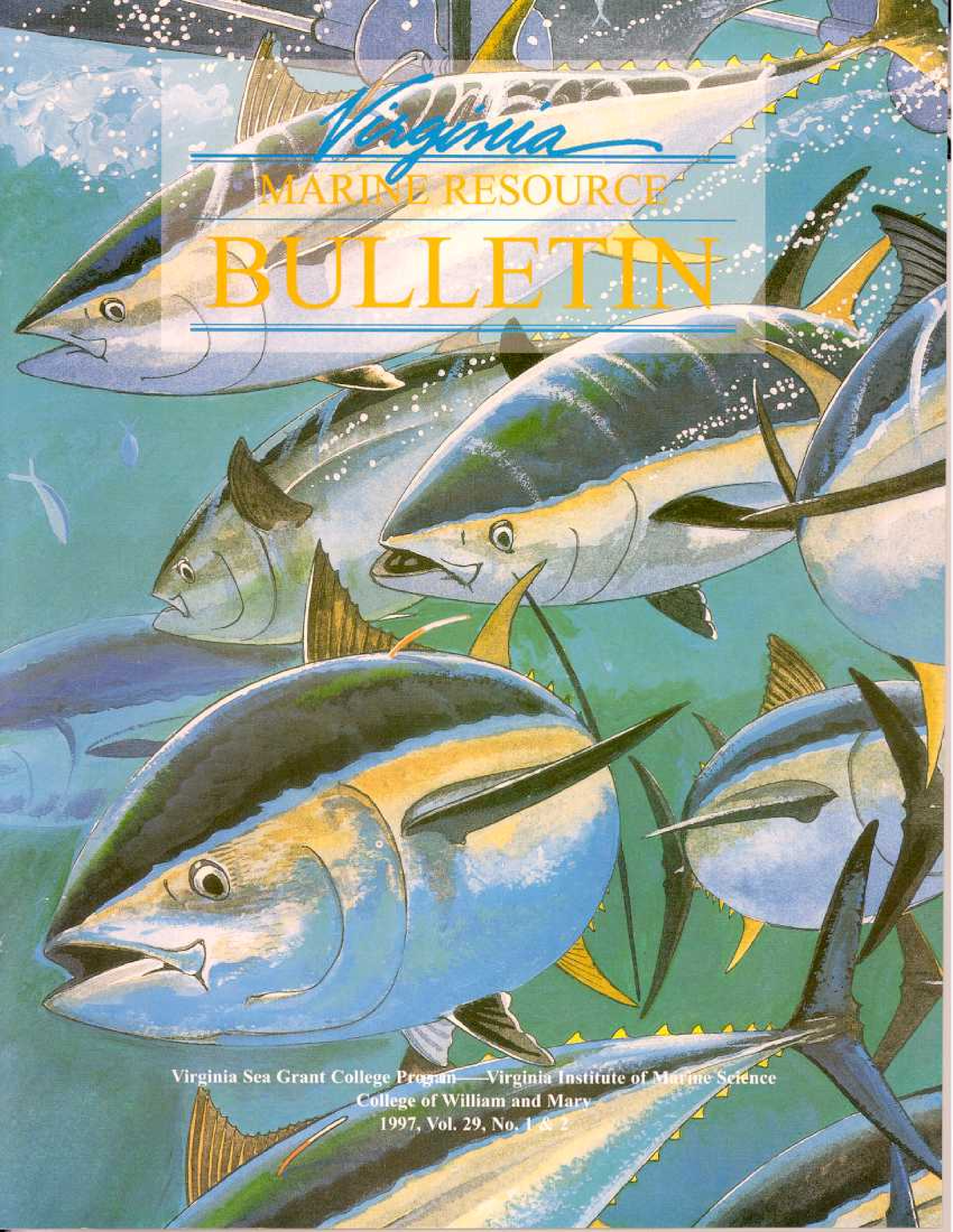
Virginia MARINE RESOURCE BULLETIN



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Contents

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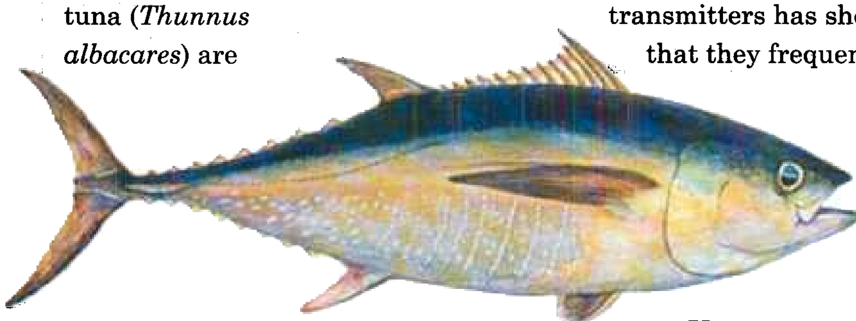
TUNAS

by
Peter G. Bushnell and Kim N. Holland

Tunas are the master swimmers of the oceans. They swim constantly, never stopping to rest on the bottom or to bask at the ocean's surface. In some species, such as the skipjack tuna (*Katsuwonus pelamis*), their movements around the oceans seem to be dictated solely by the availability of their food. With others, such as the giant bluefin tuna (*Thunnus thynnus*) of the Atlantic and Pacific oceans, their movements seem to be influenced both by the distribution of prey and the need to return to their tropical ancestral spawning grounds in time for the breeding season.

Evidence from seasonal abundances and recapture of tagged Atlantic bluefin tuna suggests that in midsummer these animals leave their spawning grounds in the Gulf of Mexico and travel north along the U.S. east coast, following the Gulf Stream to the shores of Massachusetts and Nova Scotia. There they feed on the seasonal blooms of pollock, herring, and mackerel. As summer ends, they may travel completely across the Atlantic to the shores of Europe and North Africa before returning to the Gulf of Mexico to participate in the next year's breeding season. In the Pacific, bluefin tuna that spawn near Japan have been captured thousands of miles away, off the equatorial coast of Central America.

To humans, the pelagic environment seems devoid of signposts or maps. Nevertheless, even on a daily basis, tuna move large distances and display an uncanny ability to navigate skillfully in the open ocean. For instance, in the Pacific, yellowfin tuna (*Thunnus albacares*) are frequently found patrolling their daytime haunts along the island edges where the coral reefs drop precipitously to the depths of the ocean floor. At night, however, these tuna make long excursions offshore, only to return the next morning to the same precise area they left the previous day. These nightly forays often cover up to 15 kilometers (9 miles). In human terms that represents, for a person two meters tall, a nighttime walk of 60 kilometers (37 miles)! Yellowfin tuna do it every night, possibly to feed on organisms such as squid that swim up from the much deeper levels they occupy in the daytime.



Yellowfin Tuna
Thunnus albacares

Drawn to Floating Objects

A related phenomenon is the tendency of tunas and other pelagic fish to aggregate around floating objects such as logs or manmade debris or buoys. When evening comes, pelagic tunas move away from these objects just as coastal tunas move away from the reef at night. Tracking tunas with attached radio transmitters has shown that they frequently return to the exact same log or buoy the next day.

The benefits of aggregating around floating objects, the function of these nighttime excursions, and the methods tunas use to make such precise movements around the trackless, deep oceans are still largely mysterious. The floating log or buoy may provide these oceanic nomads with a navigational reference point in their vast, three-dimensional realm. These reference points may somehow assist them in their daily wanderings and help them conserve their precious supplies of energy. Making use of these habits, entire fishing industries in many parts of the Pacific are dependent on finding logs around which to set huge seine nets to capture fish milling around underneath.

The world of the tunas is truly three dimensional because, unlike terrestrial animals which are bound by gravity to the two-dimensional surface of the land, tunas are free to travel up and down in the ocean, as well as from side to side. Again, these fish display remarkable swimming abilities in their vertical movements. A small bigeye tuna (*Thunnus obesus*), equipped with a transmitter to relay its movements to scientists, was observed to dive over 250 meters (274 yards) in less than one minute. This is a spectacular behavior which, in addition to the superb locomotor ability it demonstrates, also reveals the tremendous temperature and pressure changes that tunas can withstand.

Built for Speed

These feats of long-distance and incessant swimming, and the ability to orient in the vastness of the ocean, are reflected in the anatomy and physiology of these highly specialized fish. Many of the anatomical adaptations found in tunas serve to reduce drag during high-speed swimming. In terms of energy costs, high-speed swimming is expensive. It takes a 100-fold increase in energy expenditure to produce an eight-fold increase in swimming velocity. This is true even though fish such as tunas are specifically evolved for sustained high-speed swimming.

One structure that has evolved to reduce drag is the caudal peduncle keel located on each side of the anterior base of the caudal fin. These keels tend to reduce the turbulence at the tips of the tail fin and lower the drag created by that part of the body. Also, behind the dorsal and anal fins, there is a series of one to 11 nondepressible sail-like finlets. These are thought to act as movable slots that eliminate vortices of water that spin off the trunk and tail, thus allowing the caudal fin to work more efficiently in undisturbed water. The spinous, first dorsal fin folds down into a groove, making it flush with the body surface; this reduces drag when the fish is not maneuvering but swimming in a straight line. All these adaptations allow the tuna to move at extremely high velocities (up to 45 kilometers per hour/28 mph) and for long periods of time.

Clearly, some physiological modifications are required to support the tuna's active, nomadic, and energetically expensive life style. Tunas are similar to trained athletes in that they are capable of taking in very large amounts of oxygen and burning them metabolically. In these fishes, the active oxygen-consumption rate is on the same scale as that of mammals and is the highest recorded in any fish group. In order to consume oxygen at such a tremendous rate, fish must first extract it from the water and then move it to the tissues, where it can be used to burn the metabolic fuels that power the muscles. At each stage of this process, tunas have evolved to make these systems work as effectively as possible.

Swim or Suffocate

The first step in providing oxygen to the respiratory system is to provide water to the organ that extracts oxygen—the gill. Most fish accomplish this by contracting jaw and opercular muscles in a coordinated and rhythmic fashion, enabling them to pump water over their gills. When more oxygen is needed, the pumps are sped up.

Small Bigeye Tuna
Thunnus obesus

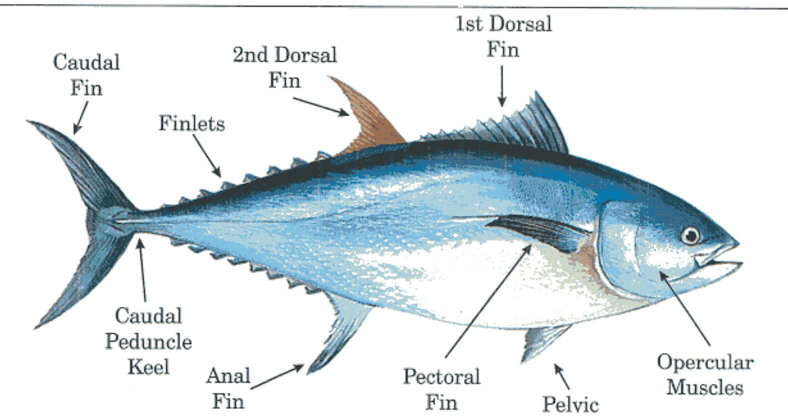
Tunas, as well as billfishes and some species of sharks, use a different system to move water over their gills; they ram ventilate. These fish swim through the water with their mouth open, using their forward motion to drive water over the gills. Tunas are obligate ram ventilators, meaning they have lost the ability to simply pump sufficient water over their gills to meet oxygen demand. The consequence of this adaptation is enormous—tunas cannot stop swimming, or they will suffocate! In fact, they must swim at a speed of at least 65 centimeters (26 inches) per second in order to provide sufficient water flow.

What are the advantages? The first is efficiency. Ram ventilation transfers the work of breathing from the head musculature to the swimming muscles, which are mechanically more efficient. Second, hydrodynamic drag is reduced because the fish's swimming is not disturbed by the water flow that results from the opening and closing of gill covers (opercals) during pumping. Third, ventilation volume can be increased to some extent, quite cheaply, by opening the mouth wider. As a result, ram ventilators spend only one to three percent of their total energy expenditure obtaining water for respiration. This contrasts to estimates of up to 15 percent for non-ram-ventilating fish such as goldfish or trout.

The ability to provide large amounts of water to the gill at a low price is a great advantage, but it is not too useful if the gill cannot use the water effectively. To this end, tunas have evolved gills that are up to 30 times larger in surface area than those of other fish. The increased surface area allows tunas to extract a high percentage of oxygen (approximately 50 percent) from the water stream flowing over their gills, as compared to the usual 10 to 30 percent extraction rate of other fish.

Not surprisingly, the circulatory system is also modified to take large amounts of oxygen from the gills and move it to the other tissues. Compared to other less-active fish, tunas have hearts that are ten times larger on a heart-weight/body-weight scale, pump blood at a rate three times higher, and have blood pressure three times higher. The blood has a hematocrit (percent packed red blood cell volume) of 40 percent, an extremely high figure usually associated with diving mammals such as seals and porpoises. A very powerful heart, pumping a higher-than-average blood volume and containing a large number of oxygen-carrying red blood cells, adds up to a circulatory system designed to move high quantities of oxygen.

The majority of oxygen moved to the tissues is used by the swimming muscles. In all fish, these muscles can be divided into two types: white and red muscle. Red muscle contracts at a comparatively slow rate and is, therefore, used for slow, continuous swimming. White muscle, on the other hand, contracts quickly and is used for short periods of high-speed-burst swimming.



Bluefin Tuna
Thunnus thynnus

White muscle makes up over 90 percent of the muscle mass and generates its energy by breaking down glucose without oxygen (anaerobic metabolism). This anaerobic pathway is not very efficient and yields lactic acid as a by-product. (The accumulation of lactic acid in the tissues is what makes you feel tired when you exercise vigorously for a prolonged time period and gives you muscle cramps if you exercise too fast.) The buildup of lactic acid in white muscle ultimately inhibits its performance because the acid is not removed or metabolized very quickly. Red muscle generates energy by metabolizing glucose with oxygen (aerobic metabolism) to yield carbon dioxide and water. As long as it has oxygen and glucose, red muscle can keep contracting indefinitely.

Tunas have a much larger proportion of red muscle than is found in the average fish. This allows them to cruise at higher speeds while generating energy aerobically. As the tuna begins to swim faster, the white muscle is slowly graded in to provide additional thrust. At this point, another adaptation comes into play. Not only does tuna white muscle work anaerobically, but it also has all the necessary biochemical equipment to work aerobically. This allows the animal to move at an even faster rate without going anaerobic. When the tuna does have to shift to an even faster rate, for instance, to catch prey, it can move with blinding speed. The final burst speed is provided by the white muscles working anaerobically. The anaerobic energy-generating ability of tuna white muscle is unsurpassed by any animal in nature.

A Warm-Blooded Fish

The breakdown of glucose to provide energy for contracting muscles generates heat as a by-product. In most fish, this heat is lost to the surrounding water and, therefore, the fish's body temperature is the same as the water it is swimming in. Not so with tunas—these fish, as well as some sharks, have evolved a specialized circulatory system that traps the heat before it escapes to the water. This particular adaptation consists of a heat exchanger comprised of small arteries and veins; it is called the rete mirabile or "wonderful net." It is so effective that core temperatures of tunas are often 10°C (50°F) warmer than the water. Giant bluefin tuna have been reported to have core temperatures 21.5°C (71°F) warmer than the surrounding water.

There are several advantages to being "warm bodied." Most biochemical reactions proceed at a more rapid rate at a warmer temperature. Therefore, all of the metabolic machinery used to generate energy, as well as use it, will operate faster. Specifically, a warmer temperature allows red muscle to contract more quickly, approaching the contraction rate of the white muscle. The more-energy-efficient red muscle can then be used at higher swimming speeds and, consequently, the white muscle does not have to simply carry around the "dead weight" of red muscle during high-speed swimming. Lactic-acid breakdown is also enhanced at higher temperatures. Finally, the transfer of oxygen from blood to muscle cells is quicker at warmer temperatures.

Clearly, all of these interrelated factors enhance the tuna's ability to sustain its high-speed cruising ability. In this vein, consider the tuna making rapid excursions up and down the water column. Water temperatures fall quickly with depth; for instance, the bigeye tuna that was observed to dive 250 meters in one minute went from water at 24°C (75°F) to water at 9°C (48°F). The heat exchanger gives tunas some "thermal inertia," allowing them to swim for short periods in colder waters without suffering a radical drop in their core temperatures. Similarly, temperate-water tunas that live in cold water all their lives will be warmer than other sympatric fish species and will have the various swimming advantages discussed.

The rete mirabile's ability to conserve heat generated by the swimming muscles can also produce a problem: insufficient heat dissipation. Heavily exercising tunas may solve the problem of getting rid of excess heat by a combination of physiological and behavioral responses. Physiologically, they appear to be able to control the efficiency of the heat exchanger by closing down some of the small arteries and veins perfusing the rete. This allows them to "dump" heat as the need arises. Behaviorally, excursions into cooler water will help them control their overheating problem. This may be why some species of tunas are found only in certain geographical areas and at depths that provide optimum temperature ranges.

This article is an adaptation of the one which first appeared, in German and French, in Documenta Maritima.

Atlantic Bluefin Management

Managing an economically valuable resource is not an easy or enviable task. In the case of bluefin tunas, which are capable of roaming an entire ocean basin, management brings disparate countries together, with contrasting stages of economic development and different perceptions of resource use. Even so, the agency which manages tunas in the Atlantic, the International Commission for the Conservation of Atlantic Tunas (ICCAT), recently made what appears to be positive steps in giving more force to regulations pertaining to the Atlantic Ocean.

International Management: Some of the Issues

One Stock or Two??

The underlying premise of Atlantic bluefin tuna stock management is that two separate stocks exist, one on either side of the ocean. This management approach was developed mid-century, and is considered by many now to be a more political approach than a strictly scientific one. Political?? Yes. The Atlantic fisheries have much to lose. Large bluefin tunas can amount to a lot of money—somewhere between $10 and $40 a pound.* Maintaining that the Atlantic contains two separate bluefin stocks means that both sides of the Atlantic can utilize their resource without considering whether either stock is being exploited twice.

Tagging information indicates that a portion of the western Atlantic population makes a transoceanic journey. This phenomenon raises many questions. What percentage makes the journey and how often? Also, to what extent do the stocks genetically intermix? Is a significant portion of the breeding stock being exploited twice?

The whole issue of country quotas becomes extremely contentious given the difference in the abundance of bluefin tuna in the western and eastern Atlantic. The allotment given a country is based upon several factors, including the estimated size of the exploitable stock and the historical use of the bluefin tuna fishery by that country. As the size of the eastern Atlantic stock is approximately ten times the size of the western Atlantic stock (estimated replacement yield of this year is 2,500 metric tons for the western Atlantic versus 40,000 metric tons for the eastern Atlantic), the quotas for countries fishing in the western Atlantic are much smaller than those for countries fishing the the eastern Atlantic and the Mediterranean.

*In actuality, the price per pound-depending on the quality—can be substantially more.

Stock Management

A common management strategy is to maintain biomass at a level that can support Maximum Sustainable Yield (MSY), an approach also used for tunas. An analogy used to simply describe the system is that MSY is like interest money;

the capital—or in this case, the reproductive core of the species–is left intact. Theoretically, MSY should work, though counting the sometimes hidden resources of the sea can be problematic. Environmental variables—if not taken into account (and not all variables are yet understood)**—could put the MSY of a fishery into question. Or, new scientific information might persuade regulators that a fishery's MSY be revised. At this point, at a juncture where a fishery management strategy might seem or might actually be debatable, opportunities are created for factions with vested interests. In plainer English: instead of being prudent, some groups use scientific uncertainty as a means for continuing resource over-exploitation. If the scientists are not *absolutely* sure, for example, that a certain percentage of adult bluefin crosses the Atlantic Ocean, why should the fishermen pay for this uncertainty with reduced quotas?***

Ironically, in world fishery after world fishery there has been a distinct pattern, says John Graves, a prominent player in ICCAT negotiations and a scientist at the Virginia Institute of Marine Science. Scientists warn that a fishery is being too heavily exploited. Any small doubt in the science, meaning that a trend cannot be absolutely quantified, and preference is given to economic concerns. Complicating this picture is the fact that historical fishing levels count when international managers determine the percentage of the bluefin stock to which a country is entitled. If a country were to agree to reducing its portion of the catch, in the future it might be entitled to less since it agreed to the initial reduction.

**For example, it has only been fairly recently that the impacts of a climate phenomenon like El Niño have been understood to be global in nature. Scientists are still sorting out (and will be for quite a while) the impacts which are clearly attributable to El Niño.

***This is becoming a perennial problem for scientists. Many people believe that knowledge does not change, especially scientific knowledge. However, in science it can be true that a concept is essentially correct, but not all the details. Also, gone are the days when lay people were tolerant of the time needed for real scientific results.

Cheating Hearts

One of the biggest obstacles to ICCAT has been lack of compliance with catch limits; declining overall stocks make this a truly critical issue. Non-compliance has the potential of undermining years of attempts to maintain a world resource and could ultimately threaten stocks. At its most recent meeting, ICCAT authorized countries to impose bans against three non-member countries found to be undermining ICCAT's conservation regime for bluefin tuna. The historic measure regarding members' compliance with catch limits for bluefin tuna in the western and eastern Atlantic and for north Atlantic swordfish calls for ICCAT member nations to repay 100 percent of any over-harvest as an initial penalty. Additionally, repeated over-harvests can result in other penalties, including quota reductions of at least 125 percent of the over-harvests and, as a last resort, import bans. Importantly, better catch reporting is being advocated, and apparently agreed upon by the nations which are involved in the ICCAT agreement.

Virginia's Offshore Fishing

By John Olney, Jr.

Fishing for deep water pelagics* in Virginia has been a passion for Commonwealth anglers ever since Captain Johnny Cass caught the first white marlin off the eastern shore of Chincoteague in July of 1937. Hired by a group of Richmond businessmen to discover what Virginia's offshore waters held, Cass brought his Florida charter boat to Virginia for the first weekend in July. Amazingly, he didn't catch one white marlin, he caught eleven, and when they were thrown on the dock during a Chincoteague wild pony auction on July 4th, people from all over were awed by fish that never before had been captured by sport fishermen in Virginia.

Charter fishing became a way of life for many on the Eastern shore in the thirties and forties, and soon after World War II charter boats began springing up on the southern coast of Virginia. By the early sixties, more than twenty boats ran offshore charters out of Lynnhaven Inlet and Ocean View. The first boats were slow, with the fastest making only around 10 knots, and the cost of a charter ran anywhere from $50 to $75 a day. By the early seventies, with the completion of Virginia Beach Fishing Center, the southern resort area had acquired the reputation for fantastic bluefin tuna fishing as well as good yellowfin and white marlin fishing.

*Living in the open ocean, rather than waters adjacent to land.

Beginning in early May every year, a scattering of school bluefin tuna (from thirty to seventy pounds) begin congregating close to the North Carolina/Virginia border and by mid-June the fish have settled around some of the well-known hot spots found directly off the coast of Virginia. The white marlin and the yellowfin fishing slowly begins to attract more interest from the fleet in mid-July as the bluefin fishing fades, and by August the boats begin to concentrate on the large numbers of white marlin that congregate on the lumps southeast of Virginia Beach, and the canyons further offshore.

Fishing Grounds

The offshore waters of Virginia hold some of the most productive fishing grounds on the East Coast. With both the Labrador and the Gulf Stream currents moving in opposite directions across Virginia's Continental Slope, a nutrient-rich environment is generated that supports life ranging from microscopic plankton and fish larvae, to large pelagic predators, like the tunas, the sharks, and the billfishes. Numerous seaknolls and mounds are present in Virginia's offshore waters, and many of them are well known hotspots for fishing activity. Places like the Hot Dog, the 21 Mile Hill, the Hambone and the Fishhook, as well as the offshore canyons such as the Norfolk, Baltimore, and Poor Man's, all support large populations of fishes at one time or another.

The historical development of this bottom structure is an interesting one. Millions of years ago, during the Ice Age, the continental shelf as we know it today was once a large coastal plain. Hills and mountains and rivers all extended far to the east of today's known coastline. At this time there was no Chesapeake Bay, there was only the Susquehanna river which flowed west to east, emptying into the ocean some sixty miles off of today's coast of Virginia.

With the end of the Ice Age came a rising of the ocean levels. The Susquehanna River began to back up and flood the coastal plain, triggering the creation of the Chesapeake Bay. The seaknolls such as the Fishhook, the Fingers, and the Hotdog are the hills and mountains that extended across this plain, long before there was a Chesapeake Bay. The Norfolk Canyon that we now know was once the mouth of the Susquehanna River that emptied into the Atlantic.

Fishing Techniques

Since the beginning of offshore fishing, everything from handlines to flyrods, live bait to lures, has been used to capture tunas, as well as everything else that swims in the ocean. What has evolved through this long history of trial and error is a set of fishing methods that have proven to be successful under certain conditions in specific geographical regions. There is an unlimited number of possible fishing methods, but the most notable and successful tactics are used by the boats that are pressured to produce fish on a daily basis, specifically, Virginia's offshore charter fleets in Wachapreague, Chincoteague, and Rudee Inlets. Though every boat claims to have its own secrets, there are two basic methods that have become the standard for consistently producing tunas in Virginia waters.

Dead Bait Trolling

This has become the standard trolling routine for almost all of the mid-Atlantic charter fleets. It's a method that is not species specific, so everything from small dolphins to tunas to 1,000 pound blue marlins can be captured with the same baits, in the same areas. The idea is to pull baits that mimic the small baitfish that all of the pelagic predators will feed upon. As the old timer's say, "elephants eat peanuts," so the best idea is to pull something small so one can catch the small ones as well as the giants. Ballyhoo is the primary bait of choice, being the most versatile and easily accessible bait on the market. The long silver baitfish usually holds together well while it is being trolled at five or six knots, it is easy to rig, and it looks good in the water. Rigged on a 9/0 hook, and crimped on a fifteen foot length of 150-200 pound monofilament leader, this rig is basically all a person would ever need to pull. The ballyhoo is wired into place with a piece of monel or copper, and a seawitch (a commonly used attractor) is often slipped in front of the bait to give it added color and movement.

Fishing seven or eight lines is the norm while trolling in this fashion, but any number of lines can be effective. Circumstances differ, and so do people. In the typical eight bait scenario, four are fished from the outriggers, two are fished directly off the stern (called flat lines), and two rods are fished from the bridge (called shotguns). This style allows for multiple strikes (which is common when tuna fishing), and a boat can cover a lot of ground in a short time while trolling at 5 knots with a wide spread of baits.

Chunking

Chunking has become an extremely successful means of fishing the seamounds that are found on Virginia's portion of the continental shelf. The bluefins are famous for holding tight to Virginia's bottom structure and the method of chunking allows the fishermen to concentrate specifically on the area where they think the bluefins are most likely to be. Chunking requires a large amount of baitfish, usually butterfish or menhaden, and these fish are cut up into chunks and continuously tossed over the side to form a chum line. A bait is drifted back in the slick with a hook in it, and the idea is to make the bait look exactly like the chum. The leaders should be strong enough to hold the class of fish that are being caught, but at the same time, it is important to go with the least visible leader. Tunas have amazing vision, and if they are beginning to get picky, chances are they are seeing the leader. Several monofilament manufacturers make camouflage or invisible leaders, and in some cases this is a good investment to catch more tunas.

> *"Los Atunes no tienen Patria, ni Domicilio constante. Todo el Mar es Patria para ellos. Son unos Peces errantes. . ." (Tunas have no native country, nor lasting domicile. All the sea is their native country. They are wandering fish. . .)*
>
> *—Fray Martin Samiento, 1757*

WACHAPREAGUE. . .

.home of Virginia's oldest charterboat fleet

By
Charlie Petrocci

Passing through the parking lot just as dawn is creeping over the nearby barrier beach islands, one can faintly make out the various vehicle license plates lined in a row. They seem to represent a collage more frequently found on the wall of some smoke filled tavern sitting astride Route 66 deep in the mid-West. New York, New Jersey, Delaware, Pennsylvania, Ohio, Maryland, North Carolina and of course Virginia are all represented here. In the background, gulls' cries are mixed with the guttural sounds of warming diesel engines. The smell of fuel and thawing butterfish is thick in the air. In the growing light, there are shadows and shapes of men as they pass by the stern of boats, some whispering and others shouting above the din of the engines. Accents reminiscent of generations gone by come and go, hardly noticeable in the excitement of the hunt. There is energy here. And it can be cut with a knife on this clear breaking day. The tuna are in and the word is out that Wachapreague is hot.

The name Wachapreague, Virginia, means many things for different sportsman across the east coast. For some it conjures up memories of railbird hunting on a rising full moon tide, or of waterfowling on ice-cold mornings. For many others it means flounder as thick as your wrist or red drum rolling just beyond the breakers. But for generations of others it has meant big-game, offshore fishing for tuna that is unequaled in this part of the mid-Atlantic. It is a town whose foundation rests on its sportfishing laurels. Today, with approximately 14 resident charter boats, Wachapreague hosts the oldest charterboat fleet in Virginia and still remains a bastion of tough men in wood boats hunting in bluewater for offshore giants.

Wachapreague is a small waterfront fishing village that is barely a spot on the map. Its ancient shell midden remains betray its past with early native Americans taking advantage of its rich shellfish waters. Gillnetters and oystermen still leave from the docks, but for well over 50 years, sportfisherman have gravitated to this place to board old time charterboats, taking advantage of the great offshore fishing. Marlin, wahoo, king mackerel, dolphin and mako have all been frequent participants in the offshore experience. But it has been the resilient tuna sport fishery that has been the backbone of the offshore trade for the Wachapreague fleet over the last four decades. The bulk of the target species has been the bluefin and yellowfin tuna with a scattering of bigeye, skipjacks, bonito, little tunny, and albacore mixed in. Their migrations are dictated by the seasons, water temperature and available natural prey. All the variables must be good here though, because they seem to reappear every year.

What has made this little town so identifiable with the competitive tuna sportfishing industry found in other resort areas? Location, location, location. Wachapreague sits tucked up behind Cedar Island, one in a chain of beautiful coastal barrier islands found along Virginia's Eastern Shore. The various inlets between these islands spill out a tremendous amount of food resources for migrating predator species, thus becoming a virtual fish factory or "chum line" for these fish. Also, Wachapreague sits close to the western edge of the Gulf Stream, which sits about 60 miles offshore. These indigo blue waters are incredibly rich with sea life. Along this 100 fathom curve the continental shelf ends and water depths tumble to over 2,000 fathoms, revealing shear rock walls and ocean bottom mounds. This productive area during the warmer months attracts offshore game fish closer to the featureless inshore sand bottom. Here there are isolated lumps, hills or deep fingers that hold countless schooling baitfish. Thus, this inshore area becomes a huge "migration corridor" for many species, including tuna. Some of the more distinct and annually productive bottom features have acquired names such as the Fingers, 21 Mile Hill, 26 Mile Hill and the Parking Lot (which received its name for all the boats that can be found there chumming for tuna on a warm summer day). Water temperature fluctuates from 40°F in the winter to over 80°F in the summer, with the profound result on fish being constant migration. This overall region is known as the mid-Atlantic Bight, considered temperate waters, and it stretches from Cape Hatteras well into New England.

Technique

Boats from as far away as Virginia Beach and Ocean City, Maryland, come to the tuna grounds off of Wachapreague each year. "The tuna run usually begins in early June with the bluefins making the first appearance," reports Henry Fabricatore owner of the Wachapreague Marina. "Depending on regulations, this gives charter boats and recreational fishermen their first crack at tuna. Next to show up are the yellowfins, usually overlapping the bluefin run by mid-July. The yellowfin tuna run is steady, providing exciting offshore action well into early October, but I believe they can be caught into November as well, if the interest were there," adds Fabricatore.

Hotspots for tuna off of the Eastern Shore include the Southeast Lumps, the Fingers, 26 Mile Hill, the 20 fathom line and the Parking Lot. Traditionally trolling the old reliable cedar plug has proven effective on countless occasions, as well as feathers, spoons, plugs, and "green machines." Trolling also allows the angler to pick up the occasional white marlin, blue marlin or wahoo as well. Fairly new to the tuna fishing game has been the advent of chumming or "chunking," long a technique used on tuna further up north. With this method the boat anchors up over a "finger" or on one of the "hills" and by tossing cut mackerel or butterfish overboard in a steady stream of bait, lures the fish to the back of the boat. A short shank hook with a piece of bait is allowed to suspend in the chum line. A stiff short rod, with a roller tip and spooled with at least 50 pound test is the way to go. This method has proven very successful over the past five years for both bluefin and yellowfin tuna. But because tuna are leader shy, monofilament leaders work best.

"People first started to come to Wachapreague years ago because of the great flounder fishing we had here," says Capt. Ray Parker of the charterboat *Hobo*. "I started fishing in 1947 and caught the first tuna and marlin here not long after that. But about 24 years ago our bluefin fishing took off. I remember seeing some boats come in with over 40 tuna each, on a good day. By that time we began to get steady customers looking just for tuna trips and that remains that way today. We lost some people when the regulations changed, just like for trout fishing. Folks won't come and spend the money only to keep a few fish. But in the last five years we have had excellent bluefin and yellowfin action to keep everyone happy," he added.

In Wachapreague there are generations of blood among the charter fleet, with many the son of a son of a sailor to be found here. Capt. Nat Atchinson, one of the younger captains here said, "The tuna fishing definitely bridges the gap between the two inshore seasons (flounder and trout) and has helped not only me, but the economy of the town as well. We're lucky to have the bluefin come in and then overlap with the yellowfin. I just wish they would iron out the regulations though. The constant change in quota definitely affects my business."

Species

The tuna tribe belongs to the mackerel family Scombridae. With a streamlined body of pure power, they provide everything a sportfisherman desires in a gamefish: speed, strength and endurance. They are true challenge for many anglers, with many a heartbroken angler loosing the fight to a powerful fish right at boatside.

Tunas have an advantage over most other fish in that they are not completely cold blooded, as their body temperature has been recorded as much as 10°C (50°F) higher in temperature than the surrounding water. It is believed that this temperature adjustment effectively triples the muscle power of these great game fish, according to the Woods Hole Oceanographic Institute.

The bluefin has sometimes been called "the greatest gamefish in the world," though maybe not the most spectacular or most colorful. By far it is the largest of the tunas, with the world record 1,496 pound bluefin taken on tackle off Nova Scotia in 1979–a true giant. Unlike other tunas, bluefin can be found fairly close to inshore waters during the summer months. But they are a highly migratory species, known to cross the Atlantic Ocean. Giant bluefin tuna migrate south in the fall and spawn in the Gulf of Mexico, while younger class fish move off to warmer eastern waters during the early fall months.

Yellowfin tuna generally prefer warmer waters. They are frequently caught near canyons and dropoffs along the continental shelf. The most distinguishing characteristic of the yellowfin is its elongated second dorsal and anal fins. At one time these colorful fish were known as Allisons, and were thought to be a different species. The most colorful of all the tunas, they have a golden yellow hue on the upper sides, complimented by yellow fins.

Economics

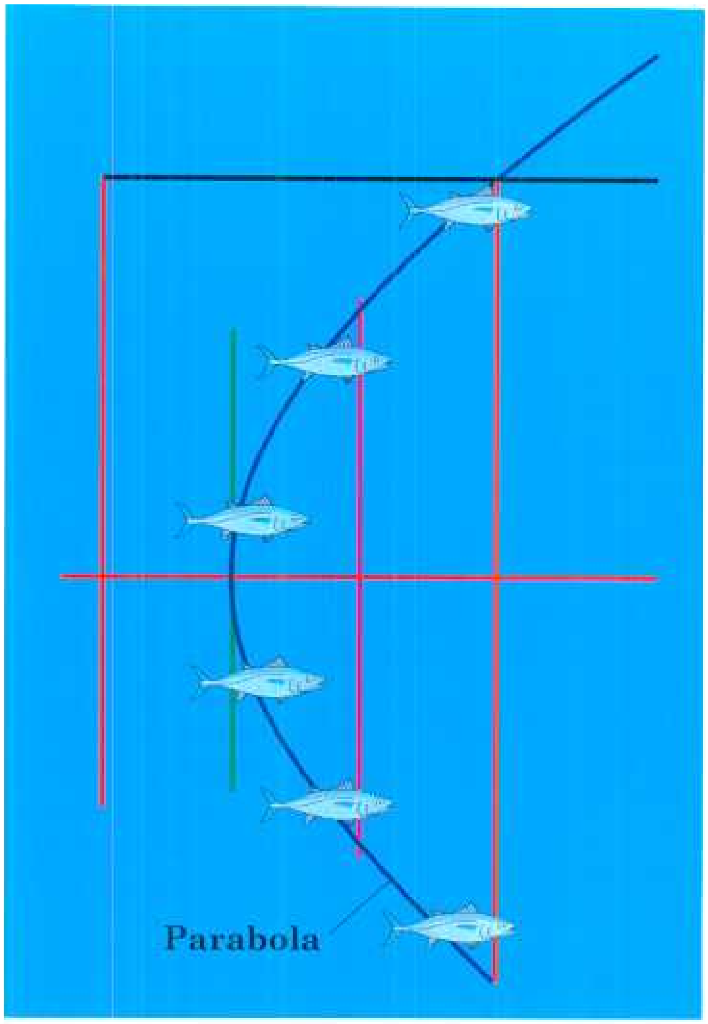
There is no doubt that sportfishing is the life and blood of Wachapreague, beginning with the late 1800s era of "seaside resorts" that once saw the likes of president Calvin Coolidge, former Confederate general Rudy Lee and Jefferson Davis himself, come to the Eastern Shore for "sporting." Later, the famous Wachapreague Hotel sprang up, entertaining both anglers and hunters alike in this unique isolated area. Since then there has been a steady stream of sportsmen to this "little city by the sea."

"For me, the summer offshore tuna season is important for all our businesses here in Wachapreague, including our family run hotel, restaurant, boat ramp, and tackleshop," said Randy Lewis Jr., owner/manager of the Island House Restaurant. "We see many of the same fisherman year after year. Some have now become old friends," he added. The tuna usually lasts from June through September, picking up at the end of the spring flounder season and leading into the fall trout fishing. "We get an awful lot of fisherman who just come down here each year for the tuna season," says Fabricatore of the Wachapreague Marina. For myself and my employees it means steady sales in bait, fuel, boat ramp fees, tackle, supplies and food items. Usually the folks who like to tuna fish have good incomes and can afford either a charter trip or have access to a good size boat to get offshore. There's no doubt the tuna season each year creates great cash flow for this town and is an economic boost for all of us," he went on to say. "We also get a lot of tourists who like to come down just to see tuna slung up on the docks and bend an ear to listen to the stories," says Lewis. There are also a number of offshore fishing tournaments held each year that attract fisherman and tourists alike, including the popular "Ladies Tuna Tournament."

Wachapreague, the little city by the sea, with its tree lined streets and signature waterfront, is struggling to hold onto the sportfishing tradition that has brought economic growth and great memories of fighting big water fish for generations of anglers. Its ancient charter boat fleet of wooden ships alongside modern boats, is still seen leaving each summer morning, heading far offshore to the bluewater tuna grounds. And as old captains retire and pass away, the question is asked, will there be enough young men to fill in the ranks behind them to keep the tradition alive? Well, as long as there are tuna to be caught and anglers willing to hunt them down, then Wachapreague will continue to fish on.

Private boats utilizing Wachapreague are increasing each year during the tuna season.

Schooling



Tunas sometimes swim in this formation when hunting prey.

When young, tunas school according to size; as large adults they are thought to be solitary in their wandering. Schooling is thought to be an adaptation, mainly for the protection of prey fish, as opposed to predators. Even so, some avid predators, such as bluefin tuna, use this process to maximize their effort to obtain the necessary sustenance for their high-energy lifestyles.

Prey Schooling

For small fish, the dog-eat-dog oceanic world poses considerable risk. It is believed that schools offer protection in a number of ways, notably by confusing the predator and by reducing the likelihood that any one single fish would be consumed once the school was detected. But first, how does a school manage within seconds to change direction, quickly form into a denser group (or groups), and, depending upon the species, head in another direction, all without colliding? (Some species even have been observed forming two distinct groups which swim past the fish on either side, only to regroup as a school *behind* the predator.) Research indicates that many fish depend upon vision and an organ which is aptly termed the lateral line, an organ which stretches horizontally along the side of the fish. The lateral line responds to pressure changes in the surrounding water, changes which could be caused by another animal or by water currents.* A fish apparently uses its lateral line and its vision to calculate the spacing and speed of others in the school. That is the simple explanation. More difficult to comprehend is how the signal to move immediately is known by all members in the school, a question that appears not to have a definitive answer as of yet.

It has been estimated that out of perhaps 20,000 species of fish, at least 10,000 species school at some point in their life cycle. This fact led researchers to believe that schooling conferred some sort of advantage for a prey fish. That the school's structure and behavior confuse the preda-

*As research in this area continues, it may be discovered that other sensory systems may be involved.

tor is one theory. Some schooling prey fish will, when threatened by a predator, condense down to a sphere shape and then move explosively away from the center of the sphere, a movement which resembles a bomb blast as the group moves away from the predator.

In the aquatic world, predators need to distinguish prey, a feat not as easy as a terrestrial animal like *Homo sapiens* would imagine. Although some oceanic predators possess highly developed vision,** water is not an ideal medium for seeing. It is believed that the way a predator spots its meal is by the contrast between the prey and its surrounding background. Research indicates that a school, as opposed to a lone fish, is not necessarily that much easier to spot in the aquatic world. If the hunter does find schooling prey fish, the school structure can confer an advantage in that only a few members will probably be consumed by a single predator. Alone, the prey fish's odds of being eaten would be great!

Schooling Predators

Tunas have been observed using schooling apparently to their advantage. It is believed they increase the area which they can collectively scan for prey. It is also believed that they use a parabola form to encircle prey. A former Virginia Institute of Marine Science graduate student, Charles Barr, described the tunas' strategy as this, "Bluefin react to both olfactory and visual stimuli. Bluefin have been observed schooling in a parabolic feeding formation with the concave side of the parabola forward. The tuna apparently work together to drive a school of prey between the outstretched ends of the parabola, then surround and consume the prey."

If the schooling of prey offers some protection, the prey are up against masterful hunters when it comes to tunas. Tunas have both strong visual skills *and* a highly developed olfactory system. For an animal like a tuna, the scent left behind by a prey fish in the water column is like a fresh trail. The scent left behind is made up of oils, proteins and amino acids contained in the mucus layer which protects fish and squids. Tunas can detect very minute solutions in the aquatic world, and these scents are not dispersed as readily as they are in the air.

When a yellowfin tuna detects its prey, basically by tracking the prey school's scent trail, ". . .it stimulates an active search response," according to Barr. "This response is characterized by a sudden stall in movement or a burst of speed which is then followed by a general increase in swimming speed, and changes in overall swimming pattern. A strong response culminates in behavior such as jaw snapping, display of feeding bars (dark vertical stripes often seen on the flanks of feeding tuna) and sometimes tight circling in the area of the secretions. Upon approaching the prey, the increased intensity of the secretion stimulus coupled with a strong visual stimulus creates a voracious feeding response in the tuna."

Other animal predators, both aquatic and terrestrial, use schooling or banding together in a group as a strategy for capturing prey. In the oceanic world, killer whales (technically dolphins) often cooperate in hunting and feeding efforts, sometimes driving their prey onto shore, where the prey has virtually no chance.

**Of course, many animals have adapted to poor water clarity and use other sensory systems for various life functions. In the Chesapeake Bay, a murky body of water, the toadfish's need to broadcast its nesting status is accommodated by the loud noises it emits. Other animals, for example those located in the deep oceanic water, might have very large eyes to catch any sort of light emitted. An animal like the bluefin tuna is supposed to be very visually attuned to the blue wave length. Other fish, with lesser energy requirements, may not have needed to evolve sensory systems which were so finely created.

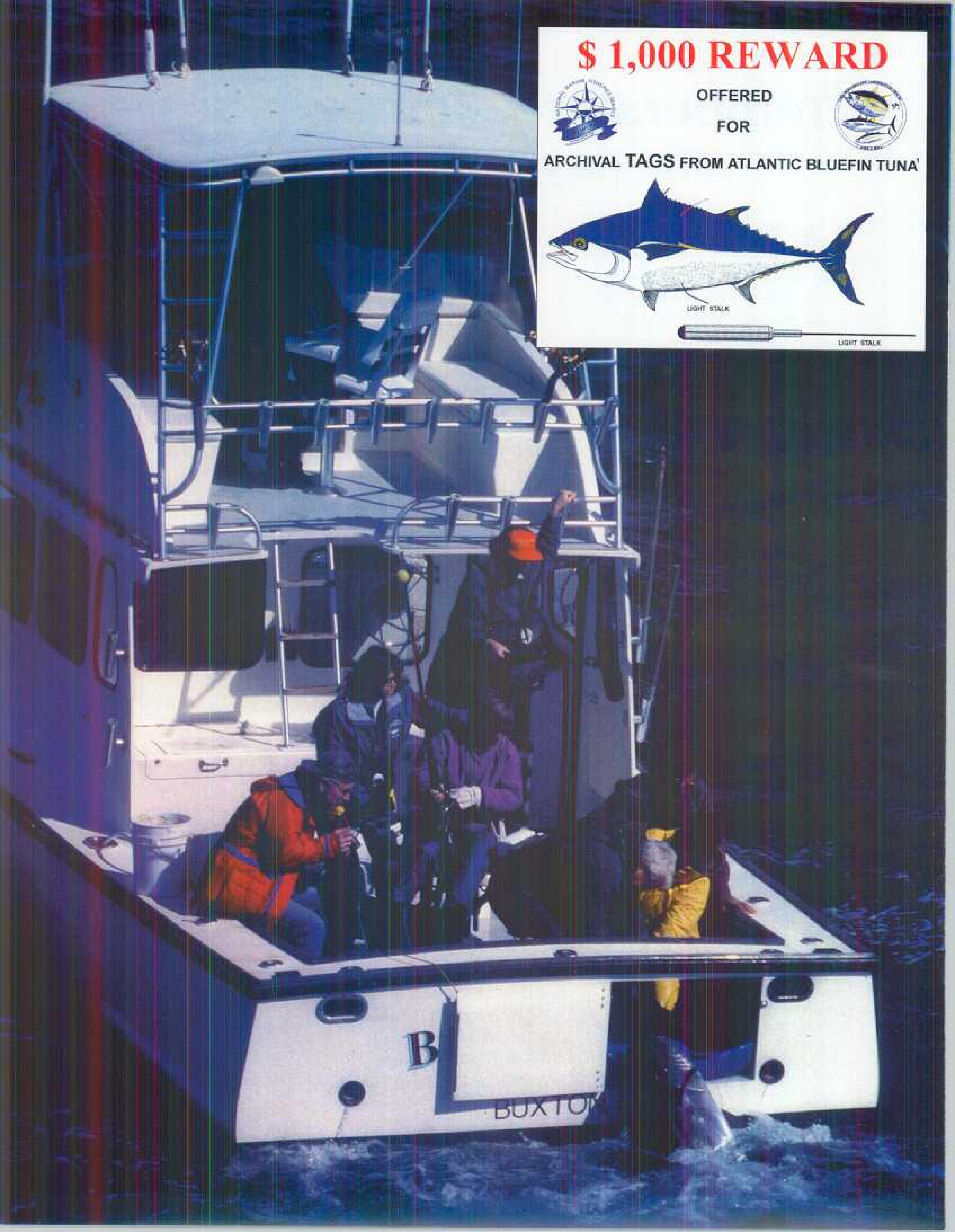
Temperature, Temperature. . .
The Key to Tuna Storage

All food requires care in handling, especially most forms of protein. Reports indicate that a majority of tuna fishermen now follow the proper methods for recreational catch storage, but the methods bear repeating, since what applies to tuna is true of other fish—especially mackerel, bluefish, dolphin, amberjack, and swordfish.*

Cooling the fish as rapidly as possible is the key to ensuring food safety, according to Sea Grant research conducted by Nancy Balcom, now Interim Program Leader with Connecticut Sea Grant. When Balcom conducted her research, data and observations indicated that the fish were poorly handled, meaning that they were left in the sun and that body temperatures were too high. Properly, the fish should be immediately gutted and then rapidly cooled. The belly cavity should be filled with crushed ice (block ice does not come into contact with as much of the fish's flesh). The catch should not be left in the sun, or in other warm areas.

Scombroid fishes—such as tuna, mackerel, bluefish, dolphin, amberjack and swordfish—can be a source of histamine intoxication, or poisoning, when the catch is inadequately refrigerated or improperly cooked. Histamine food poisoning is caused by the breakdown of the amino acid histidine to histamine in fish muscle tissues. This type of conversion is accelerated by warm temperatures (those greater than 68°F). Most forms of protein require that, in cooking, a temperature be reached to rid the product of undesirable microbes. Fish should be cooked thoroughly, until the flesh flakes.

*It is believed that the majority of food poisoning cases originate in the home. Apparently, generational information about food handling is not being passed on, or if it is, it is disregarded. Even so, there are other facets to this story. Here is but one: many people with severely compromised immune systems are surviving in our times, and constitute a population which is especially susceptible to food poisoning.



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ARCHIVAL TAGS FROM ATLANTIC BLUEFIN TUNA
LIGHT STALK
LIGHT STALK

State-of-the-Art Tags

Archival tags are "state of the art" electronic data-logging devices that provide location estimates by measuring light intensity through a light stalk. They also measure pressure and provide data on depth, water temperature, and body temperature of the fish. This information is collected on a daily basis and stored in the tag for up to seven years.

How do you determine that a bluefin tuna has an archival tag? Archival tags are implanted in the body cavity of the tuna and only the light stalk protrudes out of the stomach. However, these specially equipped bluefin tuna also carry unique external conventional streamer tags, with two-tone coloration, to help fishermen recognize these fish and return the archival tags. The external tags are placed about an inch off the dorsal midline on each side of the fish. On the white portion of the streamer tag it says "electronic tag inside stomach" and on the green or orange side it says "Big $$$ Reward."

What to do if you catch a bluefin tuna with an archival tag? If legally taken, confirmed archival tagged fish should be brought aboard the boat. **DO NOT REMOVE THE ARCHIVAL TAG BY PULLING THE EXTERNAL LIGHT STALK IN THE STOMACH CAVITY.** To remove the archival tag, make a small incision in the area of the stomach and remove the archival tag (with the light stalk attached) by hand. Do not attempt to clean the tag; simply cover it and in the west Atlantic call the National Marine Fisheries Service. During business hours call 1-800-437-3936 or (305) 361-4248, on weekends, or at night call Dr. Eric Prince COLLECT at (305) 598-0944. In the east Atlantic, call the International Commission for the Conservation of Atlantic Tunas, Madrid, Spain, at 34-1-579-3352 or your local fisheries conservation agency. Instructions will be provided regarding where and how the tag should be mailed. After verification of the tag, arrangements will be made regarding payment of the $1,000.

This experimental research program is being conducted jointly by Stanford University's Tuna Research and Conservation Center and the National Marine Fisheries Service.

Size of bluefin tuna carrying archival tags: Medium (135-310 pounds) and Giant (310 pounds and up) bluefin tuna have been equipped with archival tags. A sum of $1,000 will be paid for each tag that is properly removed from legally caught Atlantic bluefin tuna and returned.

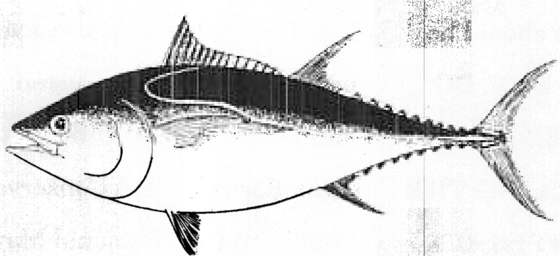
Tunas In The Western Atlantic

Tunas are a worldwide species, part of the family Scombridae. This taxonomic family includes all tunas, as well as bonitos, mackerels, seerfishes, and the butterfly kingfish. The following descriptions list the species most commonly found in the western Atlantic Ocean.

The information on these pages was compiled by the Highly Migratory Species Management Division of the National Marine Fisheries Services, and was published in a booklet entitled, *A Guide to the Tunas of the Western Atlantic Ocean,* printed in 1996.

Bluefin Tuna

Thunnus thynnus



Size

Maximum: over 118 inches

Common: 16 to 79 inches

Current IGFA (*International Game Fish Association*) all tackle record: 1,496 pounds

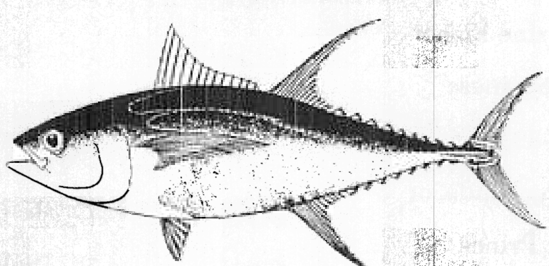
Distribution and Behavior

Widely distributed throughout the Atlantic. Found in western Atlantic along Labrador and Newfoundland, southward to Tobago, Trinidad, Venezuela, and the Brazilian Coast. Distribution in east Atlantic extends as far north as Norway and Iceland, and as far south as northern West Africa. Also exists in the Mediterranean Sea.

Western Atlantic bluefin tuna are sexually mature at approximately age 8 (80 inches Curved Fork Length*). Eastern Atlantic bluefin are sexually mature at about age 5 (60 inches CFL). Atlantic bluefin tuna spawn in the Gulf of Mexico (April-June) and in the Mediterranean Sea (June-July).

Yellowfin Tuna

Thunnus albacares



Size

Maximum: 75 inches

Common: 16 to 67 inches

Current IGFA all tackle record: 388 pounds, 12 ounces

Distribution and Behavior

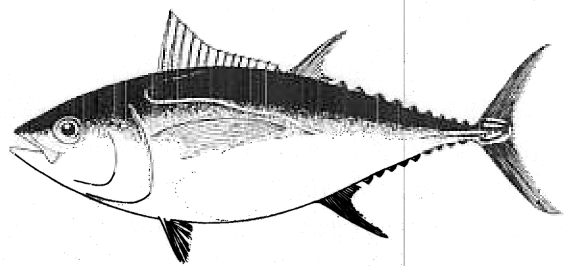
A warm-water species, yellowfin is the most tropical species of tuna. Abundant in tropical waters throughout the Atlantic. Young are known to form large schools near surface. Adults inhabit fairly deep water but also live near the surface. Often mixed with other species, especially skipjack and bigeye.

Yellowfin are sexually mature when they reach a length of approximately 40 inches, and spawning occurs throughout the year in the core areas of distribution (between 15°N and 15°S latitude), including the Gulf of Mexico, with peaks occurring in summer months.

*Total Curved Fork Length is the sole criterion for determining the size class of whole (head on) Atlantic tunas for regulatory purposes. Curved fork length means a measurement of the length of a tuna taken in a line tracing the contour of the body from the tip of the upper jaw to the fork of the tail, which abuts the bottom side of the pectoral fin and the bottom side of the caudal keel.

Bigeye tuna

Thunnus obesus



Size

Maximum: 75 inches
Common: 16 to 67 inches
Current IGFA all tackle record:
375 pounds, 8 ounces

Distribution and Behavior

Occurs in warm temperate waters of the Atlantic, Pacific, and Indian oceans. Range in Atlantic, from southern Nova Scotia to Brazil. Commonly found in schools that run in deep waters during the day. Bigeye, yellowfin, and skipjack are known to occasionally school together at the surface, especially in warm waters.

Bigeye tuna reach sexual maturity at about 40-50 inches in length. Mature bigeye spawn at least twice a year, with spawning occurring throughout the year in tropical waters, and peaking during summer months.

Albacore

Thunnus alalunga

Size

Maximum: 50 inches
Common: 16 to 43 inches
Current IGFA all tackle record:
88 pounds, 2 ounces

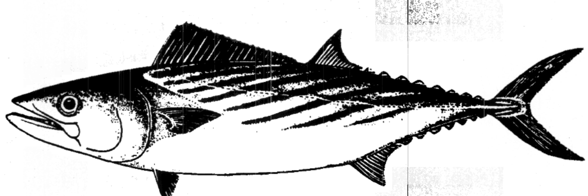
Distribution and Behavior

A temperate species, found worldwide in tropical and warm temperate seas. Seasonally found in colder zones. Usually remains in tropical or warm waters and makes migrations into colder waters, as far north as New England. In the Atlantic, larger size classes (31 to 50 inches) are associated with cooler water bodies, while smaller individuals tend to occur in warmer waters.

Albacore reach sexual maturity at about 37 inches in length, and spawn in June-July in subtropical western areas of both hemispheres and throughout the Mediterranean Sea.

Bonito

Sarda sarda



Size

Maximum: 36 inches
Common: 25 inches
Current IGFA all tackle record:
18 pounds, 4 ounces

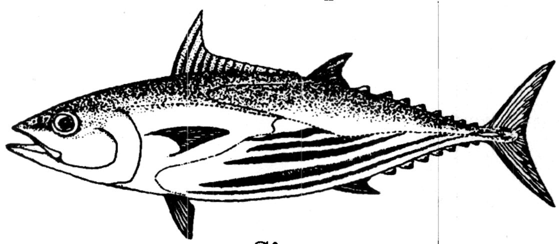
Distribution and Behavior

Common in tropical and temperate waters of the Atlantic from Argentina to Nova Scotia, and from South Africa to Norway. Rare in Caribbean and Gulf of Mexico. Known to skip or leap over the surface of the water when in pursuit of prey. Found in schools 15-20 miles offshore, but are also found close to shore.

Bonito reach sexual maturity at abut 16 inches in length and spawn in the western Atlantic in June and July. Spawning usually takes place close to shore, in warm coastal waters.

Skipjack tuna

Katsuwonus pelamis



Size

Maximum: 40 inches

Common: 16 to 28 inches

Current IGFA all tackle record:

41 pounds, 14 ounces

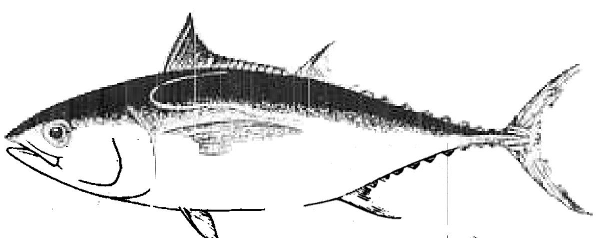
Distribution and Behavior

An oceanic species, found worldwide in tropical and subtropical waters. Common throughout the tropical Atlantic. Can be found as far north as Massachusetts in summer, and as far south as Brazil. Often schools with blackfin in the western Atlantic, with school size reaching 50,000 individuals.

Skipjack tuna reach sexual maturity at about 18 to 20 inches in length. Spawning occurs in spurts throughout the year in tropical waters, and from spring to early fall in subtropical waters with the spawning season becoming shorter with increased distance from the equator.

Blackfin tuna

Thunnus atlanticus



Size

Maximum: 40 inches

Common: 28 inches

Current IGFA all tackle record:

42 pounds, 8 ounces

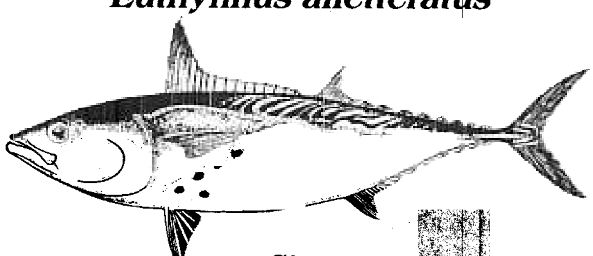
Distribution and Behavior

Found in tropical and warm temperate waters of the western Atlantic. Range extends from Brazil to Cape Cod, including the Caribbean and the Gulf of Mexico. Often feed near the surface, and frequently form large mixed schools with skipjack.

The blackfin's spawning grounds are believed to be well offshore. Off Florida, the spawning season extends from April to November with a peak in May, while in the Gulf of Mexico it lasts from June to September.

Little tunny

Euthynnus alletteratus



Size

Maximum: 40 inches

Common: 25 inches

Current IGFA all tackle record:

35 pounds, 2 ounces

Distribution and Behavior

Common in tropical and warm temperate waters of the Atlantic from New England to Brazil in the west, and from Great Britain to South Africa in the east. Not as migratory as other tuna species, and can be found regularly in inshore waters, as well as offshore. Usually found in large schools.

Little tunny reach sexual maturity at about 15 inches in length. Spawning occurs from about April to November in both the western and eastern Atlantic.

Recent Publications

Virginia's Commercial Fishing Industry: Its Economic Performance and Contributions, and *Saltwater Angling and Its Economic Importance to Virginia*

The economic importance of commercial and saltwater angling to the Commonwealth is more than substantial. Combined, the fishing industry and saltwater angling contributed nearly $1.0 billion in total sales during 1994. The commercial fishing industry generated approximately $465.4 million, and saltwater angling generated $477.2 million. Income generated by the commercial fishing industry equaled $326.6 million; saltwater angling generated income of $269.4 million. Together, the two industries generated full-time employment for 21,742 individuals.

The economic assessment of the commercial and recreational fishing was conducted by James Kirkley, an economist with Marine Advisory Services at the Virginia Institute of Marine Science. The reports are entitled *Virginia's Commercial Fishing Industry: Its Economic Performance and Contributions, and Saltwater Angling and its Economic Importance to Virginia.* The two, 70-page documents summarize important economic trends which characterize the commercial fishing industry and saltwater angling. In addition, both studies provide an assessment of the contribution of each respective sector to the state economy. The importance of the industry and saltwater angling are presented in terms of total sales, income, and employment generated by the two sectors.

Relative to the major species commercially harvested or landed in Virginia, blue crabs generated the greatest total sales, income, and employment. The species generating the second highest economic impacts was menhaden, which is an industrial fishery. Sea scallops generated the third highest sales or output but not income and full-time employment opportunities. Oysters, long a mainstay of Virginia's fisheries, generated the third highest income and full-time opportunities.

In 1994, saltwater anglers spent considerable amounts of money targeting certain species in Virginia. Anglers spent $63.7 million catching or trying to catch striped bass from Virginia waters. Relative to catching or pursuing Gulf Stream species such as tuna, marlin, sailfish, dolphin, and shark, anglers spent $54 million in 1994. Species having the third highest expenditures included spot, croaker, and scup ($44.5 million). Saltwater anglers spent $38.2 million catching or trying to catch flounder in 1994. Anglers with no expressed target species spent $24.2 million catching or trying to catch fish.

Limited copies of *Virginia's Commercial Fishing Industry: Its Economic Performance and Contributions, and Saltwater Angling and Its Economic Importance to Virginia* are available. The first copy of either publication is free to Virginia residents. Additional copies cost $5 each. A written request for either of the publications should be submitted to the Virginia Institute of Marine Science, Sea Grant Publications, Marine Advisory Services, Gloucester Point, Virginia 23062. Checks should be made payable to VIMS.

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