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Partial Survey and Critique of Ceylon's Marine Fisheries, 1953-55

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ABSTRACT

THIS is a resume of a 1953-1955 study of Ceylon's fishing gears and fisheries and of records of experimental and commercial fishing operations. Representative catches of edible fish per unit of effort for several of the gears studied are summarized in the table. They are low compared with many countries, indicating low abundance of fish.

Kind of Fishing	*Catch per unit of effort* (*lb.*)	(*lb.*)
Large trawler operation ..	500-550/hr. of towing ..	300/man/day at sea
Small-boat trawling ..	65/hr. of towing ..	26/man/hr. of towing
Handlining (bottom) Offshore ..	10-30/line/hr. ..	10-30
Inshore ..	<5/ ,, ..	<5
Bottom longlining Indigenous ..	30-40/100 hooks set ..	5/man/hr.on grounds
Motorized ..	15-30 ,, ..	10-15+ ,,
Driftlining (mid-water handlining) ..	2/line/hr. ..	4 ,,
Surface longlining ..	10-800/100 hooks set ..	1-20 ,,
Trolling (Indigenous and mechanized) ..	1-2·5/line/hr. ..	2-3·5 ,,
Gill netting (Indigenous and nylon webbing)	5-10/hr./10,000 sq. feet of net set	1-10 ,,
Dolphin (porpoise) hunting ..	105/boat hr. ..	26 ,,

Driftlining (mid-water handlining), trolling and mothership operations have inherent features which limit development. Small-boat trawling, purse-seining and several other fishing methods offer some promise and deserve further investigation. Returns from large-trawler operations, mechanized surface and bottom longlining, gill netting and dolphin (porpoise) hunting are encouraging. Recommendations are advanced on how landings by these last-mentioned fisheries may be increased and how the fisheries can be made more profitable.

INTRODUCTION

From April 1953 to April 1955 I assisted in Canadian-Ceylonese Colombo Plan fisheries development projects. During that time I was responsible to the Director of the Ceylon Department of Fisheries through a co-ordinator (Mr. D. M. Haywood in the first year and Mr. A. W. Lantz in the second) whose task it was to oversee the work of Canada's appointees who were working within the Department.

During the first year I served as leader of the Department's research officers and results of our work are partly published (Durairatnam and Medcof, 1954; Canagaratnam and Medcof, 1956; Sivalingam and Medcof, 1957). Survey work went ahead vigorously that year, however, as a co-operative effort by regular departmental staff and guest (Colombo Plan) staff from Canada and the U. K. under the immediate direction of the co-ordinator. This was in compliance with the March 1953 Colombo Plan assignment which called for:

(1) Inspection and study of Ceylon's principal marine fisheries;
(2) Conduction of fishing trials where this seemed necessary to proper assessment of the potentials of these fisheries;
(3) Presentation of recommendations on how Ceylon might increase her fish production;
(4) Preparation of a complete report on the survey.

At the end of my year's work with the fisheries research officers I was asked to lighten the task of the co-ordinator by supervising the fishery survey. My task was to see that the four terms of the assignment were fulfilled. This was not a simple undertaking and credit for what was achieved is due to the Steering Committee and those mentioned in Acknowledgments, who worked with me.

The first and most important task was to devise a sound program for the 1954 survey.

Planning the 1954 Survey

The Steering Committee had been set up in 1953 to guide the survey. It included senior officers of the Department, Mr. D. M. Haywood, the then co-ordinator of the Canadian team, and me. This meant that I was familiar with the first year's survey program and that it was not difficult in 1954 for me to fall in line with the Steering Committee's decisions on how to continue the project.

It decided to limit its interests to marine fisheries as in 1953. It decided to continue close study of routine Wadge Bank fishing operations by the Department's two trawlers but to discontinue programs of exploratory trawling in other areas. The great need was to find ways of increasing the efficiency of trawler operations. Among other projects to be continued were dolphin (porpoise) hunting, gill netting and handlining studies. Mothership operations were not recommended.

The Committee also decided that it lacked context information for assessing results of small-boat fishery surveys. It therefore requested a compilation of the Department's records of small-boat fishing trials, past and current, and a comparison of these records among themselves and with similar records for indigenous craft operated by local fishermen. It felt that comparisons of this sort were the only reliable basis for identifying possible "improvements" which the Department might choose to foster. Improvements in this case meant ways of increasing catches and net incomes to fishermen without detriment to the country as a whole and without jeopardy to fish stocks.

To search intelligently for such improvements required a good knowledge of the indigenous small-boat fisheries, their size and relative importance, the manpower and the gear they used and how efficiently these were used. It was soon apparent that there was little directly pertinent information on these subjects except fisheries statistics. These indicated which were the important indigenous small-boat fisheries but they provided only general ideas of their operational efficiencies and limitations. It was on these two points that quantitative data were required for formulating recommendations for improvement. Accordingly, in organizing the 1954 program, it was found necessary to plan for building up this knowledge simultaneously with work on other 1954 survey projects.

Organizing and conducting the collection of information on the indigenous fisheries was time-consuming. It cut down on the effort that could be expended on trials of new gear, new methods and new boats. It also delayed the study of past records which meant that parts of the 1954 program had to be planned and pursued on the basis of conjecture rather than on well organized conclusions from past experience. The Steering Committee did not relish this way of operating but the only alternative was to call a halt to new work until the information required for better planning was accumulated by field collection and study. Such a course was untenable in the face of the demand to keep going, and we did keep going. In some cases this resulted in too much attention being given to minor and too little to major small-boat fisheries.

Assembling Past Records

Sea trips on both trawlers, BRACONGLEN and MAPLE LEAF, confirmed the conclusion that the Department's long series of records of large trawler operations were well organized and sufficiently detailed to provide the information needed for the study assignment.

Review of the Department's files discovered many hundreds of useful data on small-boat fishing operations, both experimental and industrial—some with motor boats and some with unpowered indigenous craft. Many were complete enough to organize on standardized fishing record forms (Fig. I) and to permit calculation of catch per unit of effort. Many of these back records were summarized in a manuscript report that was submitted to the Department (Medcof, 1955).

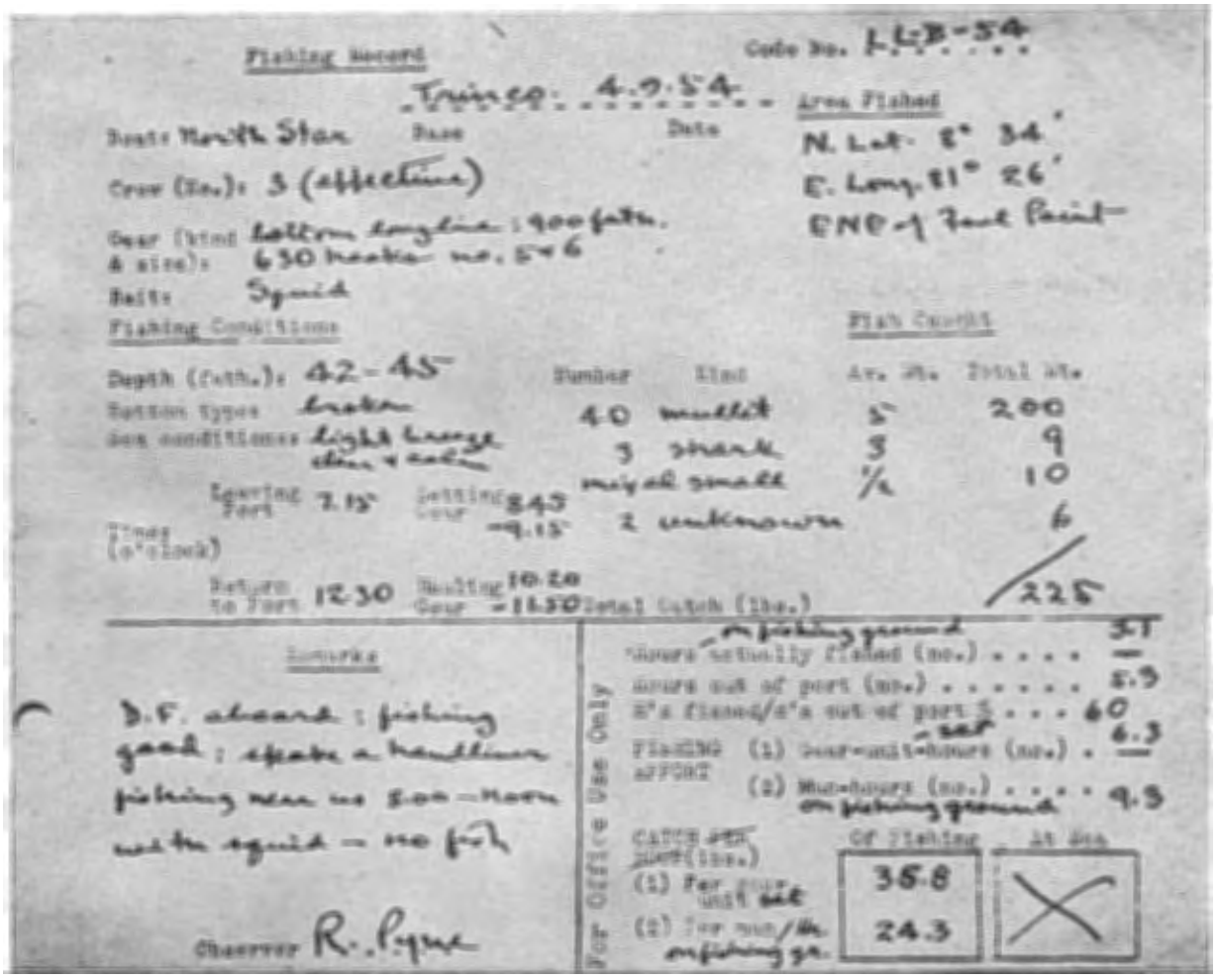

Fig. I. Fishing record form used during survey. The sample entry and modifications of original captions show how the form may be adapted to particular needs—in this case to studies of bottom longlining.

The records of 1953 operations by CANADIAN and NORTH STAR, two small boats gifted to Ceylon under Colombo Plan (De Zylva, 1958) were also treated in this way and the same form was used in reporting fishing operations of indigenous craft. Figure I is a sample of the small-boat fishing record form which was devised for general purposes and shows how it was modified in practice to report on one particular fishing operation—bottom longlining.

When assembled, these data occupied many hundreds of fishing record forms. And these had to be summarized for inclusion in the appendices to the report which was called for in the survey assignment. This presented difficulties especially where description of the composition of the catch was concerned. This is a common difficulty in reporting on tropical fisheries, as John (1951) has pointed out, because so many species are generally involved. Finally, for purposes of the survey report, it was decided to describe catch composition according to grade. Edible fish in the

catches were divided into groups of species which were assigned grade numbers, 1, 2 and 3 in accordance with their generally recognized quality as food fish. (The first grade was best and the third grade poorest.) The inedible varieties were pooled and reported as grade 4. The accompanying schedule gives fuller meaning to the grade numbers.

SCHEDULE DEFINING THE GRADE NUMBERS USED IN THE APPENDICES OF THIS REPORT TO DESCRIBE THE COMPOSITION OF THE CATCH ACCORDING TO VARIETIES TAKEN. THE COMMON NAMES OF *THE FISH IN ENGLISH, SINHALESE AND TAMIL* AND THE SCIENTIFIC NAMES OF TYPICAL GENERA ARE GIVEN FOLLOWING MENDIS (1954)

GRADE 1

Common name		*Scientific name*
Seer	(E)	Scomberomorus
Thora	(S)	
Arekula	(T)	
Baracouda	(E)	Sphyraena
Theliya	(S)	
Jeela	(T)	
Mackerel	(E)	Caranx
Parawa	(S)	
Pareh	(T)	
Bonito	(E)	Euthynnus
Baleya	(S)	
Soora	(T)	
Albacore	(E)	Thunnus
Kelawalla	(S)	
Kelavalai	(T)	
Sail fish	(E)	Istiophorus
Thalapatha	(S)	
Myl meen	(T)	
Marlin	(E)	Makaira
Koppara	(S)	
Kopparan	(T)	

GRADE 2

Common name		*Scientific name*
Mullet or Rock fish	(E)	Lutianus
Gal malu	(S)	Lethrinus
		Plecotrohynchus
		Epinephalus
Queen fish	(E)	Chorinemus
Kattawa	(S)	
Katta	(T)	
Sprats	(E)	Stolephorus
Halmessa	(S)	
Netholi	(T)	
Herrings and Sardines	(E)	Clupea
Saleya, Hurulla and Sudaya	(S)	
Schudai, Ullam	(T)	
Silver belly	(E)	Leiognathus
Karalla	(S)	
Karel	(T)	

GRADE 3

Common name		*Scientific name*
Sharks	(E)	Carcharias
Mora	(S)	
Schurai	(T)	
Ray	(E)	Dasyatis
Maduwa	(S)	Rhinoptera
Thirukai	(T)	Mylobatus
Goat fish	(E)	Parupeneus
Nagareya	(S)	
Nakharai	(T)	
Spine tail	(E)	Acanthurus
Orawa	(S)	
Thettan	(T)	
rigger	(E)	Balistes
Kukulu maha	(S)	
lathi	(T)	

GRADE 4

Common name		*Scientific name*
Puffers	(E)	Diodon
Petheya	(S)	Ostracion
Pethai	(T)	
Cow fish	(E)	Triacanthus
Thunkatuwa	(S)	
Klathi	(T)	
Purple Leather Jackets	(E)	Balistes

Many will quarrel with this system as being vague compared with others such as that adopted by Malpas (1926). However, it was agreed on because it was concise, simple enough to be workable and generally recognized and regularly used by the Ceylonese fish trade.

Collecting 1954 Records

It was considered wise to continue the past method of assembling records of large trawler operations. Printed records forms were in use and the whole task of recording was being well handled by the trawler skippers and other officers of the Department.

And it was decided to compile records of 1954 small-boat operations on the same form as was devised for assembling and analyzing past records (Fig. I). This compilation of current operations was carried out mostly by the writer and the Department's own small-boat fishing skippers during their field work. They documented their own trial fishing operations and industrial fishing operations of indigenous craft in the principal fishing centres.

Many records of the latter sort were also compiled by field officers of the Department in whom the surveyors placed special confidence.

In these records small-boat catches have been reported in pounds. The Department's experimental fishing craft were supplied with scales and weighed their catches or sold them to dealers who weighed them. So their records are precise. But records for many of the indigenous craft are not precise. Their catches were examined as they were being taken out of the boats to be sold by auction at the fish markets without weighing. In such cases the record compiler had to estimate the weights of the fish he saw being unloaded. This can be done with a relatively small error (20-30 per cent.) but it requires experience and good judgment. In order to keep the error of estimates as low as possible we regularly checked our own estimates against weighings. We encouraged those who were working with us to do the same whenever possible.

Procedure

Before trial fishing was undertaken in any area and at critical times in the course of such trials, the writer and the skippers made shore trips to inspect the local fisheries. During these shore trips the Department's field officers were most helpful in supplying information and in acting as interpreters in the many interviews with fishermen. The information gathered was useful to the Steering Committee in planning exactly how, when and where the survey effort should be disposed.

The details of program procedure, results, discussion and recommendation are presented in the several sections of the report which follow.

Limitations of the Survey

A 2-year fisheries survey can be nothing but preliminary. In such a short time it is even difficult to appreciate the problems, say nothing about solving them. As already indicated, this statement has nothing to say about the freshwater fisheries. And even in dealing with those branches of the marine fishery which it has explored, it emphasizes the efficiency of fishermen and their methods. The importance of such an approach as a basis for planned development has been stressed by Amirthalingam (1949). But survey results need supplementary information on fisheries economics, as Firth (1946) points out, to make them fully meaningful in judging the actual and potential importance of fishing operations in any national economy.

There is great need for well organized information on the economics of Ceylon's fisheries and until this can be assembled, it will be difficult to deal wisely with many fisheries problems. But at least some perspective in meeting these problems is needed now and some data on comparative catches are available. For this reason some comparisons are made in this report between poundages of fish landed by Ceylonese fisheries and by similar industrially profitable fisheries of other countries. The sole purpose of these comparisons is to promote sound thinking.

Many more years' work are needed to clarify most of Ceylon's fisheries problems but, on the other hand, many improvements can be effected now on the basis of what has been learned. It is the author's belief that the recommendations made in this report and in the MS report (Medcof, 1955), which preceded it, are well supported by the information available and it is his

hope that they will be implemented. De Zylva, who was a member of the Steering Committee and Acting Director of the Department of Fisheries while I worked in Ceylon, was a strong proponent of modernization of fishing methods. After 1955 he supervised several fishing experiments. In reporting these (De Zylva, 1958) he makes no mention of our recommendations but his statements clearly show that he had adopted at least some of them and was trying to apply them for the betterment of the fisheries and the country. It has been a pleasure to work toward this end.

CRITIQUE OF WADGE BANK TRAWLING OPERATIONS

The two trawlers, MAPLE LEAF and BRACONGLEN, are the largest single fishing units in Ceylon. It is therefore fitting that their programs should be treated first in this survey report.

In 1954 we had at our disposal what we believe was the best continuous, detailed set of tropical trawling records ever compiled up to that time. They described the operations of trawlers owned both by private fishing companies and by the Ceylon Government. The Fisheries Research Station had already recognized the importance of these records and was using them in biological studies (Sivalingam and Medcof, 1957) when the Steering Committee called for this operational efficiency study of the Wadge Bank trawl fishery. Although MAPLE LEAF'S and BRACONGLEN'S operations were similar, they involved different periods and they have been treated separately. Comparisons lead to useful conclusions.

A. Operations by Maple Leaf

History

The Department of Fisheries had been operating trawlers on the Wadge Bank for 8 years before MAPLE LEAF came to Ceylon in 1953. And for many reasons it had tentatively decided that the new vessel should fish this same ground.

Some experienced Ceylonese seamen were put aboard her to work under the three officers (captain, first mate and chief engineer) who had sailed her out from the United Kingdom. These officers were under Colombo Plan contract with the Government of Canada. They were all experienced in temperate-zone fisheries but they were new to the tropics. Their task was to learn what was new to them as quickly as they could, to direct the vessel's operations and to initiate Ceylonese understudies who should eventually take over from them.

There was an introductory period in 1953 which included some exploratory fishing off the southwest and southeast coast of India on either side of the Wadge Bank. This exploratory fishing discovered no large new stocks of groundfish that would encourage operations beyond the Wadge Bank. But it did show that there were good quantities of prawns off the southeast coast.

The records (Appendices 1 and 2) show that operations settled down quickly and that MAPLE LEAF landed over a million pounds of fish (grades 1, 2 and 3) in the 7-month period June to December 1953 and a million and a half pounds in the full year of 1954.

Condition of Catch

In the opinion of the skipper, Captain William Ellen, the condition of the fish when discharged from the ship was superior to that of catches landed in the United Kingdom by craft out of port for similar periods. This is attributed to the good functioning of the hold refrigeration equipment installed by Canada after purchase of the ship.

Usefulness of Maple Leaf

In summary we can say that during the period reviewed, MAPLE LEAF fulfilled the hopes of Colombo Planners. She contributed substantially to Ceylon's supply of quality fish in good condition. Furthermore, her operations in the hands of the Department appear to have been profitable (Goonewardena, 1956).

Comparison of Wadge Bank and other Fisheries

As a further aid to criticism of MAPLE LEAF's Wadge Bank operations, records were obtained of her last one-and-a-half years of operation (1951 and 1952) out of her former home port, Fleetwood, U. K. These are compiled in Appendices 3 and 4.

At that time she was under commission as the BOSTON ATTACKER and operated on grounds off the west coast of Scotland including the Orkneys and Shetlands. According to Captain Ellen this region is generally considered to be more productive than other " mid-water " grounds like the North Sea, the Faroe Islands and Iceland, which are exploited by United Kingdom trawlers.

Captain Ellen also reports that the gear used by BOSTON ATTACKER off Scotland was the same as that used on the Wadge Banks a 48-foot Granton trawl (total footrope length 116 feet, total headline 80 feet). Besides this, Captain Ellen states that she was then skippered by one of his acquaintances and a close rival with him for first position among the Fleetwood mid-water trawlers.

Thus we have comparable records of a first class mid-water trawler, MAPLE LEAF (BOSTON ATTACKER) using the same gear and skippered by men of comparable skill, while she operated in one of the largest, longest established, temperate-zone trawl fisheries and while she operated in what appears to be a good, well established, tropical trawl fishery. As far as we are aware, these complementary sets of records are unique. They permit confident appraisals of Wadge Bank fish stocks and of the Ceylon Department of Fisheries' methods of trawler operation against a well known standard.

Data summarized in Appendices 5 and 6 permit a less precise comparison of Wadge Bank operations with those on the Canadian Atlantic (International Commission for Northwest Atlantic Fisheries area sub-divisions 4W and 4X) and Canadian Pacific coasts.

TABLE I

COMPARISON OF TRAWLING OPERATIONS BY MAPLE LEAF (BOSTON ATTACKER) OUT OF FLEETWOOD, U. K., ON GROUNDS OFF THE WEST COAST OF SCOTLAND (1951–1952) AND OUT OF COLOMBO, CEYLON, ON THE WADGE BANK OFF THE SOUTH COAST OF INDIA (1953–1954) AND BY 151-500 GROSS-TON TRAWLERS OPERATING OUT OF CENTRAL NOVA SCOTIA PORTS (1953). (THE VALUES ARE AVERAGES FROM DATA LISTED IN APPENDICES 1 TO 5)

	Boston Attacker off Scotland	*Maple Leaf on Wadge Bank*	*Nova Scotia 151-500 gross ton trawlers*
Length of fishing trip (days)	12·9	10·5	7·3
Catch per trip (lbs.)	81,555	91,457	93,000
Catch per day at sea (lbs.)	6,363	8,578	13,300
Days on grounds/Days at sea	69%	90%	83%
Days in port per month	8·2	14·3	—
Catch/Hour on grounds (lbs.)	380	395	909*
Catch/Hour of actual trawling (lbs.)	—	538	1,239
Number of crew (officers and men combined)	15	28	—
Catch/Man/Day at sea (lbs.)	424	306	—

* Calculated from catch per hour of actual trawling (1,239) by multiplying by 0·734 which is the mean value of the ratio catch/hour on grounds : catch/hour actual trawling, for MAPLE LEAF, 1953 and 1954.

Fishing Time and Sea Time

Table I summarizes the appendices referred to and permit several interesting comparisons. It shows that MAPLE LEAF'S (BOSTON ATTACKER'S) trips out of Fleetwood averaged 2.4 days longer than those out of Colombo. But in spite of this, the average catch per trip was less (81,555 compared with 91,457 pounds). This is attributed largely to differences in distances between home

ports and fishing grounds—2 days' steaming out of Fleetwood and only 12 hours out of Colombo. The proportion of her sea time spent in actual fishing was accordingly low for Fleetwood (69%) and high for Colombo (90%).

Abundance of Fish

The relative abundance of fish on the two grounds can be judged from data on catch per hour spent on the fishing grounds (Table I). It seems that fish abundance on the Wadge Bank is about 104% of that off the west coast of Scotland (395 lb. per hr. compared with 380) but only 43% of that on the less heavily exploited Nova Scotia Banks and 62% of that off the Canadian Pacific coast (Appendix 6).

Examples of the few published records of operations on tropical trawling grounds have been reviewed (Sivalingam and Medcof, 1957). These records suggest that the Wadge Bank is as good as the best in the tropics excepting perhaps the Gulf of Thailand where an average of 298 kg. per " catch hour " has been reported by Thiews (1962). This is roughly equivalent to 220 kg. (480 lb.) per hour on the grounds (Table I). These records and handline fishing records for Mauritius and the Seychelles Islands (Wheeler and Ommanney, 1953) also cast doubt on the generally accepted notion that tropical banks are consistently poor producers of bottom fish. Indeed they show that MAPLE LEAF is engaged in a fishery that compares favourably with many that are well known and profitable as Hickling (1951) believed.

Appendices 1 and 2 also show that on Wadge Bank the catch per hour of trawling varies a good deal with season. It is generally heaviest during the southwest monsoon months, May to October. This variation is taken as evidence of seasonal changes in abundance of fish. This subject has been discussed by Sivalingam and Medcof (1957). Sivalingam's records (Goonewardena, 1956) suggest that there may also be year-to-year differences both in abundance and species composition of the stocks.

Efficiency of Crewmen and System of Feeing

Table I shows that the catch per man per day was much higher in the fishery out of Fleetwood than out of Colombo in spite of the fact that MAPLE LEAF caught less fish there than she does here. The reason is that the crew was increased in number from 15 to 28 (officers and men included) even though the amount and difficulty of the work involved did not change appreciably. Those with whom I have discussed this matter say that the extra men are needed in Ceylon for two main reasons:

1. The seamen appear to have a lower work capacity.
2. The terms of employment do not encourage the seamen to work efficiently.

If the first be true, we must expect that more than 15 men will always be needed in Ceylon to operate Maple Leaf. But if the second also be true, we can expect that she could be operated with fewer than 28 men and this might be to the advantage of both the crew and the Department.

The suggestion has often been made that the Department should abandon the wage system of paying its trawler crews and adopt the " lay system " as Kristensen (1953) has recommended for India. Under the wage system seamen receive the same pay regardless of how many fish they land. Under the lay system (which is in effect in most of the world's major industrial fisheries) a fixed proportion of the returns from the sale of catches is set aside as the crew's share and the officers' share.

Seamen are anxious that the crew's share should be as large as possible and they work together hard for the common purpose of landing the heaviest possible catches. Furthermore, each crewman is anxious that his part of the crew's share be as large as possible. His share will be greatest when the crew size is least. He is willing to work as hard as he can so the crew size can be cut down to the minimum required for efficient operation of the ship. For this reason

slow or lazy seamen are not welcome aboard. If they cannot learn to work quickly and effectively with their fellows they soon find themselves replaced by those who can and will. The rest of the crew insist on such action.

The lay system has the same stimulating effect on ship's officers as on crewmen. And it offers many other inducements to better ship operation. One of the most important is that it encourages men to be at sea (where they earn their money) as much as possible. " Turn-arounds " are quick.

Needless to say, the lay system is not adaptable to vessels engaged in experimental work or exploration. They are fishing for information, not for fish.

Sea Time

Table I shows that while fishing the Wadge Bank, MAPLE LEAF spent approximately half her time in port—14.3 days per month as compared with 8.2 days when she worked out of Fleetwood. (These averages take in the time required for annual " refits ", occasional repairs and general maintenance.)

If she had operated in 1954 as she did in 1951 and '52 she would have been in port 98 days instead of 172 days and at sea 267 instead of 193 days and she might have landed 2,300,000 pounds instead of 1,500,000 pounds of fish; that is, 50% more.

Four main reasons have been advanced why MAPLE LEAF fell so far behind her Fleetwood performance.

1. Shore facilities for discharging catches and servicing trawlers were inadequate. The " turn-around " usually took 4 days as compared with 48 hours in Fleetwood.
2. On-shore arrangements for relief crewing were not efficient. Many times sailings were delayed for want of a substitute for an " AWL " seaman.
3. Too much of the responsibility for conditioning the ship for its next trip was left to the captain who had poor facilities for this work and who needed shore respite from his gruelling 10-day sea trips.
4. The wage system of feeing the crew discouraged efficient performance.

B. Operations by Braconglen

Comparison with Maple Leaf

BRACONGLEN is a slightly larger ship than MAPLE LEAF and considerably more powerful as shown by Table II. These differences are real but in practice they are often less obvious than might be expected.

TABLE II

COMPARISON OF SIZE AND POWER OF TRAWLERS BRACONGLEN AND MAPLE LEAF

(Data taken from Lloyd's Register of Shipping, 1954)

Feature compared	*Braconglen*	*Maple Leaf*
Length over all (feet)	149·1	142·8
Length between perpendiculars (feet)	137·7	130·0
Gross tonnage	338	323
Net tonnage	123	118
Stroke of engine (inches)	27	24
Diameter of Cylinders (inches)		
High pressure	13·5	12·25
Intermediate pressure	23·0	21·0
Low pressure	38·0	34·0
Nominal horse power	91	84
Boiler heating surface (Square feet)	3,064	2,436

Both vessels were owned by the same U. K. fishing company and served as "mid-water" trawlers while they were in the United Kingdom and since they came to Ceylon they have fished exactly the same gear. It would be instructive to obtain BRACONGLEN'S U. K. operational records to permit a stricter comparison of the two vessels' potentialities.

BRACONGLEN'S Ceylon fishing records were compiled, analyzed and tabulated in the same form as that used in Appendices 1 and 2. Sheer bulk prevents their inclusion in this report. They are summarized in Table III. A comparison of Tables III and I indicates that many statements made about MAPLE LEAF apply equally to BRACONGLEN. But there are other observations that should be made about BRACONGLEN'S performance because they provide context for what has already been said and because they are important in themselves for a proper understanding of past and present operations of both trawlers in Ceylon.

Adjustment to Ceylon Fishery

When BRACONGLEN first came her trips were very short (av. 7.1 days, Table III). By 1952, however, it had been shown that it was feasible to make longer (8.6 days) trips which afforded a 25% increase in the proportion of her sea time that was devoted to actual fishing. This change effected a small (2%) increase in the catch per day at sea. This shows up when the July-December (the best fishing months) values are compared (7,867 as compared with 7,723 pounds) but it is masked when the mean value for the 12 months of 1952 (7,570 lb.) is compared with the July-December 1951 value (7,723 lb.).

TABLE III

SUMMARY OF TRAWLER BRACONGLEN'S OPERATIONS ON THE WADGE BANK OFF SOUTHERN INDIA, OUT OF COLOMBO, CEYLON, JULY 1951 TO DECEMBER, 1954

Year	*No. of trips*	*Total days at sea*	*Total catch (lbs.)*	*Average length of trip (days out of port)*	*Average catch (lbs.)*	
					Per trip	*Per day at sea*
1951 July-December	12	78	602,366	7·1	54,761	7,723
1952 July-December	11	102	802,416	9·3	72,947	7,867
1952 Whole year	20	171	1,294,548	8·6	64,727	7,570
1953 ,,	18	179	1,604,967	9·9	89,165	8,966
1954 ,,	17	152	1,526,860	8·9	89,815	10,045

But it was not until 1953 that the ship's real capacity for catching fish began to be realized. That year the length of trip was increased still further (9.9 days) and hoped-for increases amounting to 25% were realized. The catch per day at sea approximated 9,000 pounds and the year's catch exceeded 1½ million pounds.

In 1954 BRACONGLEN'S catch per day at sea rose to 10,045 pounds (Table III) which is by far the best the Department has ever realized from any of its trawlers. But her trips were shorter, her total sea time was down 15% and her year's landings were down 5%.

Reasons for Improvement

Many reasons besides those just outlined have been advanced to explain the substantial improvements in BRACONGLEN'S performance since 1951. Of these, there are four which seem most plausible. Even if these were all valid and the only reasons for the change, it would still be impossible to disentangle them and say certainly which was the most important. However, it seems worth mentioning these reasons because there has been so much debate on the "how" and "why" of the improvement.

1. There were mechanical improvements in the operation of the ship after a qualified Chief Engineer (Mr. Grisenthwait, a 1952 Colombo Plan appointee) was engaged to stay with BRACONGLEN.

2. There were improvements in shore services for ship maintenance and in general management of ship operations—the latter under Captain Ellen.

3. Fish seem to have been more abundant during at least part of the later years (Sivalingam, personal communication) and this helped raise total production.

4. Rivalry. This began in 1952 as soon as it became known that another trawler (MAPLE LEAF) was to appear on the scene and it continued after she arrived.

Possibly the last is the most important of the four proposed reasons for the improvement. Susceptibility to rivalry is a healthy human characteristic that involves officers and seamen and is nothing to be ashamed of. Its importance in stimulating fishing effort is widely recognized. It fits in naturally with the " lay " system of paying crews.

C. General Discussion

Trawler Management and Efficiency

Much credit is due Captain William Mitchell, former skipper of BRACONGLEN, for his patient efforts in the developmental period when local personnel were being trained to become competent operators of trawlers; when good engineers were not regularly available and when the Department was developing a full understanding of what trawler operations required. His successor, Captain Neville Mendis maintained and, in some ways, improved BRACONGLEN'S performance.

Captain Ellen worked hard and made many splendid catches but his ship, MAPLE LEAF, was a smaller craft and could not be expected to do as well as BRACONGLEN, other factors being equal.

In spite of these advances there is still room for substantial improvement in the performance of both ships. Much can be gained by insuring that all who are responsible for their management are well acquainted with the main features of their performance and willing to co-operate with the management officer. For example, it has been shown (Appendix 2) that fish are most abundant and of better quality (more paraw) on the Wadge Bank during the south-west monsoon (May to October). If they know this, management officers can often avoid refits and other lengthy tie-ups in port at this time when trawling is most rewarding.

When trawlers are well managed they can land fish more economically and in better condition than most other types of fishing craft. They fish day and night and can operate in all weather except severe storms. They insure heavy, regular landings and they stabilize fish marketing.

Questions of Over-fishing and Fleet Expansion

Catch per day at sea in 1954 was lower for MAPLE LEAF (She did not fish during the poor months, January to June, in 1953 as she did in 1954) and higher for BRACONGLEN than in earlier years. When values for the two vessels are averaged, however, the 1953-54 trend (3%) is toward higher catches per day's fishing. Considered separately BRACONGLEN's records, which cover a longer period, show the same trend. This could be taken as evidence of increased abundance of fish or of more efficient performance of the vessels on the fishing grounds but not as evidence that fish stocks were declining. This conclusion validates Blegvad's (1951), John's (1951) and Hickling's (1951) predictions that Ceylon could expand her Wadge Bank trawler

fleet without fear of a serious reduction in catch per boat. John suggested three trawlers for the combined exploitation of the Wadge and Pedro Banks. It would seem now that this is an under-estimate and that Blegvad's more ambitious recommendation might be followed.

Even if the catch per boat on the Wadge Bank were to drop substantially from some future over-expansion of the trawler fleet, this need not be disastrous because it is a reversible process. Fish stocks will recover when fishing pressures are reduced. Besides, there are other good trawling areas like the Pedro Bank (Blegvad, 1951) that could be fished to relieve pressure on Wadge Bank fish stocks if this were necessary. At present these other areas are not being exploited at all.

Experience alone can determine the limits to which the fleet may be profitably expanded as Kestevan (1951) rightly points out. But expansion can be undertaken courageously because, as already shown, the Wadge Bank fishery compares favourably with other tropical trawl fisheries and with some of the profitable temperate-zone fisheries.

At the same time, the data assembled here warn against unbridled optimism. There are limits. The Wadge Bank should not be expected to rival areas like the north-west Atlantic which for centuries has tempted fishermen to make trans-ocean crossings to reap its harvests.

When and if fleet expansion is undertaken, it would be well to monitor fishing conditions by analyses such as we have outlined here. This should provide advance warning of overfishing before it becomes an economic problem.

Recommendations

This critique supports the following summary statements and accompanying recommendations which may be useful to the Department of Fisheries:

1. Changing system of feeing crews

If the lay system of feeing were adopted, it should eliminate disinterested and incompetent officers and men. An efficient crew should increase landings even without improvements in management and in shore facilities. It should also reduce the size of crews and consequently the costs of equipping and rationing them.

It is therefore recommended that the Department of Fisheries adopt the " lay " system of feeing its trawler crews.

2. Improving shore servicing

MAPLE LEAF records indicate that her landings could be increased 50% beyond those of 1953-54 if shore services were improved to permit 48-hour " turn-arounds " as in Fleetwood. Presumably the same would apply to BRACONGLEN. In other words, by better shore servicing and management these two trawlers could land as many fish as three trawlers would land under present operating conditions. Costs of increasing fleet size are vastly greater than costs of increasing operating efficiency of ships already under commission.

It is therefore recommended that the Department of Fisheries in the interests of economy should:

1. Improve shore servicing for its trawlers as soon as possible.
2. Defer purchase of additional trawlers until improved services are available.

3. Increasing the trawler fleet

There is good reason to believe that Ceylon can expand its Wadge Bank trawler fleet without overtaxing the fish stocks. Use of trawlers assures steady, large supplies of good quality fish in good condition and stabilizes fish marketing. Considering the volume of fish produced, trawlers are not expensive. They are profitable.

It is recommended that the Department should:

1. Increase its fleet of large trawlers as soon as it has facilities to service them efficiently.
2. Increase the fleet slowly and monitor effects of the increase on fish stocks very carefully so that expansion can be halted before stocks are diminished to levels where exploitation becomes unprofitable.

SMALL BOAT TRAWLING

Otter trawling for groundfish (fish that live at the bottom or close to it) is the backbone of many, if not most, of the major fishing nations of the world. The main producing units are expensive, far-ranging steel vessels more than 100 feet long like the BRACONGLEN and MAPLE LEAF which Ceylon regularly operates on the Wadge Bank 150 miles from Colombo. However, important quantities of fish, especially of the flounder type, are landed the year round in these same countries by smaller trawlers operating on rich shallower-water grounds close to shore.

Appendix 6, listing data for 1948 for the Canadian Pacific coast, shows how important a fleet of small trawlers can be in contributing to total landings. The boats referred to in this appendix averaged 50 feet long and were powered by motors of 90 to 120 brake horsepower. Appendix 7, showing 1954 catches, illustrates this for the Canadian Atlantic coast and a slightly smaller class of boat. These records were assembled by the Fisheries Research Board of Canada and made available through the courtesy of Dr. A. W. H. Needler, Director of the Biological Station at Nanaimo, B. C., and of Dr. J. L. Hart, Director of the Biological Station at St. Andrews, N. B. These data are impressive but the work of the Fisheries Research Institute of Japan (1961) shows that Canadian small trawlers are surpassed in performance by those which Japan operates in the East China Sea.

A. History of Surveys in Ceylon

Southwest Coast

The survey conducted by the Ceylon government trawler LILLA in 1920 and 1921 (Malpas, 1926) indicated that the trawlable grounds off the southwest coast were too small, too rough and too poor in fish to reward commercial trawling with a large steam vessel. But Glanville (unpublished MS Report to Fisheries Research Station), from his work with HALPHA, has stated that there are moderate-sized patches of trawlable bottom off Colombo where small catches of fish can be obtained. He presumed that small commercial otter trawlers could exploit these

grounds if their operators learned their positions. But most of the fish he took (Table IV) were third quality and his trials were not extensive enough to convince him that commercial operations would be profitable. Outside these limited areas net tear-ups were so common as certainly to prohibit worthwhile bottom trawling on the southwest coast, no matter how abundant the fish might be.

TABLE IV

AVERAGE FISHING PERFORMANCE OF VARIOUS TRAWLERS ON PEDRO BANK, IN PALK STRAIT AND OFF THE SOUTHWEST COAST OF CEYLON; AND OFF THE EAST AND WEST COASTS OF CANADA. THE VALUES LISTED ARE THE SIMPLE MEANS OF THE SEVERAL ENTRIES FOR THE BOATS, REFERRED TO IN APPENDICES 6 TO 11

Region and Fishing Vessel	*Catch/Day out of Port (lbs.)*	*Catch/Hour of actual trawling (lbs.)*
North-east Coast (Pedro Bank region)		
Lilla	—	185
Bulbul and Tongkol	2,696	285*
Raglan Castle	3,549	407
Halpha	—	0
North Star (1953)	—	79
Canadian (1954)	—	26·5
Northwest Coast (Palk Strait region)		
Lilla	—	285
Halpha	—	403
Northstar (1953)	—	223
Canadian (1954)		
Regular hauls		26·1
Special hauls		
Towing alone		5·0
Tandem towing with " North Star "		10 to 25
Southwest Coast (Galle to Chilaw)		
Lilla	—	46
Halpha	—	100
North Star	—	235
Katumarams (using the Katumaram dela)	—	19·6†
Canada—Small mechanised trawlers		
Atlantic coast	1,416	161
Pacific coast	—	639‡

* Special records kept for Bulbul's last three 1929 trips out of Colombo to the Pedro Bank showed that catch per hour of actual trawling averaged 10·6 per cent. of catch per day out of port. The value 285 equals 10·6 per cent of 2,696, the mean value for Bulbul's and Tongkol's catch per day out of port, 1928 to 1935.

† The mean value for catch per hour fished (i.e. per hour on the grounds) by the katumaram dela is 13·1 (Appendix 11). The value 19·6 is calculated from 13·1 on the assumption that actual trawling occupies two thirds of the fishing time.

‡ This value is catch per hour fished (Appendix 6).

No mechanized trawlers, large or small, have tried to operate commercially in this area in spite of its proximity to the island's best market, Colombo. However, some small-boat trawling is done now off the southwest coast by log rafts (katumarams) working in pairs. Each one is paddled along and hauls one warp of a trawl known to the Sinhalese as " katumaram dela " (Pearson, 1923). This is a primitive version of the modern twin-boat trawl or " Spanish trawl ".

All the handling is manual. Although Malpas demonstrated that the grounds in this region are not suited to large otter trawler operations, the katumaram del regularly take sufficient quantities of fish there to keep their owners interested (Appendix 11 and Table IV).

Northeast Coast

LILLA'S fishing survey off the northeast coast indicated that the Pedro Bank should be well worth fishing (Malpas, 1926 and Pearson and Malpas, 1926). Later, commericial trawling by the steam trawlers, BULBUL, TONGKOL (records made available through the courtesy of Ceylon Cold Stores, Ltd.) and RAGLAN CASTLE, showed that this was indeed true. These large craft used Colombo as a base (Appendix 8) and they made good catches of "mullet" (Lutianids) and some coarse fish. However, except for one haul made by HALPHA in 1949, small boats have done no trawling there. The grounds would be readily accessible to them for they need not go beyond the narrow continental shelf (Fig. 2).

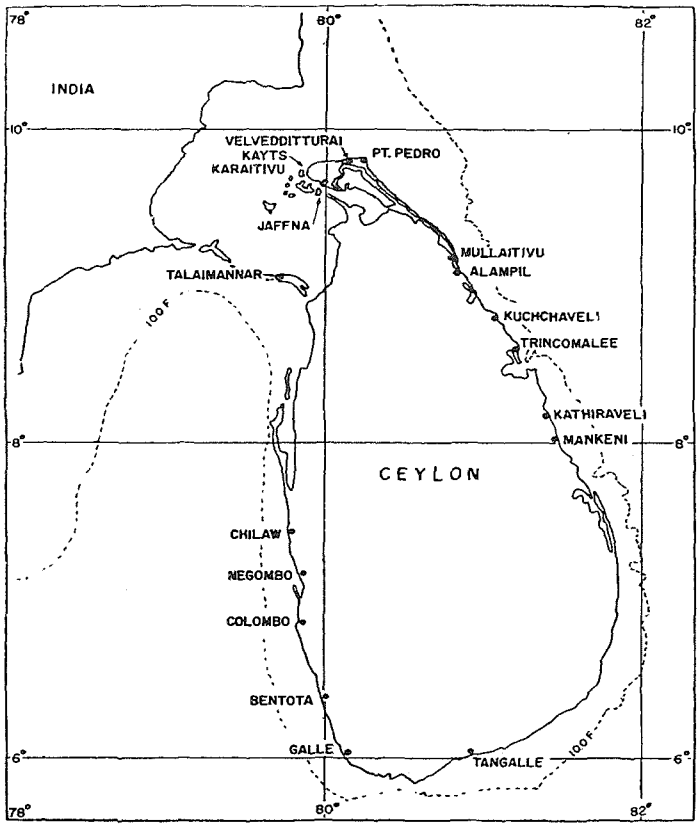

Fig. 2. Map showing positions of several fishing ports mentioned in the survey report and the extent of the continental shelf (sea area inside the 100 fathom contour) over which almost all fishing takes place.

Southeastern Palk Strait

LILLA'S work in southeastern parts of the Palk Strait (also readily accessible to small boats) showed that this is a highly productive area of poorer quality fish (Appendix 9 and Table IV). No large trawler has ever tried to operate there commercially but 1952 results reported by Glanville for HALPHA (unpublished MS, Fisheries Research Station) support the conclusion Malpas (1926) reached that this should be rewarding.

HALPHA is 75 feet long, has a gross tonnage of 54 and has two 140 horsepower diesel motors. She could scarcely be referred to as a " small boat " in the regular sense of the term. It is true to say, therefore, that previous to 1953, the only small-boat commercial trawling ever done in Ceylon was with unmechanized boats.

B. 1953 and 1954 Trials

Planning

The knowledge that lucrative catches are made by trawlers of CANADIAN'S and NORTH STAR'S size-class in places where groundfish are plentiful (Appendices 6 and 7; and Fish. Res. Inst. Japan, 1961) and the promising reports of LILLA'S and HALPHA'S efforts in areas that are readily accessible to boats of this size were encouraging. It provided all the evidence that was necessary to convince the Steering Committee that it was important for the Canadian team to try out small-boat otter trawling with their Canadian west-coast type gear.

Trawling, as a method of fishing, is not strange to Ceylon and it seemed reasonable that it would be adopted by small boats if this were shown to be worth while. It was thought of as well suited to ports like Jaffna and Kayts whose harbour mouths are too shallow for large trawlers and probably equally well suited to deeper-water ports like Colombo, Talaimannar and Trincomalee.

It was decided that the three areas offering the best prospects for exploration were the southwest and northeast coasts and southeastern Palk Strait.

1953 Trials with Conventional Gear

Mr. H. Pinchin, who had experience in trawling off the Canadian Pacific coast, was one of the first group of three Canadian skippers to come here under the Colombo Plan and he carried out the 1953 otter trawling trials using NORTH STAR. She was equipped with a double-drum winch and " A " frames placed far aft. The trawl was boarded, therefore, over the stern as is the fashion for small boats off the Canadian west coast and off the northwest coast of the United States of America.

The trawl used for most of the work had an 80-foot footrope. Toward the end of the year's work it was thought that it might be too large for NORTH STAR'S 80-horsepower diesel motor to haul at an effective speed. Mr. Pinchin therefore reduced the mouth-width until the footrope measured 55 feet. This increased the towing speed somewhat and the hauls made thereafter seemed to be better (Appenidix 10) in that they took more mullet (Lutianids). The catch records are summarized in Table IV, along with those of other boats that have fished the same areas.

Mr. Pinchin's records and general reports support two conclusions:

1. Glanville's reports are well founded and until the positions of trawlable grounds off the southwest coast are charted, it will be impossible to assess them properly.

2. The fish taken on Pedro Bank and in Palk Strait were third quality (many skates, rays, sharks and small fish) and not abundant enough to make otter trawling commercially worthwhile for boats of NORTH STAR'S size-class.

This second conclusion seemed incompatible with former records (Appendix 8 and Table IV) which showed the Pedro Bank to be highly productive of second-quality fish. While Mr. Pinchin was unable to offer a generally satisfactory explanation for this disparity, he attributed it to year-to-year differences in abundance of fish on the grounds.

1954 Trials with Conventional Gear

The total number of hauls made in 1953 (69 in all) was not great so the Steering Committee decided to continue the project in 1954 in spite of Mr. Pinchin's findings. Mr. Victor Halliday, one of the second group of Canadian skippers to come here, was put in charge. He had had several years' experience in small-boat flounder and general groundfish trawling in Nova Scotia.

The trawling gear was installed on CANADIAN and the first trials were made in July out of Trincomalee using a new 80-foot otter trawl braught out from Canada in 1953 by Mr. Pinchin. Records of the operations are reported in Appendix 11 and Table IV. Based on these and on his observations on behaviour of local varieties of fish and on the boat's performance, Mr. Halliday came to the following conclusions:

1. The fish here seem to move faster than they do off the Canadian east coast. This he attributed to the much warmer water (80° as compared with 50-60°F) and because of this one might expect that higher trawling speeds would be required to take them.

2. CANADIAN'S speed when towing the 80-foot trawl at full throttle was very low—not much over one knot per hour.

3. At this speed the net was capable of taking only the very slowest-moving species of fish like flounders. Any others taken must be regarded as accidentals and their numbers in the catch must not be considered a reliable index to their actual or relative abundance on the grounds.

4. The consistently low catches of flat fishes by the trawl and the low frequency of flat fishes in catches of local craft using other types of gear is good evidence that flat fish are scarce on these grounds as Blegvad (1951) suggested.

5. The scarcity of these slow-moving varieties, which are, in so many cases, the mainstay of small trawler catches in temperate regions, does not augur well for the success of conventional small-boat otter trawling here.

6. CANADIAN was under-powered for trawling with an 80-foot net, even if only slow-moving types of fish were being sought.

7. The smallest, commercial-sized trawl available should be used if a fisheries survey with conventional otter trawls was to be carried out.

Mr. Halliday's third conclusion is consistent with the data compiled by Mr. Pinchin in 1953. Pinchin's catches were often composed almost entirely of large skates and of almost no faster-moving forms such as mullets (Lutianids), until after he reduced the net size. This conclusion is further supported by a comparison of Mr. Halliday's trawl catches (Chundikulam, July 23, Appendix 11) with Mr. Pyne's longline catches made on the same grounds on the same day (Appendix 13). The trawl took poor catches, and of mullets only, whereas the longlines took fair numbers of mullets and some sharks (dogfish) which are fast fish. Sharks must have been on the grounds, even if they were not captured by the trawl. The logical explanation is that they were fast enough to swim out of the path of the slow-moving trawl.

Following these first east coast trials, Mr. Halliday ordered a new trawl. It was a cotton trawl— $\frac{3}{4}$ of No. 35 Style as described in Catalogue No. 2, 1953, of John Leckie Limited, Halifax. Nova Scotia, Canada. It had a 50-foot footrope. At the same time he reduced the width of the 1953 trawl from 80 to 35 feet and he was able to obtain an old worn net with a 30-foot footrope from the Department's stores. With these two smaller nets, trial hauls were made after July 20 off Mullaitivu and in Palk Strait.

These, however, were little more productive than the 80-foot trawl although they did permit an increase in trawling speed to an estimated two knots per hour. This he considered still too slow for good catches of flat fishes (which were rare) and much too slow for the faster species. Support for this opinion comes from British Columbia trawlermen who consider that, even in their cold waters, speeds of at least two knots are required for flat fish and that three knots are required to take any quantity of faster types along with them. The same opinion is held by Nova Scotia flounder trawlermen who regularly tow at two to three knots (Personal communications from St. Andrews and Nanaimo Biological Stations of the Fisheries Research Board of Canada). The Wadge Bank trawlers usually operate at four knots and it seems likely that the LILLA, TONGKOL, BULBUL and RAGLAN CASTLE all operated at such speeds when they recorded the good Pedro Bank catches listed in Appendix 8 and Table IV.

Special Trials

On October 29, 1954, off Kayts (Appendix 11), Mr. Halliday tested his theory that CANADIAN'S poor catches were the result of slow towing. He had NORTH STAR pass him a tow line so the two boats could tow in tandem. In this way the combined power of their 80-horsepower motors was used in hauling the 50-foot trawl and he achieved a towing speed estimated at $2\frac{1}{2}$ to $2\frac{3}{4}$ knots. Table IV and Appendix 11 show that the catches made in this way were two to five times as great as those made by CANADIAN alone using the same net on the same grounds on the same day. Even this increased catch would not be considered worth while by Canadian east or west-coast standards (Table IV) but it is to be noted that the hauls were not made in a part of Palk Strait designated by Malpas (1926) as worth trawling.

In 1953, Mr. Pinchin explored the possibilities of mid-water trawling with NORTH STAR. On August 19-22, off Trincomalee, he towed the 80-foot otter trawl, complete with doors, on short cables along the 40-fathom contour. By adjusting the cable-length he made tows at various depths estimated at 10, 20 and 30 fathoms (Appendix 10) to see if there were mid-water fish to be captured. The speed achieved was somewhat higher than that of bottom trawling with the same gear. In the course of the fishing he took a few small fish and jelly-fish. This result was not encouraging but the beach seines at that time were doing no better. It did show, however, that even a slow net towed in mid-water can take some fish.

In 1954, Mr. Aubrey Barry and Mr. Halliday, who joined the Canadian team that year, made another test of mid-water trawling. On July 27, off Mullaitivu, CANADIAN and NORTH STAR combined operations for a brief time. Each took a single warp of a square-mouthed box trawl 78 feet on each side (a pseudo-Larsen trawl) and hauled it close to the surface through small schools of pomfret (*Stromateus fiatola* (Bk.)) which appeared to be feeding on jellyfish. The speed was not more than one mile per hour and the boats were about 100 feet apart. They managed to straddle the schools of fish which seemed to be in no way alarmed by the boats or the net but they did not enter the net. They merely avoided it leisurely.

CANADIAN'S winch failed when the trawl was being boarded after the first haul and NORTH STAR had to board it by herself. Only one pomfret was taken. It was several days before the winch was back into operation and by that time the pomfret, which are seasonal migrants on this coast, had moved out of the area and no further trials were possible.

This brief test indicated that the method of operation was suited to the capture of this schooling species off Mullaitivu because it will " stand " in the water in spite of local disturbances. How many other local species share this characteristic is not known. Some certainly do not, but it is believed that many which are now regularly taken by beach seines do stand and could be caught by towing small, fast, mid-water trawls. Mr. Saemundsson, the F.A.O. fishing gear technologist who was working in Ceylon in 1954, expressed the view that twin-boat fishing trials using nets of various sizes and designs appropriate to the sizes of the boats available to tow them, should be given a prominent place in fisheries survey work. The two tests and the obervations made by the Canadian team support Mr. Saemundsson's view.

C. Discussion

Importance of Continuing Trials

Because the conventional otter trawl and the conventional methods of operating it from low-powered boats were found unsuitable to conditions in Ceylon, it has been suggested that small-boat trawling trials should be abandoned altogether. This we would consider unwise because the possible benefits of adapting small-boat trawls to local conditions are very great. We regard them as possible successors to beach seines. The beach seine fishery now contributes 40% of the total annual catch but is in economic distress because it requires so much manpower and manpower is becoming increasingly expensive (Canagaratnam and Medcof, 1956).

It is important therefore to continue efforts to adapt small-boat trawling to conditions in Ceylon.

Possibilities of Conventional Otter Trawling

Glanville and others have shown that conventional otter trawls will work in Ceylon's inshore waters. And Pinchin and Halliday have shown some of the problems that face their commercial operation by small boats. One of the ways of increasing the speed of trawling (which seems to be one of the main problems) without changing the type of trawl would be to increase the power of boats. This seems undesirable because it might involve increases in the size of boats which might bar them from ports like Jaffna with shallow harbour mouths. It is also undesirable because it would increase operation costs. But if efforts are to be made to adapt conventional trawls, there are ways of reducing some of the operating costs. Appendices 10 and 11 show that the number of " rip-ups " suffered is very great. These are costly in time and money. Mr. Halliday was of the opinion that " rollers " or " bobbins " should be fitted to the footrope to reduce these and a set of these was turned out for trial. Unfortunately they were made of seasoned, fine-grained wood and never did lose their buoyancy, even when sunk at 40 fathoms for 48 hours. They were therefore unfit for trials. The need for trials with bobbins still stands.

Possibilities of other Trawls

A more promising way of getting around the problem of increasing trawling speeds might be to change the design of trawls and/or methods of trawling. There are many types of trawls and many ways of using them and new types are continually being developed. Much of the power exerted as a forward thrust by the motors of otter trawlers is absorbed by the " doors " which are set at an angle so they will flare sideways and keep the mouth of the trawl open by their sideways pull. There are other ways of keeping the mouth of the net open without this loss of power.

If the doors of the otter trawl were discarded and CANADIAN and NORTH STAR (or any other pair of matched boats) each towed one of the warps of the same trawl, higher speeds should be attainable than those Mr. Halliday achieved by tandem towing. This increase might be great enough to raise both the quantity and quality of catches to commercially profitable levels. This twin-boat method of fishing groundfish is commonly practised by the Japanese " bull trawlers " that fish the China Sea (Fisheries Institute of Japan, 1961) and by trawlers from Spain which cross the Atlantic to fish the Grand Banks off Canada's east coast. It was from them that this method of trawling got its name, " Spanish trawling ", in that region. Twin-boat trawling should work in Ceylon because the weather, which is usually a limiting factor for this type of fishing, is much more favourable here than in the North Atlantic. Nobody has tried it. John (1951) thought the possibilities were good.

If twin-boat trawling with regular types of bottom trawls will not work, or even if it did prove workable, there are still other types of twin-boat trawling that are worth examining.

The conventional groundfish trawl, with its low head-rope, may not be the best gear to use in Ceylon waters where certain types of fish like flounders, that actually live on the bottom, are rare. There are two well recognized ways of fishing under such conditions. In both these methods there is little or no friction between net and bottom and high speeds can be obtained

with relatively low power. One is to use a net which need not go to the bottom—a mid-water trawl such as a herring trawl or Larsen trawl. The other is to use a box trawl to skim over the bottom.

The sides of a box trawl are high so that even when the footrope is on bottom the headrope will be well above it, thus enabling fish to enter the net even if they are swimming several feet up in the water. Because fast bottom fish are known to be abundant on close-to-shore areas that are accessible to small boats, e.g., Pedro Bank, it does seem worth conducting trials of this sort.

Similarly, surface and mid-water trawls should be tested for capturing fish that live well up in the water quite independent of the bottom. NORTH STAR'S and CANADIAN'S preliminary trials at mid-water trawling have already been described. The results were not discouraging. The hope is that systematic trials will discover efficient methods of small-boat trawling that will eventually assume the important roles they now fulfil in other countries. John (1951) had high hopes for this type of operation.

Summary

1. Small-boat otter trawling for groundfish is a highly productive method of fishing in many countries and if practicable here, might be carried on both from deep-water ports and from ports that are too shallow-mouthed to accommodate large trawlers.

2. So far, only small catches have been taken in small-boat trawling trials in Ceylon but several important points have been established that indicate promising directions for further trials.

3. Slow-moving fishes, such as flounders, that sustain conventional small-boat otter trawling in many temperate countries are rare here but faster-moving groundfish abound on some of our close-to-shore banks.

4. An important point is that small-boat trawls must be towed faster than in temperate zones if they are to capture the more abundant fast-moving species. This might be done by using more powerful and faster boats and quite small otter trawls fished in the conventional way. But there are other kinds of trawls and other methods of fast trawling with low-powered boats that have not been adequately tested here; for example, mid-water trawls and twin-boat trawling (Spanish trawling) for pomfret. The possible benefits from adapting these to Ceylon fisheries are great.

Recommendation

Because the possible benefits of small-boat trawling are great and because the Department of Fisheries now has boats that seem capable of testing and adapting at least some of the known methods to local conditions, it is recommended that small-boat trawling trials be continued vigorously.

HANDLINING FOR GROUNDFISH

Handlining is like angling without a rod. It is a very ancient but not necessarily crude form of fishing (Radcliffe, 1921) that is still commonly practised in many countries—usually from boats. Each fisherman tends at least one line and each line carries one or more baited hooks and a sinker fastened close to its lower end. The handliner pays out line until the sinker rests on bottom or is close to it, then he generally raises and lowers it with a seesaw motion of the arm. He believes that moving the baits makes them more attractive. He may also "chum" the fish; that is, periodically he may release bait in the neighbourhood of his hook to attract more fish and improve his chances of catching them. The hook-bait and the chum may be either alive or dead.

Compared with other fishing methods, handlining has the obvious advantage of low cost of equipment, and skill in its use is not too difficult to acquire. Handlining has the further advantage that it can be carried on over bottom that is too rough to permit other types of fishing

like trawling or longlining. Its disadvantages are that when currents are strong it is sometimes impossible to prosecute (Grenier, 1954) even when other types of fishing like longlining could be carried on and that it may be unprofitable in deep waters where longlines with power haulers possibly could be operated to advantage. Another disadvantage is that in handlining there is a strict limitation in the amount of gear used. In Ceylon, for example, there are seldom more than two hooks per line and fishermen seldom tend more than one line per man. This means that boat crews must be large if catches are to be kept high. In longlining, by contrast, the amount of gear set can be very great if there are facilities to handle it.

A. Traditional Ceylonese Fishery

The Canadian team's 1953 study of handlining for groundfish in Ceylon was cursory but it showed that the equipment and methods used here are highly refined and some of them most ingenious. An example that illustrates this is the device and use of the chum cone known to the Sinhalese as " eyem cooda " (Fig. 3). It is of open wicker construction, weighted below with a lead ring and fastened above to a line. Live prawns or small fish which the fishermen carry with them are placed under the cone which is then allowed to drop quickly through the water. So long as it sinks freely the chum is held in the upper part of the cone by the stream of water rushing upward through the wicker. When the fisherman clutches the line, the free fall of the cone is checked, the water pressure on the animals ceases and they swim out at whatever depth they happen to be. Glanville (1954, Figure 11) describes the live bait basket, another ingenious device which is used in conjunction with the chum cone.

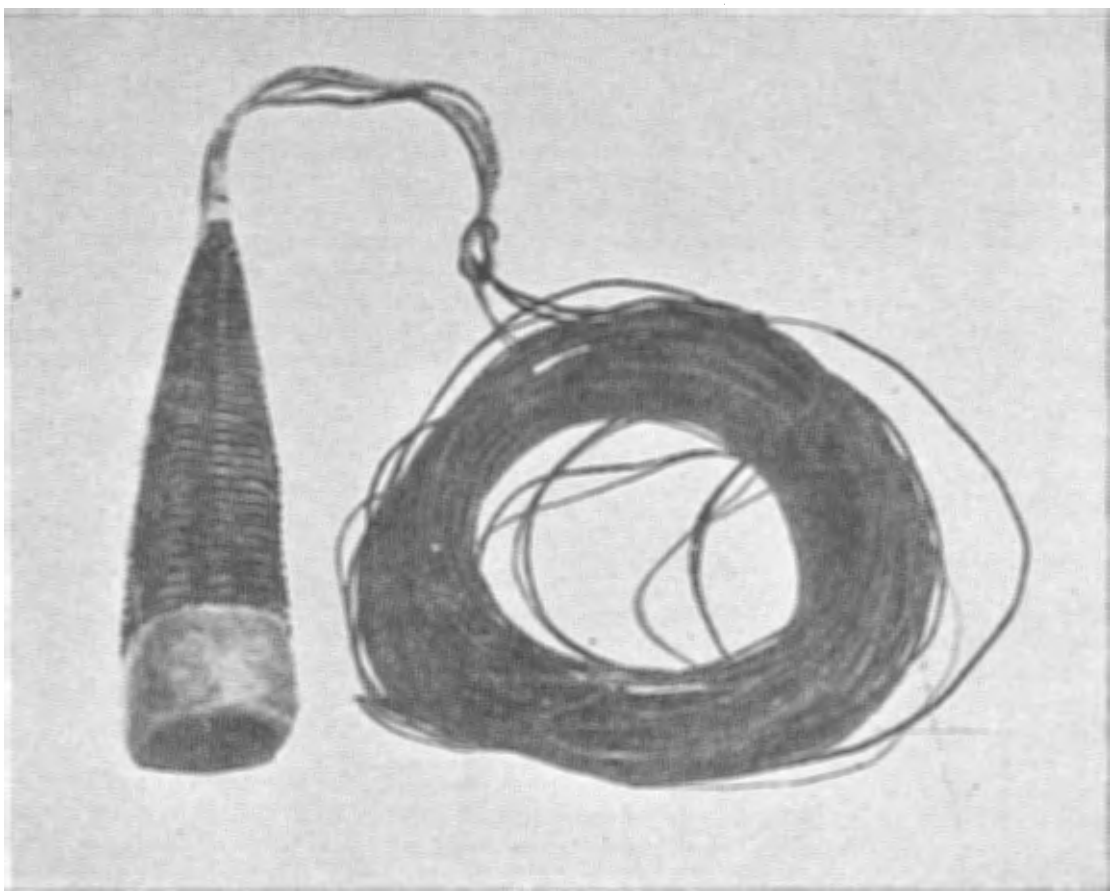

Fig. 3. Chum cone used by handliners to carry down and release live chum (small fish or prawns) at the level of baited hooks to attract large fish and improve catches. The bottom ring is of lead, the cone-proper is of wickerwork.

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Traditionally, handlines are hand-laid cotton, dressed with the juice of " timbiri " fruits (*Diospyros atrata and D. albiflora*). The hooks may be factory-made or produced locally by a hooksmith with simple blacksmith's equipment. He uses spring steel wire from such sources as coiled springs of old automobile seats and is able to turn out strong, delicate or sturdy hooks according to the exact pattern prescribed by the fishermen who stand by supervising him as he works.

B. Search for better Gear

Mr. Babcock, more than any other member of the Canadian team, directed his attention to the equipment used in handlining. He strongly advocated replacement of traditional-type lines by colourless, mono-filament nylon which he considered superior. Some fishermen adopted them. He also believed that the fishing efficiency of the popular hand-made spring-steel hooks was low because they corroded so quickly. He advocated tests of hooks made of non-corrosive metal and, through arrangements with the Steering Committee, several small lots of stanless steel hocks were made up at the Government Factory following patterns given to Mr. Babcock by fishermen. These were distributed to fishermen in different ports. Later, inquiries were conducted among these fishermen to get their appraisals. They generally approved of the non-corrosive characteristics of the new hooks but most of them were dissatisfied with the patterns. Almost every man had his own strict views of just how the hook he was to use must be made. He liked to choose the pattern and supervise the manufacture himself.

In 1954 Mr. Babcock continued his efforts along the same lines until he completed his contract and return to Canada. More fishermen tested nylon lines and several more patterns of hooks were tested but with much the same result as in 1953. Finally it was decided that the simplest way to popularize stainless steel hooks would be to place stock material in the hands of village hooksmiths. In 1955, when this report was filed, no suitable stainless steel wire stock had been obtained but this approach to the problem had been approved by fishermen and blacksmiths. Steel of the right malleability and tempering characteristics may not be easy to find.

Preoccupation with other fisheries work prevented the Canadian team from carrying out other field work on handlining for groundfish except that discussed under Mothership Operations and the collection of records of industrial operations by indigenous craft. The latter are treated in the next section.

C. Study of the Fishery

The task of fulfilling the Steering Committee's request for a review of back records was assigned to the writer and it soon became clear that annual landings of groundfish by Ceylon's many handliners are very high in spite of the fact that the catch per man per hour is often low. They are probably exceeded only by landings of beach seiners and gill netters but there were no annual statistics from which the true relative importance of these fisheries could be judged.

The Department's voluminous files describing mothership operations supplied a good deal of bottom handlining catch data for different parts of the coast. They applied to fishermen working from their own craft after being towed to fishing grounds by motorized launches (motherships) operated by the Department of Fisheries. It was agreed that these should be analyzed and that the information gained should be supplemented by assembling records of current industrial handlining operations by local craft that were unassisted by motherships. A quantity of such data was assembled with the help of fisheries officers (Appendix 12). It was also agreed that no further handline fishing trials should be carried out by the Deparment or the Canadian team until the results were available for intelligent direction of any such work.

The data assembled for Ceylon and for some fishing areas outside Ceylon are summarized in Appendix 12 and Table V. The value shown for Nova Scotia in Table V is not a statistic but an estimate of average landings so far as Mr. Pyne and Mr. Halliday could remember from their own experience in fishing those waters.

TABLE V

SUMMARY AND COMPARISONS OF HANDLINE GROUNDFISH CATCHES COMPILED IN APPENDIX 12

Fishing Ground	*Year*	*Months*	*Catch/line/hour fished (lb.) (*)*
Ceylon off:			
Colombo	1954–55	Sept.–March	1·4
Negombo	1954–55	Dec.–Jan.	0·5
Karaitivu Island	1949	April	20·0
Thalaiyadi, Pt. Pedro and Mylliddy	1954	September	0·8
Mullaitivu	1951	June–Sept.	11·5
	1952	Aug.-Sept.	5·5
Mankeni	1954	June-July	10·3
Wadge Bank	1949	Feb. and March	33·2
Seychelles Islands near shore	1948–49	April-June	50·6
Seychelles oceanic banks	1948–49	April-June	77·0
Nova Scotia (east coast of Canada)	—	—	40—50 (†)
Gulf of Oman (Western Arabian Sea)	1948	January	8·3

(*) Same as catch per man per hour in most cases.

(†) An estimate by Mr. Pyne and Mr. Halliday from recollections of their own fishing experience.

The data show that in Ceylon the catch is largely composed of " rock fish "—a loose term used here to include a wide variety of grade 2 fishes (mostly Lutianids and Lethrinids that feed about rocky ledges and coral reefs) and some grade 1 and grade 3 fish. The records for unassisted craft and reference to Figure 2 show that in most cases these are taken from grounds close to shore readily accessible to sailing or oared craft and on lines with one hook. And the catches are small—for example, out of Colombo it averaged 1.4 pounds per line per hour (Table V).

The best catches were made from small boats, " vallams ", towed by motherships to fishing grounds that are relatively far from shore, close to the edge of the continental shelf and therefore seldom visited by handliners. Off Karaitivu Island and Mullaitivu, for example, they averaged 20.0 and 11.5 pounds per line per hour.

The records show that catches even by assisted craft are highly seasonal. In some cases at least, this is attributable to the inability of these boats to withstand weather conditions rather than to lack of fish on the grounds. Handlining for groundfish off Mullaitivu, for instance, stopped in September in 1951 and 1952 but trawling records (Appendix 8) show that there is an abundance of groundfish on the Pedro Bank throughout the northeast monsoon season when no line fishing whatever is practised there.

Appendix 12 also indicates that the best catches have been made with multiple-hook lines (usually five-hook) in the hands of Indian fishermen skilled in their use, from boats that are constantly rowed during the fishing operation so as more or less to maintain their positions over the fishing ground instead of drifting over it rapidly with the variable currents that are

characteristic of such places. However, Table V shows that even with these refinements the catches were little better than those reported for the Gulf of Oman (Western Arabian Sea) by Bertram (1948). They were much lighter than those realized from 3-or 4-hook lines on the Wadge Bank (Chidambaram and Rajendran, 1951) or from 1-or 2-hook lines on the Canadian east coast or from the 10-hook handlines used in the Seychelles (Wheeler and Ommanney, 1953).

D. Discussion

Four tentative conclusions may be drawn from this study:

(1) Groundfish are probably not as abundant on the grounds oridinarily visited by Ceylon handliners as on many grounds exploited by tropical and temperate-zone fishermen. Accordingly, it would be unrealistic to expect heavy catches there. Nevertheless, returns from handlining in the better areas are so much higher than those from some other types of fishing (e.g. from trolling) that more people might be encouraged to practise it.

(2) Some of the best handlining grounds are near the edge of the continental shelf, relatively far from shore and are therefore almost consistently neglected by our handliners. This could be overcome by using larger, more seaworthy mechanized boats. These could take fishermen safely and quickly from and to their operational bases and permit them to exploit rich fishing grounds regardless of seasonal weather conditions. They could also carry heavy loads of fish. It is still questionable whether such mechanization would be rewarding to commercial fishermen unless they had government patronage of some kind because handlining requires large crews. If it were rewarding then handlining might be greatly expanded and Ceylon's landings of good-quality fish could be increased accordingly and seasonal production stabilized.

At the edge of the continental shelf, deep oceanic water (rich in nutrients) often mixes with shelf water (sometimes poor in nutrients) to produce an abundance of bottom and planktonic fish foods and abundant fish stocks. This may partly explain the heavier catches observed on the shelf edge but so far there is no local hydrographic or biological evidence that this holds true in the areas tested. Their stocks might decline if heavily fished. Investigations might reveal relationships that would be important in assessing these grounds and in discovering new fishing grounds. In the Seychelles (Wheeler, and Ommanney 1953) this relationship does not seem to apply. There, the best fishing is on top of banks—not at their edges.

(3) Better catches might be realized if multiple-hook lines were adopted by Ceylon handliners.

Following from this third conclusion, a suggestion by Mr. J. R. Seemundsson (F. A. O. fishing expert assigned to Ceylon) merits attention. He advocates the use of the " juksasnella " recently introduced in Scandinavian countries. It is a circle of line, an " endless belt " handline, so to speak, equipped with several heavy sinkers and armed with many hooks some of them baited and some bearing artificial lures. In operation, the juksasnella is hauled in continually over one side of the boat, either manually or with a power hauler, and allowed to sink back to the bottom on the other side. The amount of line in the circle and the number of hooks is adjusted to the depth of the water in such a way that several hooks are at all times being dragged over the bottom or close to it.

The part of the line on the bottom and immediately above it acts as a multiple-hook handline for taking groundfish while the parts higher in the water act in much the same way as multiple-hook drift lines or even as trolling lines useful in capturing pelagic species. Its principal disadvantages would seem to be its slightly higher cost and its greater tendency, than conventional handlines, to foul on uneven bottom. However, these disadvantages do not seem serious enough to discourage thorough trials of the device on our grounds.

(4) This study has shown that handlining is one of Ceylon's largest fisheries but that very little is known about it. It would seem that more fishermen should be encouraged to participate in it. Eventually it might be replaced by other fishing methods like bottom longlining but the fact that it is already being practised would simplify its expansion. However, before expansion

of the fishery is encouraged it should be better understood. In other words, investigational programs should take in not only an examination of current-style operations, as heretofore, but also include fishing trials with mechanized boats and new-type gear and possibly biological and hydrographic studies of good handlining grounds.

Recommendation

Handlining for groundfish is a widely practised but little known fishery and has been recognized as important. Prospects are that it could become even more important in the national economy. It is therefore recommended that investigation of the handline fishery for groundfish be continued vigorously and expanded.

BOTTOM LONGLINING

A bottom longline consists of a strong " ground line " usually about 50 fathoms long, to which short side lines called " gangings " or " snoods ", 6 inches (in Ceylon) to 3 feet long, are attached at regular intervals of 1 to 3 fathoms. A hook of any desired size is attached to the free end of each ganging. In fishing operations several lines are usually tied together into one " string " which may be any length up to 3 or 4 miles.

In some sections, especially the northern part of the island, the gear is familiar under its Tamil name, " tundi valai ", but even this term has little or no meaning outside that section. For this reason it seemed necessary to give this description of what is meant by a bottom longline.

A. Review

While the 1954 program of fisheries survey was in the planning stage we made a review of bottom longlining in Ceylon. This was intended to provide the Steering Committee with the information it needed for deciding whether bottom longline fishing trials should be included in the program. The review covered the traditional fishery and its problems, readily accessible information about longlining in other countries, and records of experimental fishing that had been done in Ceylon.

Traditional Ceylonese Fishery

Mr. E. R. A. De Zylva and other officers of the Department provided information on this fishery and the author made a first-hand inspection in company with the Chief Inspector, Mr. A. M. A. Cader. Longlines were in common use in the Jaffna peninsula and occasionally used in Koddiyar Bay. Pearson (1923) described them as in common use about Puttalam but they were not seen there during our field trip.

The Canadian team was impressed with the ingenious devices developed by the local fishermen to overcome the inherent difficulties which limit this kind of fishing.

1. The chief limiting factor was, of course, an adequate fish stock, catchable by this gear. Within the range of their fishing craft, which was not great (their boats were unpowered), the fishermen had learned where and when they could fish profitably.

2. The second limiting factor was a regular and large supply of bait, alive or at least fresh, and attractive to fish. In the Jaffna peninsula, at least, the fishermen had overcome this. There the catching and transporting of bait to longliners was the sole occupation of a group of fishermen who fished a small fish known in Tamil as " kili meen ", apparently in most cases *Cheilinus chlorurus* (Bloch), during the longlining season.

Another and more ingenious solution was the use of longlines of empty chank shells (*Turbinella pyrum*) (Fig. 4) which were set out at convenient points inshore from the longlining grounds by old men or boys. Small juvenile octopus (*Octopus* sp.) which sought shelter in the cavities of these shells were shaken out into the boats when the lines were hauled. Thereafter they were kept alive in floating boxes until they were required as live bait for longlines.

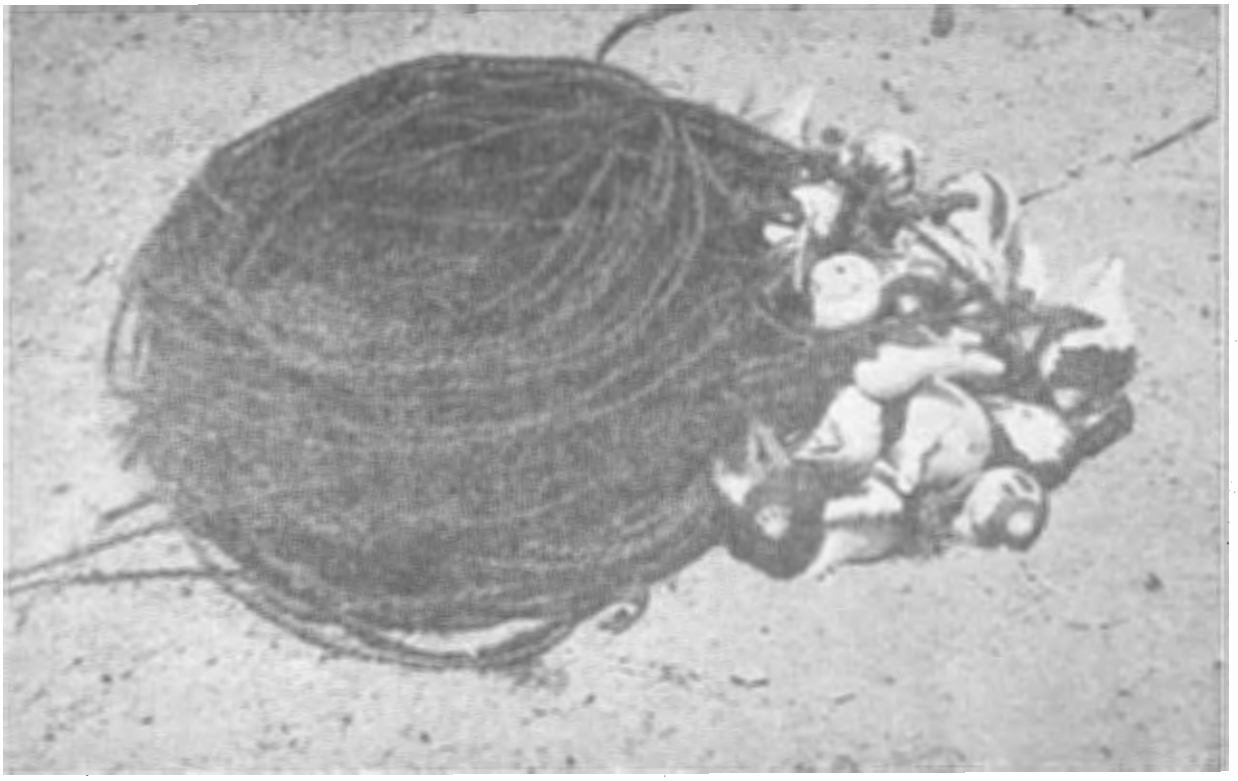

Fig. 4. Coiled longline of chank shells. Set close to shore it catches young octopus which are used alive to baitbottom longlines for groundfish.

3. The third limiting factor was the depth of water in which the lines could be set and hauled manually. Where the depth was much more than 20 fathoms, the physical effort required for hauling was so great that only short strings could be used without exhaustion of the fishermen and short strings meant small catches. Because of this, longlining in Ceylon has been limited to the few shallow-water areas where large fish regularly concentrate in sufficient numbers to be worth fishing.

4. A fourth and seriously limiting factor was the position of productive grounds relative to suitable landing points and the seasonal changes in the direction and strength of the prevailing winds. This was especially important in places like Ceylon where nearly all fishing craft were paddled, rowed or sailed. The fishermen were aware of richer fishing grounds beyond the normal range of their craft but were unable to exploit them. What they needed, they said, were motorboats.

These four factors seemed to be chiefly responsible for the restricted use of longlines in Ceylon and, for that matter, they are the same almost everywhere.

During the brief inspection trip it was impossible to gather enough data on catch to gauge the efficiency of the traditional fishery. But, from what the fishermen told us, bottom longlining seemed to be more rewarding than several of the other fishing operations we had studied. On the other hand, it seemed to have developed as far as it could so long as it depended for power on human muscles and the wind.

Longlining in other countries

In some areas, for instance parts of the Canadian Atlantic coast (Nova Scotia), this method of fishing has been highly developed and is still commonly practised (Templeman and Flemming, 1956). There, a regular bait supply has been assured by organized fishing of bait species (e.g. herring and squid) at seasons when they are abundant, and by storing large stocks of them in the frozen state until they are needed. There too, 30 to 50-foot, two-man or three-man mechanized boats are in use and allow their operators to travel to and from the most productive fishing grounds quickly and in safety. Mechanical power is also used to operate " gurdies " which haul the lines from any depth with relatively little effort on the part of the fishermen. The boats carry ice to preserve the freshness of the catch during trips which regularly last from 12 to 48 hours. Under these conditions heavy and lucrative catches are regularly landed as is shown by 1952 and 1953 data supplied by the Fisheries Research Board of Canada and presented in Appendix 14 and summarized in Table VI.

TABLE VI

SUMMARY OF APPENDICES 13 AND 14 LISTING BOTTOM LONGLINE FISH CATCHES (UNGUTTED WEIGHT)

Craft and port	*Year*	*Hooks set/ boat/trip (no.)*	*Catch/trip (lb.)*	*Catch/100 hooks/set (lb.)*	*Catch/man/ hr. on fishing grounds (lb.)*
Katumarams (Ceylon)					
Valvedditurai (mothership)	1951	200	—	38·9	—
Mylliddy (unassisted)	1954	225	64	27·0	5·4
Dory (19-foot, mechanized, Ceylon)					
Colombo	1954	210	6	2·9	1·5
North Star (Ceylon)					
Colombo	1954-55	1,068	135	12·2	9·8
Karaitivu Isl.	1954-55	1,120	134	14·2	9·6
Kayts	1954	504	16	2·8	1·1
Trincomalee and east coast	1954	687	118	24·9	14·9
M. F. R. V. No. 1 (Mauritius-Seychelles)	1948	—	—	111·8	—
Mechanized Longliners (Eastern Canada)					
Liverpool, Nova Scotia	1952-53	5,971	3,47?	67·4	206·4
Lockeport, Nova Scotia	1952-53	3,685	2,690	4·2	—

There are many other temperate zone bottom longlining fisheries that might have been examined, e.g. the halibut fishery on the United States and Canadian Pacific coasts but data on these were not readily available.

Wheeler (1953) found good fishing grounds in places where tidal currents were too strong to permit handlining for groundfish. The lines would not go to the bottom. But in some of these he was able to use bottom longlines. He has published some of the few records of bottom

longlining in the tropics. Some of his catches are described by counts of fish. To make his results comparable, Wheeler's (1953) records have been modified to conform with the system used here to describe our own and Nova Scotia operations and expressed as pounds of fish taken per 100 hooks set. These modifications required estimates of the average weight of the fish taken. The reasonableness of these estimates may be judged by the reader for himself from Wheeler's report.

These Nova Scotia and Indian Ocean data were encouraging. They showed that bottom longlining worked well both in the temperate zone and in the tropics. But they were no more encouraging than the analysis of records of experimental fishing that had been carried out in Ceylon itself.

Early Experimental Bottom Longlining in Ceylon

Blegvad (1951) observed the use of the traditional type bottom longlines by Karaitivu fishermen and in March and April 1949 he fished some he contrived himself, with promising results (Appendix 13 and Table VI).

In 1951 the Department of Fisheries used the motor craft SEER and HALPHA as " motherships " to tow Valvedditurai bottom longline fishermen to and from their established fishing grounds. Records in the Department's files showed that catches on some days approached 70 pounds per 100 hooks set (Appendix 13 and Table VI). But it is true to say that up to 1954 there had been no sustained effort to explore or expand the longline fishery. It had been omitted from the 1953 program of fishery survey.

B. 1954 Program

From this review the Steering Committee decided that bottom longlining should be thoroughly explored in 1954 and that the work should begin on the east and north-east coasts.

Fishing Trials

Following the Steering Committee's decision, NORTH STAR was equipped and Mr. Roy Pyne who had long experience at this kind of fishing in Nova Scotia, was charged with the work. He improvised a small amount of gear for the first trials using whatever materials he could obtain locally. This included a great variety of hooks and lines only a few of which could be considered suitable for power hauling, easy repair and handling.

At the same time an order was placed with the Canadian Colombo Plan authorities for a supply of lines and hooks that should be adequate for the year's trial operations. This included " 18-pound " ground lines made of steam-tarred cotton (300 fathoms weigh 18 pounds), " 4-pound " gangings, also steam-tarred cotton, and " kirbed " and " straight " large-eyed galvanized hooks mostly of size 6/0 of the Pflueger or size 17 of the Mustad scale of describing hook-size. By most standards this would be considered a small hook for groundfish.

The improvised gear was used in trials off the east coast from mid-July until the end of October 1954 when the local supplies of lines and hooks were exhausted and the lines in use were so worn that they were not worth repairing any longer (Appendix 13 and Table VI).

The Colombo Plan order was filled soon after but not in time to permit this better-type gear to be tested on the east coast. It was used, however, out of Kayts and off the south-west and west coasts in November and December 1954 and in January and February 1955, both

from the NORTH STAR and from powered Nova Scotia dories that had been gifted by Canada (Appendix 13 and Table VI). The longlines had to be hauled manually from the dories and for this reason they were obliged to fish in shallow water where catches were light.

Bait Requirements and Costs

In Nova Scotia an average of 4 pounds of herring or 3 pounds of squid is required to bait 100 hooks (Martin and McCracken, 1954). Mr. Pyne found that here the requirement of herring (Sinhalese—" saleya ") is usually only about 3 pounds because the head is small and can be used along with the body instead of being trimmed off. The squid requirement is about the same here as in Nova Scotia.

These statistics on bait consumption are useful not only in calculating bait demands of a bottom longline fishery but also in calculating and comparing operating costs of longlining. Bait costs and boat operating costs must be considered as well as the amount and value of the fish caught in judging whether it is worth while pressing the development of longlining in particular areas. In Nova Scotia the poundage catch of fish is 15 to 20 times that of the bait used (Table VI) and the bait is cheap (equivalent to 15-20 c, Ceylon, per pound). However, the price the Nova Scotia fisherman gets for his catch (equivalent to 20-30 c, Ceylon, per pound of gutted fish) is below that which Ceylon fishermen ordinarily receive for theirs. Taking this into account the poundage catch on good grounds (those averaging 30 or more pounds per 100 hooks per set) which amounts to ten or more times the weight of the bait used, would seem to be high enough to encourage commercial fishing.

Mr. Pyne considered that bait was always expensive in Ceylon. It was expensive because almost every species of fish taken here is acceptable on the market as a food fish, either in the fresh or dried or salted state. Presumably this will always be the case and bait will always be expensive to those who do not find time to catch it themselves.

Kinds of Bait

Mr. Pyne found that several kinds of small fish made satisfactory bait but that molluscan flesh (squid) gave the best catches of fish (Medcof, 1955, Appendix 13). This prompted trials in February 1955, with large mud snails (*Terebralia palustris* Brufiere) because sometimes bait was scarce. These snails abound in the shallow pools behind the barrier beach on Karaitivu Island. Mr. Pyne found that at that season at least, the flesh of these animals is too soft and watery to stay on the hook and that they were useless as bait.

The bait qualities of the terrestrial giant African snail (*Achatina fulica* Feruccac), which is so common as to be a pest in parts of the southwest coast, should also be studied. This animal has a large tough foot and a firm body. Dr. S. W. Ling of the World Food and Agricultural Organization states (personal communication) that it is regularly fed to pond-cultured fish in Indonesia. There is no reason to believe that it would not make an attractive bait for marine fish. A characteristic that recommends it especially is that it can be kept alive, and therefore fresh, for long periods with very little care.

Bait Supplies

Mr. Pyne found that bait species were abundant in and about Trincomalee most of the time but sometimes bait was hard to get. The real problem was to organize regular supplies from the fishermen. If commercial-scale bottom longlining were established the simplest solution would be to maintain supplies of frozen bait in the local cold-storage to meet emergency shortages over a wide section of the coast. Lagoon species of fish could be seined by bait catchers like those in Jaffna. And there are large quantities of squid (*Loligo* sp.) off Trincomalee from June to mid September. Both could be frozen.

Lifetime of Bait and how to measure Fishing Effort

Mr. Pyne's experience shows that the effective life of bait set out in these warm waters is usually not more than two hours and sometimes less. The bait becomes soft and crabs and other small bottom organisms, or fish that are too small to be caught, strip it off the hooks. Thus, providing the lines are left in the water for a minimum period of say an hour and a half, the length of the set is not likely to affect the amount of the catch unless hooked fish are attacked by sharks, which is rare here.

In the traditional fishery and apparently in the 1951 Valvedditurai mothership trials, the baits have usually been exposed for more than two hours. During our review this raised the question of how bottom longline fishing records should be reported to be most meaningful for most purposes. It was finally decided not to describe them in terms of catch per hour the gear was in the water as we had described trawling and handlining records. Instead, they have been expressed in Appendix 13 as catch per 100 hooks set, regardless of the length of the set and number of man-hours of labour involved. This permits direct comparison with catches in different places in spite of other and varying features of the operations.

The catch per hour of labour expended is a useful statistic in many comparisons of fishing operations but the long-lining methods now practised in Ceylon vary so greatly and have been so little studied that it is hard to decide how the human effort should be expressed. That used by Medcof (1955, Appendix 13), catch per man per hour on the fishing ground, may be useful in some instances but is not reported in our Appendix 13 because it can be misleading. In day-fishing, for instance, sets are short and all the time on the grounds is usually filled with activity. In contrast, night fishing is leisurely and the crews are usually able to sleep for several hours. The time they spend on the ground in this case is not a measure of the effort expended in making a set, which is all that really counts. When more has been learned about longlining, catch per man per day at sea (there is usually one set per trip and one trip per day) may prove to be a useful statistic in comparisons of catches by longlines with catches by other gears.

C. Discussion

Interpreting the Records

North Star's catches varied a great deal which is not to be wondered at because she was engaged in exploratory fishing on untested grounds as prescribed by the Steering Committee. These grounds were mostly beyond the range of unpowered indigenous craft but in areas considered as likely to be accessible to these same craft if they were mechanized both for propulsion and for hauling back gear. At no time did she settle down on what appeared to be a really good ground and fish it steadily as a commercial fishing craft would. It is reasonable to assume that her average catch per 100 hooks would have been considerably higher if she had done this. For this reason NORTH STAR'S performance should not be compared unreservedly, with those of craft of any description that are engaged in commercial operations. Commercial-type fishing should be carried on as a logical next step in her program because her experimental catches were most encouraging in some places.

Not only should NORTH STAR'S rates of catch per 100 hooks be treated with reservation but so also should her catch per trip records. She seldom fished more than 750 hooks per trip (Medcof, 1955, Appendix 13). This is all that is required for exploratory fishing but Appendix 14 shows that this is far below her capacity. Boats of her size-class regularly fish 3,000 to 4,000

hooks per trip in Nova Scotia. Thus, anyone interested in estimating the potentialities of fully mechanized bottom longlining fishing boats in Ceylon should multiply the catches listed for each trip, three or four times. For example, the records suggest that off Trincomalee NORTH STAR could have been landing 750 pounds per trip if she had been fishing 3,000 hooks. Such landings would be equivalent to 250 pounds per man per day at sea (for a 3-man crew) which approaches that for Wadge Bank trawlermen (Table I) and far exceeds catches made in most of the Ceylon fishing operations we have examined.

Prospects

Judging from what has been done so far, the chances for a successful mechanized bottom longline fishery on the central west coast are not promising. And south-eastern Palk Strait, where longlining by local boats is now established, seems to be less rewarding than it should be to justify mechanized operations. In contrast, the chances at depths of 30 to 50 fathoms off the central east and north-east coasts seem bright (Appendix 13) despite the fact that one of Ceylon's most intensely fished stretches of shoal water lies immediately inside it. As Hickling (1954) points out this is not unusual in areas where fishermen have not yet taken to mechanized boats.

The prospects are brightest in the reach from Mullaitivu to Kalkudah and they are brightest of all just off Trincomalee because Trincomalee is a good port and because the edge of the continental shelf is close to shore (Fig. 2) at that point. Very short runs would take fishermen to the best grounds. Weather conditions should permit a long, steady fishing season—probably February to October—and irregular fishing for another two months. Trincomalee could become the most important fishing centre on the east coast. Off open beaches like those at Mankeni, fishing would be possible for shorter but nonetheless worthwhile periods.

Bottom longline catches are lighter off the east coast of Ceylon than in Nova Scotia or in the Mauritius-Seychelles area (Table VI) where fish seem to be more abundant. Nevertheless they compare not unfavourably because the per-pound market price of fish is high in Ceylon.

These east-coast grounds are not fished now because they are outside the range of indigenous craft and too deep for manual hauling of longlines. And it is impossible to say how their fish stocks would react if a mechanized fishery were to develop and they were subjected to steady commercial fishing. But, if the Wadge Bank can be taken as an example, there is no reason for pessimism. In other parts of Ceylon the prospects should be more fully explored before fishermen are encouraged to take up long-lining.

Summary

1. Examination of the indigenous Ceylonese bottom longline fishery shows that it is rewarding in spite of the severe limitations confronting it.
2. By ingenious methods and vigorous effort the fishery seems to have discovered all the important stocks of bottom fish accessible to it and to be harvesting them to the full.
3. The fishermen appreciate this situation and state that mechanization of fishing craft is necessary for any expansion and they earnestly hope for expansion.
4. The survey showed that mechanization is needed not only for propulsion of bottom longline fishing craft but also for hauling back the gear with its catch.
5. Results of the 1954 fishing trials with full mechanization and good bait indicate that fishing off the east coast should be rewarding during most of the year. Other areas were not completely assessed.
6. The potential catch per man per day compared favourably with that of Wadge Bank trawlermen and exceeded that of fishermen with mechanized craft engaged in most other kinds of fishing in Ceylon.

Recommendations

On the basis of the survey results summarized above, it is recommended that the Department should:

1. Immediately encourage bottom longlining off the east coast by all means at its disposal.

This might include arrangement for full mechanization of suitable craft; help in organizing ready supplies of longline fishing gear and bait; advice and help in marketing and possibly some demonstration fishing.

2. Continue exploratory bottom longline fishing trials.

Explorations should cover the whole of Ceylon's continental shelf with emphasis on areas nearest good harbours and major markets.

DRIFTLINING

In reporting their 1953 observations, Captains Babcock and Homer described the traditional driftline fishery in many parts of the east, south and west coasts. They thought it could be improved in some ways but they hesitated to recommend a full-scale program of encouragement because they had gathered only general information and had made no driftline fishing trials themselves. So far as could be learned there had been no study of this fishery up to that time.

The Steering Committee therefore decided that Mr. Cader and I should examine this fishery on the south coast during our tour of inspection. We were to try to obtain information that would enable the Committee to decide whether driftlining deserved a place in the 1954 survey program.

We interviewed many fishermen, discussed their operations and examined their gear and catches. Our review was highly informative but it was so brief that it provided only very general ideas of the importance of driftlining in the fishing industry as a whole.

A. Review

Definition of Driftlining

Driftlining as practised in Ceylon may be described as mid-water handlining and is related to surface longlining (to be described in the next section) in the same way that handlining is related to bottom longlining. Driftlines and handlines are relatively short. They have a single or a few hooks at their ends and are constantly tended by the fishermen using them. In contrast, both types of longlines are long, as their names imply, and have many hooks placed at intervals along them. They are baited once, set, then hauled after some arbitrary period during which they are not tended. But, whereas handlines and bottom longlines usually take bottom fish (grade 2), driftlines and surface longlines usually take grade 1, mid-water fish such as swordfish, sailfish, and seer. They also take some sharks.

Driftlines are sometimes referred to as longlines because they are longer than most handlines but it seems best to avoid this term because of the confusion it involves. The term longline should be used solely to describe bottom and surface longlines as defined elsewhere in this report. Driftlining is also referred to as deep trolling but there is little justification for this term and it also leads to such confusion that it should be avoided. The best descriptive name might be mid-water handlining but this term is not generally understood.

Description of Gear

The driftlines were usually made of close-laid cotton corresponding in thickness to what Canadians call 14-pound steam-tarred line. They were hand-laid and usually dressed with the juice of timbiri fruits (*Diospyros albiflora* or *D. atrata* Alston; identified for me by Dr. B. A. Abeywickrema, Department of Botany, University of Ceylon). This juice acts like tar. It serves

as a preservative and a line stiffener and makes for easier handling. Dressed driftlines had a long life, coiled easily and ran out quickly without snarling. They were usually 50 to 75 fathoms long and on each end they usually had a single large, hand-forged hook.

The hooks were of steel or German silver and their size varied somewhat but approximated that of number 1 or 1/0 in the Mustad coding system. The hooks were not connected directly to the line but to the free ends of wire traces or leaders. The leaders were 3 to 6 feet long and fastened at their upper ends to the line. Wire is not easily bitten through by sharp-toothed fish that not infrequently bite off cotton gangings from bottom longlines and escape hook-in-mouth.

The commonest leaders were single strands of German silver wire although double strands were sometimes used depending on the gauge of the wire available and the fisherman's tastes. German silver wire does not corrode in sea water but it does have the disadvantage of easy kinking and becoming weak at the kinks. Sooner or later it must be renewed no matter how carefully it is handled or it will break when a strong fish strikes and the fisherman will lose his fish, his hook and part of his leader. Steel piano wire was occasionally used because it was stronger and less kinky when new but fishermen avoided it because it soon corroded in salt water, became brittle, kinky and weak. Stainless steel combines the advantages of both the other metals without their disadvantages but because of its higher cost and scarcity in local markets, it was not widely used. Sample leaders made of stainless steel distributed by Captains Babcock and Homer in 1953 in the area visited were immensely popular among driftliners and we received many enquiries as to where they could be purchased.

Operation

In operation the driftline was usually held looped close to the middle in the fisherman's hand or tied to the boat at some convenient spot so that its two-baited hooks would fish at almost but not quite the same depth in mid water. Driftlining was sometimes a deep water operation, close to or beyond the edge of the continental shelf. The boat, with its sail furled, was allowed to drift and the driftline trailed out behind.

However, most driftlining was carried on by handliners as a secondary but simultaneous operation while their boats were anchored. Their principal catch was bottom species and their attention was seldom diverted from their handlines because few fish struck driftlines. When a fish was hooked on the driftline, however, it was usually first grade (see Schedule) and large. Thus the catch amply rewarded the small effort involved in setting and tending the line.

In the Batticaloa area handliners regularly took driftlines to sea but set them only if they happened to catch fish on their handlines that made suitable live bait for driftlining. In other places this kind of fishing was more highly rated and handliners regularly carried and used only driftlines. Sometimes handliners worked out into the deep water beyond the handlining grounds and during such parts of their fishing trips they used only driftlines.

B. 1954 Program

After deliberating on the results of the examination made with Mr. Cader and on the skippers' 1953 reports, the Steering Committee decided that a driftlining project should be included in the 1954 program but that it should be given low priority. It was agreed that stainless steel leader wire would be added to the government stores of gear that was kept for sale to fishermen and that the survey effort would be limited to a compilation of records of commercial driftlining operations. This, it was hoped, would provide a sounder basis of information for determining the importance of the fishery, its possibilities for expansion and whether the Department should try to foster it.

Fishing Records

Because driftlining operations were so often combined with handlining and because the total catches were pooled when landed it was not easy to gather records of commercial operations that faithfully described the driftline catch per unit of effort. The entries in Appendix 15 are accordingly few.

C. Discussion

The data assembled indicate that the average commercial catch of driftlines per individual hook per hour of operation was higher than that of Japanese surface longliness (Appendix 16). This seems reasonable because a surface longline hook may remain in the water several hours, and is not rebaited if a fish strikes it, steals the bait and swims off without being caught. In contrast, a driftline hook is kept baited and fishes all the time it is in the water.

Although the catch per hook per hour was higher for driftlines than for surface longlines the catch per man per hour was less because each fisherman usually fishes only two hooks compared with 15 in the small Japanese surface longline boat.

Our records indicated that driftlining is very effective but general observations and fishermen's statements suggested that our records were too few to give a fair idea of average performance. Most of our data were gathered during the seasonal run of sailfish off the southwest coast where and when driftline catches were apparently high by ordinary standards.

The final consensus was:

(1) Under average conditions driftlining gives low total catches.

(2) Driftlining by handliners incidental to their principal operations is probably justified.

(3) Driftlining in deep water during good runs of grade one fish is inefficient because number of hooks fished per man is so very low (see next section on surface longlining).

(4) Fishermen will probably gradually abandon driftlines for economic reasons.

(5) Further study of this fishery might provide information that would be useful in developing the surface longline fishery.

Recommendations

From the results of this study it is recommended that the Department of Fisheries should:

1. Make no effort to encourage driftlining.
2. Make such studies of the driftline fishery as will provide information that might be helpful in developing the surface longline fishery.

SURFACE LONGLINING

So far as the writer has been able to discover, the traditional fisheries of Ceylon never did include surface longlining. The following short description of the gear and how it is used therefore seems necessary.

Description of Surface Longlines

A surface longline is like a bottom longline (see earlier section of this report) except that it is held up in the water by surface floats instead of resting on the bottom. The mainline (corresponds with the groundline in a bottom longline) is generally referred to as the headline and is not ordinarily attached directly to its supporting floats but to floatlines, 2 to 5 fathoms long, which reach down to it from the floats.

As in bottom longlines, the hooks are not attached directly to the mainline but to gangings (also called snoods) of lengths varying from 3 feet to 75 fathoms depending on the design of the gear and the depth-preferences of the species being fished. There may be wire leaders attaching the hooks to the snoods. For open-sea fishing the gangings are attached to the headline at intervals of 20 to 30 fathoms.

The number of floats varies greatly. Sometimes one is attached opposite each ganging in which case the headline is suspended almost horizontally in the water and all the hooks fish at about the same depth if the gangings are of uniform length. Sometimes the floats are attached at wider intervals—up to 500 fathoms. With this arrangement the headline sags deeply between buoys and the hooks fish at correspondingly different depths. The size of the floats varies depending on the number used and the length and weight of the headline and the gangings they support.

From this description it will be seen that reference to this gear as a surface longline is not quite apt because the headline is not at the surface and the hooks may be very deep. The same criticism applies to its other common name, floating longline, but both are useful because they distinguish this gear from bottom longlines. Perhaps mid-water longline would be a more faithfully descriptive name but it has not found favour.

History and Practice of Surface Longlining

Surface longlining is by no means a new method of fishing. In northern European countries it has been practised for many years in the Atlantic fisheries. And in Canada (Newfoundland) fishermen have resorted to it for generations to take cod which move up from the bottom into mid-waters at certain seasons where they feed on capeline (*Mallotus villosus* D. F. Muller) (personal communication from S. N. Tibbo, Fisheries Research Board of Canada), Regardless of who first developed the gear or where it was developed, the Japanese must be credited for refinement and elaboration of it for pelagic fishing in the Pacific. They are still the leaders in this field but in recent years high-seas longlining for tuna has spread to other countries (Murphy and Shomura, 1953).

As a result vast stretches of ocean formerly regarded as fishermen's deserts are now known to be productive of highly prized species. Profitable commercial fishing of these requires, first of all, a knowledge of the hydrographic features and inter-relationships of the great water masses of the open oceans. It also requires a knowledge of the habits of the species sought and the habits of their food organisms in relation to these different water masses. Aboard the larger, modern, Japanese pelagic tuna fishing boats the skill of the technicians in discovering the temperature patterns of the water their ships sail through and in selecting suitable fishing grounds is considered to be as important to the success of fishing trips as the efficiency of the fishermen and the quality of the gear and the bait they use.

A. Surface Longlining in Ceylon

Halpha

The first report of surface longlining in our waters is that of Blegvad (1951). He describes two shallow-water sets made by his colleague, Mr. Myrup, working from HALPHA, off the southwest coast in March 1949. The gear used is incompletely described and the total catch was six small sharks (Appendix 16).

Canadian

The second series of trials was made from CANADIAN, January 25 to February 17, 1954, by Captains Babcock and Homer, of the Canadian Colombo Plan fisheries team. They made eight sets mostly in deep water off the south and southwest coast. Their gear, as described by Captain Babcock, was improvised from materials brought out from Canada for other purposes. The headline was of 40-pound manila, 2,500 to 5,000 fathoms long. The floats were No. 2 " Scotchman " or the standard type made of tarred canvas, attached to the headline by 15-fathom floatlines, adjustable for depth, and placed at intervals of 500 fathoms along the headline. Every third float was flagged to show the position of the longline and thus help the fishermen to keep the boat lined up with the gear while it was being hauled. The gangings were steam-tarred cotton, 3 feet long, attached to the headline at intervals of 18 to 20 fathoms. These were attached without wire leaders to flattened, tinned, kirbed, halibut hooks approximating the size

of No. 6283 in the Pflueger and Mustad code systems for hook size. With this arrangement and with floatlines fully extended, the hooks nearest the buoys fished at a depth of 15 fathoms. Those between buoys fished deeper because of the sag in the headline and Mr. Babcock believed that at times some fished as deep as 150 fathoms. By this device a great depth of water was sampled at each setting.

CANADIAN'S efforts were no more rewarding than HALPHA'S (Appendix 16). In his reports, Captain Homer comments that tidal currents off the southern tip of Ceylon seemed stronger than charts indicate and this made the area especially difficult for fishing trials of this sort.

Some of Captain Homer's log entries are included under " Remarks " in Appendix 16 and show that several times hooks were missing when the line was hauled back. This may have resulted from bottom snags or from large fish biting off the cotton gangings in efforts to escape after being hooked. With wire traces between the hooks and the ends of the gangings, the gear might have given better catches.

Small Japanese Boat

The third series of surface longlining trials was conducted in the interests of a Negombo Fishermen's Co-operative Society by Japanese fishermen working from a 2-man, 6-horsepower motorboat based at Colombo and Negombo in September and October 1954. They reported making 15 sets with a line 1,100 fathoms long. It had 35 hooks and 35 floats and for bait, frozen "samma" (*Colobabis saira*) brought from Japan. The headline was cotton with 2-fathom, cotton floatlines and 9-fathom gangings whose upper 7 fathoms were of cotton and lower 2 fathoms of wire. The fishing reports summarized here with the permission of the Negombo Fishermen's Co-operative Society indicate an average catch rate 50 times that of earlier trials. Approximately 12 % of the hooks took first grade fish, mostly sailfish (*Istiophorus*). This figure approaches that reported by Murphy and Shomura (1953) for the better areas of the central Pacific.

Seer

The Japanese fishermen demonstrated their methods to officers of the Department of Fisheries who were convinced of the value of further trials. As a result, the fourth series of surface longlining trials was undertaken by the Department's SEER in October and November 1954, working out of Colombo harbour and using hurulla (a herring) as bait. Of the six sets reported in Appendix 16, four were made with the conventional shoal-water Japanese gear with hooks set to fish at 5 fathoms. This gear was lost on the fourth trip. The last two sets were with British-type, factory made surface longlines for shark with the hooks set to fish at 7 fathoms. There are too few data to make a good comparison of performance of the two types of gear although the Japanese type seemed better judging from the percentage of hooks that took fish (mostly sailfish). SEER'S crew were novices at fishing the surface longlines and their bait may have been less attractive than samma. Whatever the cause, their catch per 100 hooks, including both types of lines, averaged only 13% of those made by the Japanese but were nevertheless 10 to 15 times as high as those by HALPHA and CANADIAN.

North Star

The fifth series of trials was undertaken in January 1955 by Captain Roy Pyne using improvised gear with hooks set to fish at 4 fathoms. This series was incomplete at the time of writing but the two sets reported (Appendix 16) show that improvised surface longlines will catch fair quantities of shark at this season. The records suggest that for fishing shark, mollusc flesh (cuttlefish) makes better bait than fish flesh.

Large Japanese Vessels

Besides these records of operations close to the south and south-west coasts, the Department has confidential records of operations by large steel, ocean-going, Japanese ships (converted trawlers) scouting for tuna with longlines in the near and far open ocean to the south-

west and to the east of Ceylon. These indicate that there is good fishing at certain seasons in offshore areas that are accessible to motorized boats of NORTH STAR'S size-class. They also indicate that it might be profitable for Ceylon to imitate Japan and operate longline boats of BRACONGLEN'S size-class in mid-ocean fishing.

B. Discussion

Lesson to Learn

This history of surface longlining in Ceylon provides two object lessons in what to avoid in carrying out fishery surveys like ours. The lessons are:

1. Don't use improvised gear if proper gear can be obtained.
2. Don't start fishing trials before carefully reviewing all available information on how, where and when best results can be expected.

Some have rated the surface longlining work by HALPHA and CANADIAN as wasted effort. Actually it may have been worse than that. It was potentially if not actually damaging because the results have discouraged people from making trials with proper surface longlining gear. We ourselves had a poor opinion of the possibilities of this method until the small Japanese boat equipped with proven gear and manned by skilled surface-longline fishermen made sets during the sailfish season in a place where driftliners had demonstrated that these fish were available. The Steering Committee may have been unwise in authorizing Mr. Pyne to initiate the NORTH STAR trials in January and March, 1954. He had improvised gear that could not be used as a yardstick for fisheries survey work unless it were carefully described.

Opportunities Inshore

The work of the small Japanese boat and SEER shows that motorized craft can make good catches (194 pounds per 100 hooks per set) with conventional surface longlines set close to shore during the sailfish run off Colombo and Negombo. And driftline fishermen know that this run is a regular annual event over an even wider stretch of the coast. In other words, small motor craft can carry on profitable inshore surface longlining in Ceylon.

Sailing craft could probably participate in the fishery too because their crews now land sailfish caught with driftlines. They would know when and where to put out the gear and what bait to use and the higher catches would encourage them to abandon driftlines that are inefficient because they carry so few hooks.

Opportunities Offshore

From information given to the Department by the large visiting Japanese vessels it would seem that Ceylon could use motor craft the size of CANADIAN and larger, for fishing tuna from its nearer high-seas areas. To do this the crews would have to master the refined techniques of this fishing method—especially those involving hydrographic observations to determine where and when to make sets.

The possibility of developing a Ceylonese surface long-line fishery is less bright on the high seas than inshore but should not be disregarded.

Recommendations

From the results of this study it is recommended that the Department of Fisheries should:

1. Take appropriate steps to encourage inshore surface longlining.

The Department is well acquainted with different ways of encouraging development—making gear available, compiling information about where and when the fishery may be profitably pursued and demonstration of fishing procedures.

2. Assess the possibilities of surface longlining in the nearer high seas areas about Ceylon.

It is important to start compiling pertinent information now—species of fish, their seasonal occurrence and abundance, their habits and the gear used to capture them in other oceans. There is a vast literature on this subject.

TROLLING

In the old sense " trolling " meant singing or passing a bottle around the table but today it means fishing from a boat by trailing lines with hooks and artificial or real baits attached. Usually the lines are long and the boat's speed keeps the baits relatively close to the surface although special devices are sometimes used for deeper trolling. Trolling is a common method of fishing throughout the world for taking carnivorous types of fish that haunt the surface or mid waters. These are usually fast-moving, migratory types whose abundance varies greatly both from time to time and place to place. Many of these varieties are highly prized, luxury food fish and command such high market prices that the quantity taken need not be great to make trolling a worthwhile method of fishing. Because the fish are valuable, trollers usually take good care of their catches and this enhances their attractiveness to consumers.

The effort involved in trolling is relatively slight compared with that required for handlining or trawling so in most trolling operations only small crews are carried. On the whole it is a relatively pleasant and exciting method of fishing as the derivation of its name imlies.

A. Trolling in other countries

Some idea of the catch rates and the lucrative total yields that may be realized from trolling may be had from Appendix 17 which includes data on salmon trolling assembled by the Fisheries Research Board of Canada and made available to the writer by the Director of the Pacific Biological Station. These show that good catches are realized over a several-month period every year and that an important industry has been built up. The catch rates correspond closely with those published for the Mauritius-Seychelles area (Wheeler and Ommanney, 1953, table 1, page 87). Their catches of mixed tropical species averaged 4.0 pounds per line-hour from 586 hours of experimental trolling conducted throughout the years 1948 and 1949 in shelf areas (water less than 100 fathoms deep). In a few small areas it was considerably higher. The literature cited by Murphy and Shomura (1953) shows that trolling is also an effective method for taking tuna in the central Pacific where catch rates averaging three to five times those quoted above have been recorded for several successive months.

B. Trolling in Ceylon

Traditional Fishery

Trolling has long been an important method of fishing all around the coast of Ceylon but particularly toward the south where orus are popular craft. Their manoeuverability and speed suit them particularly to this method of fishing and their 2- to 4-man crews annually spend thousands of man-hours in trolling and nothing else. They seem to do most of their fishing over the contintental shelf. John (1951) and others have indicated the importance of this fishery but in spite of this it has never been properly studied. So far as the writer is aware the few data in Appendix 18 are the only systematic catch-per-effort Ceylon trolling records assembled so far.

Traditional Gear

The lines regularly used by Ceylon fishermen are like those used in driftlining (see section of this report on driftlining). In fact, the same lines, leaders (traces) and hooks are often used interchangeably for both types of fishing. In trolling, however, the line is never looped in the middle. It is always tied at one end to some part of the boat and fished in one straight piece with a single lure or bait on the end (Fig. 5A). The lure is made of shreds of the inner bark

of " ahatuwa ", which according to Dr. Abeywickrema of the Department of Botany, University of Ceylon, is the Sinhalese name for epiphytic figs such as *Ficus parasitica* and *F. heterophylla*. These strong lacy bark shreds with the consistency of fine silk, may be dyed blue or left in their natural glistening white colour and tied to the wire leader close to its connection with the hook. They stream out in the water partly obscuring the hook and are believed to be attractive to fish.

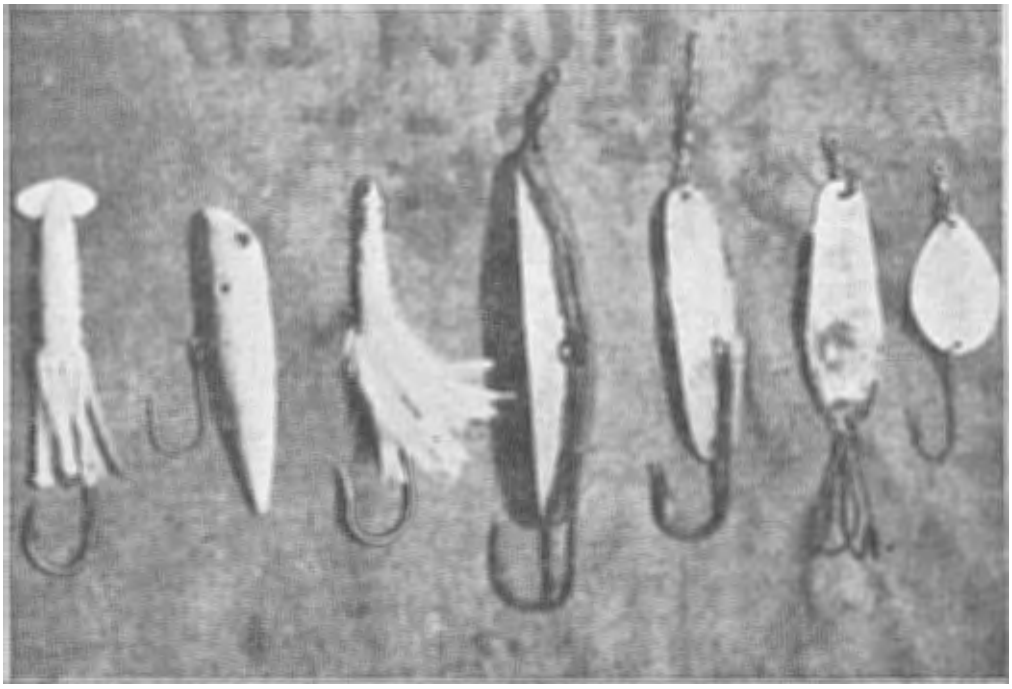

Fig. 5. Trolling lures whose performance was studied. A. Two common indigenous types—ahatuwa bark lure, baited with split fish tied on by thread, and tandem hooks as they appear before baiting. B. Commercially manufactured lures (Photo from jean, 1957) left to right—rubber squid ; wooden plug ; Japanese feather jig ; $7\frac{1}{2}''$ and $5''$ chromium-plated spoons ; brass spoon ; egg wobbler.

The lured hook is always baited, sometimes with a small fish (Fig. 5) either dried or fresh. " Hurulla ", a kind of herring, is a favourite. If fish is not available a long narrow slice of ripe coconut meat is often substituted. On the south-west coast the bark is often omitted and sometimes tandem hooks are used (Fig. 5A). In this arrangement a " trailer hook " of a size approximating number 4 or 5 (Mustad size scale) is fastened by its eye to the bow of the main hook. Whether the hook is single or double, the bait is tied on with thread so as to obscure the metal as much as possible.

Experimental Trolling 1953

Captain Homer, of the Canadian team, had many years' experience in trolling both for salmon and for tuna off the Canadian and United States Pacific coasts. He equipped CANADIAN with bamboo poles in the conventional North American Pacific-coast style (Anderson *et al,* 1953) and spent approximately 400 hours in 1953 trolling with a great variety of American and Japanese lures (Fig. 5B) cruising at 3 to 6 knots. He continued the work for a short time in 1954 and was joined in it part-time by Captain Pinchin in NORTH STAR (Appendix 18).

C. The 1954 Program

As a basis for planning the 1954 program, the Steering Committee called for a review of 1953 trolling records. The skippers' log book entries were compiled on fishing record forms (Fig. 1) and studied. From a quick review the catch per hour of trolling seemed low for all types of lures used (Appendix 18) and there were no data on the performance of traditional gear. The Committee decided to continue the project but to assign it a lower priority in the fisheries survey program. The main purpose of continuing was to establish a basis for comparing the performance of the various lures used by CANADIAN and NORTH STAR with that of the traditional lures used by local craft. Without this, the 1953 records had limited meaning.

As far as possible the trolling was to be carried out as an incidental operation during trips to and from fishing grounds where other kinds of fishing were being carried on and during the more lengthy trips from Colombo to parts of Ceylon where fishing experiments were to be conducted. The bamboo poles and other special devices used by Captain Homer were not to be installed on the boats because they interfered with the other types of fishing operations.

To permit the comparison of different lures, it was decided to introduce several refinements in methods of keeping records and to have CANADIAN and NORTH STAR include local-type lures with the other lures they trolled. Assistance in conducting the trials was to be obtained from another Department boat, SEER. Besides this, some western-type lures were distributed to oru fishermen to fish along with their own lures with the understanding that they should supply records of relative performance. And members of the Department's inspectorate service were to assist the writer in assembling records of operations by oru trollers using local gear.

Records were assembled covering 945 hours of commercial and experimental trolling in 1954 and the same scheme was continued to the end of March 1955 (Appendix 18 and Table VII). Unfortunately the records obtained from the local fishermen who used western-type lures were

few and not precise enough to warrant analysis. This was partly because our field work was too discursive to permit regular interviews with the oru fishermen to whom the gear had been distributed.

TABLE VII

SUMMARY OF AVAILABLE RECORDS OF TROLLING OPERATIONS IN CEYLON WATERS BY MOTORIZED CRAFT ALONE IN 1953 AND 1955 AND BY MOTORIZED AND SAILING CRAFT (ORUS) COMBINED IN 1954. BRACKETED VALUES UNDER 1954 ARE FOR SAILING CRAFT TREATED SEPARATELY. FOR COMPARISON DATA ARE LISTED FOR CANADIAN PACIFIC COAST TROLLING FOR SALMON AND MAURITIUS-SEYCHELLES TROLLING FOR TROPICAL SPECIES

	Ceylon			*Canada*	*Mauritius-Seychelles*
	1953 May-December	*1954 January-December*	*1955 January-March*	*1949 February-October*	*1948 and 1949*
Hours of trolling	380	945 (219)	294	29,596	586
Total catch (lb.)	3,612	5,415 (569)	2,995	—	2,357
Trolling Time/Time out of port	83%	69% (72)	87%	—	—
Catch/lure/hour (lb.) (Av. of means for trips)	1·1	0·9 (0·8)	2·5	5·7	4·0
Catch/man/hour (lb.) (Av. of means for trips)	2·6	0·5 (0·8)	3·3	20·1	—

C. Discussion

General

1. A great many of the 1954 experimental trolling catches were obtained incidentally, as prescribed by the Steering Committee, and these draw attention to the value of encouraging trolling wherever possible among fishermen who do not regard it as their main fishing occupation. It need not interfere with other fishing operations when it is carried on during trips to and from fishing grounds. Catches made at such times are clear profit.

2. A review of Appendix 18 summarized in Table VII shows that compared with other fisheries (see Tables I, V and VI), a very high proportion of a troller's time out of port is spent in actual fishing. In this sense, trolling is an efficient fishing method.

3. The quality (grade) and market value per pound were very high.

4. On the average the catch per unit of effort was low. In experimental fishing the average for 1953 and 1954 was 1.0 lb. per lure-hour fished and one trip out of every three gave a zero catch (Table VIII). Only on three occasions in 1953 did the catch per lure per hour reach 4.5 pounds, which is less than the means for commercial trolling on the Canadian Pacific coast for salmon and about the same as that for experimental trolling in the Mauritius-Seychelles for tropical varieties. In 1954 the catch per hour reached 4.5 pounds on five trips and the average was 0.8 pound. Toward the end of March 1955, catches were relatively high for Ceylon because the boats were in Palk Strait during the best trolling season.

5. The highest experimental trolling catches off the north-west coast were obtained in March and off the north-east coast in August.

6. Catches by local craft were recorded only in 1954. They are somewhat sketchily illustrated in Appendix 18 but they accord with those for motor craft being only slightly lower per lure-hour and slightly higher per man-hour than the general averages for both types of boats combined (Table VII). This observation will come as a surprise to many fishermen who assured the skippers that motor noise frightens fish and that catches per lure-hour of the experimental craft (motor boats) must always fall far below those for sailing craft.

The local sailing craft usually carry a 4-man crew and seldom if ever fish more than six lines. Their fishing potential per man is therefore quite low. When CANADIAN was rigged for trolling she regularly trolled ten lines and her effective crew was the same.

7. The records on catch per lure per hour show that trolling is a poor way to add to the nation's suplpy of fish. Even when allowance is made for the higher per-pound value of the catch, the troll fisherman's earnings are low. Wheeler and Ommanney considered that in the Mauritius-Seychelles region catches of 4.0 pounds per lure per hour were too low to justify trolling for tropical species with motorized craft as a full-time operation. With catches such as those recorded in Ceylon the same conclusion seems more than justified. Trolling as we now know it apparently cannot be relied on as an important source of income for fishermen or for large supplies of protein food for the nation. It is expected that the trolling fishery as it is known today will eventually disappear except perhaps for limited times in a few places. Fishermen are conservative and it is to be expected that they will not accommodate readily to this change and they may suffer a period of economic distress. But there are more productive methods of fishing.

8. A more general conclusion seems to follow from the records. Mid-water carnivorous fish seem less abundant in Ceylon waters that in some other parts of the world, both tropical and temperate, where trolling is considered industrially worth while.

9. Under these conditions expansion of trolling as a full-time occupation of motorized craft is a vain hope.

Efficiency of Different Lures

Gathering pertinent data. By themselves the data assembled in 1953 are of little value in deciding what is the best type of lure to use in trolling but many of those gathered in 1954 and 1955 are sufficiently complete to bear critical analysis. These apply to 122 trips by motorized craft (Table VIII) and involve almost 600 boat-hours of trolling. In compiling these 2 years' records the skippers listed the number and kinds of lures they trolled, the number of fish they caught and the number of strikes they had on each lure as well as the regular information called for in the fishing record form (Fig. 1).

TABLE VIII

DESCRIPTION OF 122 TROLLING TRIPS MADE IN 1954 AND 1955 BY NORTH STAR, CANADIAN AND SEER TO TEST THE RELATIVE EFFICIENCY OF DIFFERENT TYPES OF LURES

Conditions of fishing	*No. of fish caught per trip*	*No. of trips made*	*No. of hours fished*
Very poor	0 ..	54 ..	144
Poor	1—5 ..	52 ..	324
Fairly good	6—15 ..	9 ..	62
Good	16—25 ..	3 ..	19
Very good	2 + ..	4 ..	32
Totals	— ..	122 ..	581

A variety of lures was usually trolled but a green rubber squid with a single barbed hook (approximating size 3, Mustad scale) was always included as a standard for comparisons. This is a popular lure on the Canadian Pacific coast. Besides this there were yellow and white squids with the same hook arrangement; three sizes of oval, concave, bowed, chromium-plated spoons, 4½, 5½ and 7 inches long, each with a single barbed hook hung from the centre of the spoon and of sizes 2, 2 and 1 respectively; six-sided, oblong, flat, brass spoons 4 inches long with a single, terminal, barbed hook, size 3; " hoochie koochies ", which are cylindrical plugs, one inch long and one inch thick, trailing coloured plastic frills which conceal a single barbed hook, size 3; Japanese feather lures which are lead-weighted, size 3, barbed hooks concealed by a dressing of red feathers; egg wobblers 2-inch, oval, flat, brass or nickle spoons with single terminal, barbed hooks, size 3; and finally, baited " ahatuwa " bark lures and baited tandem hooks without " ahatuwa " bark frills as used by the Ceylonese fishermen and as described earlier in this report (Fig. 5A and 5B).

Experience shows that the length of line on which a lure is fished affects its efficiency but motorized craft usually fish long, intermediate and short lines to avoid tangling. This practice was continued in the experimental fishing but the lures on the lines were changed each trip. Having taken this precaution it is assumed that line-length effects need not be regarded as a source of error in the results.

The 122 trips for which complete records were compiled are summarily described in Table VIII. From this it appears that no fish at all were caught on about one third of the trips. Thus, data useful in judging the relative efficiency of lures emerged from only 68 trips during which 437 boat-hours of trolling were put in.

Analysis of data. In preparation for analysis, these trip data were first grouped into classes according to the number of fish caught regardless of the length of the trips (Table VIII). In a rough way this is a classification according to conditions of fishing and permits study of relative efficiencies of different lures when fishing was poor, fairly good, good and very good, by Ceylon standards.

Several conventions have been adopted in treating the grouped data. Whenever a lure of any kind was put in the water, fish are considered to have been offered one " chance " to be caught. If two of the same or of different kinds were set, fish had two chances. When there were three lures, there were three chances, etc. When two lures of the same kind were set at the same time the fish are considered to have had double the chances of being caught by that type of lure. Once a fish is caught, or if one only strikes (bites on the hook) without being caught, it is considered to have made a " selection ". After this has happened a new setting is considered to have begun (even though only one of the lines has been hauled or partly hauled) and the next fish is considered to have the same number of chances as were offered to the first. Thus, the total number of selections made during any fishing trip is equal to the number of fish caught plus the number of unsuccessful strikes. Similarly, the total number of settings (chances offered) is equal to the number of lures set multiplied by the number of selections. We found no great between-lure differences in the ratio of unsuccessful strikes and actual catches.

If the numbers and kinds of lures set had been uniform throughout the experiment the results could have been pooled and the efficiency of any type of lure could have been judged from its selection rate, i.e. the total number of times it was selected expressed as a percentage of the total number of times it was set. The attractiveness of the lure is not the only thing that affects this percentage value, however. Under identical fishing conditions it will vary inversely with the number of lures trolled and directly with the abundance of fish. In this experiment the number of lures varied greatly from trip to trip as Appendix 18 shows and such an efficiency value for any lure, if derived from pooled data, would therefore be meaningless in itself. It is not meaningless, however, if compared with a similar value calculated for the green squid lure which was always trolled with it regardless of the number of kinds of other lures trolled with them.

For example, if in 200 joint settings of lure " x " and the green squid, the former got 10 strikes (selection rate 5%) and the latter 40 strikes (selection rate 20%) it is reasonable to say that lure " x " has an efficiency relative to that of the green squid as 5% is to 20%, i.e. it is only one quarter as good. Relative efficiency measured in this way has real meaning and should be relatively stable. For convenience in description, the green squid is considered as always having an efficiency of 100 and all other lures are assigned efficiency ratings accordingly. The efficiency rating for lure " x " in the above example, for instance, would be 25. Lures that are more efficient than the green squid would have ratings exceeding 100.

Results and Discussion. Efficiency ratings were calculated in this way for 11 of the types of lures used in the experiments for four different conditions of fishing, poor to very good, and for all conditions of fishing combined. These values are presented in Table IX in which the lures are arranged in order of their efficiency rating. Some of the ratings listed are based on relatively few data and must be considered as less reliable than others where more settings and more selections were involved. To give some idea of the relative reliability of the different efficiency ratings listed, the corresponding number of times each lure was set along with the green squid lure are listed in Table IX.