

TRAWLING RESULTS OF THE R/V ANTON BRUUN IN THE BAY OF BENGAL AND ARABIAN SEA

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SUMMARY

Trawling surveys in the Bay of Bengal and in the Arabian Sea were conducted in 1963 from the National Science Foundation research vessel Anton Bruun as part of the United States contribution to the International Indian Ocean Expedition. Relatively small shrimp catches obtained may reflect a distribution of shrimp concentrations in shallower waters than were surveyed. Demersal fish in the Bay of Bengal generally were similar to those observed in the Arabian Sea. Stingray dominated the catches in all regions at depths less than 50 fathoms.

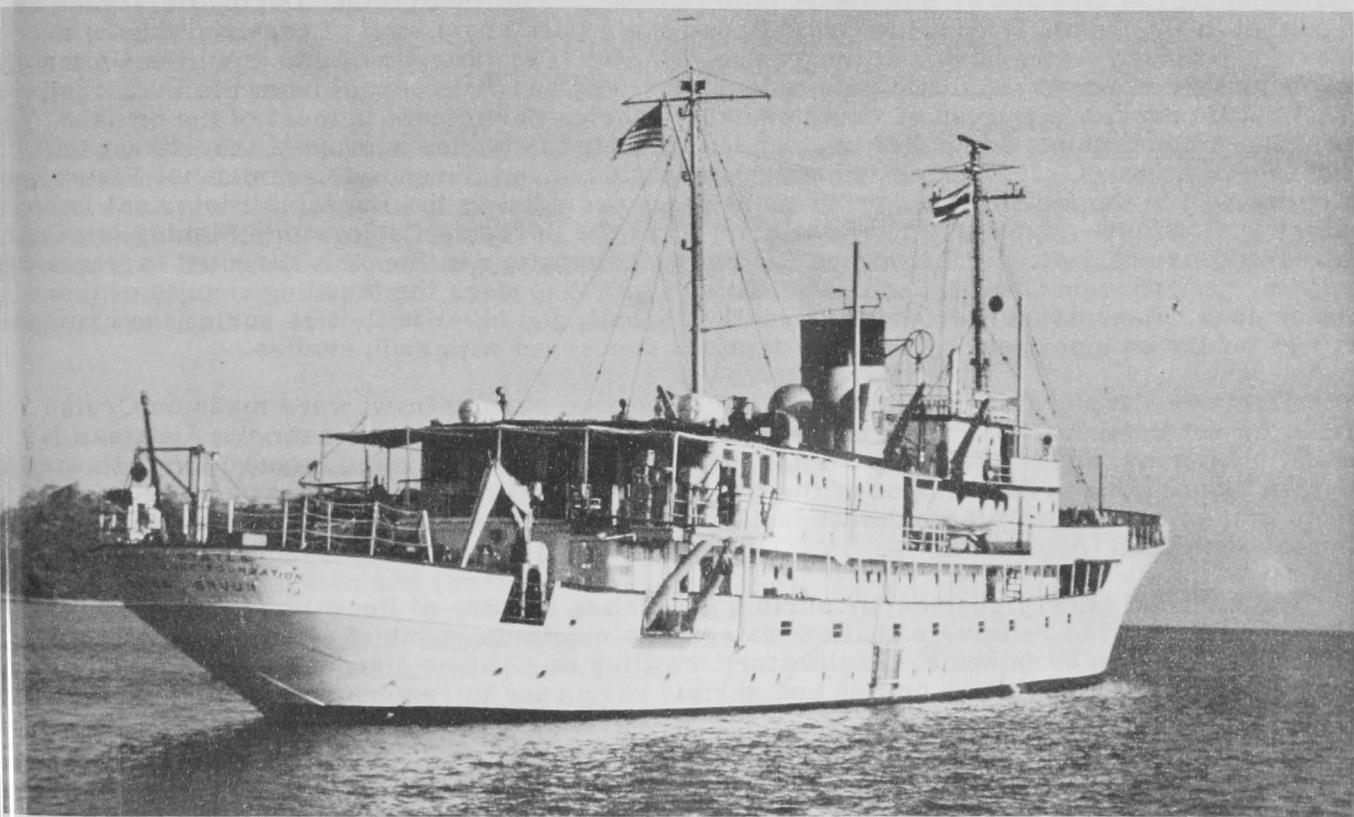


Fig. 1 - United States National Science Foundation research vessel Anton Bruun at anchor off Phuket, Thailand, during Cruise 1 in the Bay of Bengal.

Largest fish catches were taken off Muscat and Oman (Arabia). The precipitous and uneven ocean bottom at depths greater than about 100 fathoms in both the Bay of Bengal and the Arabian Sea, together with relatively few demersal fish at such depths, would seem to hinder if not preclude developing deep-water trawl fisheries.

INTRODUCTION

The International Indian Ocean Expedition (I.I.O.E.) is sponsored by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) with the cooperation of the International Fishery Biologist, Exploratory Fishing and Gear Research Base, U. S. Bureau of Commercial Fisheries, Seattle, Wash.

U. S. DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Sep. No. 717

national Council of Scientific Unions. It is an unprecedented, cooperative, international study of the seas, and represents the first attempt to study scientifically an entire ocean. More than 40 vessels and several hundred scientists from many nations are participating in the 3-year program. Information on the Indian Ocean will permit more accurate weather forecasting, charting sea currents, and more economical navigational routes, locating latent fisheries resources, and compiling new hydrographic charts.

From March 12 to May 10, 1963, and from November 12 to December 10, 1963, trawling surveys of the Bay of Bengal and the Arabian Sea, respectively, were conducted from the National Science Foundation research vessel Anton Bruun (fig. 1). Those surveys were part of the participation in the I.I.O.E. in which various governmental groups and educational and private institutions are participating.

The scientific program from the 243-foot Anton Bruun (formerly the Presidential yacht Williamsburg) is directed by the Woods Hole Oceanographic Institution. During its 2-year assignment in the Indian Ocean, the Anton Bruun has a permanent staff of oceanographers to provide continuity in the basic oceanographic program. Visiting scientists from the United States and other countries participate in individual cruises. Personnel from the U. S. Fish and Wildlife Service's Bureau of Commercial Fisheries participate in most of the cruises from the Anton Bruun, and on 4 of the cruises involving fisheries surveys¹ they direct the fishing activities. Overall direction and coordination of the Bureau of Commercial Fisheries participation in the Indian Ocean program is being provided by the Bureau's Biological Laboratory in Honolulu. Scientists and fishermen from the Bureau's Exploratory Fishing and Gear Research Base at Seattle and from the Biological Laboratory in Honolulu directed exploratory trawling activities on Cruises 1 and 4B. This report discusses the trawling results of those two cruises. Reports on hydrographic, ichthyological, and other activities during the cruises will be published elsewhere by the investigators concerned with such studies.

Thirty-one exploratory hauls with a Gulf of Mexico shrimp trawl were made on Cruise 1 in the Bay of Bengal. Hauls were made off the west coast of Thailand, near the Andaman Islands, off Burma, and off East Pakistan. The trawling phase of Cruise 1 ended 1 month earlier than planned due to malfunction of the trawl winch. On Cruise 4B, 86 trawl hauls were made in the Arabian Sea off northwest India, off West Pakistan, in the Gulf of Oman, and off Muscat and Oman (Arabia).

Commercial trawl fisheries for shrimp and fish in the Bay of Bengal and in the Arabian Sea are restricted to relatively shallow waters of a maximum depth of about 40 fathoms and generally less than 20 fathoms. Exploratory trawling on Cruises 1 and 4B was primarily designed to provide information on fish and shrimp resources in regions and at depths not presently exploited.

On Cruise 1 in the Bay of Bengal the vessel track was chosen to accommodate both oceanography and exploratory fishing; on Cruise 4B in the Arabian Sea, exploratory fishing only.

GEAR AND METHODS

Nylon Gulf of Mexico shrimp trawls (Schaefers and Johnson 1957) measuring 42 feet along the footrope and having a mesh size of $1\frac{1}{2}$ inches (stretched measurement, opening including one knot) were used on both cruises. The trawl was connected by a 25-fathom-long bridle to a single towing warp. A rectangular otter board measuring $2\frac{1}{2}$ feet by 5 feet and weighing 160 pounds was attached to each wing of the net when trawling to depths of 200 fathoms. Below 200 fathoms heavier boards (260 pounds each) were used.

The shrimp trawl was towed from an A-frame on the starboard side of the Anton Bruun. A hydraulic crane located aft of the A-frame lifted the net and doors outboard and inboard and lifted the cod end of the net aboard after each haul. A "lazy line"--a nylon rope with a loop on one end passing through puckering rings on the forward portion of the cod end--was used to pull the net alongside the Anton Bruun and to lift the cod end aboard.

¹/Cruises 2 and 5 are tuna surveys employing pelagic long-line gear; Cruises 1 and 4B are bottom-trawling surveys.

Echo-sounding tracings of the ocean bottom were obtained whenever the Anton Bruun was under way. They were supplemented by more detailed soundings prior to trawling and by samples of bottom sediments obtained with a small dredge or a spring-loaded bottom grab.

The Anton Bruun is powered by two main engines supplemented by an active rudder. Using the port engine the vessel moved at 6 to 8 knots during setting of the trawl. When approximately 50 to 100 fathoms of cable remained to be let out on each haul, the vessel was slowed by reducing speed of the port engine as low as possible and running the active rudder in reverse. This was done in an attempt to have the vessel proceeding at standard trawling speed when the trawl reached the ocean bottom. Either the port engine, the active rudder, or a combination of both was used to maintain trawling speed after the net reached the ocean bottom. Trawling speed ranged between 2 and $3\frac{1}{2}$ knots.

The ratio between the amount of towing warp out and the depth to bottom was greater in shallow water than in deep water, ranging from 6 to 1 (6 fathoms of cable to 1 fathom of depth) in less than 20 fathoms to approximately $2\frac{1}{2}$ to 1 at 1,000 fathoms. To ensure that the trawl reached bottom, a practice was followed of using slightly higher ratios than were found satisfactory in exploratory trawling with identical gear in the northeastern Pacific Ocean (Pereyra 1963).

Duration of the hauls varied between 30 and 60 minutes, counted as the time the net was on the bottom. Catches were emptied onto a sorting table and separated by family (genus or species when possible). Each group was examined (1) to determine the number of individuals present and their total weight, and (2) to estimate their range in length by measuring the total lengths of the smallest and largest individuals present. Length frequencies were obtained from representative samples of some groups of fishes. For the larger shrimp catches, estimates of the number of whole (heads on) shrimp per pound were recorded.

REGIONS SURVEYED

Locations of trawl stations in the Bay Bengal and in the Arabian Sea are shown in figures 2 and 3. The topography of the continental shelf (depths to 100 fathoms) in all regions surveyed was generally suitable for trawling except off Muscat and Oman and in the Gulf of Oman where numerous coral outcroppings were encountered. Green mud was the dominant bottom sediment in both the Bay of Bengal and the Arabian Sea. The continental slope was precipitous and uneven in all regions surveyed. This precluded much trawling at depths greater than about 100 fathoms.

For convenience in analyzing the distribution and relative abundance of fish and shrimp encountered, the survey regions were divided into the following areas: Andaman Islands, Thailand, Burma, East Pakistan, northwest India, West Pakistan, Gulf of Oman, and Muscat and Oman (Arabia). Areas were subdivided into the following depth intervals: 8-49 fathoms, 50-99 fathoms, 100-199 fathoms, 200-299 fathoms, and 1,000-1,099 fathoms (no trawling from 0 to 999 fathoms).

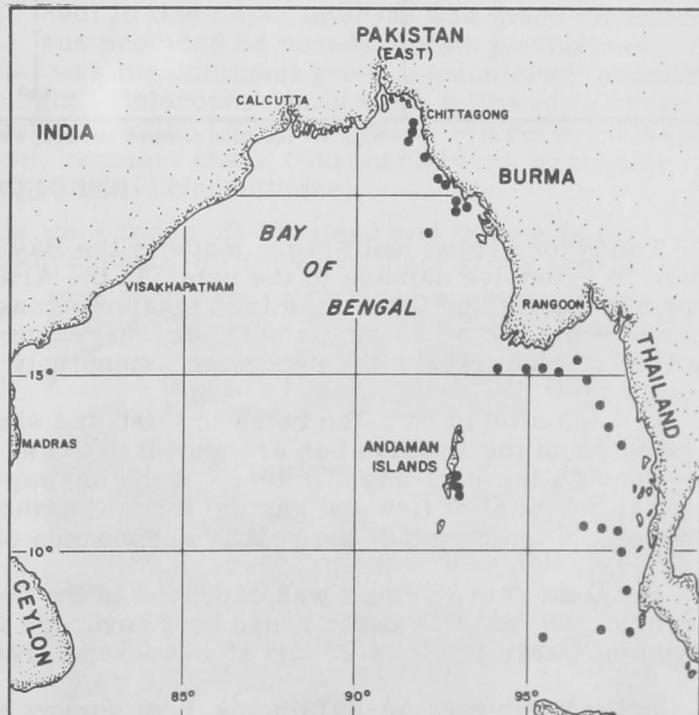


Fig. 2 - Location of trawl stations, cruise 1 of R/V Anton Bruun.

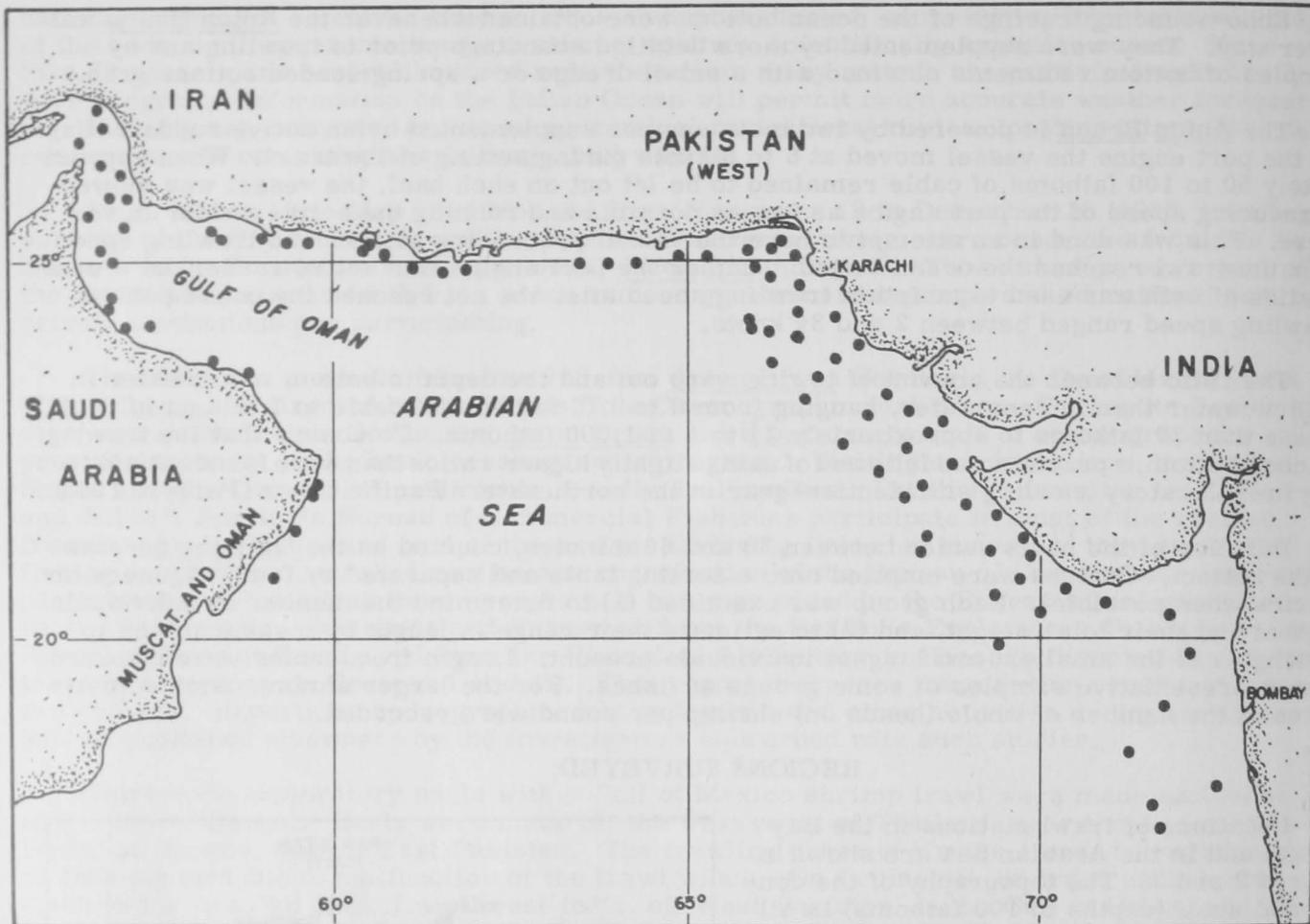


Fig. 3 - Location of trawl stations, Cruise 4B of R/V Anton Bruun.

RESULTS

Thirty-one trawl hauls were made in the Bay of Bengal; 27 were successful and 4 resulted in extensive damage to the nets. In the Arabian Sea 86 trawl hauls were completed; 77 were successful and 9 resulted in extensive damage to nets. The highest incidence of gear damage occurred off Muscat and Oman where one-half of the hauls were unsuccessful and in the Gulf of Oman where the nets were extensively damaged in one-quarter of the hauls.

Fishing effort and catch rates for fish and shrimp by areas and depth intervals in the Bay of Bengal and the Arabian Sea are shown in tables 1 and 2. Because of the few trawl hauls and the probable low catching efficiency of the shrimp trawl, it is impossible to assess the commercial potential of fish and shrimp inhabiting the various areas. The surveys do provide, however, an indication of the relative abundance of fish and shrimp between areas.

Greatest survey effort was expended in the depth range 8-49 fathoms, the shallowest zone surveyed. Within this depth range best coverage was attained off northwest India and off West Pakistan, where totals of 22 and 16 successful trawl hauls were completed (table 2).

In the depth zone 50-99 fathoms, best survey coverage was attained off northwest India, off West Pakistan, and in the Gulf of Oman where from six to seven successful trawl hauls were completed in each area (table 2).

Maximum survey effort in the depth range 100-199 fathoms was expended in the Gulf of Oman (four successful hauls) and off northwest India and West Pakistan (two successful hauls).

in each region). Only one successful haul was made in the depth interval 200-299 fathoms and one in the 1,000- to 1,099-fathom interval. Both of the latter hauls were made off Burma.

Table 1 - Number of Successful Trawl Hauls, Fishing Effort, and Catch Rates by Areas and Depth Zones in the Bay of Bengal, R/V Anton Bruun, March-April 1963

Depth Interval, Fishing Effort, and Catch Rates	Andaman Islands	Thailand	Burma	East Pakistan
8-49 fathoms				
Number of hauls	2	2	12	6
Hours trawled	1.0	1.0	8.0	3.9
Pounds fish/hour trawled .	58	50	107	157
Pounds shrimp/hour trawled	0	1	6	5
50-99 fathoms				
Number of hauls	1	0	0	0
Hours trawled	0.5	-	-	-
Pounds fish/hour trawled .	4	-	-	-
Pounds shrimp/hour trawled	0	-	-	-
100-199 fathoms				
Number of hauls	0	0	1	0
Hours trawled	-	-	0.5	-
Pounds fish/hour trawled .	-	-	68	-
Pounds shrimp/hour trawled	-	-	56	-
200-299 fathoms				
Number of hauls	0	1	1	0
Hours trawled	-	0.6	0.5	-
Pounds fish/hour trawled .	-	21	80	-
Pounds shrimp/hour trawled	-	9	34	-
1,000-1,099 fathoms				
Number of hauls	0	0	1	0
Hours trawled	-	-	1.0	-
Pounds fish/hour trawled .	-	-	2	-
Pounds shrimp/hour trawled	-	-	trace	-

rawling. Chlorophthalmid (Chlorophthalmidae) accounting for over one-half the total fish catch by weight. Chlorophthalmid were followed in order of abundance by scorpionfish (Scorpaenidae) and butterfish (Stromateidae). Miscellaneous taken included bembropsid (Bembropsidae), requiem shark (Carcharhinidae), grenadier (Macruridae), bigeyes (Priacanthidae), and tripodfish (Triacanthidae).

200- to 299-Fathom Interval: Single hauls were made off Thailand and Burma in this depth interval. Off Burma, hatchetfish (Sternoptychidae) were the dominant group encountered, accounting for over 70 percent of the total fish catch by weight. Hatchetfish were followed by requiem shark, grenadier, cutlassfish (Trichiuridae), and chlorophthalmids. Off Thailand, skate (Rajidae), sea robin (Peristediidae), and boafish (Stomiataidae) dominated the catches.

1,000- to 1,099-Fathom Interval: The one successful trawl haul made in the 1,000- to 1,099-fathom interval off Burma yielded a catch rate of 2 pounds per hour of trawling. The catch consisted of one snipe eel (Nemichthysidae), four boafish, several eel larvae, and a number of unidentified fish.

The largest fish encountered in the Bay of Bengal were stingray and guitarfish which attained maximum estimated weights of 200 and 225 pounds, respectively.

BAY OF BENGAL: Fish: 8- to 49-Fathom Interval: Highest catch rates of fish in the Bay of Bengal occurred in the 8- to 49-fathom depth interval off Burma and off East Pakistan where 107 and 157 pounds of fish, respectively, were caught per hour of trawling (table 1). In those regions and in this depth interval, stingray (Dasyatidae) and guitarfish (Rhinobatidae) dominated the catches. Other fish which comprised an important part of the catches were drum (Sciaenidae), lizardfish (Synodontidae), and snapper (Lutjanidae). Some miscellaneous fish taken included sea catfish (Ariidae), threadfin (Polynemidae), and tonguefish (Cynoglossidae).

50- to 99-Fathom Interval: The only haul in this depth interval was made in the Andaman Islands area and was unproductive, yielding only 4 pounds of fish per hour of trawling (table 1). Included in the catch were a number of small threadfin-bream (Nemipteridae), cardinalfish (Apogonidae), lizardfish, goatfish (Mullidae), and mackerel (Scombridae).

100- to 199-Fathom Interval: The single haul in this depth interval was made off Burma and provided 68 pounds of fish per hour of trawling. Chlorophthalmid were the dominant group encountered, accounting for over one-half the total fish catch by weight. Chlorophthalmid were followed in order of abundance by scorpionfish (Scorpaenidae) and butterfish (Stromateidae). Miscellaneous species taken included bembropsid (Bembropsidae), requiem shark (Carcharhinidae), grenadier (Macruridae), bigeyes (Priacanthidae), and tripodfish (Triacanthidae).



Fig. 4 - Shrimp-trawl catch in Bay of Bengal, Cruise 1 of R/V Anton Bruun.

Shrimp: With the exception of the Andaman Islands area, shrimp were taken in all depth zones and in all areas surveyed in the Bay of Bengal. However, no large catches were obtained in any area. Off Burma, several individual hauls made at depths between 14 and 35 fathoms yielded from 10 to 20 pounds of shrimp per hour of trawling. Two $\frac{1}{2}$ -hour hauls off Burma in 165 and 200 fathoms of water yielded 28 and 17 pounds of shrimp, respectively.

Most of the shrimp belonged to the family Penaeidae (genera Penaeus and Metapenaeus) and to the tribe Caridea. They generally were small, ranging from 200 to 300 heads-on count per pound, although a few penaeid shrimp weighing over one-half pound each were caught.

ARABIAN SEA: Fish: 8-to 49-Fathom Interval: Highest catch rates of fish in the Arabian Sea occurred off Muscat and Oman in the 8- to 49-fathom depth interval (table 2) where four trawl hauls were made. Numerous coral outcroppings in that area resulted in extensive damage to the trawl nets on 2 of the 4 hauls. Of the two successful hauls, one of 30 minutes made at 23 fathoms yielded an estimated 5,500 pounds of stingray plus 100 pounds of other fish; the other (45 minutes) made at 25 fathoms yielded 1,700 pounds of fish--primarily grunt (Pomadasysidae), stingray, and cardinal fish--and 1,840 pounds of swimming crab (Portunidae).

Catch rates in the 8- to 49-fathom depth interval off northwest India, West Pakistan, and in the Gulf of Oman were much lower than off Muscat and Oman, ranging from 64 to 214 pounds of fish per hour of trawling (table 2). Stingray again were dominant, accounting for from one-half to one-third of the total fish catches by weight. Other important species in all areas

Table 2 - Number of Successful Trawl Hauls, Fishing Effort and Catch Rates by Areas and Depth Zones in the Arabian Sea, R/V Anton Bruun, November-December 1963

Depth Interval, Fishing Effort, and Catch Rates	Northwest India	West Pakistan	Gulf of Oman	Muscat & Oman (Arabia)
8-49 fathoms				
Number of hauls	22	16	9	2
Hours trawled	16.4	11.9	6.5	1.3
Pounds fish/hour trawled .	214	137	64	
Pounds shrimp/hour trawled	8	trace	1	5,840 trace
50-99 fathoms				
Number of hauls	7	7	6	0
Hours trawled	5.5	6.1	4.1	-
Pounds fish/hour trawled .	132	246	118	-
Pounds shrimp/hour trawled	1	1	1	-
100-199 fathoms				
Number of hauls	2	2	4	0
Hours trawled	2.0	2.0	4.0	-
Pounds fish/hour trawled .	22	2	45	-
Pounds shrimp/hour trawled	trace	6	8	-

were threadfin-bream and drum. Grunt were numerous off West Pakistan and off Muscat and Oman. The apparent distribution of Bombay duck (Harpadontidae), a commercially important group in India, was interesting in that they were caught in substantial numbers in the Arabian Sea only off northwest India in the Gulfs of Kutch and Cambay and only in relatively shallow water (8-20 fathoms).

50- to 99-Fathom Interval: No trawling was conducted below 49 fathoms off Muscat and Oman. Catch rates in the depth interval 50-99 fathoms off West Pakistan and in the Gulf of Oman were higher than in the shallower interval surveyed in these regions. In contrast, off northwest India the catch rate in this interval was less than that in the shallower 8- to 49-fathom interval. Within the 50- to 99-fathom interval, stingray comprised an important part of the catches only off West Pakistan. Threadfin-bream were as important in the

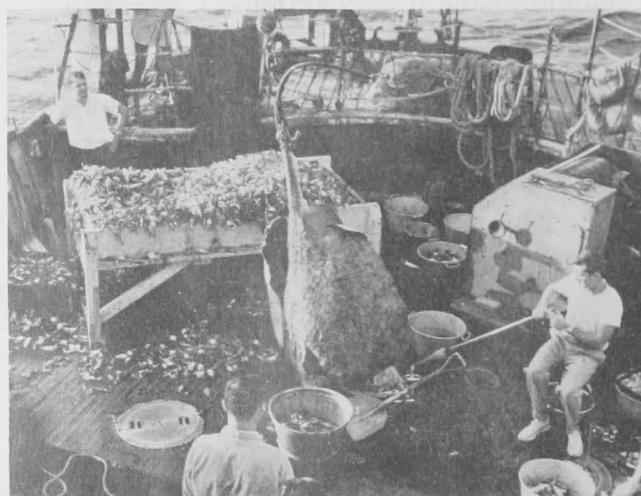


Fig. 5 - Catch of fish and swimming crabs taken in shrimp trawl off Muscat and Oman (Arabia), Cruise 4B of R/V Anton Bruun.

catches in all areas surveyed as in shallower water. Although drum and grunt were taken, they occurred less often in most areas than in the shallower 8- to 49-fathom interval. Other fish accounting for much of the catches in this interval included jack (Carangidae), sea bass (Serranidae), and lizardfish. Off West Pakistan and in the Gulf of Oman, monocle-bream (Scolopsidae) were important in the catches; however, relatively few were caught in other areas.

100- to 199-Fathom Interval: Off northwest India, West Pakistan, and in the Gulf of Oman, the catch rates declined markedly in this interval compared to those in shallower intervals (table 2). Drum and cardinalfish formed important parts of the catches in all areas. Stingray were not taken in this depth interval in any area. Off northwest India, Champsodontidae was the dominant family of fish encountered but they were virtually absent from catches off West Pakistan and in the Gulf of Oman. Threadfin-bream comprised an important part of the catches off northwest India.

The largest fish captured in the Arabian Sea were stingray, which attained a maximum estimated weight of 450 pounds. One haul made off Muscat and Oman contained approximately 5,500 pounds of stingray estimated at 40 pounds each. Occasional large guitarfish (approximately 400 pounds) were caught. Some other relatively large fish caught during the survey were false conger eel (Muraenesocidae) which ranged up to 14 pounds in weight apiece, drum of up to 22 pounds each, and threadfin of up to 15 pounds each. Many of the more abundant fish in the catches were relatively small. Grunt averaged about one-half pound and attained a maximum weight of approximately 4 pounds. Threadfin-bream averaged about one-tenth pound each. Lizardfish averaged only a few ounces, but occasional specimens ranged up to $1\frac{1}{2}$ pounds. Monocle-bream, cardinalfish, and flathead (Platycephalidae) all averaged only a few ounces in weight.

Shrimp: Shrimp were taken in all depth zones and in all regions surveyed in the Arabian Sea. Catches in all regions and depth zones, however, were disappointingly small. Best catches were taken off northwest India in the 8- to 49-fathom depth interval, and in the Gulf of Oman and off West Pakistan in the 100- to 199-fathom depth interval (table 2). The largest single haul of shrimp taken in the Arabian Sea survey was 66 pounds, caught in a 45-minute haul off northwest India at a depth of 18 fathoms. The next largest single haul was 30 pounds taken in a 1-hour haul in the Gulf of Oman at a depth of 163-170 fathoms. A 40-minute haul off northwest India in the Gulf of Cambay in 15 fathoms produced 28 pounds of Caridean shrimp (Paleomon).

Most of the shrimp belonged to the family Penaeidae (genera Penaeus, Metapenaeus, and Solenocerina) and to the tribe Caridea. As in the Bay of Bengal survey, the shrimp generally were small, although occasional hauls yielded fair numbers of 40 to 50 heads-on count per pound.

Many sea snake (Hydrophidae) were caught in the small-mesh shrimp trawls in both the Bay of Bengal and in the Arabian Sea. Because they are extremely poisonous, the snakes must be handled with care when removing them from the net or from the catches. Use of larger-mesh trawls should reduce the catch of snakes.

DISCUSSION

Catching ability of the Anton Bruun may have been impaired in shallow water due to mud being stirred up from the ocean bottom by the vessel's wake. This was noticeable in depths of about 12 fathoms and less and may have frightened some shallow-water animals away from the path of the trawl. At those depths, the catching efficiency of a smaller vessel with a shallower draft might have been higher than that of the Anton Bruun.

Shrimp catches in the Bay of Bengal and in the Arabian Sea were surprisingly small in view of the large commercial shrimp fisheries there. The commercial fisheries, however, occur in shallower waters than were explored from the Anton Bruun. Shrimp appeared about equally available throughout all depth intervals surveyed out to a depth of 299 fathoms. The larger penaeid shrimp, however, were caught in the shallower depth intervals.

Largest fish catches were taken off Muscat and Oman where two successful trawl hauls in the depth interval 8-49 fathoms yielded a catch rate over 20 times as high as that obtained in any other region or depth interval. Although catches off Muscat and Oman primarily consisted of stingray and swimming crab for which there is no market, one 45-minute haul yielded 980 pounds of grunt. It seems probable that further explorations there would locate large populations of other more desirable species.

Off northwest India, West Pakistan, and in the Gulf of Oman, demersal fish appeared as abundant in the 50- to 99-fathom interval as in the shallower 8- to 49-fathom interval. Trawling effort in other areas was too inadequate in the 50- to 99-fathom interval to provide a meaningful comparison. Relative abundance of fishes at depths greater than 99 fathoms declined markedly in all areas surveyed.

Within the depth interval 8-49 fathoms in all areas surveyed, elasmobranchs, primarily stingray, dominated the catches. The relative importance of stingray in the catches decreased greatly in the 50- to 99-fathom interval and they were virtually absent in hauls made below 100 fathoms.

Demersal fish in the Bay of Bengal generally appeared similar to those observed in the Arabian Sea. In both regions, stingray, guitarfish, threadfin-bream, drum, lizardfish, threadfin, and cardinalfish were among the dominant groups encountered on the continental shelf. Grunt were important constituents of the fish fauna throughout most of the Arabian Sea; however, in the Bay of Bengal they were caught only off Burma and only in small quantities.

Throughout most of the Bay of Bengal and Arabian Sea, the precipitous and uneven ocean bottom at depths greater than 100 fathoms prevented trawling. This factor, together with an apparent reduction in abundance of demersal fishes, would seem to hinder if not preclude future development of major commercial trawl fisheries at depths greater than about 100 fathoms.

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NEW WEATHER MACHINE DEVELOPED TO PREDICT WEATHER

Some of the drudgery experienced daily by the weather forecasters, and perhaps some of the vilification, may be reduced in the near future by the use of a machine, called the learning machine, which can be fed and taught to recognize geometric patterns found in weather formations.

The machine is called ADALINE (short for adaptive linear neuron) and learns its own mathematical procedures for processing meteorological data fed to it in training on weather patterns. Developed at Stanford University, the machine is now trained on some 200 weather patterns taken from weather records over the past five years and has been amazingly accurate in its predictions. (Sea Secrets, April 1964.)