

6 Sturgeons, *Acipenser spp.*



White Sturgeon, *Acipenser transmontanus*. Photo credit: Department.

History of the Fishery

The sturgeon fishery has been of major importance to California historically. Sturgeon remains found in Native American middens in the San Francisco Bay area, Sacramento-San Joaquin Delta and Elkhorn Slough indicate that sturgeon were an important nutrition source for some California native populations. A commercial sturgeon fishery developed in the San Francisco Bay estuary between the 1860s and 1901 to supply the increasing demand for caviar and smoked sturgeon in the eastern United States. White sturgeon, *Acipenser transmontanus*, has been the primary species taken in the commercial and recreational fisheries with green sturgeon, *A. mediostris*, taken in smaller amounts. Gear used in the commercial fishery included gill nets, long lines and snagging hooks. The commercial fishery peaked in 1887 when 1.65 million pounds (748 metric tons) were landed, fell to 0.3 million pounds (136 metric tons) in 1895, and to 0.2 million pounds (91 metric tons) in 1901. Heavy commercial fishing led to serious resource depletion by 1900 and the fishery for sturgeon closed in 1901. The fishery reopened in 1909; however, small catches indicated that the population was still depressed. The commercial and recreational sturgeon fisheries closed in 1917; the commercial fishery closing permanently.

The recreational fishery for sturgeon (white and green combined) was re-established in 1954 with a 40 inch (102 centimeter) total length (TL) minimum size limit, no seasonal closure, and a one fish per day bag limit. A tagging study conducted in 1954 showed that white sturgeon weight increases slowly until the total length reaches 35 inches (89 centimeters) and then varies depending on size. The study also showed the fishery is dependent upon widely spaced strong year classes. This tagging study resulted in a recommendation of a 50 inch (127 centimeter) size limit for both species to provide a buffer stock of larger fish for anglers and to insure maintenance of an adequate spawning stock.

The new size limit was implemented in 1956, the same year snagging sturgeon became illegal—sturgeon may only be taken by angling, which is defined as the fish voluntarily taking the bait or lure in its mouth (Title 14, CCR, §5.80). The minimum size limit returned to 40 inches (201 centimeters) in 1964. Concern over potential depletion of the sturgeon resource in the late 1980s prompted regulation changes starting in 1990 with the implementation of a 72 inch (183 centimeter) TL maximum size limit, creating

the first slot size limit regulation for a marine species. The slot size limit protects smaller, juvenile fish as well as larger fish with the highest reproductive capacity. In 1990 the minimum size limit was increased by 2 inches (5 centimeters) each year until 1992 when a minimum size limit of 46 inches (117 centimeters) was reached (Title 14, CCR, §5.80).

In 2006 the National Marine Fisheries Service (NMFS) determined that the North American green sturgeon Southern Distinct Population Segment (DPS), which includes the populations originating from coastal watersheds south of the Eel River, is at risk of extinction in the foreseeable future throughout all or a significant portion of its range and listed the species as Threatened under the Federal Endangered Species Act (ESA). As a result, the California Fish and Game Commission, upon a recommendation by the California Department of Fish and Game (Department), closed the recreational fishery for green sturgeon in 2007 (Title 14, CCR, §5.81).

In 2007, a suite of new recreational fishing regulations were implemented for the white sturgeon fishery to reduce the white sturgeon catch and the bycatch of threatened green sturgeon, and to assist enforcement. The new regulations provide for an annual limit of three white sturgeon, a reduction in the maximum size limit to 66 inches (168 centimeters) TL, a requirement to record all catch on a Sturgeon Fishing Report Card, and a requirement to tag all retained white sturgeon (Title 14, CCR, §5.79 and 5.80).

The report card information will provide fishery-dependent data, and the tagging requirement is intended to help anglers to comply with the annual bag limit. All anglers targeting or retaining sturgeon are required to possess the card, including those anglers that are not required to possess a fishing license, such as anglers under the age of 16 and people fishing from a public pier or fishing on free fishing days. Regulations require anglers that catch and release green sturgeon incidentally while fishing for white sturgeon record their green sturgeon catch on the Sturgeon Fishing Report Card along with any white sturgeon taken (whether kept or released). Anglers are required to return the card to the Department by January 31 of the following year.

Data from the 2007 Sturgeon Fishing Report Card show that approximately 41,000 cards were issued. Of these, 6573 cards were returned by anglers and 1801 cards had data on sturgeon catch. Anglers reported keeping 1399 white sturgeon, and releasing 4612 white sturgeon and 311 green sturgeon. White sturgeon catch was greatest in Suisun Bay, the Sacramento River from Rio Vista to Chipps Island [10 mile (16 kilometer) stretch of river near Suisun Bay], and Montezuma Slough (north of Suisun Bay). Angler reported lengths of retained white sturgeon averaged 55 inches (139 centimeters) TL and ranged from 12 to 68 inches (30 to 172 centimeters). While anglers are not required to provide the length of released white sturgeon, many volunteered such data. The average TL of released white sturgeon was approximately 44 inches (112 centimeters).

Green sturgeon catch was greatest in the Sacramento River from Red Bluff to Colusa (100-mile stretch of river north of Sacramento), and the Sacramento River from Rio Vista to Chipps Island (20-mile stretch of river inland from Suisan Bay). While anglers are not required to provide the length of green sturgeon released, many anglers

did provide green sturgeon length information. The reported lengths ranged from 19 to 86 inches (48 to 218 centimeters) and averaged 37 inches (94 centimeters) TL.

Sturgeon is an important target species for some commercial passenger fishing vessels (CPFV) fishing inside San Francisco and San Pablo bays. Some operators specialize in sturgeon fishing, offering passengers sturgeon-only trips. All CPFV operators are required to submit a log of daily fishing activity to the Department. Green and white sturgeon are not differentiated on the CPFV logs and the catch is reported as “sturgeon”. As white sturgeon make up the majority of the total sturgeon recreational catch, it is believed that the CPFV catch of white sturgeon is larger than the green sturgeon catch. Following regulatory changes for white sturgeon beginning in 1990, reported catch by anglers aboard CPFVs decreased compared to catch reported for the 1980s (Figure 6-1).

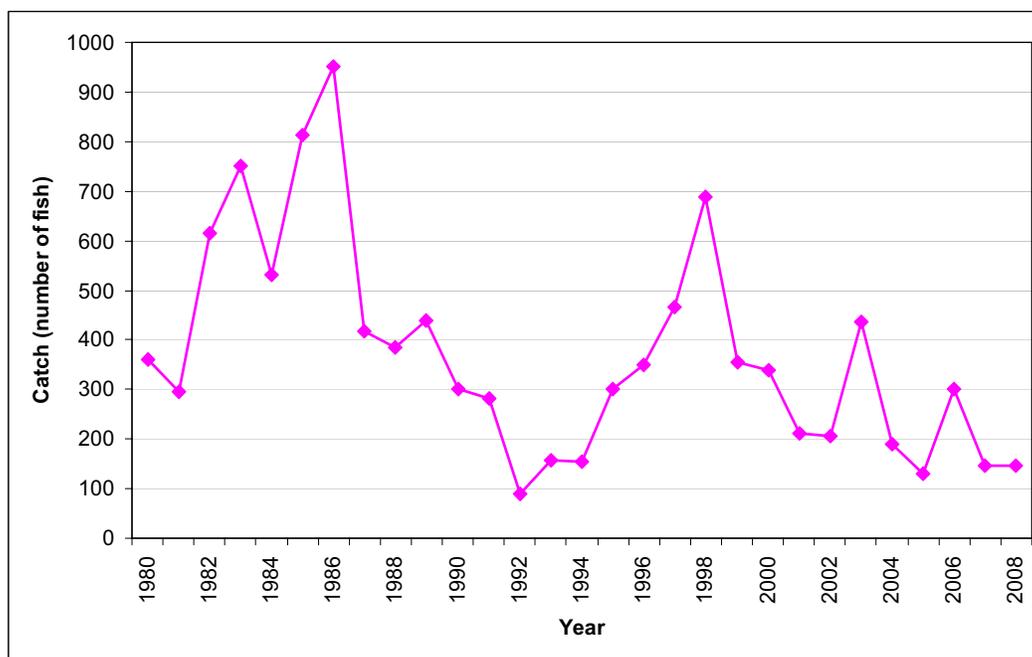


Figure 6-1. Sturgeon commercial passenger fishing vessel (CPFV) catch (all species combined), 1980-2008. Data Source: CPFV logbook data.

Green sturgeon may have been of historical importance to Native Americans living on California’s north coast. While recreational fishing regulations prohibit recreational anglers from taking sturgeon in the rivers of Del Norte, Humboldt and Mendocino counties, a tribal fishery for green sturgeon continues today on the Klamath River in California. These green sturgeon are believed to be from the Northern DPS and are not protected.

Poaching, primarily to supply black market demand for caviar, makes up an unknown yet potentially significant portion of the white sturgeon total catch and is a serious concern. For green sturgeon, poaching represents a real threat to the survival of the species. Undercover operations by Department wardens have resulted in 8 major cases against sturgeon poaching rings since 2003. Recent amendments to FGC

§7370, 12006 and 12157 (Assembly Bill 1187, DeSaulnier 2007) substantially increased the penalty for illegal commercialization of sturgeon and made it easier to establish intent to illegally commercialize sturgeon.

Status of Biological Knowledge

White Sturgeon

White sturgeon are long-lived, slow growing anadromous fish ranging from the Gulf of Alaska to Ensenada, Mexico. Spawning populations have been found only in large rivers from the Sacramento-San Joaquin River system north. In California, white sturgeon are most abundant in the San Francisco Bay estuary. Some white sturgeon move into the Sacramento River Delta and lower Sacramento River during late fall and winter. Some fish move 90 miles (145 kilometers) up the river to the Knights Landing-Hamilton City area (Yolo County) to spawn. Anecdotal information indicates that a small number of adult white sturgeon occur in the San Joaquin River mainstream upstream from the Delta. White sturgeon spawning in the San Joaquin River is suspected to occur in wet, high water years but has never been confirmed. Catches of two unidentified juvenile sturgeon in the Mokelumne River in 2003 could be the first documentation of sturgeon spawning in a San Joaquin River tributary. Spawning may also occur in the Feather River, but has not yet been documented there.

Spawning occurs in the Sacramento River between mid February and late May when water temperatures are 46 to 72°F (8 to 22°C). The spawning season of white sturgeon in the Klamath River is unknown. Little is known about sturgeon spawning behavior. White sturgeon are broadcast spawners in deep holes with fast-moving water. Compared with most freshwater or anadromous fishes, white sturgeon are quite old when they become sexually mature. Age at maturity differs between the sexes – mature males are 9 to 25 years old and 3.6 to 6 feet long (1.1 to 1.8 meters), while mature females are generally 14 to 30 years old and 4.6 to 6.6 feet long (1.4 to 2.0 meters). High natural variability in the size at sexual maturity has been observed, especially among females. Studies suggest that female white sturgeon do not spawn every year; several years may pass between successive spawning by an individual female. One study showed that approximately 50 percent of the males captured were approaching spawning condition for that year, compared with only about 15 percent of the captured females. The female white sturgeon fecundity is impressive; one 9.2 foot, 460 pound (2.8 meters, 209 kilogram) female contained 4.7 million eggs. Smaller females (less than 5 feet; 1.5 meters) may contain 100,000 eggs. Fertilized eggs hatch after 4 to 12 days on the bottom. Larvae stay close to the bottom and rear in both the river and the estuary. Rearing location is at least partly determined by river flow – when freshwater flows are high, more larvae are washed into the estuary.

Young white sturgeon grow rapidly, reaching 17 inches (43 centimeters) TL during the first year. Growth slows after the first year to 1 to 2.5 inches (2.5 to 6 centimeters) per year, reaching the current minimum size limit of 46 inches (117 centimeters) TL after 9 to 16 years. Water temperature and dissolved oxygen concentration have a significant impact on growth. The rapid growth capability of white

sturgeon has resulted in aquaculture farm development to raise sturgeon for the caviar and fish meat markets.

Historical records of large white sturgeon indicate fish that may have reached lengths greater than 18 feet long, weighed more than 1800 pounds (549 centimeters, 816 kilograms), and possibly reached 100 years of age. This makes the white sturgeon the largest freshwater fish in North America. The current world record recreationally-caught white sturgeon was a 468 pound (212 kilogram) fish taken from the Carquinez Strait area (inland from San Pablo Bay, Solano County) in 1983.

While the oceanic movements of sturgeon are poorly known, most recoveries from tagging programs in the San Francisco Bay estuary have come from the estuary and its tributaries; a few fish have moved along the Pacific coast and been recovered in Oregon and Washington. One white sturgeon was recently documented with radio telemetry to move between the Klamath River in northern California and the Fraser River in British Columbia, Canada. This fish spent long periods of time in at least two very different river systems (one clear and one highly turbid), making determination of the home river uncertain. Large scale movements of sturgeon outside the home river may have serious implications for stock assessments and management.

Young white sturgeon feed primarily on small crustaceans such as amphipods. As they grow, white sturgeon begin to prey upon a wider variety of benthic invertebrates such as crabs, clams and shrimp. The diet of larger white sturgeon includes fishes and, during winter in San Francisco Bay, herring roe. A diet study of fish caught by anglers aboard CPFVs from 1965 through 1967 in the San Pablo Bay and Carquinez Strait-Lower Suisun Bay areas showed that prey items were closely associated with shallow estuarine mudflat areas. Sturgeon feed by suction with their ventral, protrusible mouths. Dense aggregations of taste buds located on the barbels are believed to assist with food identification.

Very little is known about white sturgeon predators. Larger fish are taken by sea lions. Smaller sturgeon are preyed upon by various fish and perhaps birds. The sturgeon's five lines of sharp, bony scutes may discourage predators and send them searching for more desirable prey.

White sturgeon may be distinguished from green sturgeon by the number of scutes; white sturgeon have more than 38 scutes along the body and no scutes behind the dorsal fin while green sturgeon have 28-30 scutes along the body and 1 to 2 scutes behind the dorsal fin. White sturgeon have a comparatively short and broad snout, with barbells closer to the end of the snout than to the mouth.

Green Sturgeon

Green sturgeon (Figure 6-2) are long-lived, slow growing, anadromous fish and are the most marine-oriented and widely distributed of the sturgeon species, ranging from the Bering Sea to Ensenada, Mexico. Green sturgeon spend the majority of their lives in nearshore marine waters, bays and estuaries. It is believed that green sturgeon spend much less time in the San Francisco Bay estuary, either as young or adults, than

white sturgeon. Spawning populations have been found only in medium sized rivers from the Sacramento-San Joaquin River system northward. Current California spawning areas are believed to include the Klamath River Basin and the Sacramento River. Green sturgeon have been reported from the Feather, Yuba, Bear, Trinity and Eel rivers, but it is unclear if spawning takes place in these rivers. There is no evidence to indicate that green sturgeon were historically present or are currently present in the San Joaquin River upstream from the Delta.



Figure 6-2. Green Sturgeon, *Acipenser medirostris*. Photo credit: Department.

Adult green sturgeon usually migrate from salt water into fresh water beginning in late February. Spawning takes place in the Sacramento River from April-July, peaking in May, and March-July, peaking April-June, in the Klamath River. Green sturgeon spawn less frequently with age. Spawning occurs in deep, fast-moving water in river mainstems. Little is known about sturgeon spawning behavior. Age at maturity differs between the sexes—first spawning for males occurs at 14 years and at 16 years for females. Fecundity is dependent on the size of the female, ranging from approximately 59,000 to 242,000 eggs per female. These numbers are lower than those for white sturgeon, as green sturgeon are smaller than white sturgeon and green sturgeon eggs are larger than white sturgeon eggs. Fertilized eggs hatch after 4 to 12 days. Larvae stay close to the bottom and are believed to reside and develop in rivers well upstream of estuaries. Young fish grow rapidly, possibly reaching 12 inches (31 centimeters) in the first year. By 9 years an average green sturgeon will be 39 inches (100 centimeters) TL; an average 33 year old fish will be 79 inches (201 centimeters) TL. Juvenile green sturgeon are believed to reside in fresh water for the first one to three years of life, then migrate to the ocean, where they disperse widely until they reach sexual maturity and return to their natal waters to spawn.

Green sturgeon have been reported to reach ages of 60-70 years, and historical accounts report fish up to 350 pounds (159 kilograms). The oldest fish sampled from the Klamath River tribal fishery from 1999 through 2003 were estimated to be about 40 years old; the largest fish was 95 inches (241 centimeters) TL and weighed 160 pounds (73 kilograms).

Young green sturgeon feed primarily on small crustaceans such as amphipods. As they grow, green sturgeon begin to prey upon a wider variety of benthic invertebrates such as crabs, clams and shrimp. The diet of larger sturgeon includes fishes. Sturgeon feed by suction with their ventral, protrusible mouths. Dense aggregations of taste buds located on the barbels are believed to assist with food identification.

Very little is known about green sturgeon predators. Large fish are taken by sea lions. Smaller sturgeon are preyed upon by various fish and perhaps birds. The sturgeon's five lines of sharp, bony scutes may discourage predators and send them in search for more desirable prey.

Green sturgeon may be distinguished from white sturgeon, with which they co-occur, by the number of scutes—green sturgeon have 23-30 scutes along the body and 1-2 scutes behind the dorsal fin; white sturgeon have more than 38 scutes along the body and no scutes behind the dorsal fin. Green sturgeon also have a relatively long snout with barbels closer to the mouth than to the tip of the snout compared to white sturgeon.

Status of the Population

The decline in white sturgeon landings in the commercial fishery that took place in the late 1800s and early 1900s shows the species' vulnerability to overexploitation. The length of time required to reach sexual maturity compared to other freshwater and anadromous species and infrequent spawning by females contribute to this vulnerability. Department tagging studies found that angler harvest rates were high during the 1980s. The relatively high catches in the 1980s renewed concern over possible depletion of the resource and led to angling regulation changes starting in 1990 with the creation of the slot size limit.

White sturgeon abundance in the Sacramento-San Joaquin watershed has varied greatly over time. Angler catch and mark-recapture study information suggest that strong year classes since 1980 have been produced only during 5 of the 10 years when the Sacramento Valley Water Year Index was rated 'wet'. Abundance estimates of white sturgeon in the Sacramento River–San Joaquin River Estuary estimated that approximately 142,000 adults greater than 40 inches (102 centimeters) TL were present in 1997. Spawning biomass has at times been very low due in part to the interaction of harvest and successive years of poor recruitment. Research and monitoring is focused on learning more about the factors affecting year class strength, improving the precision of abundance estimates, understanding out-of-system migrations, and developing the potential to limit harvest through use of a quota.

Management Considerations

NMFS listed the green sturgeon's Southern DPS, which includes the spawning population in the Sacramento River, as Threatened under the ESA on April 7, 2006. The Department considers the green sturgeon a Species of Special Concern. The Northern DPS, which includes all spawning populations north of the Sacramento River, is considered a federal Species of Concern.

The Southern DPS is considered likely to become endangered in the foreseeable future. The determination to list the Southern DPS as federal Threatened was based on a number of risk factors including: information showing that the majority of spawning

adults are concentrated into one spawning river, the Sacramento, which increases the risk of extinction due to catastrophic events; and information showing evidence of lost spawning habitat in the Sacramento River above Shasta Dam and in the Feather River above Oroville Dam. Unlike white sturgeon, green sturgeon are present in the upper Sacramento River below Shasta Dam year round and angler bycatch of green sturgeon on spawning grounds may be a cause for concern. Insufficient freshwater flow rates in spawning areas, contaminants, elevated water temperatures and entrainment of individuals into water diversion projects are additional risk sources.

The Northern DPS includes populations in the Rogue, Klamath-Trinity and Eel rivers. The Northern DPS is not considered to be in danger of extinction or likely to become an endangered species in the foreseeable future. The two main spawning populations, in the Rogue and Klamath-Trinity rivers, occupy separate basins, reducing the potential for loss of the DPS through catastrophic events. While harvest has been reduced and green sturgeon in this DPS do not face substantial entrainment loss, there are significant concerns due to lack of information, water flow and temperature issues, and habitat degradation.

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Further Reading

Adams PB, Grimes CB, Hightower JE, Lindley ST and Moser ML. 2002. Status Review for the North American green sturgeon. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA. 49 p. Available from: NMFS-SWFSC, Santa Cruz, CA.

Adams PB, Grimes CB, Hightower JE, Lindley ST, Moser ML and Parsley MJ. 2007. Population status of North American green sturgeon, *Acipenser medirostris*. Environ. Biol. Fishes. 79(3-4): 339-356.

Beamesderfer B, Simpson M, Kopp G, Inman J, Fuller A and Demko D (SP Cramer and Associates, Inc). 2004. Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin rivers and tributaries. California: State Water Contractors. 46 p. Available from:
http://www.fishsciences.net/reports/2004/Green_Sturgeon_Report_draft_081004revb.pdf

Beamesderfer B, Simpson M, Kopp G and Demko D (SP Cramer and Associates, Inc.). 2006. Distribution, life history, and population characteristics of green sturgeon *Acipenser medirostris* in California's Central Valley Report California: State Water Contractors. 42 p. Available from: State Water Contractors, Sacramento, CA.

Chapman FA, Van Eenennaam JP and Doroshov SI. 1996. The reproductive condition of white sturgeon, *Acipenser transmontanus*, in San Francisco Bay, Calif. Fish. Bull. 94:628-634.

Donnellan M and Gingras M. 2007. 2006 Field season summary for adult sturgeon population study. California Department of Fish and Game. 14 p. Available from: California Department of Fish and Game, Bay Delta Region, Stockton, CA.

Gleason E, Gingras M and DuBois J. 2008. Sturgeon Fishing Report Card: Preliminary Data Report. California Department of Fish and Game. 13 p. Available from: California Department of Fish and Game, Bay Delta Region, Stockton, CA.

Kohlhorst DW, Miller LW and Orsi JJ. 1980. Age and growth of white sturgeon collected in the Sacramento-San Joaquin Estuary, California: 1965-1970 and 1973-1976. Calif. Fish Game 66:83-95.

McKechnie RJ and Fenner RB. 1971. Food habits of white sturgeon, *Acipenser transmontanus*, in San Pablo and Suisun Bays, California. Calif. Fish Game 57:209-212.

Moyle PB. 2002. Inland fishes of California revised and expanded. Berkeley: University of California Press. 502 p.

Moyle PB, Foley PJ and Yoshiyama RM. 1992. Status of green sturgeon, *Acipenser medirostris*, in California. Final Report submitted to National Marine Fisheries Service. University of California, Davis, CA. 11 p.

Nakamoto R J, Kisanuki TT and Goldsmith GH. 1995. Age and growth of Klamath green sturgeon (*Acipenser medirostris*). U.S. Fish and Wildlife Service, Klamath River Fishery Resource Office, Project 93-FP-13, Yreka, CA. 27 p. Available from: Department of Fish and Game, Marine Region, Eureka, CA.

Naslund, B. [Internet] Operation Colusa Clan Nets Seven Suspected Sturgeon Poachers. California Department of Fish and Game. [April 10, 2009; cited April 29, 2009] Available from: www.dfg.ca.gov/news/news09/2009041001.asp.

NMFS 2005. Green sturgeon (*Acipenser medirostris*) status review update. Biological Review Team, Southwest Fisheries Science Center, Santa Cruz, CA. 35 p. Available from: NMFS-SWFSC, Santa Cruz, CA.

Schaffter RG. 1997. White sturgeon spawning migrations and location of spawning habitat in the Sacramento River, California. Calif. Fish Game 83:1-20.

Schaffter RG and Kohlhorst DW. 1999. Status of white sturgeon in the Sacramento-San Joaquin Estuary. Calif. Fish Game 85:37-41.

Schreier B and Donnellan M. 2007. 2007 Field season summary for the adult sturgeon population study. California Department of Fish and Game, 11 p. Available from: California Department of Fish and Game, Bay Delta Region, Stockton, CA.

Van Eenennaam JP, Linares J, Doroshov SI, Hillemeier DC, Willson TE and Nova AA. 2006. Reproductive conditions of the Klamath River green sturgeon. Trans. Am. Fish. Soc. 135:151-163.

Welch DW, Turo S and Batten SD. 2006. Large-scale marine and freshwater movements of white sturgeon. Trans. Am. Fish. Soc. 135:386-389.

Sturgeon recreational commercial passenger fishing vessel (CPFV) catch (all species combined), 1980-2008.			
Year	Number of fish	Year	Number of fish
1980	361	1995	300
1981	295	1996	349
1982	614	1997	466
1983	750	1998	688
1984	530	1999	354
1985	812	2000	339
1986	952	2001	212
1987	418	2002	207
1988	386	2003	436
1989	438	2004	191
1990	302	2005	130
1991	283	2006	301
1992	90	2007	147
1993	156	2008	147
1994	155		

Data source: CPFV logbook data.