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Observed and Estimated Bycatch of Green Sturgeon in 2002-2021 U.S. West Coast Groundfish Fisheries

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Executive summary

This report presents observed and estimated bycatch of green sturgeon (*Acipenser medirostris*) in federally-managed fishery sectors observed by the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP) from 2002-2021. Three federal groundfish fisheries observed by the WCGOP and A-SHOP encountered green sturgeon over this time period, though none of these observations occurred during the most recent two years (2020 and 2021). These fisheries with observed green sturgeon bycatch consist of the limited entry (LE) bottom trawl fishery (active 2002-2010), the individual fishing quota (IFQ) bottom trawl fishery (active 2011-present), and the at-sea hake fishery (active 2002-present).

The southern distinct population segment (Southern DPS) of North American green sturgeon was listed as threatened under the Endangered Species Act in 2006, and landings and sales of green sturgeon has been prohibited since the effective date of the protective regulations (July 2, 2010). The Biological Opinion (BiOp; NMFS 2012) for the Pacific Coast Groundfish Fishery states that incidental take of Southern DPS green sturgeon in the combined federally managed fisheries should not exceed more than 28 fish per year, while allowing for up to 86 takes per year in no more than two years within a nine-year period. While the BiOp only concerns Southern DPS as a listed species, currently there is no direct method to distinguish between Southern and Northern DPS fish at sea. Based on data from the WCGOP and A-SHOP, the observed take of all green sturgeon (regardless of DPS) in all federally-managed sectors combined in the most recent five years (2017-2021) was zero in all years, except 2017 when two green sturgeon were caught. Between 2007 and 2017 some bycatch samples were analyzed with genetic stock identification (GSI) methods to differentiate between Northern and Southern DPS fish (pers. comm. Dr. Carlos Garza, SWFSC, NMFS). The GSI analyses indicated that the proportions between the DPSs differed spatially, with 48% of green sturgeon caught off the Oregon and Washington coasts and 96% of individuals caught off the California coast assigned to the Southern DPS. Based on the individual assignments and the estimated DPS proportions from each area, we estimate that one Southern DPS green sturgeon was caught between 2017 and 2021 in federally-managed groundfish sectors. This fish was caught in 2017. Annual estimates from 2002-2021 are shown in Figure 0-1.

Estimates of green sturgeon bycatch in state-managed fisheries (including the LE California halibut fishery) and the IPHC Pacific halibut directed fishery are not included in this report.

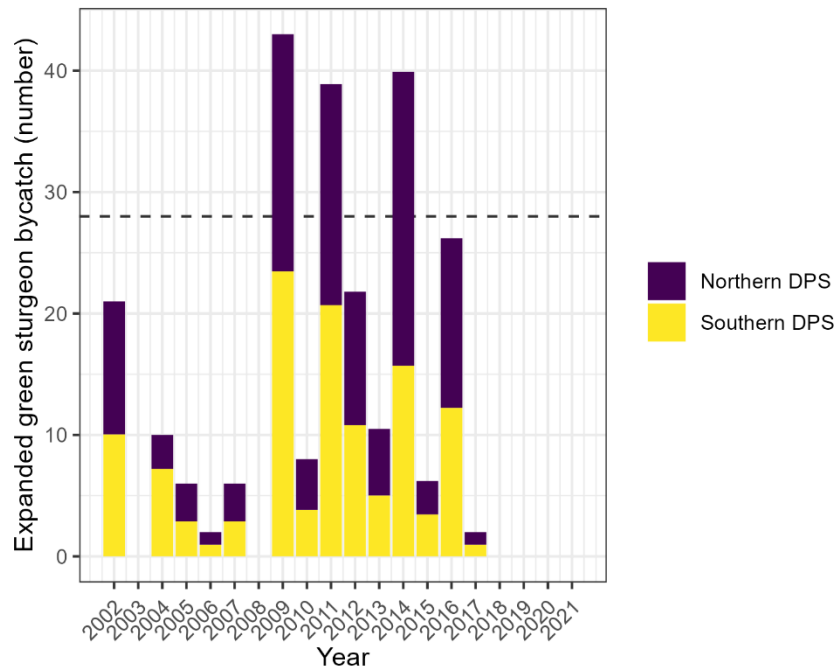


Figure 0-1. Green sturgeon bycatch estimates (number of individuals) in observed federally-managed groundfish fisheries by distinct population segment (DPS). Estimates of bycatch by DPS are calculated based on individual assignments of genetic stock identification (GSI) and GSI proportions by catch areas (48% Southern DPS for Washington and Oregon, 96% Southern DPS for California). The horizontal dashed line shows the annual limit of 28 Southern DPS individuals that may be taken each year by combined federal groundfish fisheries according to the Biological Opinion for the Pacific Coast Groundfish Fishery.

Federal Groundfish Fisheries

Introduction

In accordance with the National Marine Fisheries Service's (NMFS) Biological Opinion (BiOp) on Continuing Operation of the Pacific Coast Groundfish Fishery (NMFS 2012, p. 126-127), this section provides observed bycatch and fleet-wide take estimates of green sturgeon (*Acipenser medirostris*) for all federal fisheries observed by the West Coast Groundfish Observer Program (WCGOP) and At-Sea Hake Observer Program (A-SHOP) from 2002-2021. Since the start of the individual fishing quota (IFQ) program in 2011, all trips and nearly 100% of catch in the IFQ fisheries have been monitored by onboard observers or electronic monitoring. From 2011 to 2021, the observed bycatch in the IFQ fisheries represents a near-complete census of fleet-wide total bycatch.

Green sturgeon background

Green sturgeon are a long-lived, slow-growing, anadromous fish species. They spend the majority of their adult life in marine and estuarine environments, but migrate into rivers for spawning every 1-4 years. Between spawning runs, green sturgeon migrate along the west coast of North America, and can be found from Baja California to the Bering Sea. Due to their life history, wide distribution, and dependence on freshwater systems, green sturgeon are particularly susceptible to human-induced environmental changes, including impassible dams and barriers in spawning rivers, insufficient freshwater flows, non-native species, poaching, chemical contaminants, and entrainment by water projects (Adams et al. 2007).

Green sturgeon are separated into two distinct population segments (DPSs), based on spawning site fidelity and genetic information. The Northern DPS includes individuals spawning in the Rogue and Klamath-Trinity

river systems, while the Southern DPS includes individuals spawning in the Sacramento River and its tributaries. Northern DPS fish do not appear to occur in natal waters of the Southern DPS and vice versa; however, the two DPSs overlap in marine and estuarine habitats. This is important because the Southern DPS is listed as threatened under the Endangered Species Act (ESA), whereas the Northern DPS is not (NMFS 2006). Because green sturgeon from the Northern and Southern DPS are morphologically indistinguishable, physical tagging or genetic data are needed to determine to which DPS an individual belongs. The total population size of the Southern DPS is estimated at 12,614-22,482 individuals (1,246-2,966 adults, 6,540-15,571 sub-adults, and 2,595-6,179 juveniles; Mora et al. 2018), and the population of the Northern DPS is likely considerably larger (Adams et al. 2007).

In marine waters, adults and sub-adults primarily occur at depths of 40-110 m (Erickson and Hightower 2007). Once green sturgeon enter coastal habitats, they tend to migrate northward from their natal habitats (Erickson and Hightower 2007, Lindley et al. 2008). The coastal marine waters from Monterey Bay to Vancouver Island are recognized as the primary migratory habitat, and in 2009 NMFS designated coastal marine waters within 60 fathoms (approximately 110 m) from Monterey Bay to the U.S.A-Canada border as critical habitat for the Southern DPS (NMFS 2009). NMFS also designated the Sacramento River system and the adjacent estuaries as critical habitat, as well as several coastal estuaries in California, Oregon, and Washington (NMFS 2009). Genetic and acoustic telemetry studies suggest that Northern DPS and Southern DPS fish co-occur in large concentrations in the Columbia River estuary, Grays Harbor, and Willapa Bay. The proportions of Southern DPS fish in those estuaries were found to be moderate to high (41- 81%), although they varied between years, between estuaries, and between the estimation methods (Israel et al. 2009). Genetic analyses on green sturgeon bycatch samples collected by observers for the years 2007-2017 indicated that the proportions of Southern DPS fish varied between years and fishing areas (pers. comm. Dr. Carlos Garza, SWFSC, NMFS, NOAA). When data are aggregated across the years, about 48% of the green sturgeon sampled off Oregon and Washington and 96% of the green sturgeon sampled off the California coast likely belonged to the Southern DPS.

West Coast groundfish fishery

The West Coast groundfish fishery is a multi-species fishery that utilizes a variety of gear types off the U.S. West Coast (California, Oregon, and Washington). The fishery harvests species designated in the Pacific Coast Groundfish Fishery Management Plan (FMP) and is managed by the Pacific Fishery Management Council (PFMC; PFMC 2016). Under the FMP, the groundfish fishery consists of four management components:

- 1) The Limited Entry (LE) component encompasses all commercial fishers who hold a federal limited entry permit. The total number of limited entry permits available is restricted. Vessels with an LE permit are allocated a larger portion of the total allowable catch for commercially desirable species than vessels without an LE permit.
- 2) The Open Access (OA) component encompasses federal commercial fishers who do not hold a federal LE permit. Some states require fishers to carry a state-issued permit for certain OA sectors.
- 3) The Recreational component includes recreational anglers who target or incidentally catch groundfish species. Recreational fisheries are not included in this report.
- 4) The Tribal component includes native tribal commercial fishers in Washington that have treaty rights to harvest groundfish. Tribal fisheries other than the Tribal at-sea hake fishery are not included in this report.

The NWFSC Observer Program

A core goal of the NWFSC Observer Program is to improve estimates of total catch and discards by observing commercial fishery sectors along the U.S. West Coast that target or incidentally take groundfish. Table 1-1 shows generalized descriptions of these sectors covered by this program. The program has two operational units: the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP). The WCGOP was established in May 2001 by NMFS in accordance with the Pacific Coast Groundfish Fishery Management Plan (NMFS 2001, implemented as 50 CFR Part 660). This regulation requires all vessels that catch groundfish in the U.S. Exclusive Economic Zone (EEZ) from 3-200 miles offshore to carry an observer when notified to do so by NMFS or its designated agent. Subsequent state rule-making has extended NMFS's ability to require vessels fishing in the 0-3 mile state territorial zone to carry observers.

The WCGOP and A-SHOP observe distinct sectors of the groundfish fishery. The WCGOP observes the following groundfish sectors: IFQ (formerly LE) shore-based delivery of trawl-allocated groundfish and Pacific hake, LE and OA non-nearshore fixed gear; and state-permitted nearshore fixed gear sectors. The WCGOP also observes several state-managed fisheries that incidentally catch groundfish, including the California halibut trawl and ocean shrimp trawl fisheries, and the directed Pacific halibut fishery, which is permitted by the International Pacific Halibut Commission. The A-SHOP observes the IFQ fishery that processes Pacific hake at sea including catcher-processor, mothership, and tribal vessels. Details on how fishery observers operate in both the IFQ and non-IFQ sectors can be found online at the [Fisheries Observation Program website](#).

Amount and extent of take

The BiOp (NMFS 2012, p. 121-122) states that

"... take of threatened Southern DPS green sturgeon will occur as a result of the continued operation of the Pacific Coast groundfish fishery. Incidental take of Southern DPS green sturgeon is expected to occur as a result of incidental capture and handling in the fishery, mortalities resulting from encounter with fishing gear and/or removal of captured fish from the water, and handling by the NMFS observer program. Under the proposed action, incidental take of Southern DPS green sturgeon because of bycatch and handling in the fishery is not expected to exceed 28 fish per year; however, we recognize the potential for incidental take of greater numbers of Southern DPS green sturgeon in some years. Therefore, this take statement allows for incidental take of up to 86 Southern DPS green sturgeon per year in no more than 2 years within a period of 9 consecutive years."

While the ESA listing and BiOp only apply to Southern DPS green sturgeon, this report includes information on all green sturgeon bycatch due to our limited ability to assign bycatch observations to DPS. We currently have limited information on the recapture rate of the same individual green sturgeon or level of mortality of green sturgeon after being caught, landed on the deck, observed, handled, and released by observers. Most observed green sturgeon in the groundfish bottom trawl fisheries are released alive, and the BiOp assumes a 5.2% mortality rate for bycatch in the LE trawl sector. However, using data from green sturgeon tagged by WCGOP observers onboard vessels targeting California halibut, Doukakis et al. (2020) estimated that post-release mortality ranged from 2% (0.53 hours after release) to 26% (~28 days after release).

Federal sectors that encountered green sturgeon

This section contains information from the LE and IFQ groundfish bottom trawl fishery and the at-sea hake fishery. No other federal sector covered by WCGOP or A-SHOP had observed green sturgeon bycatch during 2002-2021. Starting in 2015, the Pacific State Marine Fisheries Commission (PSMFC) has administered an Electronic Monitoring (EM) program in the IFQ fishery. This program has partial WCGOP observer coverage at sea and full video coverage that has been reviewed for the presence of green sturgeon. No green sturgeon bycatch was observed on the EM video system (Pers. Comm. Courtney Paiva, PSMFC), and we

consider this to be a complete accounting of bycatch in EM trips. For details on observer coverage and EM coverage, see Somers et al. (2022a).

Methods

Data sources

The analyses in this report use observer data from the WCGOP/A-SHOP and fish ticket data (i.e. landing receipts) from the Pacific Fisheries Information Network (PacFIN). For information on observer sampling protocols see the WCGOP and A-SHOP manuals (NWFSC 2020, 2021). For information on how observer and fish ticket data are processed, see Somers et al. (2022b).

Bycatch estimation

We use ratio estimators to estimate fleet-wide green sturgeon bycatch within each sector. This is a simple and widely-used method for expanding observed discarding rates to unobserved catches. The general method is to estimate the total amount of bycatch in a stratum as

$$\text{Estimated bycatch} = \frac{\text{Observed bycatch}}{\text{Observed effort}} * \text{Total effort}$$

The stratum typically represents some combination of fishery sector, year, state, and time of year (winter or summer, defined as November-April or May-October, respectively). The ratio of observed bycatch to observed effort is called the bycatch ratio, and the total effort is termed the expansion factor. In this report, bycatch is counted in units of individual fish and effort is measured as the total retained weight of the target species (groundfish or Pacific hake, depending on the sector).

In sectors with less than 100% observer coverage, we quantify uncertainty around our estimates using a nonparametric bootstrap procedure. This procedure randomly selects vessels that were observed within a stratum with replacement to create a sample with the same number of vessels as the observed data. Random selection of vessels is intended to approximate the WCGOP vessel selection process. We calculate the bycatch ratio for each of 10,000 bootstrapped data sets to obtain a bootstrapped distribution of bycatch ratio estimates, and then determine the 2.5th and 97.5th percentiles of the estimates. We then calculate the 95% confidence interval of fleet-wide bycatch in the stratum by multiplying the confidence limits of the bycatch ratio by total landed weight of the target species in a given stratum. The lower confidence bound of the total fleet-wide bycatch estimate is truncated at the observed bycatch amount if the estimated lower bound was less than the observed bycatch amount.

If fewer than three vessels were observed in a given stratum, we calculated the bycatch ratio and performed bootstrapping using data pooled across two adjacent strata to ensure confidentiality. The resulting ratio estimates can be viewed as a three-year running average (see Lee et al. 2017 for details). Further sector specific methods are described below.

Individual fishing quota bottom trawl

All IFQ fishing trips carry an observer or electronic monitoring, but a very small number of tows or a small portion of catch from a given tow may be unsampled due to observer illness or other circumstances. Less than 0.4% of all landings on average were unsampled over 2011-2021 (Somers et al. 2022a). Three types of unsampled catch categories can occur during observed trips: completely unsorted catch (discards and retained), unsampled discards, and unsampled non-IFQ species. Both completely unsorted catch and unsampled discard could contain both IFQ and non-IFQ species, but unsampled non-IFQ species only contains species that are not managed as individual quota species. Estimates of green sturgeon bycatch for the unsampled portion are derived for each unsampled category type separately using the ratio approach described above. We use the weight of the sampled catch as the denominator of the ratio and the weight of

the unsampled catch as the expansion factor. Estimated bycatch from the unsampled portion of the catch is then added to the observed bycatch amount to obtain the total bycatch estimate. If no green sturgeon were observed in a stratum we assume no green sturgeon was encountered in the unsampled catch.

At-sea hake trawl

We report observed and expanded bycatch data obtained directly from A-SHOP for each at-sea hake fishery sector (catcher-processors, motherships, and tribal catch delivered at-sea). All vessels fishing in the at-sea hake fishery carry two A-SHOP observers for every fishing trip. On rare occasions, entire hauls might not be sampled due to unforeseen circumstances. These unsampled hauls are expanded at the strata level. Typically greater than 99% of hauls are sampled each year (Somers et al. 2022a), thus the unsampled portion needing expansion is a very small fraction. The green sturgeon catch in unsampled hauls is estimated by multiplying the green sturgeon catch from the sampled hauls by the proportion of unsampled hauls over the total number of hauls per given stratum. This estimated green sturgeon catch for unsampled hauls is then added to the sum of all green sturgeon catch in the sampled hauls to produce the total estimated green sturgeon bycatch per given strata.

Genetic stock identification

Tissue samples collected by observers were analyzed by Dr. Carlos Garza (SFWC, NMFS, NOAA), and the resulting GSI data from 2007-2017 were used to estimate the expanded bycatch numbers in each DPS. From the samples that have been analyzed, the overall proportion of Southern DPS was 48% for those bycatch samples ($n = 92$) collected off Columbia River/Willapa Bay/Grays Harbor areas in the LE and IFQ-bottom trawl fishery sectors, when calculated across the all available years. The proportion of Southern DPS was 96% for those green sturgeon bycatch samples ($n = 306$) caught off San Francisco Bay/Half Moon Bay from the California halibut fishery sectors. Thus, the bycatch estimates not analyzed with GSI are multiplied by 0.48 for Washington and Oregon bycatch and by 0.96 for California to estimate the Southern DPS numbers per stratum. We apply the point estimates of DPS proportions to point estimates of expanded bycatch, so our estimates do not include uncertainty in bycatch or in DPS assignment.

Results and discussion

Bycatch overview

Between 2002 and 2021, green sturgeon were encountered in the following federal sectors and years:

- LE bottom trawl fishery (in 2002, 2004, 2005, 2007, 2009, and 2010). Note that this fishery transitioned into the IFQ bottom trawl fishery in 2011.
- IFQ bottom trawl fishery (in 2011-2017).
- At-sea hake fishery (in 2005 and 2006).

Estimated bycatch was higher in the LE/IFQ bottom trawl compared to the at-sea hake fishery. All other federal sectors covered by the WCGOP had no observed green sturgeon bycatch. Figure 1-1 shows expanded bycatch estimates for all federal sectors 2002-2021. For information about tow depth, length frequencies, seasonal patterns, and exploration of environmental correlates of bycatch, see Richerson et al. (2022).

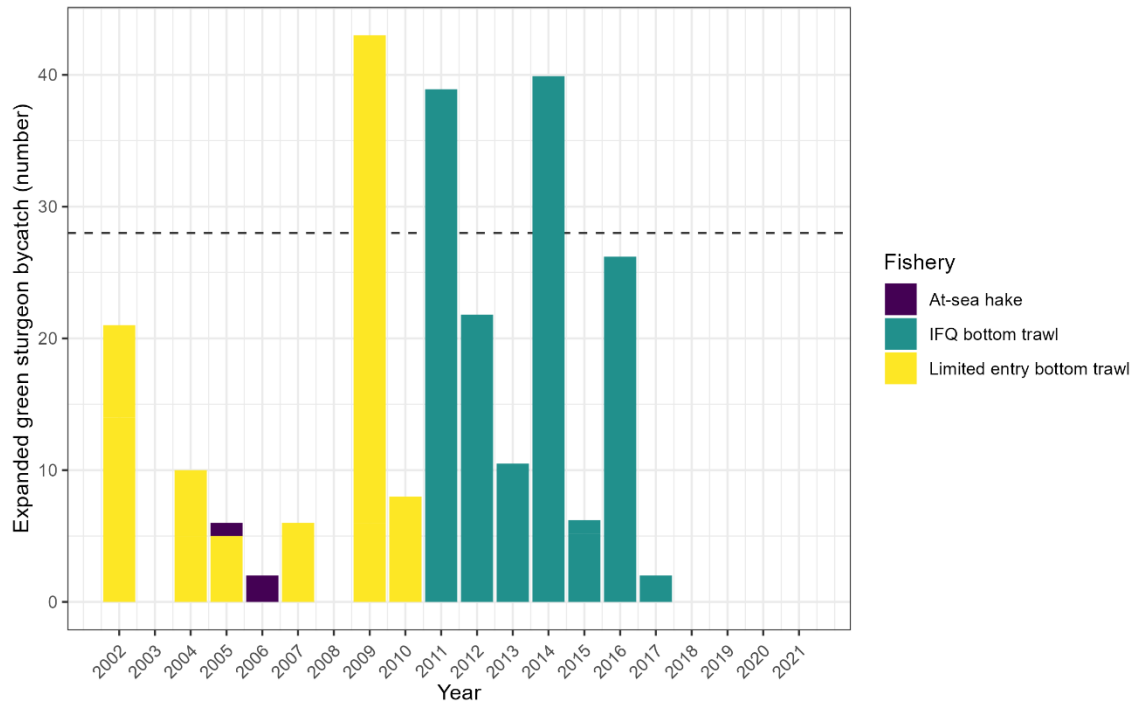


Figure 1-1. Combined Northern and Southern DPS green sturgeon bycatch estimates (number of individuals) for all federal sectors covered by the WCGOP and A-SHOP. The dashed line shows the annual limit of 28 Southern DPS individuals established by the BiOp.

Genetic stock identification

The estimated number of Northern and Southern DPS individuals encountered by federal groundfish fisheries from 2002-2021 are shown in Figure 0-1. The estimate for total green sturgeon bycatch in the IFQ fishery ranged from 0-2 per year over the most recent five-year period (2017-2021; Table 1-2). This is well below the limit of 28 Southern DPS takes established by the BiOp. The at-sea hake fishery did not have any green sturgeon bycatch in 2017-2021 (Table 1-3).

Limited entry bottom trawl

Expanded green sturgeon bycatch numbers in the LE bottom trawl fishery (2002-2010) are shown by state and time of year in Figure 1-2. Bycatch estimates, target landings, bycatch ratios, and coverage are presented in Table 1-4.

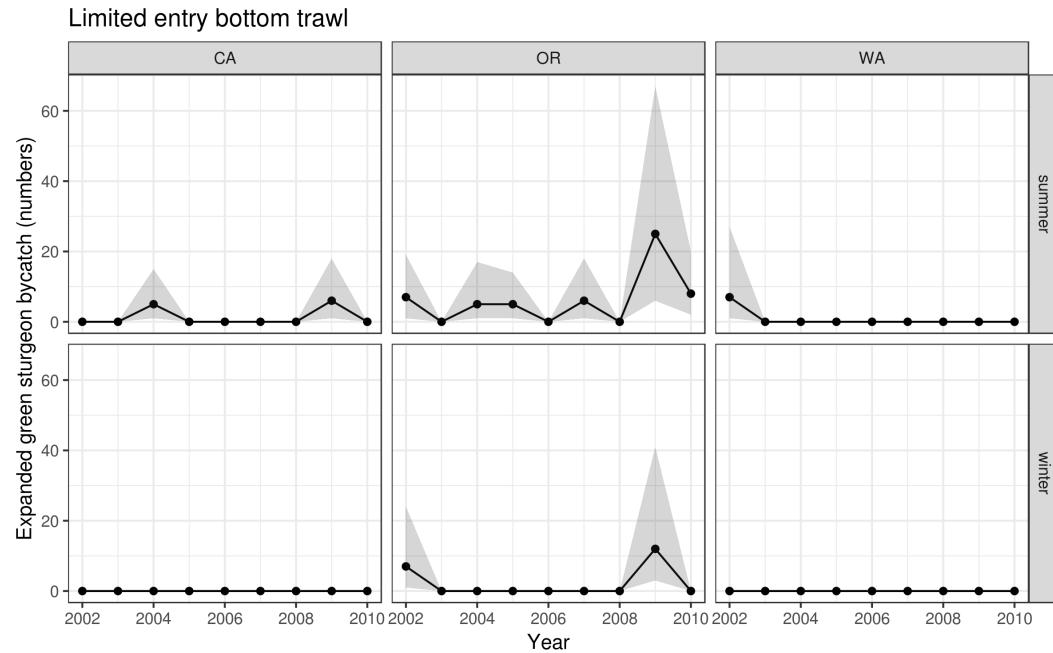


Figure 1-2. Green sturgeon bycatch estimates (numbers of individuals) in the limited entry bottom trawl fishery by state and time of year from 2002-2010. Winter is November-April and summer is May-October. Gray shading represents bootstrapped 95% confidence intervals.

Individual fishing quota bottom trawl

Expanded green sturgeon bycatch numbers in the IFQ bottom trawl fishery 2011-2021 are shown by state in Figure 1-3. Note that catch in this fishery is observed at close to 100%. Bycatch estimates, target landings, bycatch ratios, and coverage are presented in Table 1-5. Estimates for Washington in 2020 cannot be shown in order to maintain confidentiality where less than 3 vessels were active.

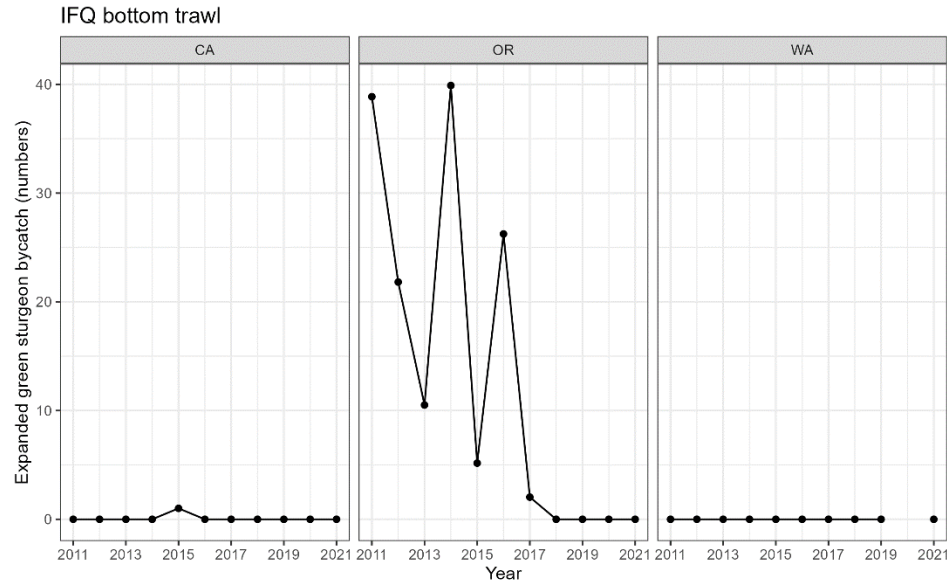


Figure 1-3. Green sturgeon bycatch estimates (numbers of individuals) in individual fishing quota (IFQ) bottom trawl fishery by state from 2011-2021. Note that catch in this fishery has nearly 100% observer coverage or electronic monitoring. Estimates are not shown for Washington in 2020 due to confidentiality.

At-sea hake

Observed green sturgeon bycatch in the at-sea hake fishery is shown in Figure 1-4. Because of the high coverage rate, these values are equivalent to the expanded numbers. No bycatch of green sturgeon in this fishery has been observed since 2006. Bycatch estimates, target landings, bycatch ratios, and coverage are presented in Table 1-6.

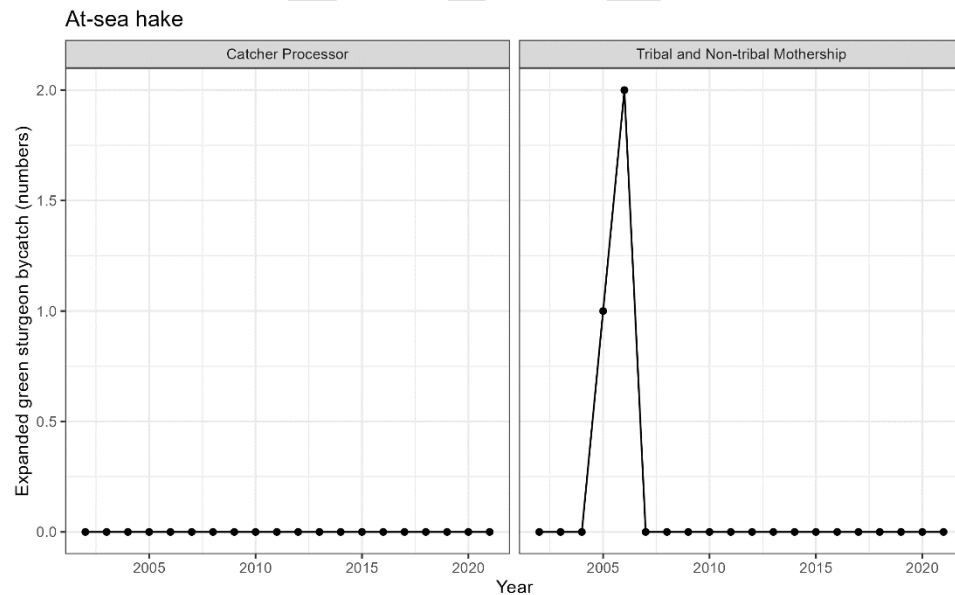


Figure 1-4. Green sturgeon bycatch estimates (number of individuals) in the at-sea hake fishery by sector from 2002-2021. Note that nearly 100% of hauls are sampled in this fishery.

Tables

Sector descriptions

Table 1-1. Generalized descriptions of U.S. West coast fisheries observed by the West Coast Groundfish Observer Program and the At-Sea Hake Observer Program. Sectors that did not have observed green sturgeon bycatch at any time over 2002-2021 are in gray and sectors that did have observed green sturgeon bycatch are in black. Estimates of green sturgeon bycatch in state-managed fisheries (including the LE California halibut sector) and the IPHC Pacific halibut directed fishery are not included in this report.

Federally managed Catch Shares fisheries								
Sector	Sub-Sector	Permits	Gear(s)	Target(s)	Vessel Length (m)	Depths (m)	Management 2002-2010	Management 2011-present
Federally managed Catch Shares fisheries								
Limited Entry (LE) Trawl	Limited Entry (LE) Trawl	Federal LE permit ¹ with trawl endorsement	Bottom Trawl, after Jan 1, 2011 also Hook & Line and Pot gear	Groundfish assemblage	11-29	Wide range	Cumulative two-month trip limits; depth-based closures; 14-23% observer coverage	Individual Fishing Quotas (IFQ); 100% observer coverage
	LE California Halibut	CA Halibut permit ² and LE permit with trawl endorsement ¹	Bottom Trawl	California halibut ⁵	9-22	< 55	Cumulative two-month trip-limits; depth-based closures; 3-23% observer coverage	IFQ; 100% observer coverage
At-Sea Hake	Mothership-Catcher Vessel (MSCV)	LE permit with MSCV endorsement ¹	Midwater Trawl	Pacific hake ⁶	26-45 ⁴	53-460 ⁴	Seasonal quotas for target and bycatch species of concern; 100% observer coverage	IFQ; Seasonal; 100% observer coverage
	Catcher-processors (CP)	LE permit with CP endorsement ¹	Midwater Trawl	Pacific hake	82-115	60-570	Seasonal quotas for target and bycatch species of concern; 100% observer coverage	IFQ; Seasonal; 100% observer coverage
	Tribal	(none)	Midwater Trawl	Pacific hake	< 38	53-460	Tribal	Seasonal; 100% observer coverage of at-sea deliveries

Shoreside Hake	n/a	LE permit with trawl endorsement ¹	Midwater Trawl	Pacific hake	17-29	Wide range	Seasonal quotas for target and bycatch species of concern; electronic monitoring	IFQ; Seasonal; 100% observer coverage
Other Federally managed fisheries								
Sector	Sub-Sector	Permits	Gear(s)	Target(s)	Length (m)	Depths (m)	Management 2002-present	
Non-Nearshore Fixed Gear	Sablefish endorsed	LE permit with fixed gear endorsement ¹ and sablefish quota	Longlines, Pots	Sablefish ⁷	11-32	> 145	Sablefish tier quotas; seven month season; 9-27% observer coverage	
	Sablefish non-endorsed (a.k.a. Zero Tier)	LE permit with fixed gear endorsement ¹ w/o sablefish quota	Longlines, Pots	Sablefish, rockfish ⁸ and flatfish ⁹	5-18	> 145	Trip limits; 1-12% observer coverage	
	Open Access	(none)	Longlines, Pots	Sablefish and other groundfish	3-30	> 64	Trip limits; 1-6% observer coverage	
	IPHC Pacific halibut directed	Pacific halibut permit from the International Pacific Halibut Commission	Longlines	Pacific halibut	3-32	40–400	Trip limits; 10-hr fishing periods south of Pt. Chehalis, WA Legal size: >82 cm	
State managed fisheries								
Sector	Permits		Gear(s)	Target(s)	Length (m)	Depth (m)	Management	
Open Access (OA) California Halibut	CA Halibut permit ²		Bottom Trawl	California halibut	9-22	< 55	All fishing occurs within CA waters, most in the California Halibut Trawl Grounds where minimum mesh sizes, seven month season, and minimum size requirements hold; 1-	

						33% observer coverage
Nearshore Fixed Gear³	CA or OR state nearshore permits and endorsements	Variety of hand lines, pot gear, stick gear, rod and reel	Rockfish, Cabezon ¹⁰ , Greenlings ¹¹	3-15	< 110 (usu. < 55 in OR waters)	Federal and CA or OR state nearshore regulations; area closures; two-month trip limits; minimum size limits; 2-8% observer coverage
Pink Shrimp	WA, OR, or CA state pink shrimp permit	Shrimp trawl	Pink shrimp ¹²	11.5-33	91-256	WA, OR, or CA state pink shrimp regulations; Bycatch Reduction Devices required; trip limits on groundfish landed; 4-14% observer coverage

¹a.k.a., LE permit; all LE permits are issued by Federal agency (NOAA).

²Issued by the state of California.

³The state of WA does not conduct a nearshore fishery.

⁴Average values for catcher vessels delivering catch to motherships.

⁵ *Paralichthys californicus*

⁶ *Merluccius productus*

⁷ *Anoplopoma fimbria*

⁸ *Sebastes* spp.

⁹ Pleuronectiformes

¹⁰ *Scorpaenichthys marmoratus*

¹¹ Hexagrammidae

¹² *Pandalus jordani*

Limited entry and individual fishing quota bottom trawl GSI table

Table 1-2. Summary of expanded bycatch numbers of green sturgeon in limited entry bottom trawl (LE) and IFQ bottom trawl (IFQ) sectors by state (WA = Washington, OR = Oregon, and CA = California). Estimates of Southern DPS (SDPS) and Northern DPS (NDPS) bycatch are calculated based on individual assignments of genetic stock identification (GSI) and GSI proportions by catch areas (48% for WA and OR, 96% for CA). The LE sector was active 2002-2010 and the IFQ sector was active 2011-2021.

Year	CA SDP S	CA NDPS	CA total	OR SDPS	OR NDPS	OR total	WA SDPS	WA NDPS	WA total	SDPS total	NDPS + SDPS total
2002	0	0	0	6.6	7.3	13.9	3.5	3.8	7.2	10.1	21.2
2003	0	0	0	0	0	0	0	0	0	0	0
2004	4.5	0.2	4.7	2.5	2.7	5.3	0	0	0	7	9.9
2005	0	0	0	2.2	2.4	4.5	0	0	0	2.2	4.6
2006	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	3.7	1.8	5.5	0	0	0	3.7	5.5
2008	0	0	0	0	0	0	0	0	0	0	0
2009	5.4	0.1	5.5	17.3	20.3	37.6	0	0	0	22.7	43.1
2010	0	0	0	5.9	2.1	8	0	0	0	5.9	8
2011	0	0	0	19.2	19.6	38.9	0	0	0	19.2	38.8
2012	0	0	0	10.8	11	21.8	0	0	0	10.8	21.8
2013	0	0	0	5	5.5	10.5	0	0	0	5	10.5
2014	0	0	0	19.5	20.4	39.9	0	0	0	19.5	39.9
2015	1	0	1	2.5	2.7	5.2	0	0	0	3.5	6.2
2016	0	0	0	12.7	13.5	26.2	0	0	0	12.7	26.2
2017	0	0	0	1	1.1	2	0	0	0	1	2.1
2018	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0

At-sea hake GSI table

Table 1-3. Summary of expanded bycatch numbers of green sturgeon in the at-sea hake fishery. Estimates of Southern DPS (SDPS) and Northern DPS (NDPS) bycatch are calculated based on GSI proportions by catch area (48% for WA and OR, 96% for CA). For simplicity years and sectors without green sturgeon bycatch are not shown.

Year	Sector	SDPS total	NDPS + SDPS total
2005	Mothership	0.48	1
2006	Mothership	0.96	2

Limited entry trawl bycatch table

Table 1-4. Observed and fleet-wide total expanded numbers of green sturgeon bycatch from the limited entry bottom trawl fishery from 2002-2010. Asterisks (*) signify confidential strata with fewer than three observed vessels. Confidence intervals (CIs) in years with no bycatch are denoted as NA.

State	Year	Season	Observed bycatch	Observed target landings (MT)	Fleet-total target landings (MT)	Target landings sampled (%)	Bycatch ratio	Lower CI of ratio	Upper CI of ratio	Fleet total bycatch	Lower CI of bycatch	Upper CI of bycatch
2002	WA	winter	0	297	1276.5	23.3	0	-	-	0	-	-
2002	WA	summer	1	142.4	1032.7	13.8	0.01	0	0.03	7	1	27
2003	WA	winter	0	124.3	1265.9	9.8	0	-	-	0	-	-
2003	WA	summer	0	56.4	647.9	8.7	0	-	-	0	-	-
2004	WA	winter	0	335.7	878.8	38.2	0	-	-	0	-	-
2004	WA	summer	0	179	902.5	19.8	0	-	-	0	-	-
2005	WA	winter	0	167.9	977.1	17.2	0	-	-	0	-	-
2005	WA	summer	0	408.6	1932.8	21.1	0	-	-	0	-	-
2006	WA	winter	0	89.1	511.3	17.4	0	-	-	0	-	-
2006	WA	summer	0	276.4	1194.6	23.1	0	-	-	0	-	-
2007	WA	winter	0	166	701	23.7	0	-	-	0	-	-
2007	WA	summer	0	60.7	813.1	7.5	0	-	-	0	-	-
2008	WA	winter	*	*	767	*	0	-	-	0	-	-

2008	WA	summer	0	292.1	832.7	35.1	0	-	-	0	-	-
2009	WA	winter	0	352	1355.8	26	0	-	-	0	-	-
2009	WA	summer	0	384	1200.4	32	0	-	-	0	-	-
2010	WA	winter	0	280.9	1230.6	22.8	0	-	-	0	-	-
2010	WA	summer	0	221.7	882.4	25.1	0	-	-	0	-	-
2002	OR	winter	1	579.8	4070.7	14.2	0	0	0.01	7	1	24
2002	OR	summer	1	490.8	3376.9	14.5	0	0	0.01	7	1	19
2003	OR	winter	0	801.5	4177.5	19.2	0	-	-	0	-	-
2003	OR	summer	0	551.2	4369.5	12.6	0	-	-	0	-	-
2004	OR	winter	0	1181.1	4372.8	27	0	-	-	0	-	-
2004	OR	summer	1	989.3	5201.2	19	0	0	0	5	1	17
2005	OR	winter	0	1204.2	4669.5	25.8	0	-	-	0	-	-
2005	OR	summer	1	1179.6	5348.4	22.1	0	0	0	5	1	14
2006	OR	winter	0	801.9	4070.1	19.7	0	-	-	0	-	-
2006	OR	summer	0	1123.5	6151.2	18.3	0	-	-	0	-	-
2007	OR	winter	0	851.2	5864.9	14.5	0	-	-	0	-	-
2007	OR	summer	1	1114.2	6147.7	18.1	0	0	0	6	1	18
2008	OR	winter	0	1335.7	7522.1	17.8	0	-	-	0	-	-
2008	OR	summer	0	1820.7	7360.1	24.7	0	-	-	0	-	-
2009	OR	winter	3	2167.9	8834.2	24.5	0	0	0	12	3	41
2009	OR	summer	6	1858.5	7846.9	23.7	0	0	0.01	25	6	67
2010	OR	winter	0	903.9	7445.9	12.1	0	-	-	0	-	-
2010	OR	summer	2	1850.6	7392.4	25	0	0	0	8	2	20
2002	CA	winter	0	462.8	3727.6	12.4	0	-	-	0	-	-
2002	CA	summer	0	523.5	3909.3	13.4	0	-	-	0	-	-
2003	CA	winter	0	333.4	2875.6	11.6	0	-	-	0	-	-
2003	CA	summer	0	566.9	4068.8	13.9	0	-	-	0	-	-
2004	CA	winter	0	734.4	2194.1	33.5	0	-	-	0	-	-
2004	CA	summer	1	756.6	3547.4	21.3	0	0	0	5	1	15
2005	CA	winter	0	496.7	2473.1	20.1	0	-	-	0	-	-

2005	CA	summer	0	585.8	3019.9	19.4	0	-	-	0	-	-
2006	CA	winter	0	365.4	1911.2	19.1	0	-	-	0	-	-
2006	CA	summer	0	590.8	2935.1	20.1	0	-	-	0	-	-
2007	CA	winter	0	424.5	2374.3	17.9	0	-	-	0	-	-
2007	CA	summer	0	694.8	3674.6	18.9	0	-	-	0	-	-
2008	CA	winter	0	555.6	3091.9	18	0	-	-	0	-	-
2008	CA	summer	0	648.5	3355.9	19.3	0	-	-	0	-	-
2009	CA	winter	0	548.4	2825.4	19.4	0	-	-	0	-	-
2009	CA	summer	1	636.6	3513.6	18.1	0	0	0	6	1	17
2010	CA	winter	0	203.5	2131	9.6	0	-	-	0	-	-
2010	CA	summer	0	581.9	3051.5	19.1	0	-	-	0	-	-

Individual fishing quota trawl bycatch table

Table 1-5. Observed and fleet-wide total expanded numbers of green sturgeon bycatch from the IFQ bottom trawl fishery from 2011-2021. Note that the IFQ fisheries are sampled at close to 100%. Asterisks (*) represent confidential data.

State	Year	Observed bycatch	Observed groundfish landings (MT)	Fleet-total groundfish landings (MT)	Groundfish landings sampled (%)	Estimated bycatch from unsampled catch	Fleet total bycatch
2011	WA	0	1832.6	1855	98.8	0	0
2012	WA	0	2068.9	2119.6	97.6	0	0
2013	WA	0	1451.4	1463.9	99.1	0	0
2014	WA	0	717.3	719.9	99.6	0	0
2015	WA	0	434.8	434.8	100	0	0
2016	WA	0	446.7	451	99	0	0
2017	WA	0	831	834	99.6	0	0
2018	WA	0	747.2	747.2	100	0	0
2019	WA	0	838.4	838.4	100	0	0
2020	WA	*	*	*	100	*	*
2021	WA	0	494.3	561.8	88	0	0
2011	OR	37	10533.4	10637.2	99	1.9	38.9
2012	OR	21	10380	10469	99.2	0.8	21.8
2013	OR	10	11973.8	12034.5	99.5	0.5	10.5
2014	OR	39	10124.4	10184	99.4	0.9	39.9
2015	OR	5	11015.8	11080.8	99.4	0.2	5.2
2016	OR	25	12003.9	12101.5	99.2	1.2	26.2
2017	OR	2	12114	12131.8	99.9	0	2
2018	OR	0	9736	9824.5	99.1	0	0
2019	OR	0	9651.8	9714.4	99.4	0	0
2020	OR	0	7144.7	7273.6	98.2	0	0
2021	OR	0	7558.5	7861.2	96.1	0	0

2011	CA	0	4570	4577	99.8	0	0
2012	CA	0	4453.2	4461.7	99.8	0	0
2013	CA	0	5059	5072.7	99.7	0	0
2014	CA	0	4889.4	4934.8	99.1	0	0
2015	CA	1	4139.7	4142.6	99.9	0	1
2016	CA	0	2353.2	2353.2	100	0	0
2017	CA	0	3101.3	3109	99.8	0	0
2018	CA	0	2206.2	2208.4	99.9	0	0
2019	CA	0	2178.3	2188.5	99.5	0	0
2020	CA	0	2231.3	2248.6	99.2	0	0
2021	CA	0	2818.6	2818.6	100	0	0

At-sea hake bycatch table

Table 1-6. Observed and expanded bycatch numbers of green sturgeon from the at-sea hake fishery from 2002-2021. Note nearly 100% of hauls are sampled in this fishery. The tribal mothership sector did not participate in this fishery after 2012. Asterisks (*) signify confidential strata.

Sector	Year	Observed bycatch	Fleetwide expanded bycatch	Number sampled tows	Sampled hake landings (MT)	% tows sampled
Catcher Processor	2002	0	0	556	36313.5	99.5
Catcher Processor	2003	0	0	766	41452.4	99.7
Catcher Processor	2004	0	0	1492	72839.1	99.4
Catcher Processor	2005	0	0	1332	78420.8	99.6
Catcher Processor	2006	0	0	1488	78095.5	99.4
Catcher Processor	2007	0	0	1566	72799.8	99.3
Catcher Processor	2008	0	0	1864	107845.5	98.8
Catcher Processor	2009	0	0	863	34541.7	99.4
Catcher Processor	2010	0	0	1063	54210.3	99.5
Catcher Processor	2011	0	0	1530	71282.1	98.8
Catcher Processor	2012	0	0	1100	55457	99.4

Catcher Processor	2013	0	0	1439	77906.3	98.6
Catcher Processor	2014	0	0	1683	103171.6	99.2
Catcher Processor	2015	0	0	1503	68435.2	98.9
Catcher Processor	2016	0	0	2188	108780.6	99.2
Catcher Processor	2017	0	0	2143	137104.5	99.3
Catcher Processor	2018	0	0	1954	116005.5	99.1
Catcher Processor	2019	0	0	1936	116352.4	99.4
Catcher Processor	2020	0	0	1496	111014.6	99.4
Catcher Processor	2021	0	0	1477	103260.9	97
Tribal and Non-tribal Mothership	2002	0	0	1198	48106.2	99.3
Tribal and Non-tribal Mothership	2003	0	0	1059	44746.2	98.4
Tribal and Non-tribal Mothership	2004	0	0	1201	47508.6	99.8
Tribal and Non-tribal Mothership	2005	1	1	1670	72091.8	99.8
Tribal and Non-tribal Mothership	2006	2	2	1397	59429.5	96.8
Tribal and Non-tribal Mothership	2007	0	0	1291	52335	99.1
Tribal and Non-tribal Mothership	2008	0	0	1726	72726.2	99.7
Tribal and Non-tribal Mothership	2009	0	0	1000	37482.4	99.6
Tribal and Non-tribal Mothership	2010	0	0	1424	51926.4	100
Tribal and Non-tribal Mothership	2011	0	0	1474	56074.5	99.9
Tribal and Non-tribal Mothership	2012	0	0	934	38018.5	98
Tribal and Non-tribal Mothership	2013	0	0	1249	52305	99.4

Tribal and Non-tribal Mothership	2014	0	0	1288	61793.8	98.5
Tribal and Non-tribal Mothership	2015	0	0	625	27548.8	97.7
Tribal and Non-tribal Mothership	2016	0	0	1550	64597.5	99
Tribal and Non-tribal Mothership	2017	0	0	1287	65358.5	98.3
Tribal and Non-tribal Mothership	2018	0	0	1509	65979.1	98.3
Tribal and Non-tribal Mothership	2019	0	0	1220	51829.1	99
Tribal and Non-tribal Mothership	2020	0	0	765	37260.7	99.5
Tribal and Non-tribal Mothership	2021	0	0	701	35506.8	97.9

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