WPRFMC Reports: *Important Pelagic Fishes of the Pacific*

Introduction

The most important fish (economically, culturally and socially) in the Pacific are oceanic and pelagic, meaning they live in the near-surface waters of the ocean, often far from shore. Tuna, billfish and other large pelagic species are among the world's most popular fish sought for food and sport. These fish are noteworthy for their rapid growth and, for the tunas, high rates of reproduction, as well as their remarkable swimming speed and stamina. Unlike nearshore pelagic species or bottom-dwelling fish that spend most of their lives near islands, pelagic fish move freely in the oceanic environment. Variations in the distribution and abundance of these nomadic species are often related to differences between their life history profiles, migration patterns and habits that are affected by ever-changing environmental influences, such as water temperatures, current patterns and the availability of food.

Geographic Range

Species of oceanic pelagic fish live in tropical and temperate waters throughout the world's oceans, including the Pacific. They are capable of long migrations that reflect complex relationships to oceanic environmental conditions. These relationships are different for larval, juvenile and adult stages of life. The larvae and juveniles of most species are more abundant in tropical waters, whereas the adults are more widely distributed. Geographic distribution varies with seasonal changes in ocean temperature. In both the northern and southern hemispheres, there is seasonal movement of tunas and related species toward the pole in the warmer seasons and a return toward the equator in the colder seasons. In the western Pacific, adults of pelagic fish range from as far north as Japan and as far south as New Zealand. Albacore, striped marlin and swordfish can be found in even cooler waters -- at latitudes as far north as 50° N and as far south as 50° S. As a result, fishing for these species is conducted year-round in tropical waters and seasonally in temperate waters.

Movement and Stock Structure

Migration patterns of pelagic fish stocks in the Pacific Ocean are not easily understood or categorized, despite extensive tag and release projects for many of the species. This is particularly evident for the more tropical tuna species (yellowfin, skipjack, bigeye) which appear to roam extensively within a broad expanse of the Pacific centered on the Equator. In other words, their migrations appear to be mainly restricted by water temperature and continental land masses and are often linked to large scale water movements that physically transport fish from one area to another within a favorable temperature range. Although tagging and genetic studies have shown that some interchange does occur, it appears that short life spans and rapid growth rates restrict large-scale interchange and genetic mixing of eastern, central and farwestern Pacific stocks of yellowfin and skipjack tunas. Morphometric studies of yellowfin tuna also support the hypothesis that yellowfin tuna from the eastern and western Pacific derive from relatively distinct sub-stocks in the Pacific. The stock structure of bigeye in the Pacific is poorly understood, but a single, Pacific-wide population is assumed. The movement of the cooler-water tunas (blue fin, albacore) is more predictable and defined, with tagging studies documenting regular and well-defined seasonal movement patterns relating to specific feeding and spawning grounds. The oceanic migrations of billfish are poorly understood, but the results of limited tagging work conclude that most billfish species are capable of trans-oceanic movement, and some seasonal regularity has been noted.

Physiology

Tunas and billfish have many physiological adaptations for life in the open ocean. Tunas and tuna-like species are the fastest fish in the world. Bursts of speed exceeding 12-20 kph (20-30 mph) are not unusual. Tunas have streamlined bodies that are specifically adapted for efficient swimming. They have large white muscle masses useful for swimming long distances, and red muscle masses for short bursts of speed when chasing prey or escaping predators. Tunas also have circulatory heat exchangers that can raise or lower their body temperatures in response to heating up resulting from vigorous feeding or swimming activity or cooling down when entering sub-surface waters. Unlike most fishes, the circulatory system of tuna can maintain their body temperatures above that of the water in which they live, effectively making them a "warm blooded" animal. This adaptation may allow tunas to utilize their energy reserves quickly, which can translate to a rapid burst of speed, and increased efficiency of the brain and eyes which are necessary for hunting prey in cold, deep water.

The tuna's circulatory and respiratory systems are unique in the fish world. Fish are cold-blooded and, for most, the temperature difference between shallow and deep layers of the ocean is a physical barrier to vertical migrations. Tunas, however, have evolved the necessary physiological adaptations to accomplish this activity. The ability to make vertical migrations between cold, deep ocean waters and warm, surface waters increases the tuna's available habitat for feeding and ability to maintain a relatively constant body temperature. Some tunas move into deeper water to dissipate excess heat produced by feeding in warmer surface waters. Other tunas exhibit the reverse behavior. The tuna's circulatory system is also designed to conserve heat when the fish is relatively inactive, and to dissipate heat when activity increases.

Billfish have a large white muscle mass, but a smaller mass of red muscle than tunas. Thus, billfishes must rely on different defenses against the deleterious effects of changes in water temperature. For example, swordfish have heater organs that warm the brain and eyes to help to protect the central nervous system from rapid temperature changes. The bill of a billfish may also be a special adaptation to reduce drag and increase speed, as well as a weapon for killing prey and for defense.

To orient and guide themselves on their extensive migrations across the open ocean, tuna and billfish are thought to rely somehow on small particles of magnetite, a magnetic material found near nerve endings in the skulls of these fish. Combined with other environmental cues, the fish may use magnetite to navigate using a 'biological compass" attuned to the earth's magnetic field.

Spawning and early life history

Most oceanic pelagic fish spawn over vast areas of the Pacific in warm surface waters. Spawning generally occurs throughout the year in the tropics, and more seasonally at higher latitudes when sea surface temperatures are over 24° C (75° F). Individual females may spawn many times during the season at short intervals. All tunas and tuna-like species have high reproductive rates, producing millions of eggs per year to compensate for the large percentage of eggs that do not survive to adults. The tiny eggs (about 1 mm diameter) float with the help of an enclosed oil droplet. Billfish eggs are somewhat larger than those of tuna. A spawning female tuna or billfish may release about 100,000 eggs per kilogram of her body weight.

Growth and maturation

Although these pelagic fish begin life at only a few millimeters in length, they can reach large sizes. All species grow rapidly during the early years of life with a gradual slowing of growth thereafter. A young tuna may add 2-4 cm (0.8-1.6 in) per month to its body length during the first two years of life, and 0.5-2 cm (0.2-0.8 in) per month thereafter. Growth rates vary considerably depending on ocean conditions and food availability. The rates at which pelagic fish grow to their final size, and their ages at various sizes, vary greatly among species, and to a large degree determine the level of fishing pressure they can withstand. For instance, skipjack tuna that grow and mature quickly can be safely harvested at very high levels, whale slower growing blue fin tuna are easily overfished. The relationship between age and size in billfish is not as well understood.

As subadults, male and female pelagic fish grow at approximately the same rate. After reaching sexual maturity, however, the growth rate of female tuna slows, apparently in response to their higher energy requirements for egg maturation and spawning compared to the males. In contrast, female marlin and swordfish grow faster than males after maturation and female marlin reach much larger sizes than the males. Dolphinfish males tend to be heavier than females of the same length after 68 cm (27 in) due to differences in body morphology, i.e., the large head of male dolphin fish. Species such as skipjack tuna and dolphinfish have short lives (4-5 years) and reach sexual maturity in their first year of life. Some billfish and larger tunas may live 10-20 years, and do not reproduce until they are 3 to 5 years old. Swordfish may first reproduce at 5 or 6 years old.

Diet

The energy demands of swimming are great, and tunas and other pelagic fish have voracious appetites. Some species consume as much as 25% of their own body weight every day. Most oceanic pelagic fish are opportunistic carnivores with variable diets. The major prey items can vary substantially during different stages of life, in different regions of the Pacific, and in different seasons. Adults feed on a variety of small fish, shrimp and squid, while juveniles are more opportunistic, feeding on pelagic invertebrates such as crab larvae, isopods and copepods. Some species have very specific and well-known predator-prey relationships, such as dolphinfish preying on flying fish, swordfish on squid, and blue marlin on skipjack tuna. Larval and juvenile tuna are, in turn, prey for fish, seabirds, porpoises and other animals. Adult tunas are often cannibalistic, feeding on the young of their own species. The presence of tuna larvae in tuna stomach samples is common enough that this occurrence has been used to identify areas of recent tuna spawning activity. Only humans, marine mammals and sharks are known to prey on adult tuna and billfish.

Distribution

Large pelagic fish are closely associated with their physical and chemical environment. At the latitudes of the US Pacific islands, tuna and billfish are generally caught by fishermen during predictable seasons. Their actual abundance in any particular year, however, is difficult or impossible to predict and is subject to countless factors in the oceanic environment. This variability is probably related to annual fluctuations in standing stock size and oceanographic characteristics. Tunas tend to be most concentrated where food is abundant, commonly near islands and seamounts that create divergences, convergences and upwelling zones, along ocean current boundaries, and along gradients in temperature, oxygen and salinity. Swordfish tend to concentrate along food-rich temperature fronts between cold, upwelled water and warmer oceanic water masses.

Gradients in temperature, oxygen or salinity determine whether or not the surrounding water mass is suitable for pelagic fish. Fishermen sometimes use satellite images to help locate these thermal fronts. Oceanic pelagic fish such as skipjack and yellowfin tunas and blue marlin prefer warm surface layers, where the water is well mixed by waves and is relatively uniform in temperature. Other fish such as albacore, bigeye tuna, striped marlin and swordfish, prefer cooler, more temperate waters, often meaning higher latitudes or greater depths.

Preferred water temperature often varies with the size of the fish. Adult pelagic fish usually have a wide temperature tolerance, and during spawning they generally move to warmer waters that are preferred by larval and juvenile stages.

Large-scale oceanographic events (such as the El Nino - Southern Oscillation) change the characteristics of water temperature and productivity across the Pacific, and these events have a significant effect on the habitat range and movements of pelagic species.

Depth Range

Tuna movements are related to oceanographic characteristics, particularly water temperature and oxygen concentration. In the ocean, light penetration and water temperature diminish rapidly with increasing depth and, once below the thermocline, the water temperature is only a few degrees above freezing. Many pelagic fish make vertical migrations through the water column. They tend to inhabit surface waters at night and deeper waters during the day, but several species make extensive vertical migrations between surface and deeper waters throughout the day. Certain species, such as swordfish and bigeye tuna, are more vulnerable to fishing when they are concentrated near the surface at night. Bigeye tuna may visit the surface during the night, but generally, longline catches of this fish are highest when hooks are set in deeper, cooler waters just above the thermocline (275-550 m or 150-300 fro). Surface concentrations of juvenile albacore are largely concentrated where the warm mixed layer of the ocean is shallow (above 90 m or 50 fm), but adults are caught mostly in deeper water (90-275 m or 50-150 fm). Swordfish are usually caught near the ocean surface, but are known to venture into deeper waters.

Associations

Tunas, billfish, dolphinfish and wahoo are caught collectively by a variety of fishing gear types. Direct interactions among these species are not known, although they compete at the top of the food chain for the same prey. Most of the oceanic pelagic fish form schools (wahoo less commonly so). Schools are most compact when the fish are spawning or attracted to a common food source near features such as seamounts, flotsam or man-made fish aggregation buoys. Marlins are often seen in pairs or in groups of several males with a single female. Tuna schools that are associated with dolphins are common in the eastern tropical Pacific, but are rare in the western and central Pacific. The distribution of surface skipjack and juvenile yellowfin tuna schools (as well as dolphinfish and wahoo) are frequently associated with logs and other flotsam, and fish aggregation buoys. Fishermen also search for flocks of seabirds which help to reveal tuna schools feeding on bait fish at the surface. Although skipjack, small yellowfin and small bigeye tunas are sometimes caught together, they maintain discrete schools and their co-occurrence around flotsam is probably the result of mutual attraction to food. In the western Pacific, in addition to floating objects, yellowfin and skipjack tunas are sometimes associated with the presence of whales and whale sharks.

Current Status of Stocks

For most species of tuna and billfish it is reasonable to assume a single, ocean-wide stock in the Pacific where a mingling of fish takes place gradually through the fishes' whole lifespan. The exchange of fish among areas is difficult to determine because these fish move seasonally between feeding and spawning areas, toward the poles and back. Sub-stocks may exist, with some studies supporting the idea of stock discrimination between the eastern and western Pacific. Results from genetic and tagging studies, however, indicate that some degree of mixing does occur. For albacore and striped marlin, there is evidence of distinct North and South Pacific sub-stocks.

Yellowfin Tuna -- Semi-independent stocks may exist in the western and central Pacific, which are considered relatively distinct from eastern Pacific yellowfin, but the maximum sustainable yield (MSY) of these stocks is still not well known despite considerable scientific research. Estimates based on surface fisheries (purse seine) and sub-surface fisheries (longline) provide different perspectives. The western and central Pacific regional catch has reached 3 7 5,000 metric tens (mt) per year (of which, less than 1% comes from domestic landings in the US Pacific islands region). It appears that western Pacific yellow fin stocks are not yet fully utilized, but fishing effort and catch are expected to steadily increase in coming years.

Bigeye Tuna -- A single ocean-wide stock of bigeye tuna is assumed. The Pacific-wide catch has reached' 152,000 mt per year (of which, about 1% comes from domestic landings in the US Pacific islands region). This is close to the estimated MSY, and the stock is considered fully utilized. Because juvenile bigeye are known to associate strongly with flotsam, increasing purse seine catches around flotsam and fish aggregating buoys raises concern about potential overfishing.

Skipjack Tuna -- Tagging results indicate considerable movement of skipjack in the Pacific. Even so, complete mixing of the population does not occur across the whole region within one generation of fish. Contradictory results of genetic studies suggest uncertainty about stock structure. The total annual catch from the central and western Pacific is approaching 800,000 mt (of which, less than 1% is produced by domestic fisheries of the US Pacific islands). Although the current level of catch and fishing effort is at a record high, fishing mortality accounts for only a small fraction of stock attrition because of the skipjack's high rates of reproduction, growth and mortality. Thus, while MSY has yet to be determined, the stock appears to be under-utilized and is expected to easily sustain expanded fishing pressure by expanding fisheries.

Albacore -- Discrete spawning areas and larval distributions are apparent for North and South Pacific albacore stocks. Low catches of adults in equatorial waters suggest that the exchange of fish is limited between hemispheres. Domestic fisheries from the US Pacific islands produce less than 1% of the 59,000 mt annual Pacific-wide catch. MSY estimates for albacore in the North and South Pacific appeared to give reasonable stock assessments before the development of the high seas drift gillnet fishery. With the rapid development and cessation of the driftnet fishery, however, there are now uncertainties about the reliability of those earlier stock assessments. Adult fish in the South Pacific stock are considered fully or over-exploited. Expansion of surface fisheries targeting juvenile fish could have a detrimental impact on the abundance of adult albacore in the South Pacific. In the North Pacific, some assessments conclude that the stock is over-exploited, but other research concludes that the adult stock remains stable.

Striped Marlin -- Separate North and South Pacific sub-stocks are hypothesized on the basis of a north- south separation of spawning grounds, except in the equatorial eastern and western Pacific. These fish spawn in the western Pacific, are recruited into the Mexican fishery of the eastern Pacific, and move westward as they mature. In the North Pacific, semi-independent sub-populations are thought to blend over time. Domestic fisheries from the US Pacific islands contribute about 4% of the annual regional catch of l0,000 mt. MSY is unknown, but the stock is considered under-utilized because there has been no decline in yield under increased levels of fishing pressure.

Blue Marlin -- Pacific blue marlin are thought to belong to a single, ocean-wide stock due to an observed homogeneous distribution of larval and adult fish. The current stock status is unclear. The total annual Pacific catch in recent years is estimated to be around 20,000 mt (domestic landings from the US Pacific islands comprise less than 5% of the total). A recent MSY estimate of 20,000 mt/yr was 2,000 mt/yr less than previous estimates. During the 1970s the stock may have been over-utilized, but as longline fleets have changed fishing methods to target deeper-swimming bigeye tuna, the incidental catch of blue marlin has decreased. There may have been some recovery of the stock, evidenced by an increase in the average weight of blue marlin taken by the Japanese longline fishery since 1975.

Swordfish -- The stock structure of swordfish in the western, central and South Pacific is unclear. Domestic landings from the US Pacific islands (mainly the Hawaii longline fishery) produce more than 20% of the 18,000 mt of swordfish caught in the northwest and eastern central Pacific, and about 15% of the Pacificwide catch. The distribution of catches indicates the possibility of, at least, North and South Pacific stocks. Changes in the longline fisheries have cast doubt on the way previous MSY estimates were calculated, and current catch levels have exceeded the two previous Pacific MSY estimates. To date, however, no indication of decreasing swordfish size has been found in the Hawaii fishery, and stocks do not appear to have been exploited on a Pacific-wide basis to the extent that would cause a declining trend in catch rates.

Dolphinfish and Wahoo -- North and South Pacific stocks of dolphinfish are apparently separate. Little is known of the stock structure of wahoo. No estimates of maximum sustainable yield are available for either species. The risk of overfishing dolphin fish is probably slight due to the apparent high natural turnover (with a maximum life span of four years). Too little is known about wahoo to allow an assessment of maximum sustainable yield.

Pacific pelagic fisheries are dynamic, and the information in this document is subject to change.

Estimated Size of Some Pelagic Fish Species at Various Ages

Age	**Albacore**	**Bigeye Tuna**	**Central Pacific Yellowfin Tuna**	**Central Pacific Skipjack Tuna**	**Dolphinfish**
1 yr	**35 cm (14 in)**	**n/a**	**50-64 cm (20-25 in)**	**44-50 cm (17-20 in)**	**85 cm (33 in)**
	<1.1 kg (2.5 lb)		**2.4 kg (5.5 lb)**	**2 kg (4.5 lb)**	**4.5 kg (10 lb)**
2 yr	**52 cm (20 in)**	**90 cm (35 in)**	**92-105 cm (36-41 in)**	**68 cm (27 in)**	**100 cm (39 in)**
	2.9kg (6.51b)		**14kg (31 lb)**	**5kg (11 lb)**	**9kg (20lb)**
3 yr	**65 cm (26 in)**	**120-130 cm (47-51 in)**	**119-135 cm (47-53 in)**	**83 cm (33 in)**	
	5.7 kg		**25 kg (55 lb)**		

	(12.5 lb)				
4 yr	**76 cm (30 in)**	**140-145 cm (55-57 in)**	**139-156 cm (55-61 in)**	**91 cm (36 in)**	
	9 kg (20 lb)		**40-43 kg (88-94 lb)**		
5 yr	**93 cm (37 in)**	**150 cm (59 in)**	**154-169 cm (61-67 in)**		
	16.4 kg (36 lb)		**61-67 kg (134-148 lb)**		

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Major Species and Distinguishing Characteristics	
Pelagic fish landings in the main US Pacific island areas (American Samoa, Guam, Hawaii, Northern Mariana Islands) are comprised mostly of four tuna species (yellowfin, bigeye, albacore, skipjack) three billfish species (blue marlin, striped marlin and swordfish) and two other species (dolphinfish and wahoo). Black marlin, sailfish, short-billed spearfish and bluefin tuna also contribute to the pelagic landings.	
Yellowfin tuna, *Thunnus albacares* Hawaiian or Hawaii local: *`Ahi, Shibi* Samoan or American Samoa local: *Asiasi, To'ou* Chamoru or Guam local: Yellowfin tuna Carolinian or Northern Marianas local: *Toghu, Toghu hangar* Features: Elongated body, small head and eyes; long second dorsal and anal fins in some mature fish; blue-black skin Market or maximum size: 2-115 kg (5-250 lb)	

Bigeye tuna, *Thunnus obesus* Hawaiian or Hawaii local: *Ahi, 'Ahi po'onui, Mebachi* Samoan or American Samoa local: *Asiasi, To'ou* Chamoru or Guam local: Bigeye tuna Carolinian or Northern Marianas local: *Toghu, Sangir* Features: Plump body, large head and eyes; longer pectoral fin compared to yellowfin; short second dorsal and anal fins; blue-black skin Market or maximum size: 2-115 kg (5-250 lb)	
Albacore, *Thunnus alalunga* Hawaiian or Hawaii local: *'Ahi palaha, Tombo* Samoan or American Samoa local: *Apakoa* Chamoru or Guam local: Albacore Carolinian or Northern Marianas local: *Angaraap, Hangaraap* Features: Slender body; blue-black skin; long, curved pectoral fins Market or maximum size: 2-36 kg (5-80 lb)	

Skipjack tuna, *Katsuwonus pelamis* Hawaiian or Hawaii local: Aku Samoan or American Samoa local: *Atu, Faolua, Ga'oga* Chamoru or Guam local: *Bunita* Carolinian or Northern Marianas local: *Arangaap, Hangaraap* Features: Smaller than tunas listed above; metallic blue-black back with silvery sides and prominent longitudinal stripes on belly Market or maximum size: 1.3-13 kg (3-25 lb)	
Indo-Pacific blue marlin, *Makaira mazara* Hawaiian or Hawaii local: *A'u, Kajiki* Samoan or American Samoa local: *Sa'ula* Chamoru or Guam local: *Batto'* Carolinian or Northern Marianas local: *Taghalaar* Features: Large, robust body and rough blue-grey skin; dorsal fin short in proportion to body depth; bill rounded in cross-section Market or maximum size: 18-135+ kg (40-300+ lb)	

Striped marlin, *Tetrapterus audax* Hawaiian or Hawaii local: *A'u, Nairagi* Features: Body narrower than blue marlin; high pointed dorsal fin, generally as long as or longer than body depth; vertical stripes on blue-black skin; bill rounded in cross-section Market or maximum size: 5-68 kg (10-150 lb)	
Swordfish, *Xiphias gladius* Hawaiian or Hawaii local: Broadbill, *Shutome* Samoan or American Samoa local: *Sa'ula malie* Chamoru or Guam local: Swordfish Carolinian or Northern Marianas local: *Taghalaar* Features: Large, tapered body; large eyes; grooved, silvery-grey skin; single large caudal keel in front of tail; absence of pelvic fins; long, bill flattened in cross-section Market or maximum size: 5-225+ kg (10-500+ lb)	

Dolphinfish, *Coryphaena hippurus* Hawaiian or Hawaii local: *Mahimahi* Samoan or American Samoa local: *Masimasi* Chamoru or Guam local: *Botague* Carolinian or Northern Marianas local: *Sopor, Habwur* Features: Slender, tapered body; greenish-yellow skin; dorsal fin is a high sail extending length of body; prominent bony crest on front of head of mature males Market or maximum size: 2-20 kg (5-50 lb)	
Wahoo, *Acanthocybium solandri* Hawaiian or Hawaii local: *Ono* Samoan or American Samoa local: *Paala* Chamoru or Guam local: *Toson* Carolinian or Northern Marianas local: *Ngaal* Features: Long, slender rounded body; sharp-pointed head with sharp teeth; blue-silver skin Market or maximum size: 5-20 kg (10-50 lb)	