MFR PAPER 997

Off the glorious Kona coast of the Island of Hawaii, sportsmen and scientists have gathered for 11 summers to study the habits of the billfish.

Investigations of Billfish Biology at the Hawaiian International Billfish Tournament

JOHN J. NAUGHTON

ABSTRACT

Since 1962 the Southwest Fisheries Center's Honolulu Laboratory, National Marine Fisheries Service, has sent an investigating team to the annual Hawaiian International Billfish Tournament. There the team collected biological data for marine sport fisheries research. This paper outlines the tournament and NMFS participation and summarizes data collected there from 1962 to 1972. In order of abundance, billfish species taken by tournament anglers were Pacific blue marlin, Makaira nigricans; *striped marlin,* Tetrapturus audax; *black marlin,* M. indica; *sailfish,* Istiophorus platypterus; *and shortbill spearfish,* T. angustirostris. *Yellowfin tuna,* Thunnus albacares, *weighing 100 lb. or more also qualified and was the second most abundant game fish species taken. Results of investigations are discussed including marlin diet, sex ratio, sexual dimorphism, fishing effort, and marlin movements on the fishing grounds.*

INTRODUCTION

The Hawaiian International Billfish Tournament (HIBT) has been conducted off the west (Kona) coast of the island of Hawaii every summer since 1959. Beginning in 1962, the Southwest Fisheries Center's Honolulu Laboratory, National Marine Fisheries Service (NMFS), has sent an investigating team to each tournament to collect biological data from billfish taken by tournament anglers. This paper outlines the Honolulu Laboratory's participation in the tournament, describes the methods of collecting data, and presents a summary of these data.

John J. Naughton is a Fishery Biologist, Southwest Fisheries Center, NMFS, NOAA, Honolulu, HI 96812.

THE TOURNAMENT

The HIBT is an 8-day event held each year during the summer months, usually July or August. Fishing is done for 5 days, Monday through Friday, from 8 a.m. to 5 p.m. Some 50 to 85 select foreign and U.S. teams participate, with Hawaiian teams comprising a large part of the U.S. representation. Each team consists of up to six members, with any four permitted to fish on a given day.

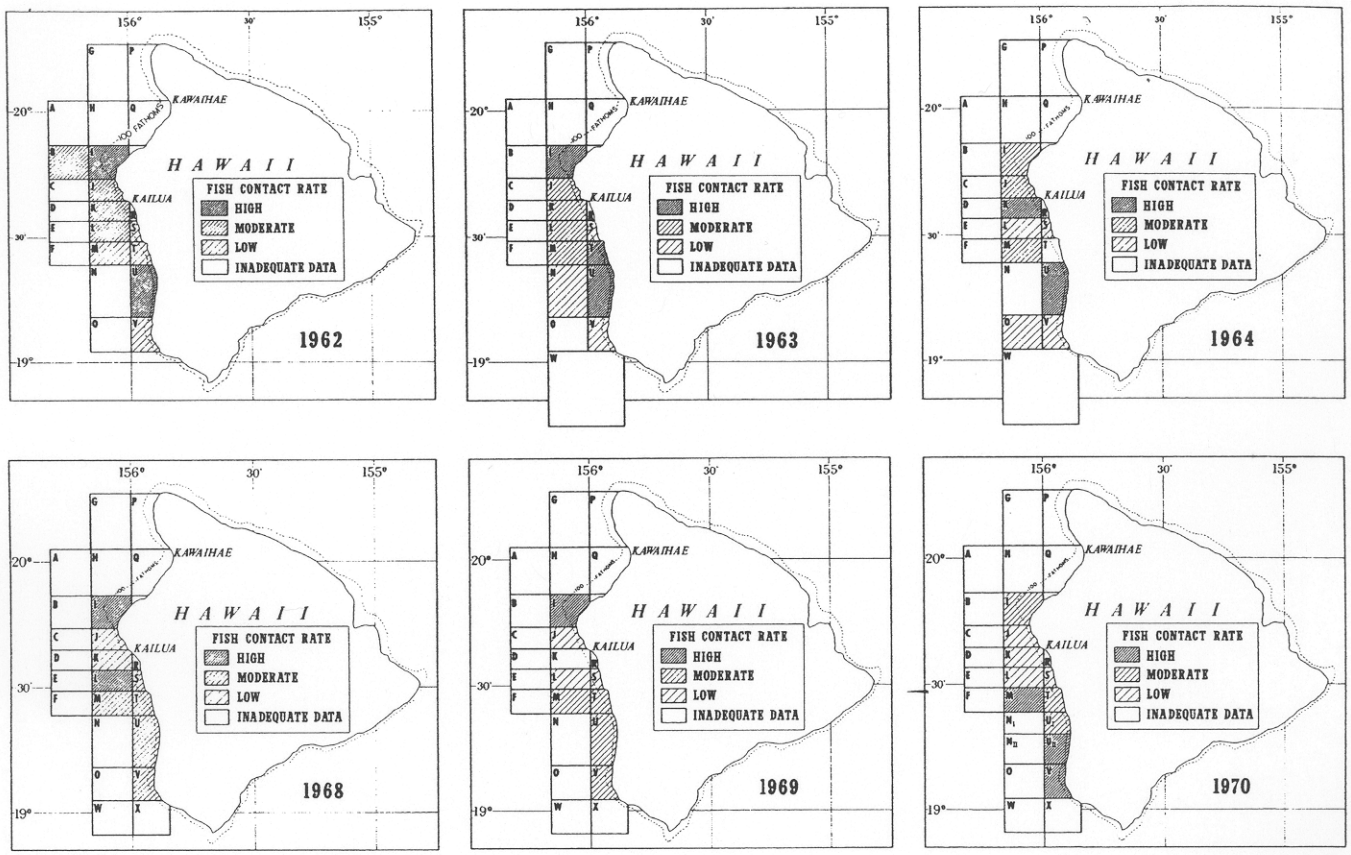
Trolling artificial lures at 5 to 8 knots or live bait at either very slow speeds or while drifting are the two methods of fishing allowed. International Game Fish Association rules are strictly adhered to. Fishing is done from individually owned or chartered trolling boats ranging in length from 16-ft outboards to 50-ft diesel powered sampans. Only fish caught on rod and reel qualify. Handlines are permitted solely for the catching of bait.

The fishing area extends the entire length of the west coast (Kona Coast) of the island of Hawaii. A grid system divides it into 26 different areas (Figure 1). All fish submitted for scoring are landed at the pier in Kailua-Kona and weighed on the official scale. Anglers fill out prize entry forms and exhibit the bait, rod, reel, gaff, and tackle with which their fish were caught, as well as furnish names of all witnesses.

Although the tournament is a billfish tournament, tuna weighing 100 lb. and over qualify. The yellowfin tuna, *Thunnus albacares*, is the predominant species of large tuna taken by trolling in Hawaiian waters and the only species weighing over 100 lb. recorded from the tournament catch.

Scoring in the HIBT is as follows:

1. Marlin competition is on a team basis.
2. Tuna competition is on an individual basis.
3. The basic award in both divisions is one point per pound.
4. There is a 30% bonus for marlin caught on 80-lb. test line.
5. There is a 100% bonus for marlin caught on 50-lb. test line.
6. There is a 100-point bonus for the largest marlin of the day.
7. There is a 100-point bonus for the largest marlin of the tournament.
8. Bonus points for the largest fish of the day and the tournament are awarded on the basis of the weight of the fish exclusive of any bonus points for line strength.
9. In the event of a tie for the biggest fish of the day or the tournament, bonus points will be divided evenly.
10. In case of a tie in points at the conclusion of the tournament in the billfish division, the team having



caught the largest fish of the tournament will be declared the winner.

PARTICIPATION BY THE NATIONAL MARINE FISHERIES SERVICE

At least one staff member from the Honolulu Laboratory, NMFS, is at the tournament each year in an official capacity as tournament biologist. Prior to each tournament he prepares a newsletter which is distributed to all participating anglers. It asks for their continued cooperation and outlines exactly what data will be collected at the tournament that particular year. The biologist sets up a display at tournament headquarters depicting fishery research activities carried out by the Honolulu Laboratory. He presents a talk at the pre-tournament briefing session for charter boat skippers and competitors, again going over what data will be collected and assuring anglers that no fish will be touched without the angler's permission.

During fishing days the biologist compiles fish contact and fishing effort data by monitoring the three daily radio reports transmitted to tournament headquarters by the fishing fleet. Tabulation of these data enables a fish contact rate chart to be compiled for each tournament (Figure 1).

After the fish are landed they are hoisted and weighed. At this time the biologist assists in the species identification. The fish are then transported to an observation area where the biologist takes morphometrics, dissects the fish for stomach content analysis, determines sex and condition of gonads, and carries out other specific sampling, e.g., collecting different tissues for determination of mercury content.

The weigh-in activities are of great interest to tourists and residents, and large crowds accumulate on the pier. Bleachers are set up for spectators, and an announcer describes weigh-in activities. The biologist periodically provides the announcer with the results of his examinations, such as the stomach contents and sex of each fish and other information of possible interest to the spectators. A variety of questions on billfish biology and fishery biology in general are often directed by the spectators to the biologist. The tournament participants themselves ask many questions of the same nature. The attending biologist must have therefore an up-to-date recall of basic as well as specific information concerning billfish and research programs of the Honolulu Laboratory.

Upon completion of the tournament

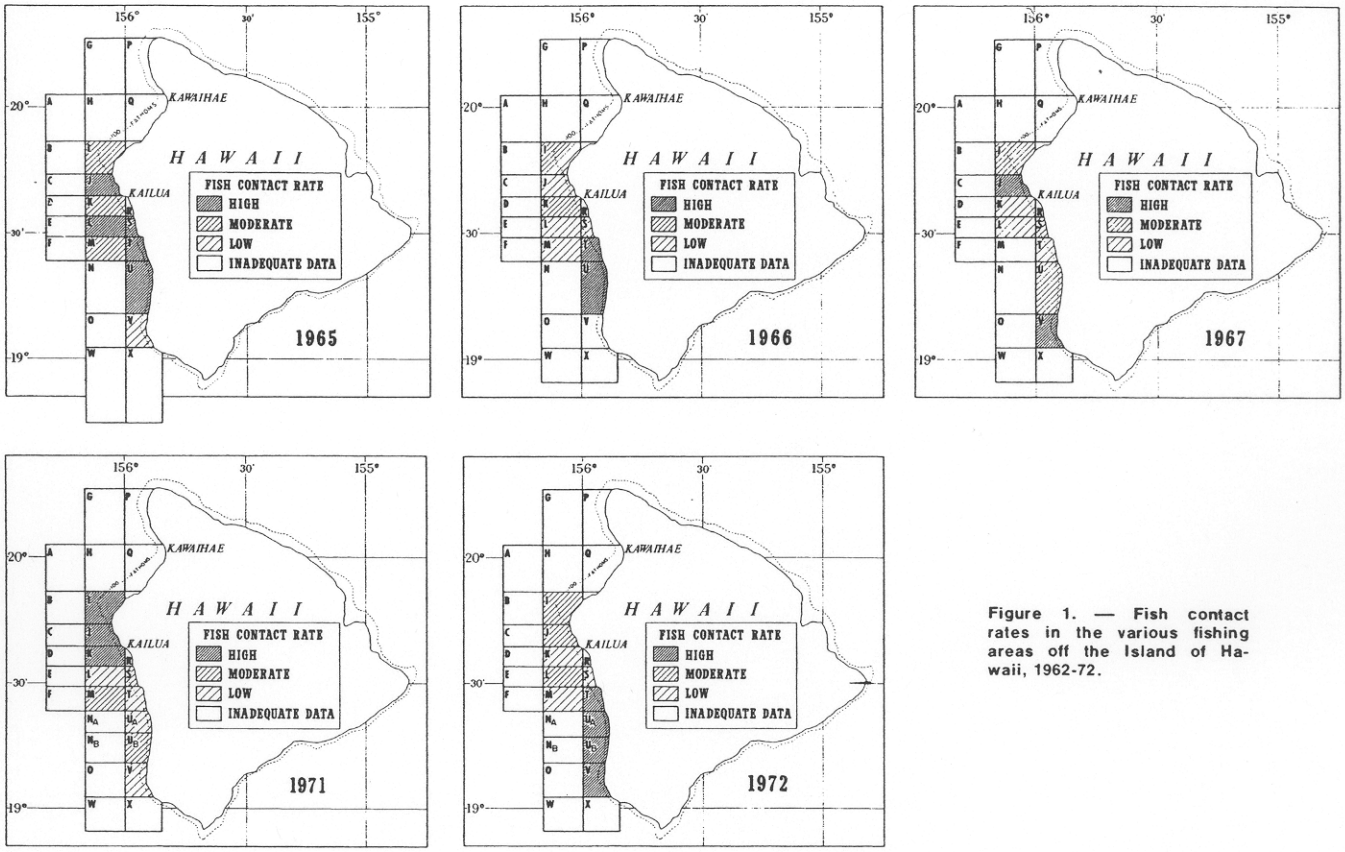


Figure 1. — Fish contact rates in the various fishing areas off the Island of Hawaii, 1962-72.

the biologist compiles a report.[1] describing the results of his investigations. This report is sent to all tournament participants, charter boat captains, and tournament staff.

During recent tournaments biologists on the Honolulu Laboratory's research vessel *Charles H. Gilbert,* working in conjunction with local charter boats, have been involved in tracking marlin for studies of their movements in Kona waters. The tags used in tracking are acoustic transmitters which are temperature sensitive. Thus, the water temperature around the fish may be determined by measuring the pulse rates. By combining this information with data on the temperature-depth profile of the water, the depth of the marlin can be determined.

Tracking is generally done during the week prior to the tournament. Once a marlin is hooked by the smaller, more maneuverable charter boat, the research vessel is contacted and alerted for tracking. As quickly and carefully as possible the marlin is brought alongside, where its condition is checked and its size estimated. If it appears to be in good condition the transmitter is attached to the dorsal surface of the marlin with a small anchor plate inserted just beneath the tough skin. The fish is released, and tracking begins.

In earlier tournaments large plastic drift panels were released in the fishing area by Honolulu Laboratory research vessels as part of a study of the surface currents off the Kona Coast. Whenever a panel was sighted by a tournament fishing boat its position was radioed back to headquarters. This enabled the NMFS biologist to plot the movements of the panels while they stayed on the fishing grounds. These experiments were carried out for five consecutive tournaments (1965-69) with excellent cooperation received from both charter boat captains and tournament anglers. Results confirmed the existence of a pair of large eddies in the fishing area, the northern one rotating counterclockwise and the southern rotating clockwise. Attempts to correlate fishing success with different features of these currents yielded no conclusive information; therefore, the drift panel experiments were terminated.

RESULT OF INVESTIGATIONS

The Catch

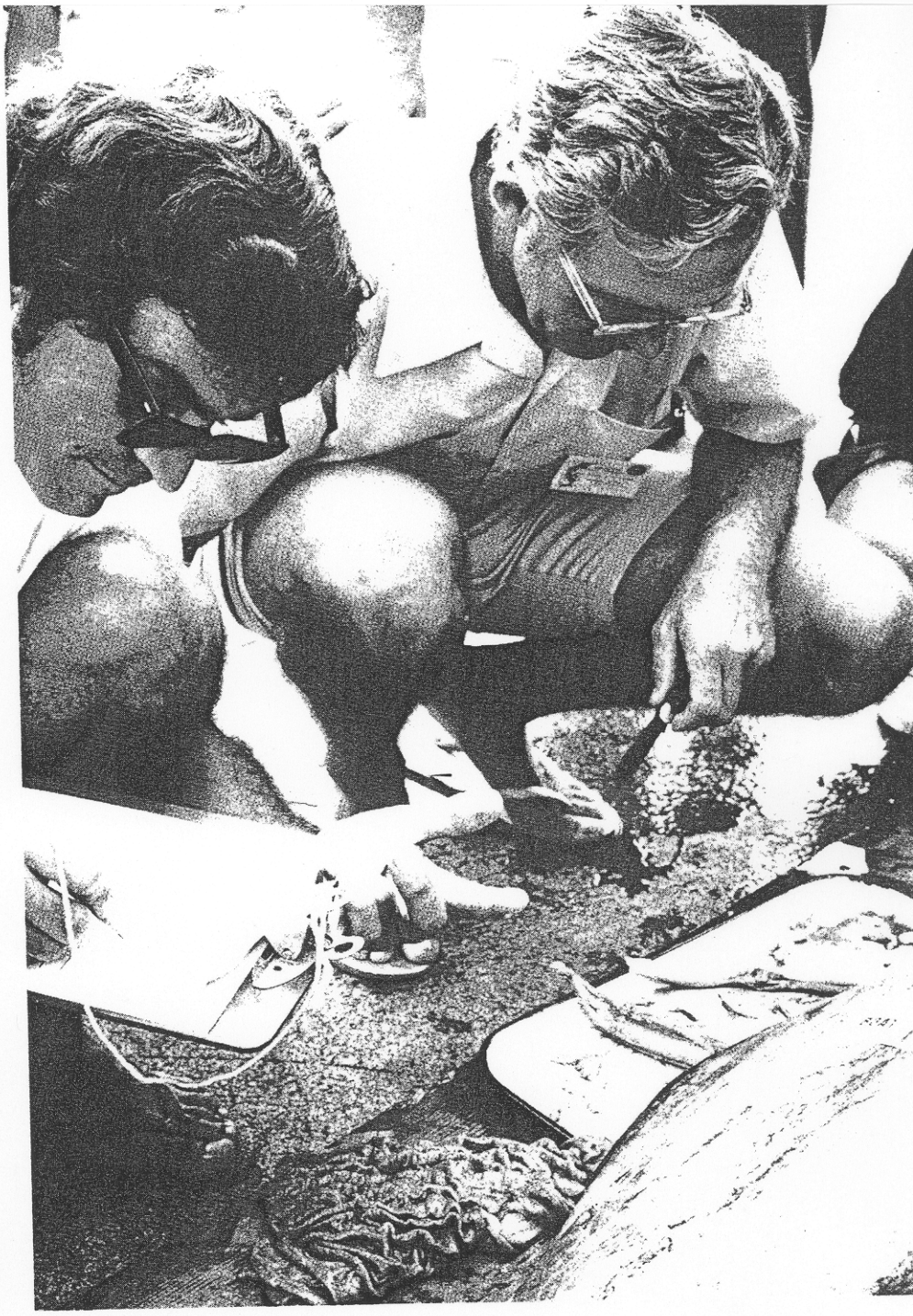
The total catches of qualifying game fish for the HIBT from 1962 to 1972

[1]Report to participants of the Hawaiian International Billfish Tournament from 1962 to 1972. Mimeogr. Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96812

are documented in Table 1. For billfish, the Pacific blue marlin, *Makaira nigricans,* made up the greatest proportion of the catch (72.4%) with striped marlin, *Tetrapturus audax,* a poor second (2.1%). Black marlin, *M. indica* (1.3%), sailfish, *Istiophorus platypterus* (0.4%), and shortbill spearfish, *T. angustirostris* (0.2%) were taken rarely during the tournament. Because the blue marlin made up such a high percent of the tournament catch it is the only billfish species yielding sufficient data to discuss.

The abundance of blue marlin and lack of striped marlin taken during the tournaments is not surprising. Investigations of longline catches from Hawaiian waters clearly reveal a high catch rate for blue marlin during summer months and low catches during the winter (Strasburg, 1970). The reverse is true with striped marlin, which tend to be taken in large numbers when the blue marlin catch is lowest.

There are two possible factors to explain this segregation of species. The most probable is temperature. Striped marlin tend to live in cooler waters; therefore they move north in the summer (Howard and Ueyanagi, 1965), while the blue marlin possibly replace them from the south. Although trolling records are poor for year-round billfish catches in Hawaiian waters, personal observations indicate a substantial number of blue marlin taken by trolling even in the winter months. This tends to substantiate temperature as a major segregating factor, assuming those blue marlin that are still in Hawaiian waters remain in the warmer surface waters during winter and are therefore more susceptible to trolling and less to deep fishing longline gear.



Biologists John J. Naughton (left) and Robert T.B. Iversen examine stomach contents of fish caught at Hawaiian International Billfish Tournament.

Another factor which may explain this segregation is food supply. As discussed below, stomach contents of blue marlin caught during the tournament contain a high percentage of tuna, while striped marlin seem to prefer a variety of smaller fish, squid, and crustaceans. It has been shown that seasonal distribution of blue marlin and skipjack tuna, *Katsuwonus pelamis,* in Hawaiian waters coincide quite well (Strasburg, 1970). This would indicate that the appearance of large numbers of blue marlin may be related to the presence of one of their primary forage species.

It is not surprising that black marlin and sailfish are low in the tournament catches, since they are primarily found near continental land masses (Howard and Ueyanagi, 1965). Both are taken infrequently by local commercial longline vessels. The shortbill spearfish is rarely taken trolling although it is often seen in the local longline catches. This would indicate a subsurface exis-

tence for this species, at least in Hawaiian waters. The same is true for the swordfish, *Xiphias gladius*, which yields no record of having been taken by trolling in Hawaii, yet during late spring and early summer is common in local longline catches.

Yellowfin tuna weighing 100 lb. and greater is the second most abundant sport fish taken during the tournaments, as evidenced in Table 1 (23.6%). In fact, in 1971 it was the most abundant species in the catch. Generally these large yellowfin are more commonly caught by trolling in Hawaii during the summer months when the tournament is held. However, they can be taken year-round with spectacular runs developing at any time.

Table 1. — Numbers of qualifying game fish landed and teams fishing during Hawaiian International Billfish Tournaments, 1962-72.

Year	Blue marlin	Black marlin	Striped marlin	Shortbill spearfish	Sailfish	Yellowfin tuna ≥ 100 lb.	Total qualifying fish	Number of teams	Number of boat days fishing per fish
1962	30	1	—	—	1	19	51	68	6.7
1963	19	2	1	—	—	26	48	72	7.5
1964	31	—	1	—	—	2	34	69	10.1
1965	47	—	—	—	—	9	56	78	6.9
1966	26	3	2	—	—	7	38	72	9.5
1967	63	—	1	—	—	18	82	68	4.2
1968	36	2	4	—	—	4	46	85	9.2
1969	32	1	—	—	—	4	37	75	10.1
1970	91	—	2	—	2	14	109	73	3.3
1971	41	—	3	1	—	47	92	77	3.4
1972	77	—	—	—	—	11	88	59	3.4
Total	493	9	14	1	3	161	681	72*	6.8*
Percent of catch	72.4	1.3	2.1	0.2	0.4	23.6	100		

*Average.

Marlin Diet

Although billfish show great variations in dietary trends between different species as well as among separate populations of the same species (Strasburg, 1970), they are often quite consistent in their diets from any one area. The blue marlin stomach contents examined at the tournaments match contents of blue marlin caught on local longline, in that smaller scombrids (skipjack, yellowfin, kawakawa, *Euthynnus affinis*, and albacore, *Thunnus alalunga*), carangids, and squid predominate. During some tournaments, however, a sudden change occurs in their diet when an influx of uncommon forage items appears on the fishing grounds. As an example, during the 1972 tournament (Table 2), the young of a goatfish, *Mulloidichthys* sp., and a species of spiny puffer, Diodontidae, obviously became important food items, ranking comparably with the more conventional blue marlin food. It would appear, therefore, that blue marlin in Hawaiian waters feed on whatever forage species are available.

Some of the more unusual stomach contents from tournament-caught blue marlin have included juvenile billfish (including swordfish), deepwater lancetfish (Alepisauridae), and a 63-lb. bigeye tuna, *T. obesus*, found in the stomach of a 748-lb. blue marlin. The occurrence of deepwater lancetfish in very fresh condition indicates that blue marlin may be feeding at considerable depths during the day.

The few striped marlin from the tournament that have been examined usually contain pelagic stages of reef fish, squid, and crustaceans in their stomachs. Invariably the angler who takes an unusual billfish species (sailfish or shortbill spearfish) wants it mounted for a trophy; therefore, they rarely are dissected.

Table 2. — Stomach contents of blue marlin, *Makaira nigricans*, from Hawaiian International Billfish Tournament, 1972.

Food items		Day and number of stomachs containing listed food items					Percentage of occurrence
		August					
		7	8	9	10	11	
Fish							
Tuna	Scombridae						
Skipjack	*Katsuwonus pelamis*	—	—	—	1	1	3
Kawakawa	*Euthynnus affinis*	—	—	—	1	—	1
Unidentified		2	7	9	5	5	39
Mahimahi	Coryphaenidae	—	—	4	—	4	11
Jacks	Carangidae						
Opelu	*Decapterus pinnulatus*	—	2	2	1	3	11
Unidentified		1	—	—	—	1	3
Lancetfish	Alepisauridae	—	—	—	1	1	3
Goatfish	Mullidae						
Oama	*Mulloidichthys* sp.	2	3	2	4	4	21
Cardinalfish	Apogonidae	—	—	—	1	—	1
Squirrelfish	Holocentridae	—	—	2	1	—	4
Surgeonfish	Acanthuridae	—	—	—	—	1	1
Bonnetmouth	Emmelichthyidae	1	—	—	—	—	1
Pelagic spiny puffer	Diodontidae	3	6	7	2	4	31
Puffer	Tetraodontidae	—	1	—	—	—	1
Unidentified fish							
Large >12 inches		—	—	2	2	—	6
Small <12 inches		1	2	7	4	3	24
Invertebrates							
Squid	Decapoda	1	8	9	4	6	39
Empty or everted stomachs		3	2	1	5	2	18
Number of blue marlin examined		11	17	17	17	10	—
Total: 72							

Sex Ratio and Sexual Dimorphism

An unusual phenomenon noted from blue marlin catches in the tournament is the high ratio of males to females (Table 3). A random sample of 694 blue marlin from the Hawaiian longline catch consisted of 334 males and 360 females (Strasburg, 1970). Only during the 1964 tournament, however, did the sex ratio approach this expected 1:1 condition. It would seem that during the other 10 tournaments the blue marlin were segregated by sex on the fishing grounds.

Tournaments which produced the highest numbers of blue marlin (1965, 1967, 1970, 1972) also revealed the largest male to female ratios (4.4:1, 3.9:1, 4.5:1, and 8.0:1, respectively). The 8:1 ratio from the 1972 tournament catch is especially noteworthy. The unusual abundance of male blue marlin during these years was a major factor contributing to the success of those particular tournaments. Whether this surplus of males is due to fishing gear selectivity, a feature of reproduction or feeding behavior, or some other unknown factor is not yet known.

The weights of the 493 blue marlin caught in the tournaments from 1962 to 1972 ranged from 48 to 809 lb. Males ranged from 48 to 377 lb. whereas females were from 96 to 809 lb. Blue marlin, as well as black marlin, are known for their marked sexual dimorphism, with females attaining a much larger size (Royce, 1957). A general rule is that a blue marlin heavier than 300 lb. is a female. Of the 340 males taken during the tournaments only three were over 300 lb., weighing 309, 314, and 377 lb. each.

Table 3. — Sex ratios for blue marlin, *Makaira nigricans*, examined from Hawaiian International Billfish Tournaments, 1962-72.

Year	Number of males	Number of females	Ratio males to females
1962	16	7	2.3:1
1963	13	6	2.2:1
1964	14	12	1.2:1
1965	35	8	4.4:1
1966	16	8	2.0:1
1967	51	13	3.9:1
1968	24	10	2.4:1
1969	23	8	2.9:1
1970	63	14	4.5:1
1971	21	9	2.3:1
1972	64	8	8.0:1
Total	340	103	3.3:1*

*Average.

Fishing Effort

Team radio reports are given at 10 a.m., 12 noon, and 3 p.m. Each team reports fishing areas and time spent in each, number of strikes, hook-ups, or boated fish since the last report, and the area of its reported fish contacts. Fishing effort is measured by fish contact per boat hour by fishing area. Each fish contact is counted only once as either a strike, hook-up, or boated fish. Allowance is made for the different lengths of the reporting periods and for the varying number of boats in each period and area. Only those areas in which five or more boats fished for one or more reporting periods are assigned a final rating.

The distribution of fish contact rates by fishing area for the 1962 to 1972 tournaments is shown in Figure 1. Often areas that produced the greatest catches did not necessarily have the highest fish contact rates. For example, area I produced the most blue marlin in 1972, but in final tabulation it only warranted a moderate contact rating (Figure I). This indicates that fishing effort was more intense in I, but that if the same boats had ventured south during the tournament to areas T, U_A, U_B, or V, their chances of taking a fish would have been better.

The last column in Table 1 summarizes fishing effort for the HIBT from 1962 to 1972. When number of boat days fishing per fish landed are considered, the 1967, 1970, 1971, and 1972 tournaments are all well below the average of 6.8 boat days per fish. As mentioned previously an influx of male blue marlin appears to be responsible for the success of three of these four tournaments. The exception, the 1971 tournament, was successful because of a tremendous run of large yellowfin tuna that year.

Another factor which perhaps contributed to the success of these tournaments was tidal phase. The NMFS biologists have been plotting fish contact rates against tidal cycle for most of the tournaments. Early observers noted from these data a suggestion that fishing for the most part was better during a rising tide with maximum range, such as that associated with a new moon. These observations were confirmed by charter boat captains and several tournament staff members. Because of this, recent tournaments have been scheduled to coincide with this feature of the tidal cycle, and, as can be seen from Table 1, the last three tournaments have been most successful.

Marlin Movements on Fishing Grounds

One week prior to the 1971 and 1972 tournaments five blue marlin were tagged with sonic tags and tracked: one during July 14-15, 1971 and four between July 25 and 28, 1972. Following is a summary of these tracking experiments from Yuen (in press). The first tagged marlin was tracked for 22 hr and 25 min before a malfunction in the tracking equipment forced a halt (Figure 2). This fish was a blue marlin estimated to weigh 600 lb. The second marlin was in doubtful condition when released and was difficult to track. Contact was lost after an hour. The third fish was tracked for 5 hr and 22 min before it was lost owing to a tactical error. The fourth marlin was abandoned after 7 hr when it remained stationary on the bottom soon after it was tagged, indicating that in all probability it had died. After 2 hr of swimming, the fifth marlin also went to the bottom.

Several features stand out from the marlin tracking studies. All viable marlin showed indication of staying above precipitous bottom, in this case between the 100- and 1,000-fathom iso-

baths. Although usually well above these depths, they apparently could sense some feature of the rapidly sloping escarpments far beneath them. The viable marlin also all moved in a northerly direction when released. From the drift panel studies it was determined that the current system west of the northern half of the island of Hawaii forms a counterclockwise eddy during the summer months with the inshore portion flowing northward. All marlin tracked appeared to be in this current system, and the fact that they moved north suggests the possibility that blue marlin orient or swim with currents. Swimming depths were quite different among the marlin tracked, ranging from the surface to 185 m. Vertical movements showed no pattern that could be related to time of day.

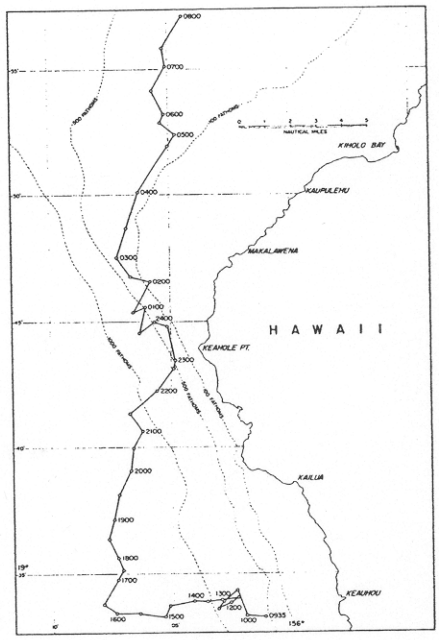


Figure 2. — Track of tagged Pacific blue marlin (ca. 600 lb.) during July 14-15, 1971. Positions on track taken at half-hour intervals.

CONTINUED INVESTIGATIONS

The HIBT has a long history of sports fisherman-scientist cooperation. This was highlighted by the unique International Billfish Symposium held to coincide with the 1972 tournament (Anonymous, 1972). Because relatively little is known concerning the status of billfish, both from a commercial as well as a sport fishing point of view, it is important to monitor these periods of intensive sampling that occur during tournaments. A substantial number of billfish tournaments are held throughout the world every year. It would be helpful if scientific investigations could be carried out at each tournament on a continuing basis.

ACKNOWLEDGMENT

I would like to thank Mr. Peter Fithian and the other members of the Board of Governors, HIBT, for their continuing cooperation in helping us collect data at the tournaments. I am also indebted to the charter boat captains and tournament anglers who provide fishing statistics and allow us to examine their catches.

LITERATURE CITED

Anonymous. 1972. 8 countries represented at billfish symposium. Mar. Fish. Rev. 24 (9-10):58-61.

Howard, J. K., and S. Ueyanagi. 1965. Distribution and relative abundance of billfishes (*Istiophoridae*) of the Pacific Ocean. Stud. Trop. Oceanogr. Inst. Mar. Sci., Univ. Miami 2, 134 p.

Royce, W. F. 1957. Observations on the spearfishes of the central Pacific. U.S. Fish Wildl. Serv., Fish. Bull. 57:497-554.

Strasburg, D. W. 1970. A report on the billfishes of the central Pacific Ocean. Bull. Mar. Sci. 20:575-604.

Yuen, H. S. H., A. E. Dizon, and J. H. Uchiyama. In press. Notes on the tracking of the Pacific blue marlin, *Makaira nigricans*. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF.

MFR Paper 997. The paper above is from Marine Fisheries Review, *Vol. 35, No. 8. Reprints of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.*

☆GPO 799-41