## DISCUSSION

### Biological Session

Discussion Leader: PAUL S. GALTSOFF

Discussion Panel: GERARDO CANET, B. F. OSORIO-TAFALL

### A Comparison of Nova Scotia and Bahamas Bluefin Tuna with Reference to Migration and Population Identity

LUIS RENE RIVAS

Q. Osorio: How fast can a bluefin tuna swim?

A. Rivas: I don't know. In 1938 a man equipped his reel with a speedometer and went to Nova Scotia to obtain information about the speed of this tuna. He found out that the speedometer showed 45 miles per hour when the tuna was hooked and frightened. This may be open to question. We usually fly over the Bahama waters around noon. We can see the schools clearly from an altitude of 500 feet, and in the early part of the season it is possible to pick out a solid school, which could not be confused with anything else and follow it from around Orange Bay all the way up to Great Isaac. Timing about a 12 or 15 mile run, the average speed came to about 3.3 or 3.5 knots. Sometimes we've timed them to 4 or 5 knots; sometimes much slower. The bursts of speed which people sometimes observe might be caused by frightening the fish. Judging from the time it takes the tuna to get from the Bahamas to Nova Scotia waters which is about 16 days, the rate again comes to about 3.5 miles per hour.

Q. Canet: What type of research should be conducted in Cuban waters to assist in the exploitation of a tuna fishery?

A. Rivas: You have heard the results of the work in the Gulf of Mexico by the Fish and Wildlife Service, as reported upon by Mr. Harvey Bullis. The first step is to get long lines and all other types of gear and explore the waters around Cuba. Once you have established the fact that there is an exploitable population of tuna then the investigations should be pursued on the assessment of the population, the fishes migratory habits, their breeding seasons, the times of the year when the fish are more abundant, and a routine life history investigations.

Q. Moore: Mr. Rivas mentioned that the final proof of the migration of this tuna from the southern waters to the northern would be tagging. I am curious what techniques might be employed.

A. Rivas: We started our tagging program in 1952 in cooperation with the Woods Hole Oceanographic Institution represented by Mr. Frank Mathers. We decided that by using hooks with a very fine leader we could sink the hook deeply in the jaws of the tuna and the leader wire would

break, automatically releasing a tagged fish. With the cooperation of the sportsmen, we succeeded in tagging about 35 fish by that method.

Q. Mather: I think it might be profitable to put more effort into tagging. A new style of tag developed by the California Fish and Game in the Pacific tuna investigation gave us new hopes on the possibility of tagging our tuna successfully. We tried their method this summer and got one return from the sixth fish we tagged. We've modified that tag a bit so it could be applied to large tuna without bringing them into the boat. Mr. Rivas, I have heard from very reliable witnesses that tuna schools are seen feeding at Walker Key, a short distance from Bimini. You mentioned that they started feeding off Jersey. I wonder if you could give an opinion whether that is where they really start feeding?

A. Rivas: The stomachs of practically all the specimens caught in the Bahamas are empty. In addition the stomachs are shrunk, so there is evidence that these fish do not feed there. Where they begin to feed after leaving the Bahamas, I don't know, but it is reasonable to assume that these tuna fill up with mainly herring and mackerel in northern waters.

Smith (Comment): It might be in order to point out some rather broad implications of this tuna migration. It was not until comparatively recent years that the tuna had even been seen going through the Florida straits, and yet there is no reason to believe that they had not been going through there in very considerable numbers for a long period of time. They were there, but nobody had seen them. So, there is a very considerable stock of potentially commercial fish that was not known. If we trace this migration back, there exists a strong possibility that it begins somewhere in the Caribbean Sea. In that case there must be a very considerable tonnage of these pelagic migrants in the Caribbean which have not been seen except possibly by Mr. Rivas and his associates, when they are flying there deliberately looking for them. The importance of this is that in the northern hemisphere at least, where the demersal fisheries of the continental shelf have been pretty completely explored, if we're going to look for a greater production of fish we have to look to these pelagic migrants. Therefore, I think that any study of the patterns and mechanisms of migrations in the case of a fish like the bluefin tuna has implications which extend far beyond this particular species.

Rivas (Comment): I would like to add something concerning the movements of bluefin tuna after they leave Nova Scotia waters in the fall. The general consensus of fishermen was that after the tuna left Nova Scotia in the fall they went directly east, over to Europe. European tuna have a migra-

tory pattern very similar and simultaneous with our western Atlantic tuna. We now know that our tuna spawn in the Straits of Florida during May and June. In the Mediterranean the same thing happens, 4000 miles away, during May and June. Then our big tuna disappear from here and big tuna disappear in the Mediterranean too. Later, behavior is likewise similar in the two groups. In the past two or three years we have been trying to follow our fish on their southern migration by flying out of Bermuda and Puerto Rico and the coast of South America. We've been fortunate enough to pick up a few going south off Bermuda and off Cuba in February, off Puerto Rico, off the island of Tobago and off the coast of South America. Over the Bahama banks we've seen schools of tuna going south out of the Tongue of the Ocean in December. The same thing apparently happens in Europe, so there are two separate simultaneous north and south migrations every year.

Q. Wheeler: Is there anything known about the nocturnal movement of tunas?

A. Rivas: I'm still waiting for an opportunity to fly off the Bahamas at night. So far I don't know whether they move at night.

Q. Wheeler: Do you have any idea what guides the tuna in their migratory behavior?

A. Rivas: I have an idea that they may use sunlight to guide themselves but we know very little about it.

Q. Wheeler: If we assume that light is a consideration in their migratory pattern, then this would surely rule out nocturnal movements, would it not?

A. Rivas: No, because once they had started in a given direction they would keep going in that general direction. Ocean currents seem to affect their migration patterns. Another interesting thing is that these tuna seem to be within a certain isotherm all the way from the Caribbean to the Florida Straits where they spawn. Once the spawning is over they start north and apparently don't pay any more attention to isotherms in temperature. They go in 2 or 3 weeks from temperatures of 28 or 29 degrees Centigrade into waters which are 16 to 18 degrees Centigrade.

Mowbray (Comment): This is a suggestion to answer Dr. Canet's question about tuna investigation in Cuba. It is my opinion that the majority of the bluefin tuna which go by the Bahama's shore migrate past the north shore of Cuba, from the east. I think they come up the old Bahama channel. There is a migration by Bermuda simultaneously with the Bahamas one, and my opinion is that those go in a direct line through Mona Passage or the Windward Passage. I believe if some aerial observation could be carried out in the shallower waters near the eastern and east central portion of Cuba, on the north shore, from about the 15th day of

May to the middle of June, I suspect tuna might be encountered. Whether they can be exploited can only be answered by trying. This year in the Bahamas tournaments they caught 80 to 90 fish during the tournament, and they were wasted, whereas 80 to 90 500 pound fish in Cuba could be utilized. Also, the yellowfin tuna appear off the south shore of Puerto Rico, and I am quite convinced that if long lining were tried off the south coast of Cuba that results would be comparable to those found in the U. S. Fish and Wildlife Service investigation.

Rivas (Comment): We have from the air explored the Bahama channel and the waters all around Cuba for three years, and we have never seen a tuna in that area.

Mowbray (Comment): The reason I seriously believe there may be a migration through the Bahama channel is that Bernard Wheelam tells me bluefin tuna migrate past the coast of Venezuela. It is reasonable to suppose that those fish go around the western end of Cuba, but there is no reason to assume that when they come through the Florida Straits they would cross the Gulf Stream to go up the eastern side of the strait. I still believe that they come up the eastern side of the strait. I still believe that they come up the eastern side through the old Bahama Channel.

## Growth Rate of Sub-Populations of Mullet *(M. cephalus)* On the West Coast of Florida

GORDON C. BROADHEAD

Q. Lindner: What was your method of measuring the tagged mullet when released and upon recovery?

A. Broadhead: The original measurements were made on live fish, of course, and the final measurements on dead fish. I adjusted the final length because of shrinkage which always occurred, due to freezing or handling. This ran around 1½ per cent, but even after this adjustment, I still had a slight "negative" growth on some individuals probably due to greater than average shrinkage, or to inaccurate measurements.

Lindner (Comment): On our shrimp we also got mostly negative growths after short periods too, but I think it was the method of handling, most of them being preserved in formalin.

Q. Van Engel: How were the recaptured tagged mullet recovered? Did you get them from the commercial fisheries from sport fishermen, and if so how did you ask them for the information? It's something that is not very well done in other places, and if we could learn something from your method it would be worthwhile.

A. Broadhead: The recaptured tagged fish come principally from the commercial fishery. Fishermen have been alerted to watch for the fish by personal contact, newspaper publicity and

posters in the fish houses. Mimeographed forms in the fish houses give instructions on how to handle tagged fish caught, and dealers are asked to pay rewards and hold the fish in freezers. The tag bears return instructions too. However, the only certain way to get tagged fish back is with frequent and repeated visits to the fishing areas.

Q. Eddie: Formerly there was quite a mullet fishery carried on in Lake Thorn in Louisiana by Florida and Alabama fishermen. The fishermen came there in the latter weeks of October and caught these migrating mullet heavily laden with roe. This year we encouraged fishermen in Louisiana to fish those mullet, and the fish appeared in the French market for the first time. They were large mullet, up to five pounds, and I wondered in view of the fact that Florida fishermen have had a problem selling small mullet why they had not returned in the Louisiana fishery.

A. Broadhead: Actually the price being paid for large fish now is running from 8 to 10 cents a pound whereas in 1950 the price was as high as 18 cents. So even big mullet do not demand a good price now.

Q. Eddie: Can you throw any light on the area in which the mullet spawn? We are unable to find spawning mullet in the inshore areas.

A. Broadhead: This point has never been been established definitely. Some of our indirect evidence points to an offshore spawning. In our tagging program we examine the fish carefully when they are tagged, and on many occasions in the tagging record it was noted that certain fish were fully ripe, that is either the eggs or the milt were observed. About half of a dozen of these were returned from the commercial fishery in a period of less than two weeks. The fish were from schools that were running offshore, and when the fish were recovered they were taken on the outside, suggesting that they were moving offshore to spawn.

Q. Eddie: The consensus among the fishermen in Louisiana is that the mullet which has already spawned does not return.

A. Broadhead: This does not seem to be right. We have had many fish returned after the spawning season which were tagged several months prior to the spawning period. In fact, the rates of tag return from taggings made during the spawning runs are just as high as are the returns from taggings at other times of the year.

## Seasonal Movements and Growth of the Atlantic Croaker *(Micropogon undulatus)* Along the East Louisiana Coast

ROYAL D. SUTTKUS

Q. Galtsoff: Is the increase in the observed average size explained by the movements of fish to different areas as they grow?

A. Suttkus: Taking a particular year, say 1953, the earliest spawned individuals produced in October, are the first to move out starting in September, October and November of the next year, along with the year class before this, which is the 1952 group. The latter are the individuals resulting from the later spawning, even as late as January and February of 1952. Later spawned individuals, however, will remain in the lake at times as late as November, December, January or February of 1955 more and more of those individuals will move out, leaving the smaller ones in the lake. Thus sampling in the lake does not reflect the size composition of the population.

Q. Eddie: Is the age and the size of the croaker that urges him to move, or is there a correlation between the spawning migration and the season?

A. Suttkus: Temperature can be correlated very nicely with the movement of the bulk of the croakers out of the lake.

Q. Eddie: The hook and line fishermen have also noticed that when croakers migrate in September and October the bulk of the catch is of females. Is there a separate migration or do they migrate simultaneously?

A. Suttkus: The sexes migrate at different times.

Van Engel (Comment): The distribution of croakers is a very interesting subject to us in the Chesapeake Bay. We have had an investigation on the croaker for a number of years. Mr. Dexter Haven of our Laboratory has found large numbers of small croakers at the head of the tide in the rivers of Virginia. In the York River the small croakers of sizes down to about 10 mm. are found December, January and February in a salinity no more than half a part per mill. Also, the number of croakers in Chesapeake Bay and the size of each of the individual fishes may be dependent upon the strength and direction of the tidal currents not only at the mouth of the capes but also in the rivers.

## Behavior of Shrimp in an Electrical Field

JAMES B. HIGMAN

Q. Galler: I gather from the summary of your paper that there is no future for electrical fishing in the shrimp industry. I had a definite impression that the Germans are using electrical fishing in the North Sea with a marked degree of success. What is the difference between their type of fishing and shrimping which makes electrical fishing feasible in Germany?

A. Higman: The German fishing has been experimental and not on a commercial basis. This equipment has since been brought to the United States by the menhaden interests with the idea of catching menhaden at sea. It has not, however, worked as yet on a commercial basis.

Q. Galler: Are the calculations for the amount of amperage and

voltage required based on the type of equipment used in your experiments or are they based on equipment using condensors where it is possible to obtain a tremendous build-up of current?

A. Higman: The power requirement were calculated on the basis of the optimum electrical conditions found in the experimental work.

Q. Osorio: Have you observed any change in reaction after several successive stimulations? Also, what was the effect of size and sex on the reaction of the shrimp to the electrical field?

A. Higman: The stimulation of the fish or shrimp by an electrical impulse is inversely proportionate to their length. It was necessary to use similar size groups in all the tests. Perhaps in this phenomenon we have a conservation measure through selection of the size groups to be taken by the commercial fishery. There was no difference between the sexes in reaction to the electrical stimulus. Preliminary tests showed that you could not run the same batch of shrimp twice, as successive tests rapidly weakened the response.

Q. Menzel: Would the electrical equipment be used on a trawl or would a net type of shrimping gear be necessary?

A. Higman: Some very fundamental work with electrical equipment must be done before it can be applied commercially. Initially we had thought of electrifying a trawl, although not to compete with the standard shrimp net fishing on known shrimp grounds. We did have in mind a pelagic trawl, for fishing above bottom.

## Experiments With Shark Repellants

STEWART SPRINGER

Q. Osorio: In my early years in the northwest of Spain, I learned of the fishermen's tradition that the best repellent for sharks is a rotten shark. I would like you to elaborate some more about this possibility. Also, how do you think sharks which you tested in tanks would react in the natural conditions to the same stimuli?

A. Springer: I would like to answer the last question first. After doing this work with sharks in tanks, experimentation with the sharks in the field was continued for approximately two years, and it was my observation that the sharks in the field reacted very much as did the sharks in the tanks. In the field some additional compounds were found that were effective as feeding inhibiters for sharks. Unfortunately these have been called "repellents", but none of them actually drive the sharks away. The inhibition of shark feeding doesn't even prevent the shark from coming up and bumping the bait. That is a common activity of sharks, and they do it in checking to see if the object is edible.

Presumably they knock a little bit of the material off so that they can judge whether it is edible. Some sharks, such as the tiger shark, will eat *almost* anything—garbage, old shoes and pieces of wire, tin cans and so on—whether or not there is any nourishment in it.

Q. Moore: I believe the implication of your last remark is that the tiger shark will not be deterred by the shark repellent.

A. Springer: We never did get a chance to check on the tiger shark. Unfortunately—or fortunately—they are nocturnal and are extremely cautious. I think that this inhibition involves an automatic reaction. We shouldn't think of sharks as operating on the same level as we do; since their nervous organization is entirely different.

Q. Galler: When was this work conducted?

A. Springer: It was conducted in 1942, between July 1st and some date in September, when the onset of cold weather kept us from getting any more sharks. The use of sharks in tanks is quite complicated and difficult. It is difficult to get enough sharks, and difficult to get them properly adjusted to tank life. These were the limiting factors on the work at Woods Hole—time ran out on us and we had to go on to something else, without answering a lot of questions that come up.

Q. Galler: Are you familiar with the work done recently in Hawaii using irritant substances that effect either the olfactory organs or the eyes of fish and appear to be quite effective with some kinds of fishes?

A. Springer: We tested thiocyanates extensively on dog fish and didn't get favorable results. Substances that are effective on sharks are often not effective on bony fishes.

Q. Franco: You said that the shark flesh was held for four to six days at room temperature. I would like to know what this temperature was.

A. Springer: Approximately 20°C. The shark flesh on being exposed to decomposition becomes slightly alkaline and evidently there is a breakdown, giving off ammonia. One might think that ammonia was the substance that acted as the repellent. Apparently it was not. Neither was trimethylamine or several other of the common decomposition products. We are still not sure what is the essential compound although chemical studies by Dr. Todd indicated that they were organic acids. Almost no other common animal, on decomposition, becomes alkaline. In mammals or reptiles the flesh becomes slightly acid on decomposition.

Q. Wiles: Would a shark 6 to 10 feet long exhibit the same behavior as your trial specimens of 30 inches? I have noticed from my personal experience that sharks of that size are very reluctant to take bait while sharks 5 to 8 feet long go for it. Do you think that the bigger shark would react as cautiously as your smaller shark?

A. Springer: That depends on the size of the bait or of the object being taken. I suspect that all sharks are reasonably cautious when confronted with something of their own size, whereas they have no reason for caution with something small. About 1940 I published an account of the contents of the stomachs of some 200 sharks of the species *Carcharhinus milberti*. This was interesting in that the larger sharks, about 10 feet long, had eaten whole groupers of considerable size whereas the smaller sharks had eaten smaller groupers.

Butler (Comment): On the Pacific coast the common species of shark is *Squalus sucklei* which is similar in size to the ones Mr. Springer worked with. The fishermen trawled for these sharks. Over a period of years, if they dumped the carcasses in an area they were no longer able to make good catches there and they came to the conclusion that the rotting carcasses were the cause for it. One of the processors who wanted to check this for himself built a pen under his plant, captured some of these dog fish and put them in the pen alive. He threw sharks carcasses in one of the corners of the pen and observed that the sharks would avoid that corner.

Q. Moore: During the latter part of the war shark repellents were provided in airplanes to military personnel on a large scale. It appears from what you said that this was largely for morale, or that there was a misplaced confidence in it.

A. Springer: I didn't mean to imply that this material was of benefit only to morale. As long as a bait was within a cloud of the noxious material the effectiveness (as determined by the number of the bites on controls compared with those on protected bait was 95%. This is about as high as you can get, because some sharks will always approach from the upcurrent direction and will not get in the cloud at all. These feeding inhibitors actually do work, but they are difficult to get around the bait at the time that you want to use them. They are not usually effective against sharks that attack nets, because a net is too large to protect, and can only be protected from one side—the downcurrent side—anyway. I hoped that in presenting this paper I would stimulate a careful long term study of shark repellents.

Q. Menzel: Do you think the repellent has a practical application for protecting the yellowfin tuna?

A. Springer: I don't think it would be practical. The substance costs something on the order of a dollar for enough to protect one bait and you can get an average of only 12 to 15 dollars apiece for the tuna. Also, you don't catch them on every hook.

Q. Galler: Did you work with dyes such as the nigrosine?

A. Springer: Yes we did work with dyes. It happened that at the naval research laboratory, a great deal of work was being done

on the dyes and many dyes were on hand. One of them, a water soluable nigrosine apparently had the same feeding inhibition qualities that the shark meat did. It had the additional advantage of showing what area was protected.

Galtsoff (Comment): This interesting discussion of the paper reminds me that the scientific approach always pays good dividends. I wish to call your attention, for instance, to the recent work of the Canadians who found that salmon show a very definite reaction away from low concentrations of materials derived from natural enemies of the fish.

## Problems Concerning the Protection of Shrimp

MILTON J. LINDNER

Q. Osorio: How do you think the commercial shrimp industry will react to your findings?

A. Lindner: I think I tried to explain this morning that you have to decide what you're going after. Make up your mind what you want, and then work it that way. At the moment what you're interested in is, we'll say profits; if you're interested in politics. It depends and fluctuates according to the circumstances.

Q. Llano: Could you elaborate on your statement that the shrimp is its worst enemy?

A. Lindner: My suggestion was that shrimp might be its own worst enemy was based on the 3 waves of spawning success. Spawning is more or less uniform perhaps rising to a peak sometime in June or July, but the success of the spawning comes in waves and seems to be associated with the movement of the shrimp from the nursery grounds into the fishery.

Q. Idyll: This question of the competition among the species is of very fundamental importance. Did you make any reference to data that you may have on competition between the species of shrimp?

A. Lindner: In North Carolina there seems to be a correlation between success of the brown shrimp fishery and failure of white shrimp fishery. This may have happened since 1945 in the northern Gulf of Mexico as the white shrimp have dropped off considerably there while other species are more abundant than formerly.

Q. Idyll: Concerning the rising dominance of the grooved species compared with the white, one suggestion is that there has been a definite change in the population sizes. Another is that the grooved shrimps are more important only because we have discovered how to exploit them. Have you any comment on the two ideas?

A. Lindner: I haven't studied the shrimp since the grooved shrimp fishery became prominent. Undoubtedly, the increased exploitation of the grooved stocks has a great deal to do with it.