.27 | 60 | 46 | 0.00 | 99.94 |
| WHITESEABASS | 81.82 | 0.00 | 18.18 | 61 | 49 | 0.00 | 99.94 |
| OARFISH | 9.09 | 0.00 | 90.91 | 65 | 8 | 0.00 | 99.95 |
| UNIDBILLFISH | 0.00 | 0.00 | 100.00 | 56 | 0 | 0.00 | 99.95 |
| SPINYDOGFISHSHARK | 20.00 | 40.00 | 40.00 | 55 | 10 | 0.00 | 99.96 |
| RNDSTINGRAY | 0.00 | 90.00 | 10.00 | 51 | 0 | 0.00 | 99.96 |
| MEGAMOUTHSHARK | 0.00 | 100.00 | 0.00 | 45 | 0 | 0.00 | 99.96 |
| PACANGELSHARK | 0.00 | 62.50 | 0.00 | 57 | 0 | 0.00 | 99.97 |
| UNIDROCKFISH | 0.00 | 87.50 | 12.50 | 44 | 0 | 0.00 | 99.97 |
| UNIDSHARK | 0.00 | 0.00 | 37.50 | 47 | 0 | 0.00 | 99.97 |
| LONGNOSELANCETFISH | 0.00 | 100.00 | 0.00 | 32 | 0 | 0.00 | 99.97 |
| PRICKLYSHARK | 0.00 | 57.14 | 42.86 | 37 | 0 | 0.00 | 99.98 |
| ESCOLAR | 66.67 | 0.00 | 33.33 | 35 | 26 | 0.00 | 99.98 |
| BASKINGSHARK | 0.00 | 33.33 | 66.67 | 34 | 0 | 0.00 | 99.98 |
| WHITESHARK | 60.00 | 0.00 | 40.00 | 29 | 19 | 0.00 | 99.98 |
| UNIDSKATE | 0.00 | 20.00 | 80.00 | 28 | 0 | 0.00 | 99.99 |
| SAILFISH | 0.00 | 0.00 | 100.00 | 23 | 0 | 0.00 | 99.99 |
| BAYPIPEFISH | 0.00 | 25.00 | 50.00 | 42 | 0 | 0.00 | 99.99 |
| DOLPHINFISH | 100.00 | 0.00 | 0.00 | 18 | 18 | 0.00 | 99.99 |
| UNIDHAMMERHEAD | 33.33 | 0.00 | 66.67 | 23 | 8 | 0.00 | 99.99 |
| SIXGILLSHARK | 0.00 | 100.00 | 0.00 | 14 | 0 | 0.00 | 99.99 |
| CASKATE | 0.00 | 100.00 | 0.00 | 14 | 0 | 0.00 | 99.99 |
| CANEEDLEFISH | 0.00 | 66.67 | 33.33 | 18 | 0 | 0.00 | 99.99 |
| KINGOFSALMON | 100.00 | 0.00 | 0.00 | 19 | 19 | 0.00 | 100.00 |
| PACHERRING | 100.00 | 0.00 | 0.00 | 20 | 20 | 0.00 | 100.00 |
| SEVENGILLSHARK | 50.00 | 50.00 | 0.00 | 11 | 6 | 0.00 | 100.00 |
| BIGSKATE | 0.00 | 100.00 | 0.00 | 10 | 0 | 0.00 | 100.00 |
| POMFRET | 0.00 | 0.00 | 100.00 | 9 | 0 | 0.00 | 100.00 |
| SHORTSPEAR | 100.00 | 0.00 | 0.00 | 8 | 8 | 0.00 | 100.00 |
| BLACKSMITH | 0.00 | 100.00 | 0.00 | 6 | 0 | 0.00 | 100.00 |
| PACIFICHAGFISH | 0.00 | 0.00 | 100.00 | 6 | 0 | 0.00 | 100.00 |
| CRESTFISH | 100.00 | 0.00 | 0.00 | 8 | 8 | 0.00 | 100.00 |
| UNIDTHRESHER | 100.00 | 0.00 | 0.00 | 5 | 5 | 0.00 | 100.00 |

## Annex F: Overall catch trends (CPUE) of individual species that account for the top 98.16 % of catches between 2001 and 2013. Tables ranked in order of importance in terms of catch numbers between 1990 and 2013.

### Common mola

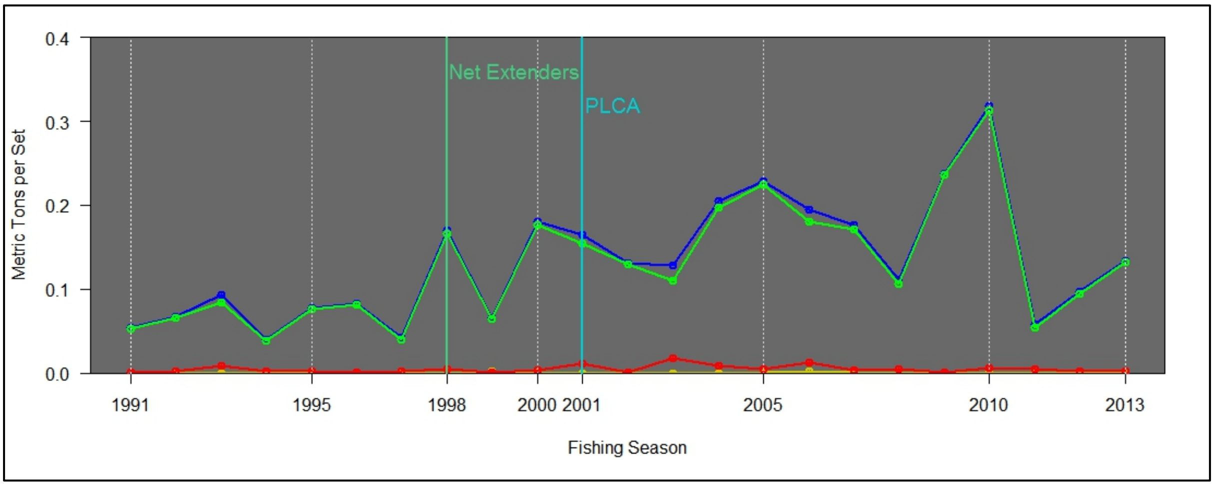


Figure 10: Catches and discard per unit effort of common mola. Source: author's own

### Broadbill swordfish

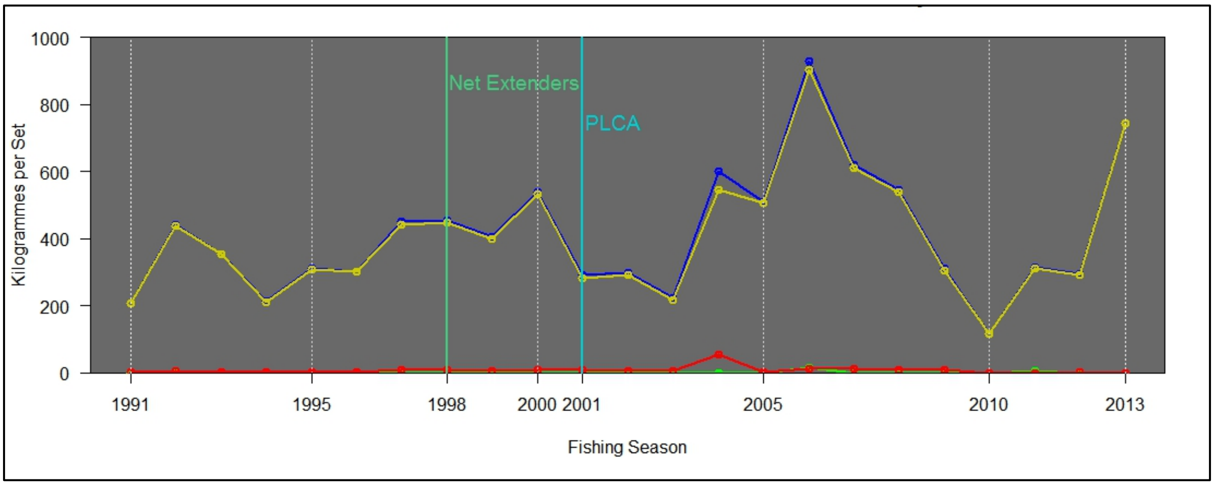


Figure 11: Catches and discards per unit effort of broadbill swordfish. Source: author's own

### Albacore tuna

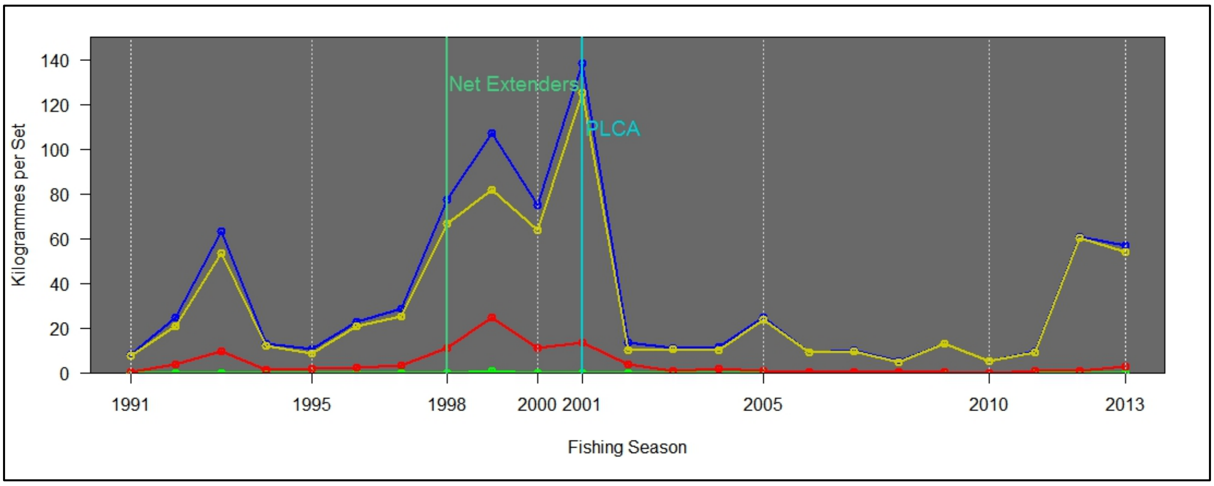


Figure 12:Catches and discards per unit effort of albacore tuna. Source: author's own

## Shortfin mako shark

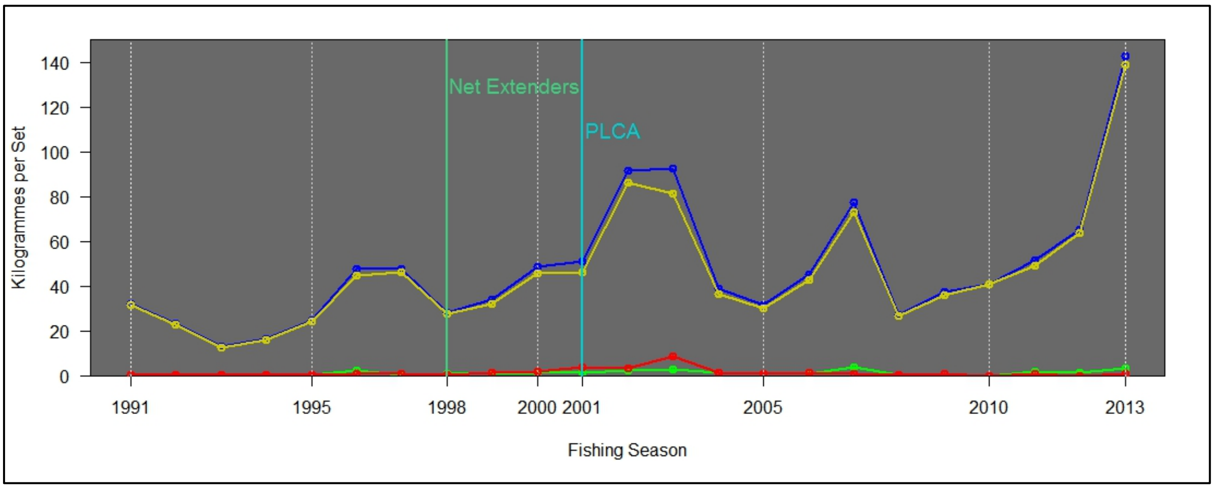


**Figure 13: Catches and discards per unit effort of shortfin mako shark. Source: author's own**

## Blue shark

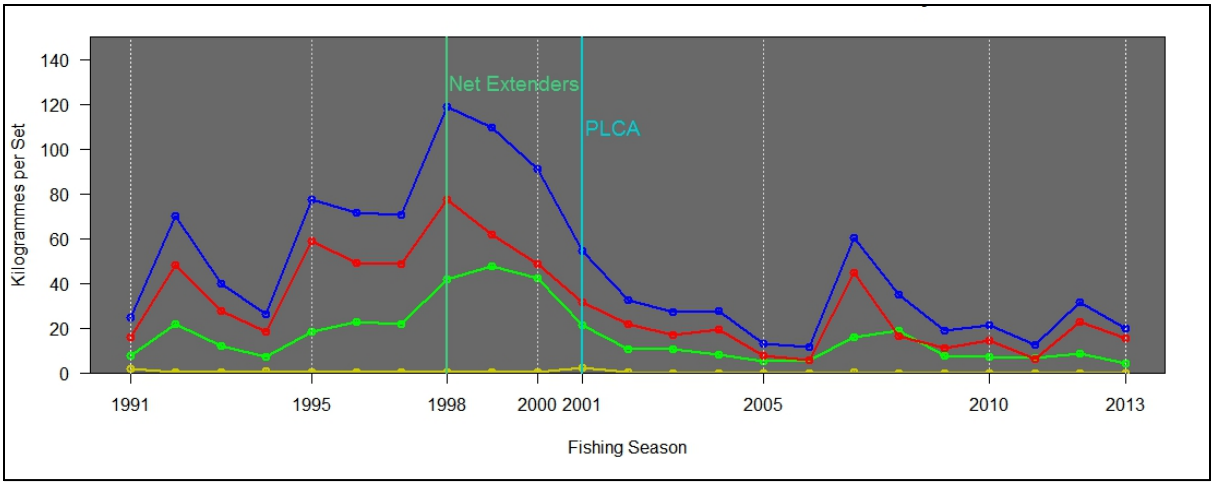


**Figure 14: Catches and discards per unit effort of blue shark. Source: author's own**

## Opah

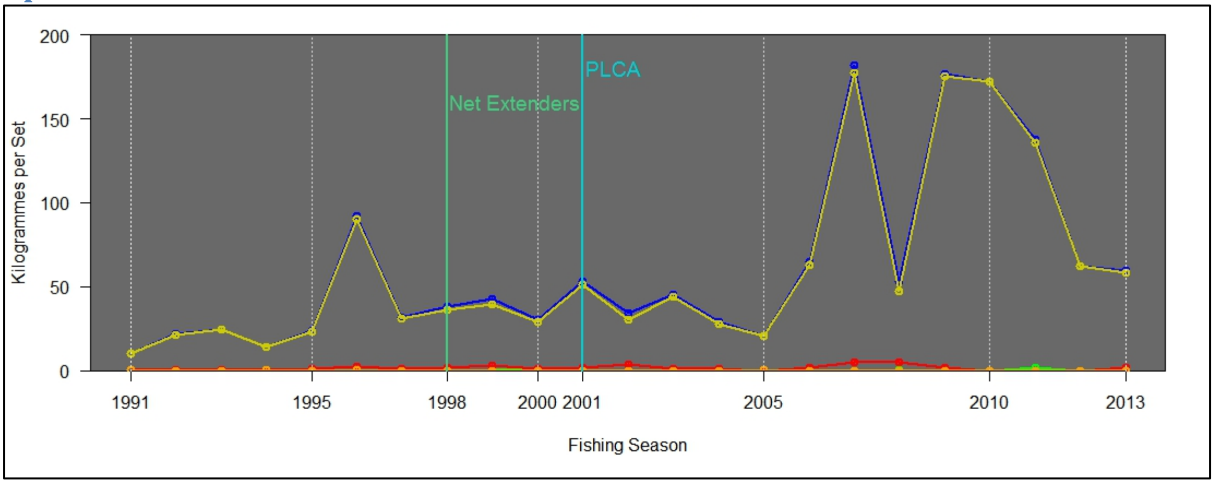


**Figure 15: Catches and discards per unit effort of opah. Source: author's own**

## Skipjack

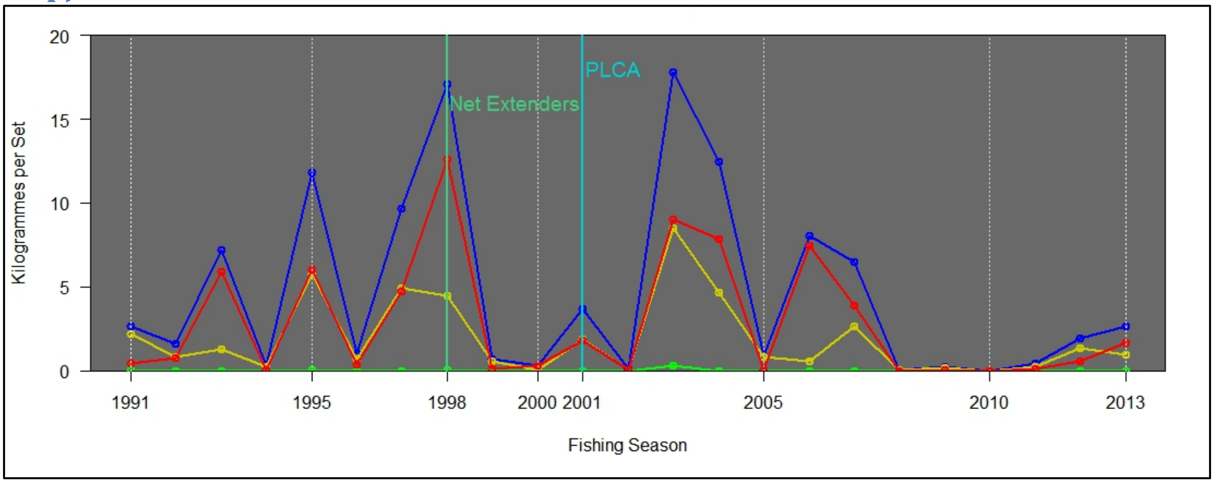


Figure 16: Catches and discards per unit effort of skipjack. Source: author's own

## Common thresher shark

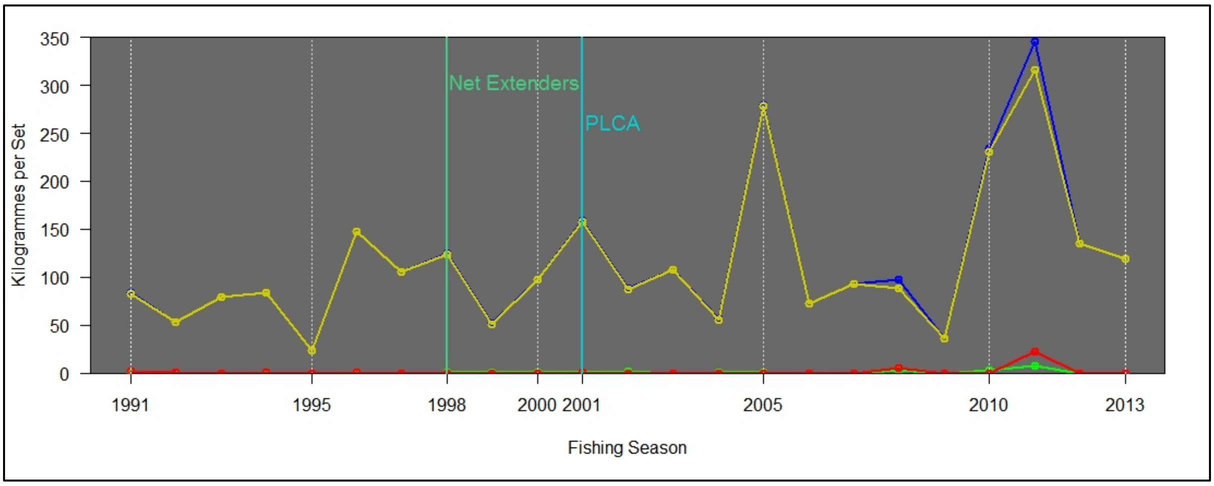


Figure 17: Catches and discards per unit effort of common thresher shark. Source: author's own

## Pacific mackerel

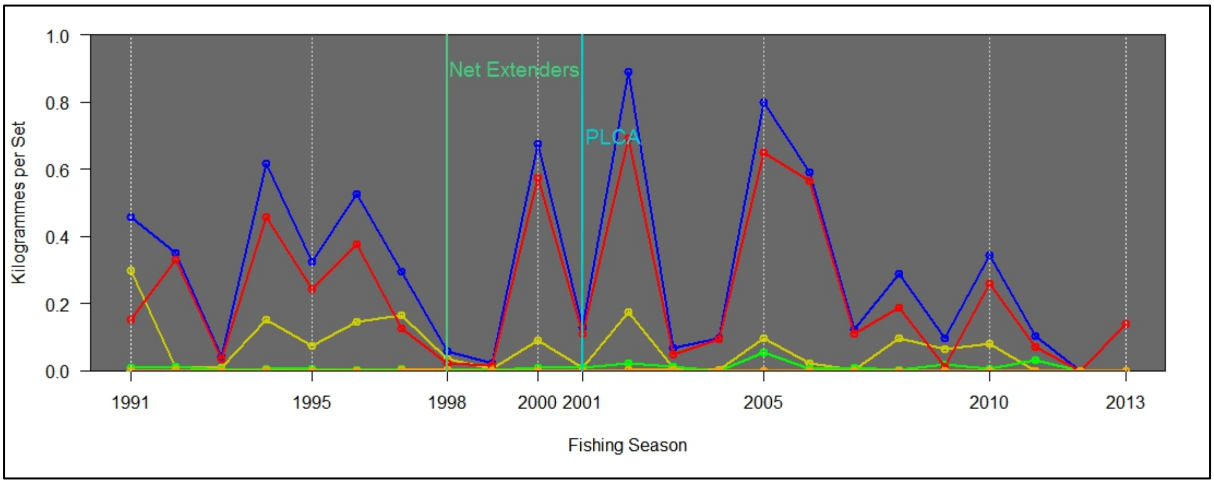


Figure 18: Catches and discards per unit effort of Pacific mackerel. Source: author's own

## Bluefin tuna

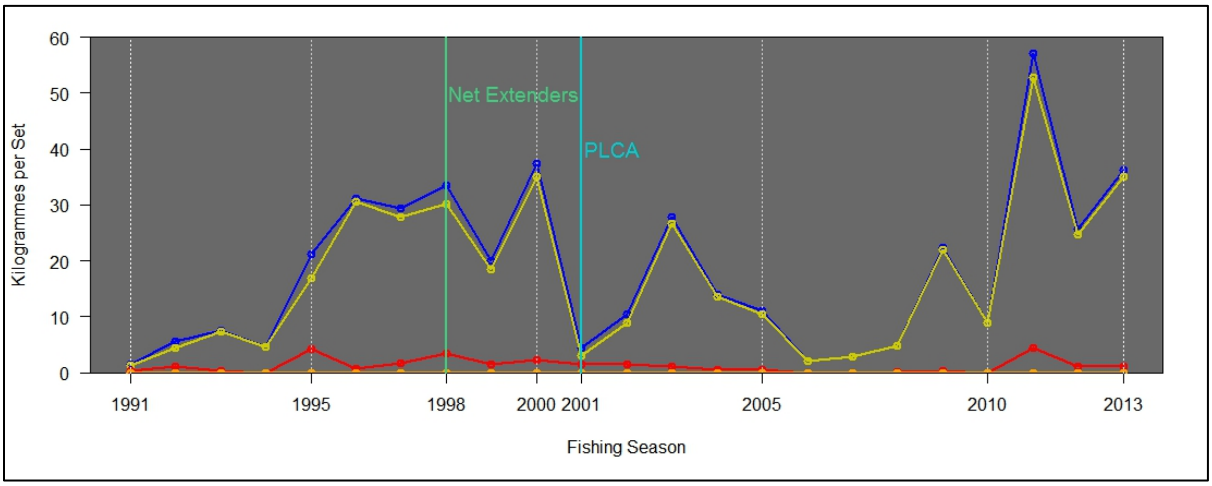


Figure 19: Catches and discards per unit effort of bluefin tuna. Source: author's own. Source: author's own

## Bonito

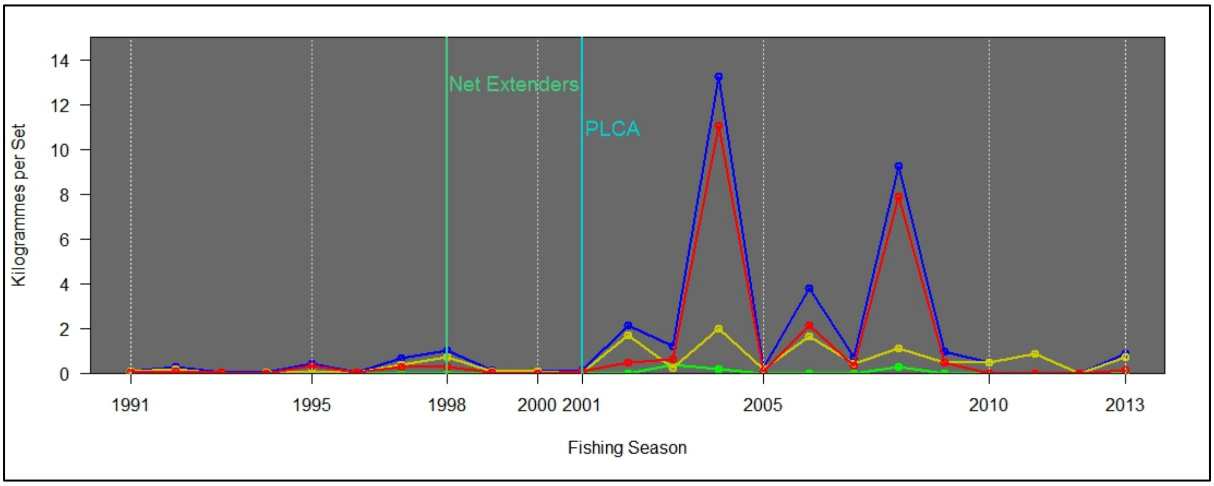


Figure 20: Catches and discards per unit effort of bonito. Source: author's own

## Bullet mackerel

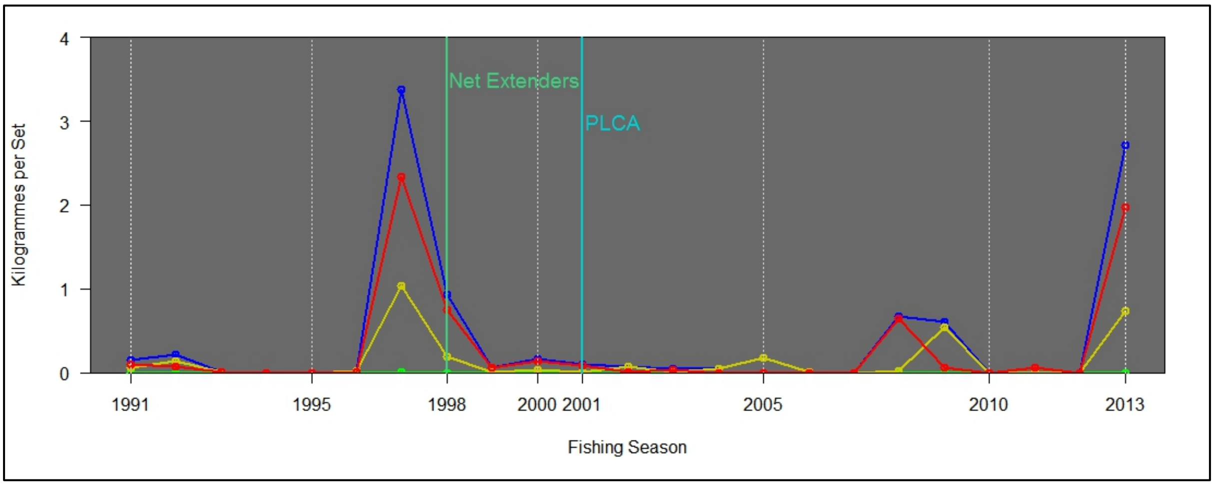


Figure 21: Catches and discards per unit effort of bullet mackerel. Source: author's own

## Yellowfin tuna

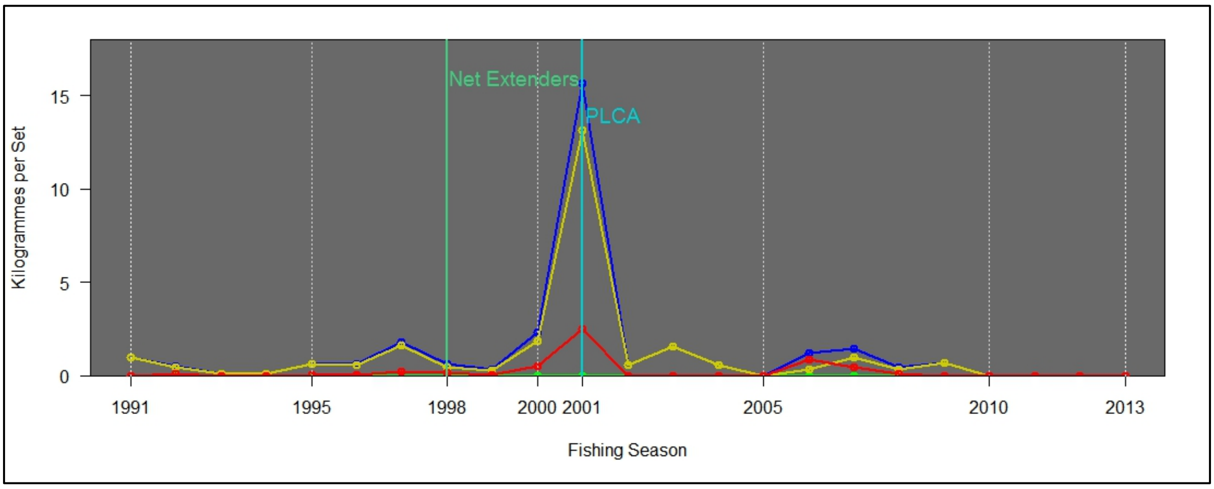


**Figure 22: Catches and discards per unit effort of yellowfin tuna. Source: author's own**

## Bigeye thresher shark

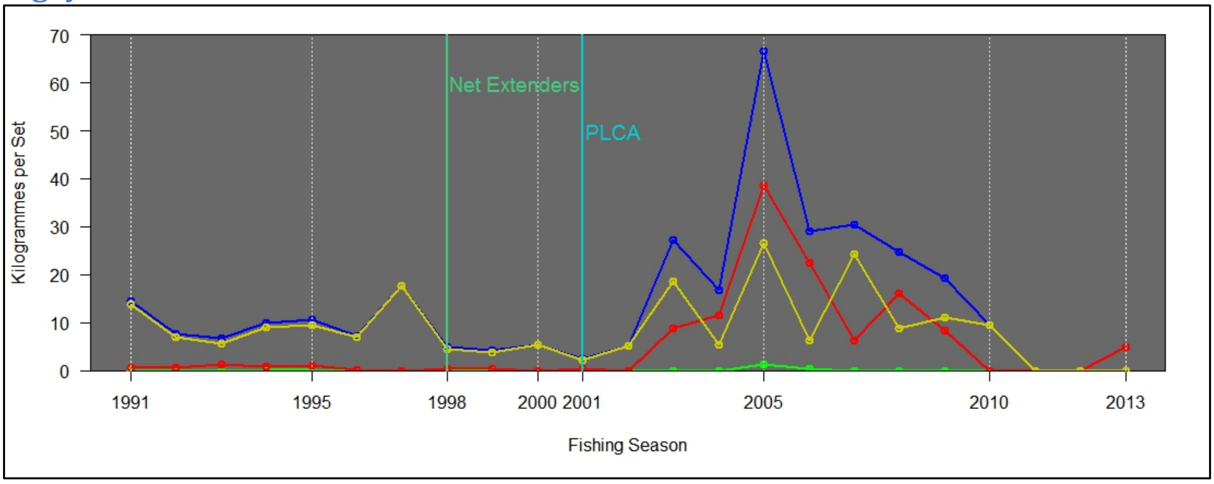


**Figure 23: Catches and discards per unit effort of bigeye thresher shark. Source: author's own**

## Annex G: 1990 to 2000 (included) North of Point Conception catch rankings

| Species | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes | Expanded Total Retained | Percentage of Total Finfish Catch | Cumulative Percentageof Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| SPECIES IN PURPLE | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) | | | | | | |
| MOLA | 0.36 | 93.27 | 3.82 | 211228 | 570 | 39.00 | 39.00 |
| BLUESHARK | 0.85 | 30.51 | 61.82 | 58143 | 627 | 10.52 | 49.53 |
| BROADBILLSWO | 97.61 | 0.00 | 2.38 | 40852 | 40019 | 8.07 | 57.59 |
| SHORTFINMAKO | 96.18 | 2.15 | 1.53 | 37994 | 36724 | 7.17 | 64.76 |
| PACMACKEREL | 30.48 | 1.87 | 67.13 | 32008 | 10056 | 6.54 | 71.30 |
| BULLETMACKEREL | 32.95 | 0.17 | 63.29 | 29246 | 11225 | 5.59 | 76.89 |
| SKIPJACK | 47.15 | 0.11 | 52.60 | 29416 | 14366 | 5.47 | 82.36 |
| OPAH | 96.45 | 0.11 | 3.36 | 23452 | 22736 | 4.48 | 86.84 |
| COMMONTHRESHER | 99.72 | 0.08 | 0.14 | 23101 | 23031 | 4.37 | 91.21 |
| ALBACORE | 83.97 | 0.00 | 15.98 | 9751 | 8220 | 2.49 | 93.70 |
| BLUEFIN | 86.70 | 0.00 | 13.11 | 8918 | 7676 | 1.86 | 95.56 |
| STRMARLIN | 14.64 | 1.35 | 80.63 | 2932 | 498 | 0.54 | 96.10 |
| BONITO | 61.41 | 0.47 | 34.35 | 3510 | 2292 | 0.52 | 96.62 |
| UNIDFISH | 8.62 | 5.42 | 83.00 | 2712 | 273 | 0.50 | 97.12 |
| PELAGICSTINGRAY | 0.60 | 73.13 | 22.69 | 1884 | 12 | 0.41 | 97.53 |
| YELLOWFIN | 85.29 | 0.00 | 14.11 | 1909 | 1623 | 0.41 | 97.94 |
| LOUVAR | 86.88 | 0.31 | 12.81 | 1937 | 1722 | 0.39 | 98.33 |
| BIGEYETHRESHER | 96.31 | 0.34 | 3.36 | 1722 | 1657 | 0.36 | 98.69 |
| PELAGICTHRESHER | 98.01 | 0.00 | 1.99 | 737 | 722 | 0.18 | 98.88 |
| UNIDMACKEREL | 13.67 | 0.00 | 86.33 | 633 | 88 | 0.17 | 99.05 |
| YELLOWTAIL | 98.04 | 0.00 | 0.98 | 628 | 601 | 0.12 | 99.17 |
| JACKMACKEREL | 94.00 | 0.00 | 6.00 | 540 | 505 | 0.12 | 99.29 |
| SMOOTHHAMMERHEAD | 28.00 | 0.00 | 72.00 | 452 | 143 | 0.09 | 99.38 |
| REMORA | 0.00 | 88.24 | 9.80 | 321 | 0 | 0.06 | 99.45 |
| PACPOMFRET | 61.22 | 0.00 | 38.78 | 224 | 140 | 0.06 | 99.51 |
| BLUEMARLIN | 6.25 | 0.00 | 91.67 | 275 | 22 | 0.06 | 99.56 |
| PACIFICHAKE | 2.22 | 26.67 | 71.11 | 266 | 8 | 0.05 | 99.62 |
| PACSARDINE | 20.93 | 0.00 | 79.07 | 268 | 57 | 0.05 | 99.67 |
| CABARRACUDA | 80.00 | 10.00 | 10.00 | 223 | 186 | 0.05 | 99.72 |
| PACELECTRAY | 0.00 | 50.00 | 21.05 | 217 | 0 | 0.05 | 99.77 |
| MANTA | 0.00 | 23.08 | 69.23 | 136 | 0 | 0.03 | 99.80 |
| BLACKMARLIN | 0.00 | 0.00 | 100.00 | 132 | 0 | 0.02 | 99.82 |
| BIGEYETUNA | 100.00 | 0.00 | 0.00 | 114 | 114 | 0.02 | 99.84 |
| SOUTHANCHOVY | 14.29 | 7.14 | 78.57 | 85 | 9 | 0.02 | 99.86 |
| UNIDRAY | 0.00 | 36.36 | 54.55 | 86 | 0 | 0.01 | 99.87 |
| BATRAY | 0.00 | 90.91 | 0.00 | 86 | 0 | 0.01 | 99.89 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MOBULA | 60.00 | 40.00 | 0.00 | 49 | 28 | 0.01 | 99.90 |
| OARFISH | 10.00 | 0.00 | 90.00 | 59 | 8 | 0.01 | 99.91 |
| SALMONSHARK | 11.11 | 0.00 | 88.89 | 47 | 6 | 0.01 | 99.92 |
| PACANGELSHARK | 0.00 | 62.50 | 0.00 | 57 | 0 | 0.01 | 99.93 |
| WHITESEABASS | 87.50 | 0.00 | 12.50 | 47 | 40 | 0.01 | 99.94 |
| UNIDSHARK | 0.00 | 0.00 | 33.33 | 30 | 0 | 0.01 | 99.95 |
| UNIDSKATE | 0.00 | 20.00 | 80.00 | 28 | 0 | 0.01 | 99.95 |
| SAILFISH | 0.00 | 0.00 | 100.00 | 23 | 0 | 0.00 | 99.96 |
| RNDSTINGRAY | 0.00 | 75.00 | 25.00 | 22 | 0 | 0.00 | 99.96 |
| WHITESHARK | 33.33 | 0.00 | 66.67 | 14 | 5 | 0.00 | 99.97 |
| BAYPIPEFISH | 0.00 | 0.00 | 66.67 | 37 | 0 | 0.00 | 99.97 |
| SPINYDOGFISHSHARK | 0.00 | 100.00 | 0.00 | 14 | 0 | 0.00 | 99.98 |
| SOUPFINSHARK | 0.00 | 0.00 | 100.00 | 14 | 0 | 0.00 | 99.98 |
| SIXGILLSHARK | 0.00 | 100.00 | 0.00 | 14 | 0 | 0.00 | 99.98 |
| PRICKLYSHARK | 0.00 | 66.67 | 33.33 | 17 | 0 | 0.00 | 99.99 |
| MEGAMOUTHSHARK | 0.00 | 100.00 | 0.00 | 9 | 0 | 0.00 | 99.99 |
| CANEEDLEFISH | 0.00 | 100.00 | 0.00 | 12 | 0 | 0.00 | 99.99 |
| POMFRET | 0.00 | 0.00 | 100.00 | 9 | 0 | 0.00 | 99.99 |
| DOLPHINFISH | 100.00 | 0.00 | 0.00 | 10 | 10 | 0.00 | 100.00 |
| PACHERRING | 100.00 | 0.00 | 0.00 | 10 | 10 | 0.00 | 100.00 |
| SEVENGILLSHARK | 100.00 | 0.00 | 0.00 | 6 | 6 | 0.00 | 100.00 |
| BIGSKATE | 0.00 | 100.00 | 0.00 | 5 | 0 | 0.00 | 100.00 |

## Annex H: 1990 to 2000 (included) South of Point Conception catch rankings

| Species | Percentage Retained | Percentage returned alive | Percentage returned dead | Expanded Total Takes | Expanded Total Retained | Percentage of Total Finfish Catch | Cumulative Percentageof Total Finfish Catch |
|---|---|---|---|---|---|---|---|
| SPECIES IN PURPLE | Species managed under the Highly Migratory Species Fisheries Management Plan (HMS FMP) | | | | | | |
| BLUESHARK | 0.26 | 33.67 | 62.51 | 128458 | 540 | 22.34 | 22.34 |
| ALBACORE | 83.77 | 0.13 | 15.98 | 117114 | 98584 | 21.59 | 43.93 |
| MOLA | 0.23 | 92.41 | 2.16 | 127174 | 247 | 20.72 | 64.66 |
| BROADBILLSWO | 99.50 | 0.00 | 0.38 | 82749 | 82137 | 13.16 | 77.82 |
| SKIPJACK | 34.52 | 0.04 | 65.44 | 33117 | 11128 | 5.90 | 83.72 |
| BLUEFIN | 93.95 | 0.00 | 5.75 | 20987 | 19542 | 3.92 | 87.64 |
| COMMONTHRESHER | 99.49 | 0.17 | 0.34 | 23248 | 23125 | 3.22 | 90.86 |
| PACMACKEREL | 26.02 | 0.82 | 72.92 | 15736 | 4969 | 2.29 | 93.15 |
| SHORTFINMAKO | 98.06 | 0.74 | 0.91 | 12852 | 12580 | 1.93 | 95.07 |
| OPAH | 96.82 | 0.34 | 2.57 | 9624 | 9347 | 1.62 | 96.69 |
| PACPOMFRET | 66.09 | 0.94 | 31.87 | 3632 | 2225 | 0.70 | 97.39 |
| LOUVAR | 83.65 | 0.34 | 15.50 | 3879 | 3277 | 0.64 | 98.04 |
| UNIDFISH | 4.59 | 18.37 | 72.86 | 3336 | 300 | 0.53 | 98.56 |
| PACIFICHAKE | 2.67 | 2.97 | 94.07 | 2344 | 57 | 0.37 | 98.93 |
| BIGEYETHRESHER | 89.24 | 0.40 | 9.16 | 2203 | 1962 | 0.28 | 99.21 |
| SALMONSHARK | 16.67 | 0.00 | 83.33 | 971 | 190 | 0.22 | 99.43 |
| REMORA | 1.85 | 93.52 | 0.93 | 636 | 9 | 0.12 | 99.55 |
| JACKMACKEREL | 39.29 | 3.57 | 57.14 | 573 | 280 | 0.09 | 99.64 |
| BULLETMACKEREL | 3.80 | 0.00 | 91.14 | 516 | 14 | 0.09 | 99.72 |
| PELAGICSTINGRAY | 0.00 | 68.85 | 24.59 | 403 | 0 | 0.07 | 99.79 |
| YELLOWFIN | 94.59 | 0.00 | 5.41 | 255 | 242 | 0.04 | 99.83 |
| BONITO | 65.38 | 0.00 | 26.92 | 204 | 111 | 0.03 | 99.86 |
| STRMARLIN | 9.09 | 0.00 | 90.91 | 164 | 32 | 0.02 | 99.88 |
| PACELECTRAY | 0.00 | 72.73 | 13.64 | 137 | 0 | 0.02 | 99.91 |
| PACSARDINE | 11.76 | 0.00 | 88.24 | 105 | 15 | 0.02 | 99.93 |
| BIGEYETUNA | 100.00 | 0.00 | 0.00 | 112 | 112 | 0.02 | 99.94 |
| CABARRACUDA | 20.00 | 0.00 | 80.00 | 49 | 12 | 0.01 | 99.95 |
| SOUPFINSHARK | 100.00 | 0.00 | 0.00 | 36 | 36 | 0.01 | 99.96 |
| SPINYDOGFISHSHARK | 0.00 | 0.00 | 100.00 | 24 | 0 | 0.00 | 99.97 |
| RNDSTINGRAY | 0.00 | 100.00 | 0.00 | 19 | 0 | 0.00 | 99.97 |
| UNIDRAY | 0.00 | 66.67 | 33.33 | 24 | 0 | 0.00 | 99.97 |
| BLUEMARLIN | 0.00 | 0.00 | 100.00 | 12 | 0 | 0.00 | 99.98 |
| WHITESHARK | 100.00 | 0.00 | 0.00 | 15 | 15 | 0.00 | 99.98 |
| BASKINGSHARK | 0.00 | 0.00 | 100.00 | 15 | 0 | 0.00 | 99.98 |
| BATRAY | 0.00 | 100.00 | 0.00 | 12 | 0 | 0.00 | 99.98 |
| UNIDROCKFISH | 0.00 | 50.00 | 50.00 | 12 | 0 | 0.00 | 99.98 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DOLPHINFISH | 100.00 | 0.00 | 0.00 | 9 | 9 | 0.00 | 99.99 |
| UNIDSHARK | 0.00 | 0.00 | 50.00 | 17 | 0 | 0.00 | 99.99 |
| YELLOWTAIL | 100.00 | 0.00 | 0.00 | 6 | 6 | 0.00 | 99.99 |
| SHORTSPEAR | 100.00 | 0.00 | 0.00 | 8 | 8 | 0.00 | 99.99 |
| NORTHANCHOVY | 0.00 | 100.00 | 0.00 | 5 | 0 | 0.00 | 99.99 |
| PACHERRING | 100.00 | 0.00 | 0.00 | 10 | 10 | 0.00 | 99.99 |
| BIGSKATE | 0.00 | 100.00 | 0.00 | 6 | 0 | 0.00 | 99.99 |
| CANEEDLEFISH | 0.00 | 0.00 | 100.00 | 6 | 0 | 0.00 | 100.00 |
| BLACKSMITH | 0.00 | 100.00 | 0.00 | 6 | 0 | 0.00 | 100.00 |
| PACIFICHAGFISH | 0.00 | 0.00 | 100.00 | 6 | 0 | 0.00 | 100.00 |
| KINGOFSALMON | 100.00 | 0.00 | 0.00 | 10 | 10 | 0.00 | 100.00 |
| PRICKLYSHARK | 0.00 | 100.00 | 0.00 | 6 | 0 | 0.00 | 100.00 |