DEPARTMENT OF AGRICULTURE AND FISHERIES
FOR SCOTLAND

Fisheries of Scotland

Report for 1967

Presented to Parliament by the Secretary of State for Scotland
by Command of Her Majesty
November 1968

EDINBURGH
HER MAJESTY'S STATIONERY OFFICE
17*s.* 6*d.* NET

Cmnd. 3800

SBN 10 138000 3

CONTENTS

CONTENTS (*Continued*)

APPENDICES

INDEX TO TABLES

REPORT ON THE FISHERIES OF SCOTLAND

for the year 1967

CHAPTER I

GENERAL

In 1967 the total return on the first-hand sale of wet fish and shellfish in Scotland from British vessels was approximately the same as in 1966 at £20·7 million. White fish landings were down by 6·8 per cent in weight compared to the previous year but their value increased by 2·1 per cent because of a rise of 6s 7d in the average price obtained per cwt compared with 1966.

After three successive years in which increases were recorded, landings of herring showed a reduction in 1967. The catch decreased by 13 per cent in quantity and 9 per cent in value compared with 1966.

The value of shellfish landings rose by some 10 per cent to a new record level of over £2·1 million, although the increase by weight amounted to only 4·2 per cent. Landings of nephrops (which, processed, are known as scampi) made up 61 per cent of the total catch and provided a return of almost £1·3 million. A feature of the year was the improvement in escallop landings which increased 64 per cent in weight and 56 per cent in value.

The 1967 catch of sprats was only about one-third of that in 1966. As in previous years most of this catch was used for conversion to fish meal and oil.

The increasing complexity of the inshore fishery regulations and the growing difficulty of enforcing them led to the appointment, on 8th December, of a Committee of Inquiry, under the Chairmanship of the Hon. Lord Cameron, D.S.C., Q.C.

Towards the end of the year the Highlands and Islands Development Board announced that their fisheries development scheme had been extended to provide for the building of an additional 10 boats, bringing the number to be assisted under the scheme to 35. The original programme was mainly aimed at increasing the fleet in the Western Isles and the extra boats will be directed chiefly towards building up the fleet in the Orkney/Pentland Firth area.

The disease which first affected salmon and sea trout in some of the rivers flowing into the Solway Firth in 1966 and which is now generally called ulcerative dermal necrosis spread over a wide area during 1967. By the end of the year most of the important salmon rivers in the area from the Tweed to the Nairn, with the exception of the Tay and the Forth, were affected as well as a number of rivers in Ayrshire and on the Solway. District fishery boards and proprietors were given advice about the steps which should be taken in order to try to control the spread of infection. The programme of scientific research into the disease was developed along various lines in an attempt to establish the precise nature of the causative organism.

As noted in the Department's report for 1966, the report of a Sub-Committee of the Estimates Committee of the House of Commons was published in January 1967 (House of Commons Paper 274 of Session 1966–67—'Assistance to the Fishing Industry'). Observations on the recommendations were made by the Fisheries Departments and by the White Fish Authority and the Herring Industry Board and published later in the year (House of Commons Paper 547).

The fifth Annual Meeting of the North East Atlantic Fisheries Commission met in Paris and was attended by representatives of the Department. The Commission agreed to a scheme for the joint enforcement of its conservation regulations on the high seas in the convention area to operate from 1st January 1969. This scheme, when in force, should assist in ensuring that the Commission's conservation measures are adhered to in practice. The conservation of herring stocks in the North Sea was again considered by the Commission and it was resolved that scientific investigation should continue on stocks in the southern North Sea and that research work should be intensified in the northern part, with a further research programme formulated for the central area. The Commission also agreed that it should be permissible to fish for certain additional species of white fish, suitable for industrial exploitation, with nets with meshes of under 50 mm.

A representative of the Department attended the 17th Annual Meeting in Boston, Massachusetts, of the International Commission for the Northwest Atlantic Fisheries. The question of effort regulation was further considered by the Commission and it was decided to set up a standing committee on regulatory measures which should present a preliminary report to the next annual meeting.

The 55th Meeting of the International Council for the Exploration of the Sea, which was held in Hamburg, was attended by representatives of the Department. Arising out of consideration by the North East Atlantic Fisheries Commission of the position of herring stocks in the southern North Sea, it was proposed that member states should co-operate in a substantial herring tagging experiment on the Blöden fishing grounds.

The information available as a result of research into the effects of the Greenland coastal fishery on the north Atlantic salmon stocks was reviewed by a joint Working Party of the International Council for the Exploration of the Sea and the International Council for the Northwest Atlantic Fisheries and the general lines of further research, including investigations into the developing high seas drift net fishery, were agreed upon.

The International Conference, which since 1965 had been considering a modern code of conduct for fishing operations in the north Atlantic, agreed in March, ad referendum, on a draft convention; 18 states were represented at the Conference. This Convention, which is subject to ratification, makes provision for such matters as the registration and marking of fishing vessels, the conduct of fishing operations on fishing grounds, and for machinery for the settlement of disputes arising from the damage to gear or to vessels through entanglement of gear. The United Kingdom signed the Convention on 9th October.

* * *

Attention is drawn to the altered sequence of the chapters in this report. Some of the material, which in recent years has been included in appendices, has been brought within the chapters relating to the same subject and some tables which also appear in the Scottish Sea Fisheries Statistical Tables have been excluded.

CHAPTER II

MEANS OF CAPTURE AND PERSONS ENGAGED

1. Scottish Fishing Fleet

The number of fishing vessels operating from Scottish ports at 31st December 1967 was 2,877, an increase of two over the year and a slight reversal of the downward trend of past years. At the end of the year the fleet consisted entirely of motor vessels as the last steam trawler and all sail vessels ceased fishing before the end of the year. Most of the inshore fleet engaged during the year in more than one method of fishing. There was a significant decrease in the number of vessels employed mainly in herring fishing although the number of pelagic trawlers and purse-seiners increased. Seine-net vessels showed an increase for the first time for a few years while the number of vessels mainly engaged in nephrops trawling continued to expand. Vessels using other methods of fishing remained approximately the same.

PARTICULARS OF SCOTTISH FISHING VESSELS

TABLE 1 — *As at 31st December*

	1938*	1966	1967
All types	5,067	2,875	2,877
Steam trawlers	320	1	—
Motor trawlers	—	121	124
Other Motor Vessels	2,471	2,742	2,753
Steam Drifters and Liners	428	—	—
Sail Vessels	1,848	11	—

*As at 30th November

(*a*) TRAWLERS AND LINERS (80 ft and over)

The number of trawlers fishing out of Scottish ports increased by two during the year although no new vessels were built for Scottish owners. At Aberdeen eight motor trawlers were acquired from England against the transfer of two to England, one to the Isle of Man and one to Norway. In addition one trawler was wrecked off Orkney. The remaining oil-fired steam trawler in service in 1966 was sold to Eire.

The motor trawling fleet at Aberdeen comprised 105 vessels and at Granton 19 vessels. The number of liners of 80 ft and over decreased by one; all four remaining liners were based at Aberdeen.

(*b*) MOTOR VESSELS

The composition, by size, of the fleet of motor vessels at 31st December 1966 and 1967 is shown in Table 2. Table 2A analyses the same fleet according to the method of fishing in which they mainly engaged during 1966 and 1967.

TABLE 2 *As at 31st December*

Registered Length	1966	1967
Total	2,863	2,877
Under 30 ft	1,545	1,539
30–39 ft	290	291
40–64 ft	683	693
65–79 ft	218	223
80 ft and over	127	131

TABLE 2A *As at 31st December*

Method of fishing	1966	1967
Total	2,863	2,877
White fish fishing—total	1,382	1,388
Trawl—80 ft and over	121	124
under 80 ft (including light trawl)	96	86
Lines	547	543
Seine	564	588
Other methods	54	47
Herring fishing—total	148	122
Drift	66	42
Ring	73	55
Purse-Seine	2	7
Pelagic trawl	7	18
Shellfish fishing	1,172	1,177
Nephrops trawl	161	190

Table 3 gives by size the number of new motor vessels which commenced fishing from Scottish ports during the 12 months ended 31st December 1966 and 1967.

TABLE 3 *As at 31st December*

Registered Length	1966	1967
TOTAL	51	47
Under 30 ft	11	12
30–39 ft	6	8
40–64 ft	22	18
65–79 ft	10	8
80 ft and over	2	1

2. Number of Fishermen

Fishermen employed at the end of 1938, 1966 and 1967, including men only partially engaged in fishing and crofter fishermen, were as given in Table 4.

TABLE 4 — *As at 31st December*

	Total	Regularly employed	Partially employed	Crofters
1938[1]	17,915	12,976	872	4,067
1966	10,157	8,073	1,292	792
1967	9,904	8,057	1,295	552

[1]As at 30th November.

3. Grants and Loans to Fishermen for the Purchase of Boats and Engines

Until March 1967 grants continued to be made by the White Fish Authority and the Herring Industry Board towards the cost of new fishing boats and engines and the improvement of white fish vessels under the provisions of earlier legislation.

On 16th March 1967 the Fishing Vessels (Acquisition and Improvement) (Grants) Scheme 1967 (S.I. 1967 No. 372) came into operation. This scheme implemented an increase in grant maxima for fishing vessels provided for in Section 28 of the Industrial Development Act 1966, and to take account of the abolition of tax investment allowances had retrospective effect from 17th January 1966.

Under the new scheme the rate of grant on approved expenditure for vessels of 80 ft registered length and over was increased from 25 to 35 per cent and for vessels under 80 ft from 30 to 40 per cent. The scheme removed restrictions imposed by earlier schemes on the amount of grant that might be paid in individual cases and also enabled assistance to be given towards the improvement of all classes of fishing vessel.

Following an announcement that industrial development grants were to be temporarily increased by a further 5 per cent for the period from 1st January 1967 to 31st December 1968, it was agreed that fisheries grants would be similarly increased. To enable the additional rates of grant to be applied, it was necessary to remove the limits on grant imposed by Section 28 of the Industrial Development Act 1966. This was done by the Fishing Vessel Grants Act 1967, which was enacted on 28th June 1967. An amendment scheme to give effect to the 5 per cent increase in the rate of grant, the Fishing Vessels (Acquisition and Improvement) (Grants) (Amendments) Scheme 1967 (S.I. 1967 No. 1131) came into operation on 9th August 1967.

During 1967, the Committee for Scotland and Northern Ireland of the White Fish Authority approved grants for the building of 37 inshore vessels, the re-engining of 32 inshore vessels and for 355 improvements to vessels, 38 of which were for vessels over 80 ft in length. The Herring Industry Board approved grants for 12 new herring vessels, the re-engining of 9 vessels and for 111 improvements to vessels. Grants for 21 of the new inshore vessels approved were supplemented by loans from the Authority; grants for four of the new herring vessels approved were supplemented by loans from the Board; the Highlands and Islands Development Board offered loan under their Fisheries Development Scheme for six of the new vessels grant-assisted by the White Fish Authority and for five of the new vessels grant-assisted by the Herring Industry Board. During 1967 the Highlands and Islands Development Board also approved loans towards the purchase of 25 second-hand fishing vessels.

In December 1967 the Highlands and Islands Development Board's Fisheries Development Scheme was extended to provide for the building of an additional 10 boats, bringing the number to be assisted under the scheme to 35, to be built over a period of seven years to 1972.

4. Price of Gear and Oil

The cost of most items of fishing gear rose slightly during the year. A temporary surcharge on oil fuel prices took effect from 1st July 1967.

5. Casualties

Seven Scottish fishermen lost their lives at sea in 1967. Five Scottish fishing vessels were wrecked or lost at sea during the year, including the Aberdeen trawler Juniper.

CHAPTER III

WHITE FISH

The total quantity of demersal fish landed at Scottish ports in 1967 by British vessels was slightly lower than in the previous year as shown in Table 5. Haddock, cod and whiting were again the principal species landed, making up 79·2 per cent of the total catch. Compared to 1966, haddock landings at 1·6 million cwt (81,300 metric tons) fell by 14·9 per cent, cod landings at 1·0 million cwt (50,810 metric tons) rose by 11·8 per cent and whiting landings at 741,097 cwt fell by 16·9 per cent.

As shown in Table 9 the value of the demersal catch rose by about £334,000 to £16·1 million in 1967. This can be attributed mainly to higher average prices obtained for whiting, haddock, and some other species. The average annual value of the demersal catch in the five year period 1962–1966 amounted to £13·7 million. In 1967 the average price of all demersal fish was 75s 7d per cwt against 69s per cwt in 1966.

Landings of demersal fish at English and Welsh ports totalled 9·6 million cwt valued at £37·4 million in 1967 compared with 9·4 million cwt valued at £38·5 million in 1966.

Of all fish landed 86·5 per cent was consumed in Scotland, or sent to England, in fresh or filleted form, while 12·4 per cent went for further processing by various methods (mainly smoking, canning, drying, pickling or quick-freezing), 0·4 per cent was sold as mink or pet food and the remaining 0·7 per cent was converted into fish meal. The processing was carried out mainly at Aberdeen and Fraserburgh. Aberdeen produced 115,489 cwt of smoked fish which consisted mainly of haddock (45 per cent of the total cured), saithe and whiting at a value of £1·2 million. Quick-frozen fish production in 1967—mainly fresh and smoked white fish fillets, but including some whole fish such as haddock, whiting and plaice—totalled 343,176 cwt in terms of whole fish equivalent, a decrease of 9·5 per cent from the 1966 production figures of 379,232 cwt. During the year 9,492 cwt of dried salt fish were produced in Scotland, mainly at Aberdeen.

LANDINGS OF DEMERSAL FISH FROM THE PRINCIPAL FISHING REGIONS

TABLE 5

	Weight Thousand cwt			Per cent		
	1938	1966	1967	1938	1966	1967
All regions . . .	2,504·2	4,582·4	4,268·7	100	100	100
North Sea . .	1,885·7	2,972·4	2,862·6	75·3	64·8	67·1
West of Scotland .	232·1	1,070·9	922·4	9·3	23·4	21·6
Faroe . . .	242·1	360·6	356·3	9·7	7·9	8·3
Iceland . . .	81·6	155·0	115·2	3·2	3·4	2·7
Other catches . .	62·7	23·5	12·2	2·5	0·5	0·3

CONTRIBUTION TO TOTAL DEMERSAL CATCH MADE BY EACH FISHING METHOD

TABLE 6

	1938				1966				1967			
	Quantity Thous. cwt	Per cent	Value Thous. £	Per cent	Quantity Thous. cwt	Per cent	Value Thous. £	Per cent	Quantity Thous. cwt	Per cent	Value Thous. £	Per cent
Trawl . .	1,896	75·7	2,037	74·3	2,014	43·9	7,219	45·7	1,969	46·1	7,533	46·7
Seine Net . .	259	10·4	348	12·7	2,355	51·4	7,732	48·9	2,088	48·9	7,713	47·8
Great Line .	180	7·2	203	7·4	68	1·5	371	2·4	65	1·5	397	2·5
Small and Hand Lines .	153	6·1	141	5·1	50	1·1	177	1·1	51	1·2	177	1·1
Other . .	16	0·6	13	0·5	95	2·1	307	1·9	96	2·3	320	1·9

CONTRIBUTION TO TOTAL DEMERSAL CATCH BY VESSEL LENGTH GROUP

TABLE 7

	Inshore (under 80 ft)		Near water (80 ft–109·9 ft)		Middle water (110 ft–139·9 ft)		Distant water (140 ft and over)	
	Quantity Thous. cwt	Value Thous. £	Quantity Thous. cwt	Value Thous. £	Quantity Thous. cwt	Value Thous. £	Quantity Thous. cwt	Value Thous. £
1966 . .	2,765·7	9,392·0	734·7	2,699·8	1,050·4	3,589·2	31·6	125·3
1967 . .	2,538·9	9,581·0	647·2	2,603·1	1,050·8	3,849·5	31·8	106·6

In 1967 landings of sprats, mackerel and sparling amounted to 546,808 cwt valued at £229,616 compared with 1·4 million cwt valued at about £560,000 in 1966. The sprat catch in 1967 amounted to 522,356 cwt in weight and £191,753 in value, decreases of 878,229 cwt and £332,356 on the 1966 figures. As in previous years, most of the sprat landings (393,108 cwt valued at £127,258) went for reduction to oil and meal, but some 18,600 cwt valued at £6,948 went for export to Norway, Denmark and Germany.

In 1967 two new fishery awards—the Gold Haddock trophies—were instituted by Mr. Joseph Croan, one for competition amongst vessels from 80 ft upwards to 135 ft and the second for vessels of less than 80 ft in length. In each case the trophy is awarded annually to the vessel making the largest gross in the previous calendar year. For 1966 landings the 'senior' award was won by the *Malcolm Croan* (skipper Mr J. L. Banyard) of Granton and the 'junior' award was won by *Argonaut* (Skipper Mr. D. Smith) of Anstruther; for 1967 landings the 'senior' award was won by the *Netta Croan* (skipper Mr J. G. Barclay) of Granton and the 'junior' award was again won by the *Argonaut* skippered by Mr D. Smith.

NETS

(*a*) *Deep Sea Trawl* (*Vessels over* 80 *ft*)

Overall the gross earnings of Scottish deep sea trawlers per day at sea increased in 1967 by £11 5s (5·0 per cent) compared with 1966. There was an increase (4s 8d per cwt) (6·6 per cent) in the average price obtained in 1967 compared with 1966. The catch decreased in quantity by 0·8 per cent but increased in total value by £341,219. The total catch, amounting to 1·7 million cwt, represented 39·6 per cent of the total demersal catch. Most of the landings were made at Aberdeen and Granton but a number of trawlers from the latter port landed at Ayr when fishing on the west coast. The average catch per day landed in Scotland by Aberdeen vessels increased from 61·7 cwt in 1966 to 63·5 cwt in 1967: the average catch per 100 hours fishing increased from 544·4 cwt in 1966 to 563·8 cwt in 1967. Landings by Aberdeen trawlers at English ports, amounting in total to 83,065 cwt valued at £340,028, showed decreases of 38,797 cwt and of £127,436 compared with 1966.

Arrivals of deep sea trawlers from the various fishing regions were as follows:

	1966	1967
North Sea	2,695	3,002
West of Scotland	744	589
Faroes	491	429
Iceland	182	115
Other Regions	—	6

(*b*) *Light Trawl* (*Vessels under* 80 *ft*)

Landings by light trawlers were fairly widespread on the coast, the principal landing ports being Gairloch, Ayr, Campbeltown and Buckie.

LANDINGS OF DEMERSAL FISH AT SCOTTISH PORTS BY BRITISH INSHORE VESSELS ENGAGED IN TRAWLING FOR WHITE FISH

TABLE 8

	Thousand cwt	£ thousand
1965 . .	250	892
1966 . .	241	954
1967 . .	262	1,106

(c) *Seine*

The seine-net fishing fleet continued to make an important contribution to the total demersal catch. A large number of motor vessels, mostly under 70 ft in length, engaged in seining from all ports around the Scottish coasts; many of these are dual-purpose vessels and are able to fish seasonally for herring. The bulk of the catch continues to be landed on the east coast, the principal districts there being Aberdeen, Fraserburgh, Peterhead and Buckie, in that order. Many vessels from the east coast and Moray Firth ports fished for much of their time on the west coast, landing at Kinlochbervie, Lochinver, and Oban.

(d) *Other Nets*

The use of cod nets, ground nets and bag nets continued to decline. Smaller boats fished periodically on the west coast, mainly in the Inner and Raasay Sounds, and the main species caught were saithe, cod, dogfish, lythe and skate. The sprat catch in the Moray Firth, mainly taken by pair-trawl, was substantially reduced compared with 1966 and the sprat catch in the Lerwick district was down by about half. There was, however, an increase in sprat landings from the Firth of Forth grounds.

LINES

(a) *Great Lines*

Landings in Scotland of white fish taken by great lines were made mainly by vessels operating from Aberdeen. 130 trips were made to Faroese waters compared with 99 in 1966 and there were 18 trips to waters off Iceland, where 22 trips were made in 1966. Liners fished also in the North Sea off Shetland and to the north-west and west of Scotland. In order of value the main species taken by great lines were halibut, cod, skate, ling and torsk.

(b) *Small and Hand Lines*

Next to cod and haddock, mackerel catches are the most important in this type of fishing and when the catch of pelagic fish, other than herring, was added to the demersal catch the total catch in 1967 amounted to 61,823 cwt valued at £194,432 compared with 60,714 cwt valued at £195,124 in 1966. The largest landings were made in Arbroath district which accounted for 39 per cent of the total. The other east coast district which contributed largely to the catch was Fraserburgh where 'ripper' fishing for cod was carried on. Landings were made at all other east coast districts except Lossiemouth.

Demersal Landings by Districts

(a) *Aberdeen District*

The principal activity at Aberdeen is trawling and landings there by trawlers amounted in 1967 to 1·5 million cwt valued at £5·7 million compared with 1·5 million cwt valued at £5·4 million in 1966 and formed 78·3 per cent of the total trawl landings in Scotland.

The total number of vessels in the trawler fleet at Aberdeen rose during the year from 121 to 123.

Aberdeen was also the main port of landing in Scotland for both great line and seine-net fishing vessels, the landings being 61,159 cwt and 487,638 cwt

LANDINGS OF DEMERSAL FISH BY BRITISH VESSELS IN FISHERY DISTRICTS

TABLE 9

	1938		1966		1967	
	Weight cwt	Value £	Weight cwt	Value £	Weight cwt	Value £
TOTAL . .	2,504,245	2,742,219	4,582,424	15,806,321	4,268,723	16,140,256
Eyemouth .	13,362	14,229	139,733	416,759	107,623	400,004
Leith . .	409,942	415,140	320,465	1,258,521	255,706	1,072,620
Anstruther .	14,076	16,730	69,831	254,420	85,233	337,297
Arbroath .	60,396	72,430	81,672	283,297	88,752	304,513
Aberdeen .	1,607,393	1,763,943	2,099,839	7,292,696	2,091,516	7,881,567
Peterhead .	7,152	9,595	89,967	310,726	154,457	539,056
Fraserburgh .	25,414	30,398	337,717	1,051,045	275,056	984,041
Macduff . .	39,530	56,342	117,906	459,781	92,844	404,044
Buckie . .	9,443	14,064	196,808	720,114	144,737	614,836
Lossiemouth .	103,396	129,288	147,919	538,785	96,448	376,691
Helmsdale[1] .	19,086	22,070	—	—	—	—
Wick . .	35,763	48,665	134,398	507,743	103,104	415,825
Lerwick[2] .	32,624	24,092	213,627	438,149	155,410	347,852
Stornoway .	20,351	14,363	9,050	26,330	8,939	30,169
Ullapool .	3,383	1,872	382,881	1,258,471	310,215	1,163,992
Mallaig . .	5,979	6,057	17,643	45,299	22,247	68,986
Oban . .	45,631	42,574	61,151	270,111	67,541	290,964
Campbeltown .	8,054	9,373	35,643	129,911	60,250	233,848
Ayr . .	43,270	50,994	126,174	544,163	148,645	673,951

[1]Merged with Lossiemouth and Wick Districts from 1957.
[2]Prior to 1960 these figures were shown as Orkney and Shetland Districts.

AVERAGE CATCH PER DAY ABSENT AND PER 100 HOURS' FISHING AND AVERAGE EARNINGS PER DAY ABSENT, BY ABERDEEN TRAWLERS 80 ft AND OVER IN LENGTH LANDING IN SCOTLAND

TABLE 10

	Average catch per day absent	Average catch per 100 hours' fishing	Average gross earnings per day absent
	cwt		£
1938 . .	24·8	247	25·7
1966 . .	61·7	544	212·2
1967 . .	63·5	564	233·5

respectively. In addition, considerable quantities of fish continued to be consigned to Aberdeen market from other ports mainly on the east coast. In 1967 consignments to Aberdeen totalled 236,000 cwt compared with 316,000 cwt in 1966.

Of the demersal fish brought to Scotland by foreign vessels, 95·9 per cent was landed at Aberdeen Port in 1967: demersal landings direct from the fishing grounds totalled 57,716 cwt compared with 57,519 cwt in 1966.

(*b*) *Leith and Granton*

Of total landings of 255,706 cwt, 96·0 per cent was made by the local fleet of trawlers which also made landings at other ports, notably at Ayr. The fleet fished mainly off the north and west coast of Scotland, including Rockall and St. Kilda, off Shetland and at Faroe. At the end of the year, as in 1966, the trawler fleet numbered 19. Landings made in the district during the year by seine-net vessels amounted in total to 4,344 cwt valued at £18,449.

(*c*) *Other East Coast Districts*

Fraserburgh, Buckie, Peterhead, Eyemouth and Wick were other principal districts on the east coast for the landing of demersal fish, most of which was taken by seine nets. The largest single fleet of seine-net vessels belongs to Macduff district. Some vessels from there and elsewhere in the Moray Firth fished for considerable periods on the west coast.

(*d*) *Lerwick District*

In 1967 landings in the district decreased substantially. While the main part of the catch by local boats was landed locally, some of the larger boats continued to trip to Aberdeen. Of the total local landings in Shetland, 11,335 cwt valued at £46,118 were consigned to Aberdeen for sale and the local fleet landed 44,192 cwt direct at Aberdeen where it sold for £152,481.

The contract arrangements between local fishermen and processing firms continued, the agreement being reviewed periodically.

(*e*) *West Coast Districts*

Most of the fish landed at ports on the west coast was taken by seine-net vessels, many of which, as already mentioned, belonged to Moray Firth ports. Landings during the year were made mainly in the Ullapool, Ayr and Oban districts. Most of the fish landed in the Ullapool district and at Mallaig and Ayr was sold in the local markets, but about 89 per cent of the landings at Oban were consigned to Glasgow.

Seining, light trawling for white fish and for nephrops, hand-lining and ground netting were carried out by local fishermen, some of whom are crofters.

Total west coast landings were 2·3 per cent lower than in 1966.

Foreign Landings

Foreign landings in 1967 of wet fish at 183,500 cwt were higher than in 1966 by 75·4 per cent. Faroese fishing vessels accounted for 31·7 per cent of the direct foreign landings.

Landings of white fish by carrier vessels (eight Icelandic and one Faroese) at Aberdeen, rose by 1,009 cwt to 4,147 cwt compared with the previous year, and included haddock, plaice, lemon sole, cod and halibut. There were two landings of mackerel by Norwegian carriers at Peterhead during the year.

Subsidy

In 1967, a total of £991,643 was paid in direct white fish subsidy in Scotland, £739,938 of which went to the inshore fleet, i.e. vessels under 80 ft registered length. In the five-year period 1962–66 total direct payments averaged £1·6 million a year.

In accordance with the provisions of the Sea Fish Industry Act 1962 the initial basic subsidy rates for vessels 80 ft in length and over were reduced by a further 7½ per cent on 1st August 1967 and new rates, ranging from £5 3s 6d to £8 12s 6d per day, were introduced in the White Fish and Herring Subsidies (United Kingdom) Scheme 1967. No provision was made for the payment of special rates of subsidy to Scottish trawlers during the year. The scheme also provided for daily rates of subsidy, ranging from £3 10s 0d to £4 9s 0d for vessels over 35 ft but under 60 ft registered length which were registered in the United Kingdom as fishing vessels prior to 1st January 1967 and earned at least £500 subsidy in 1965 or £300 subsidy in 1966 for white fish and/or herring landed. The rates for white fish vessels of 60 ft to 64·9 ft registered length and 65 ft to 79·9 ft registered length were set at £4 9s 0d and £5 5s 0d per day respectively. All vessels under 35 ft and those under 60 ft ineligible for daily rates, continued to receive stonage rates which were set at 11d per stone for all whole gutted fish normally sold for human consumption and for certain varieties of ungutted fish; 8½d per stone for all other whole ungutted fish sold for human consumption; and 2¾d per stone for all other whole fish of species normally sold for human consumption.

Statutory minimum prices

In February the White Fish Authority published its draft proposals for a statutory minimum prices scheme for white fish but subsequently informed the Fisheries Ministers on 30th March that the objections to the scheme were such that the Authority felt unable to recommend it to them. Ministers reconsidered the possibility of Exchequer support but it was evident that, financial considerations apart, there were substantial objections to the principle of a scheme and they came to the view that in the circumstances the question of an Exchequer contribution could not be usefully pursued.

CHAPTER IV

HERRING

1. General

Herring landings by United Kingdom vessels at Scottish ports totalled 1,734,960 cwt (88,141 metric tons) valued at £2,188,959 in 1967. This represented a decrease of 13 per cent by weight and 9 per cent by value compared with the 1966 figures of 1,997,485 cwt (101,477 metric tons) valued at £2,400,684. The average price per cwt at 25s 3d was 1s 3d (5 per cent) higher than the 1966 average.

The Shetland fishery produced good catches but the Buchan season was disappointing. Heavy landings were made in the Minch winter season, but the Inverness fishery failed to reproduce the excellent results of 1966. Moderate yields were obtained in the Clyde.

Landings in Scotland by drift-net vessels fell in weight to 575,782 cwt and in value to £883,454 compared with the 1966 figures of 882,579 cwt valued at £1,158,178. Landings by ring-net vessels also fell both in weight and in value in 1967 from 731,145 cwt to 623,222 cwt and from £856,253 to £770,160. Trawlers increased their total landings in 1967 from 331,080 cwt to 446,544 cwt, with an increase in value from £309,787 to £400,752. By the end of 1967, six Scottish

vessels were equipped with purse-seine nets and the total landings by this method increased from 51,568 cwt to 87,976 cwt and in value from £73,382 to £130,472.

The amount of herring supplied to some of the main outlets decreased in 1967. Compared with 1966, the supply of herring for the home market dropped by 17·8 per cent, for canning by 22·2 per cent, for marinating by 24·2 per cent, for reduction to oil and meal by 41·7 per cent and for redding by 49·3 per cent. The quantities disposed of for curing and for pet food both decreased by 3·8 per cent. There was a substantial increase of 42·6 per cent compared with 1966 in the quantity bought for klondyking, while purchases for freezing also increased by 9·7 per cent. Exports of fresh and processed herring increased in value by 1·5 per cent to £1·97 million.

A new minimum prices rule proposed by the Herring Industry Board and approved by Ministers came into operation on 1st May 1967. Most prices remained unchanged, but there were some increases in the minimum prices of herring sold for quick-freezing and for klondyking.

The payment of herring subsidy was continued by the White Fish and Herring Subsidies (United Kingdom) Scheme 1967. The rates of subsidy were reduced from 1st August 1967, the payments per day at sea being: for vessels between 40 ft and 60 ft £4 13s, for vessels between 60 ft and 80 ft £5 5s, and for vessels 80 ft and over £6 10s. A change was made in the method of paying herring subsidy to some vessels of 35 ft to 39·9 ft. Those registered before 1st January 1967 which earned by way of white fish and herring subsidy less than £500 in 1965 and less than £300 in 1966 remained on stonage payment, which was reduced to 4d per stone of herring landed: other vessels in the size group were allocated voyage payment of £3 10s per day at sea. The payment of grant for herring disposed of for reduction to oil, meal or other approved products remained at 21s per cran, subject to a quota of 20 per cent of total landings at prescribed ports in any calendar month.

In 1967 a total of £192,685 was paid in herring subsidy in Scotland, of which £51,992 represented grant payable on herring consigned for reduction to oil and meal. In addition, a sum of £3,428 was reimbursed to the Isle of Man Government for subsidy paid by them to vessels registered in the United Kingdom landing herring at Isle of Man ports. Of this, £368 was for herring sent for reduction.

The decline in the East Anglian herring fisheries during the past few years continued, the number of Scottish boats participating being 17 compared with 28 in 1966. While the number of Scottish boats fell by about 40 per cent, the total quantity and value of herring they landed dropped by about 70 per cent.

2. Scottish Fishings

(*a*) East Coast Summer Fishing

The Buchan grounds again produced disappointing results, Shetland waters contributing largely to the east coast summer landings. Total landings at north-east ports were down by 5 and up by 2 per cent in weight and value compared with 1966. Although the landings at Aberdeen and Fraserburgh fell in weight by about 31 and 1 per cent respectively, those at Peterhead increased by about 17 per cent. The value of the landings at Aberdeen decreased by about 40 per cent but increased at Fraserburgh and Peterhead by about 11 and 19 per cent respectively.

The total quantity of herring landed at Aberdeen, Fraserburgh and Peterhead

LANDINGS OF HERRING BY BRITISH VESSELS IN THE PRINCIPAL FISHING DISTRICTS IN SCOTLAND

TABLE 11 *Thousand cwt*

	Scotland	Aberdeen	Peterhead and Fraserburgh	Lossiemouth	Wick	Shetland	Stornoway and Ullapool	Oban and Malaig	Firth of Clyde
1938									
TOTAL	2,800·6	190·8	746·3	24·0	103·2	599·8	195·4	97·2	355·9
1966									
TOTAL	1,997·5	39·8	176·6	268·4	0·5	141·5	580·2	578·4	202·8
January	273·2	—	0·5	65·7	—	3·8	60·1	126·4	15·7
February	274·2	—	2·3	67·8	—	—	93·2	59·0	51·6
March	212·6	—	3·9	94·1	—	—	64·3	24·6	25·1
April	20·9	0·4	0·1	10·3	—	—	7·5	0·6	1·2
May	33·9	5·5	18·0	—	—	6·7	0·5	0·3	2·9
June	120·6	11·2	58·6	—	—	34·9	1·5	1·8	10·5
July	140·8	8·7	41·4	—	0·2	37·6	13·1	16·1	23·6
August	182·0	9·0	48·1	—	0·3	58·2	21·8	20·4	23·4
September	86·3	0·3	2·0	3·6	—	0·3	22·6	41·2	16·2
October	128·5	1·7	—	6·2	—	—	79·3	25·9	15·4
November	268·7	1·4	0·1	15·8	—	—	133·0	104·3	10·0
December	255·8	1·6	1·6	4·9	—	—	83·3	157·8	7·2
1967									
TOTAL	1,735·0	26·4	177·0	30·7	2·0	155·2	568·2	592·3	173·6
January	312·9	—	—	4·5	—	—	156·8	144·9	6·3
February	202·6	—	4·4	15·1	—	—	89·2	62·5	29·8
March	94·3	—	0·1	1·3	—	—	56·0	25·7	11·2
April	23·0	—	—	—	—	—	9·3	0·7	12·9
May	52·0	1·7	21·9	—	—	12·9	5·0	4·7	5·7
June	103·3	5·5	52·4	—	—	37·1	1·3	3·2	3·7
July	93·3	2·6	38·1	—	1·7	33·4	4·3	1·7	8·4
August	191·3	12·6	51·2	—	—	71·4	15·8	14·0	24·0
September	77·5	1·8	4·7	—	0·3	0·4	17·7	30·2	21·8
October	88·2	0·4	0·1	0·1	—	—	22·9	36·8	27·9
November	265·5	—	—	5·3	—	—	110·2	133·9	16·1
December	231·1	1·8	4·1	4·4	—	—	79·7	134·0	5·8

fishery districts was 192,539 cwt valued at £412,015 compared with 203,109 cwt valued at £404,349 in 1966.

Aberdeen

Total landings amounted to 24,222 cwt valued at £45,807 compared with 34,964 cwt valued at £76,496 in 1966. Only two East Anglian drifters participated in the fishery contributing about 22 per cent of the total landings compared with five drifters contributing 53 per cent of the landings in 1966. Foreign trawlers landed a total of 9,398 cwt compared with 14,739 cwt in 1966.

The two English drifters commenced operations at the end of April concentrating on the Shetland grounds off Ve Skerries and east of Fetlar. Catches were light to moderate and while herring from the western area were of good quality, those from Fetlar were small and soft. Trials were later made off Bard Head and around 75 to 90 miles N.E. x E. and 100 miles N.E. of Aberdeen where the best results were obtained with hauls of up to 525 cwt. By

early July, however, the English drifters had left the area and were principally based on North Shields. From mid-July only occasional catches were landed at Aberdeen by Scottish drifters, usually when supplies from Shetland grounds at Fraserburgh were heavy, or when boats returned from grounds off north-east England at weekends.

Three purse-seiners from Gardenstown and Peterhead made intermittent landings at Aberdeen during the summer. From the beginning of August a Leith purse-seiner, fitted with tanks of chilled sea-water for storing its catch and a pump for discharging the fish into containers, worked for six weeks from Aberdeen. An English purse-seine vessel fished in Scottish waters for several weeks without success, returning to Lowestoft early in June. In all, purse-seine vessels landed a total of 8,874 cwt representing about 37 per cent of the total landings.

Of the total landings of 24,222 cwt, freshers and kipperers took 17,095 cwt representing about 71 per cent of the total landings. The pet food manufacturers, canners and curers took 3,542, 1,236 and 1,092 cwt respectively. The remainder, 1,257 cwt, went for reduction to oil and meal. The average price per cran fell to 132s 4d from 153s 2d in 1966.

Fraserburgh and Peterhead

The first landings of the season were made at Fraserburgh during the first week in May by two drifters which had been operating on the Ramna Stacks grounds. The number of vessels operating built up quickly until the maximum number of 44 vessels was reached in mid-June, eight fewer than in 1966. Six purse-seine vessels, including two local boats new to the method, contributed about 11 per cent of the total area landings compared with about 3 per cent in 1966. Pair-trawlers also landed at the ports contributing about 5 per cent of the total area landings. The quality of the herring, much of it taken in Shetland waters, ranged from poor to excellent and the average prices obtained at Fraserburgh and Peterhead were 154s 10d and 112s 9d per cran respectively.

Total landings over the season amounted to 168,317 cwt, showing little change from 1966 while the value at £366,208 represented an increase of about 12 per cent. Purchases for freshing and kippering, freezing (including kippering and subsequent quick-freezing) and pet food amounted to 91,949, 45,703 and 7,641 cwt respectively representing increases of about 7, 24 and 87 per cent respectively compared with 1966. The redders, who made no purchases in 1966, purchased 511 cwt in 1967. Canners took 14,123 cwt, a decrease of 29 per cent, and curers 2,352 cwt, a decrease of 66 per cent, while the remainder, 6,038 cwt, went for reduction to oil and meal.

The Maitland Trophy for the best catch of the season at Fraserburgh was won by the motor drifter Margaret Rose (Skipper Alex Watt) with a catch of 466 cwt. The Boothby Trophy, presented to the drifter making the largest landing at Peterhead, was not awarded in 1967, the total drifter landings at the port for the whole summer season amounting to only 32 cwt.

(*b*) SHETLAND

For the third successive year increases were recorded in both weight and value of the total catch for the season. The weight at 155,190 cwt (the highest summer season since 1952) showed an increase of about 13 per cent, while the value at £235,598 (the highest summer season since 1948) increased by about 23 per cent compared with 1966.

The first landings of the season were made by two local drifters during the first week of May. The fleet rapidly increased until 21 drifters were operating at the end of May, fishing mainly on the westerly grounds round Foula and Ve Skerries, with catches also coming from the Ramna Stacks, Muckle Skerry and Score Point grounds. During June the fleet built up until 31 drifters and 4 purse-seiners were operating on grounds at Ramna Stacks, Muckle Skerry, Foula, Ve Skerries, Balta and Bard Head. In July the maximum number of vessels engaged was reached when 35 drifters and 2 trawlers were operating; also during the month the number of purse-seiners operating reached the maximum of 6 vessels. The main fishing grounds were at Muckle Skerry, Bard Head, Burra Haaf and Balta. During August the drifter fleet gradually reduced in number until 22 vessels were operating at the end of the month. These vessels, which were complemented by purse-seiners, operated mainly on the fishing grounds at Bard Head and Sumburgh Head. Demand had been very good throughout the season, but towards the end of August it became very limited and the fishermen imposed restrictions on the fishing effort by reducing to 70 the number of drift-nets carried by each vessel. At the beginning of September the season ended abruptly because of the limited demand and the poor quality of the fish. During the season Scottish purse-seiners made landings amounting to 9,656 cwt, representing 6 per cent of the total landings, compared with 6,822 cwt in 1966, representing 5 per cent of the total landings.

As in 1966, four carrier vessels were intensively employed in transporting herring to the mainland.

The average price per cran amounted to 106s 3d compared with 97s in 1966. The following table gives the details of the total quantities taken up by processors operating in the district:

LANDINGS AND DISPOSAL OF HERRING IN SHETLAND FROM APRIL TO SEPTEMBER

TABLE 12

	Total landings		Disposal				
	Quantity Thous. cwt	Value £ Thous.	Curing	Freshing	Kippering	Quick-freezing	Oil and Meal
1938	600	225	Not Available				
1966	138	191	32	36	16	38	16
1967	155	236	37	33	23	46	16

(c) NORTH-WEST COAST

The total catch for the whole of 1967 fell slightly by weight but increased in value compared with 1966. Pair-trawlers and purse-seiners increased their fishing effort while that of the drifters decreased.

(i) *Winter Fishing*

Both in weight and in value the catch for the season was the highest recorded in any winter season of post-war years. This was due to increased landings at Ullapool and Oban.

LANDINGS OF HERRING ON THE NORTH-WEST COAST: ANALYSIS BY SEASON

TABLE 13

	January to March		April to September		October to December	
	Quantity	Average price per cwt	Quantity	Average price per cwt	Quantity	Average price per cwt
	Thousand cwt	s d	Thousand cwt	s d	Thousand cwt	s d
1938 .	37	7 7	238	11 0	56	7 5
1966 .	428	20 0	147	28 7	584	20 6
1967 .	535	16 3	108	30 11	518	21 3

The season started off well in the North Minch where an assorted fleet of drifters, ringers and pair-trawlers operated throughout the winter. During January the vessels fished mainly on grounds from Stoer northwards finding heavy shoals in Lochs Glendhu, Cairnbahn and Glencoul. The maximum fishing effort was reached during the first week in February when 66 vessels (21 drifters, 20 ringers and 25 trawlers) operated, although the fleet dwindled soon after. Throughout March bad weather severely curtailed fishing and the fishermen then removed the quota restrictions, varying at times between 30 and 70 crans per boat, which they had imposed at the beginning of the season. The quality of the herring was often poor. The demand, however, was fairly good and the marketing of the catch was greatly eased by the presence of klondykers almost throughout the season. The quantity sold at home market prices was relatively small, while a fair amount of poor quality fish was sent for reduction to oil and meal.

At Mallaig the fleet was at its largest in the first week of January, when 22 ringers and 19 trawlers were working. Grounds at Barra and South Uist, and off Portree, Raasay and Applecross were tried. Results were fairly good at first but catches soon decreased and by mid-February only ten boats were fishing. Both quality and demand tended to be low.

In the South Minch up to 53 trawlers and 21 ring-net boats operated out of Oban, on grounds from Barra Head to South Uist. Quota restrictions and bad weather limited the fishing in January. During February dense concentrations of herring were found in the area between Barra Head and Ushinish, but these rapidly dispersed and fishing was then concentrated on the grounds around Vatersay, Muldoanich and Boisdale. Severe weather limited the fishing effort in March with a few trawlers fishing the grounds between Barra Head and Eriskay and in the Muldoanich and Curachan areas. Quality was poor throughout the season and the limited demand was helped by the presence of klondykers.

The total area catch amounted to 535,090 cwt valued at £433,715 compared with 427,621 cwt valued at £428,345 in the corresponding season of 1966. This represents increases of 25 and 1 per cent respectively.

Purchases of herring for pet food (66,349 cwt) and for klondyking (160,913 cwt) showed striking increases of 244 per cent and 183 per cent respectively over 1966. Purchases for freezing amounted to 86,629 cwt (an increase of 37 per cent), for canning 26,796 cwt (19 per cent), and for reduction to oil and meal 123,728 cwt (12 per cent). Compared with 1966, smaller quantities were

bought by the marinators who took 29,004 cwt (a decrease of 28 per cent); freshers and kipperers 40,173 cwt (61 per cent); curers 938 cwt (83 per cent) and redders 560 cwt (92 per cent).

(ii) *Summer Fishing*

Compared with the same season of 1966 there were decreases of about 27 and 21 per cent in weight and value respectively in the 1967 season's catch, mainly because the drift-net activity during August and September was on a much smaller scale. There were no quota restrictions placed on the fishing effort throughout the season. Purse-seiners were for the first time evident in the area, confining their operations mainly to the South Minch.

In the North Minch the drift-net fleet based at Ullapool for the winter fishery continued its operations into April. During the first half of that month, 27 drifters fished the grounds from Lochinver to Melvaig and from Bayble to the Shiants with generally poor results. With no sign of improvement and with falling demand, the drifter fleet was reduced to one or two boats at the end of April. From then until the end of July there was only small-scale activity in the North Minch area, mainly by ring-net vessels. From about mid-July until the end of September the ring-net fleet increased in size to 14 vessels which fished mainly in the area from Kebbock Head to Glass Light. About mid-August up to 13 east coast drifters returned to the area trying various grounds, including Handa and Bulgie, South Bank and Glass Light, with only limited success. Unsettled weather conditions and the general scarcity of herring on the grounds restricted drift-net fishing operations. The herring were generally of good quality and the bulk of the landings was absorbed by the home market.

In the South Minch the unusual intensity of drift-net fishing in the corresponding season of 1966 was not repeated, with a consequent drop in the results. Only a few drifters appeared in this area towards the end of the season, obtaining very ordinary results. A small ring-net fleet operated from early May, reaching a maximum of 11 vessels at the end of August. Fishing was mainly prosecuted at the grounds at Hysgeir, Canna, Score Bay, Pooltiel, Lochboisdale, Glass Light, Kilmaluag and Loch Shell. The herring were generally of good quality and, as in the North Minch, the bulk of the landings was absorbed by the home market.

Total landings in the North and South Minch areas amounted to 107,965 cwt valued at £166,782 compared with 147,436 cwt valued at £210,790 in 1966. Landings in the Stornoway district amounted to 6,762 cwt, in the Ullapool district 46,600 cwt, in the Mallaig district 53,281 cwt and at Oban 1,322 cwt. Purchases by the freshers and kipperers amounted to 60,323 cwt, the freezers 21,224 cwt and pet food manufacturers 16,569 cwt. Smaller quantities were also purchased by the curers (896 cwt), the redders (105 cwt), the canners (4,851 cwt) and the marinators (38 cwt), while 3,959 cwt were sent for reduction to oil and meal.

(iii) *Autumn Fishing*

Both in weight and value the season's catch was lower than the corresponding season of 1966. The weight at 517,532 cwt showed a decrease of 11 per cent and the value at £548,989 decreased by 8 per cent, compared with the 1966 figures of 583,563 cwt valued at £597,439.

A fleet of drifters and ringers built up in the North Minch during October and was augmented by pair-trawlers and purse-seiners. Fishing was concentrated mainly on grounds at Stoer, Rhu Re, Broad Bay, Kebbock Head and

Lochmaddy, but bad weather frequently interrupted operations. The fleet continued to increase during November when up to 29 drifters, 16 ringers and 6 pair-trawlers were operating, mainly in the areas from Loch Cairnbahn to Melvaig and Tiumpan Head to the Shiants. Poor demand during the month resulted in a quota of 70 crans per vessel being imposed by the fishermen towards the end of the month. During December the maximum fishing effort was reached when 30 drifters, 20 ringers and 11 pair-trawlers were operating, but falling demand prompted the fishermen to reduce their landing quotas. Little difficulty was found in obtaining the quotas as herring were plentiful on the fishing grounds, which included Lochbroom, Little Lochbroom, Loch Ewe, Cairnbahn, Glendhu, Inver Bay and Tiumpan Head.

During October up to 24 pair-trawlers, 14 ringers and 7 purse-seiners were operating in the South Minch, concentrating their efforts mainly on the grounds off South Uist, West Skye, Hysgeir and Coll Bank. The fleet built up during November when fishing was carried out in the area from Eriskay to Loch Skiport, and on the Barra, Curachan and Coll Bank grounds. During the second week of December the maximum fishing effort was reached when 40 ringers, 34 pair-trawlers and 6 purse-seiners were operating. Operations were concentrated mainly on the areas between Barra Head and Lochmaddy where generally good results were obtained. There were no restrictions on the fishing effort in the South Minch.

Landings in the Stornoway district amounted to 15,509 cwt, in the Ullapool district 197,310 cwt, in the Mallaig district 196,227 cwt and at Oban 108,486 cwt. Compared with 1966 increased purchases were made by the freshers and kipperers at 119,998 cwt (8 per cent increase), pet food manufacturers 70,906 cwt (6 per cent increase) and curers 14,577 cwt (5 per cent increase). Decreased purchases were made by the freezers at 125,037 cwt (7 per cent decrease), klondykers 47,918 cwt (46 per cent decrease), marinators 33,677 cwt (18 per cent decrease), canners 26,624 cwt (30 per cent decrease) and redders 3,283 cwt. (28 per cent decrease); 75,512 cwt went for reduction to oil and meal, a decrease of 13 per cent compared with 1966.

(*d*) Firth of Clyde

In weight and value the catches for the winter and summer seasons fell below the 1966 results. There was, however, some improvement in the autumn season, but the year as a whole was less productive than 1966.

Landings of Herring in the Firth of Clyde: Analysis by Season

Table 14

	January to March		April to September		October to December	
	Quantity	Average price per cwt	Quantity	Average price per cwt	Quantity	Average price per cwt
	Thousand cwt		Thousand cwt		Thousand cwt	
		s d		s d		s d
1938 .	82	10 6	148	5 10	126	4 0
1966 .	92	39 6	78	36 5	33	50 8
1967 .	47	57 11	77	32 5	50	35 2

(i) *Winter Fishing*

Both in weight and in value the season's catch fell below the corresponding period of 1966.

During January up to 32 ringers made landings in the Ayr and Campbeltown districts, about two-thirds of the catch being landed at Tarbert. At the beginning of the month the vessels fished the grounds off Skipness and Kilbrannan Sound. The quality of the herring was not very good and a substantial part of the catch was sold for pet food. Later in the month the ringers concentrated on the fishing grounds in the vicinities of Brown Head, Pladda and mainly off Turnberry, where they found moderate shoals of excellent quality fish which commanded very high prices. A total of seven trammel net vessels started operations at the end of the month working out of Ayr, concentrating on the Ballantrae Banks with very poor results. During February the bad weather had an adverse effect on landings, although up to 38 ringers and 8 trammel net vessels operated during the month. The fishermen located some good quality herring on grounds in the vicinities of Ballantrae Banks, Turnberry and Pladda. Ayr became the main landing port where the home market and freezing outlets absorbed almost the whole catch. During March, 28 district ringers participated in the fishery, operating mainly on the grounds off the south-west of Arran. Herring were not plentiful, the catches being almost entirely sold to the home market.

The total area catch for the season amounted to 47,327 cwt valued at £136,961 compared with 92,495 cwt valued at £182,652 in the 1966 winter season. Although purchases by the freshers and kipperers were greatly reduced, to 37,212 cwt from 63,626 cwt in 1966, their share of the total catch was about 79 per cent compared with about 69 per cent in 1966. The redders, who purchased 1,757 cwt compared with 2,387 cwt in 1966, slightly increased their share of the total catch to 4 from 3 per cent. Purchases for freezing and pet food showed sharp decreases to 5,180 cwt and 2,107 cwt compared with 13,062 cwt and 8,866 cwt in 1966, their shares of the total catch being reduced to 11 and 4 per cent respectively from 14 and 10 per cent in 1966. Small quantities were taken by the marinators and curers but no purchases were made by the canners and klondykers and no herring were sent for reduction to oil and meal.

(ii) *Summer Fishing*

The total landings in the Ayr and Campbeltown districts amounted to 76,541 cwt valued at £124,068 compared with 77,711 cwt valued at £141,542 in 1966, representing decreases of 2 and 12 per cent respectively.

During the season up to 32 ring-net vessels, nine fewer than the 1966 maximum, participated in the fishery at one time or another.

During April, May and June the number of ring-net vessels operating ranged from 6 to 24, fishing chiefly on grounds at Kilbrannan Sound, off Carradale and the Cumbraes. The quality of the herring ranged from poor to fairly good, with the demand ranging from poor to keen according to the quality of the fish. Throughout July the fishing effort remained at 24 vessels fishing chiefly on the grounds at Kilbrannan Sound, Loch Long and Loch Fyne. The quality was good throughout the month with a consequent good market demand. In August up to 26 ringers took part, fishing mainly the Kilbrannan Sound, lower Loch Fyne, Loch Long and Loch Striven grounds and off Portavogie in the Irish Sea. Both quality and demand ranged from poor to good. In September up to 28 vessels took part, concentrating on grounds at Kilbrannan Sound and

Lochs Long, Goil and Striven. Quality again ranged from poor to good with a a good demand for the better fish.

Of the total landings 38,476 cwt and 24,164 cwt were sold for freshing and kippering and for pet food respectively compared with 51,202 cwt and 15,428 cwt in 1966. Purchases for freezing and canning amounted to 8,088 cwt and 3,238 cwt respectively. Of the remainder, 2,002 cwt were sent for reduction to oil and meal, while small quantities were purchased for redding and curing.

(iii) *Autumn Fishing*

Total landings for the area amounted to 49,769 cwt valued at £87,498 compared with 32,587 cwt valued at £82,492 in the corresponding season of 1966, representing increases of 53 and 6 per cent respectively. The average price per cwt fell from 50s 8d to 35s 2d.

The maximum fishing effort was reached in October when up to 32 ring-net vessels were operating. The fleet gradually decreased, with vessels departing for the Minch, until 18 vessels were operating at the end of the season. Fishing operations were concentrated mainly on the grounds in Kilbrannan Sound and Lochs Long, Goil and Striven.

Quality varied from poor to good, with demand mainly good but keen for the good quality fish. The canners, who made no purchases in 1966, purchased 12,932 cwt. Purchases by the freshers and kipperers increased by 8 per cent to 19,092 cwt from 17,626 cwt in 1966. The pet food manufacturers increased their purchases by 17 per cent to 16,810 cwt from 14,350 cwt in 1966. There was a considerable increase in the amount of herring purchased for freezing, 609 cwt compared with 130 cwt in the autumn season of 1966. Curers took 280 cwt compared with 238 cwt in 1966, an increase of 18 per cent. The remainder, 46 cwt (243 cwt in 1966), was sent for reduction to oil and meal.

(*e*) Inverness

Compared with the exceptionally good winter fishery of 1966 the 1967 winter season was very poor. No drift-netting was carried on in the Inverness Firth during the winter as there was insufficient herring in the area to make drifting worthwhile. A number of pair-trawlers, mainly engaged at sprat fishing, brought in catches of herring from time to time. The season's landings amounted to 20,891 cwt valued at £12,590 compared with 227,533 cwt valued at £112,585 in the 1966 winter season. The canners purchased 8,218 cwt (17,220 cwt in 1966), pet food manufacturers 1,239 cwt (61,593 cwt) and freshers and kipperers 88 cwt (60 cwt). The remainder, 11,346 cwt (148,660 cwt), was sent for reduction to oil and meal.

No landings were made in the summer season.

Compared with 1966 the 1967 autumn season was a failure. Total landings amounting to 9,828 cwt valued at £2,815 compared with 26,941 cwt valued at £20,240 in 1966, were made by pair-trawlers engaged mainly in sprat fishing. The canners purchased only 119 cwt (17,045 cwt in 1966) while the bulk of the catch, 9,709 cwt (8,853 cwt in 1966), was sent for reduction to oil and meal.

3. English and Irish Fishings

In addition to operations in home waters, Scottish fishermen engaged in herring fishing off the English and Irish coasts. These fishings accounted for approximately ten per cent of the gross earnings of the Scottish fleet.

LANDINGS OF HERRING BY SCOTTISH VESSELS IN ENGLAND, NORTHERN IRELAND AND THE ISLE OF MAN

TABLE 15

	Total		East Anglia			Other English			N. Irish and Isle of Man		
	Quantity	Value	Vessels	Quantity	Value	Vessels	Quantity	Value	Vessels	Quantity	Value
	Thous. cwt	£ thousand	Number	Thous. cwt	£ thousand	Number	Thous. cwt	£ thousand	Number	Thous. cwt	£ thousand
1938	931·3	251·8	444	891·8	239·3	20	11·4	3·7	27	28·1	8·7
1966	158·1	252·3	28	37·7	80·8	74	120·3	171·4	2	0·1	0·1
1967	167·2	262·7	17	10·0	23·6	62	150·8	232·0	10	6·4	7·1

In former years Scottish interest in English fishing was mainly at East Anglia, but in the past few years interest in this area has declined considerably, with greater emphasis on the fishery off the Northumberland, Yorkshire and Westmorland coasts; so much so that a few Scottish drifters now start their summer season at Shields and spend little or no time on the traditional Scottish summer grounds. For the period to the end of September a fleet of 61 vessels engaged in the fishery off the north-east English coast and made landings at Seahouses, North Shields, Whitby, Scarborough and Grimsby. Drift-netting accounted for the bulk of the 113,750 cwt valued at £175,900 landed at these ports, but pair-trawlers accounted for an increasing proportion of the catch, with small quantities landed by purse-seiners and ring-netters. The ring net, which was very popular in the Seahouses/Whitby area some years ago, has been replaced by the more efficient pair-trawl and only two Fisherrow pairs employed the ring-net method in the Northumbrian area in 1967.

North Shields, with a Scottish landing of 64,708 cwt valued at £103,409, accounted for the major part of the landings from the Northumbrian and Yorkshire coasts, with Scarborough the next important port by catch and value. The Scottish vessel Fertile (Skipper Andrew Tait) gained the Scarborough Herring Trophy for having the highest total catch for the season, 3,297 cwt. Quality was quite good and, with supplies being taken for all the usual outlets, the quantities which had to be sold for conversion into oil and meal were

SCOTTISH PARTICIPATION IN EAST ANGLIAN FISHING

TABLE 16

	1938	1966	1967
VESSELS (number)			
Total	444	28	17
Steam	378	—	—
Motor	66	28	17
LANDINGS (thousand cwt)			
Quantity	892	37·7	10·0
Steam	806	—	—
Motor	85	37·7	10·0
VALUE (£ thousand)			
Total	239	80·8	23·6
Steam	215	—	—
Motor	24	80·8	23·6

relatively small. In 1966 profitable landings had been made at Whitehaven from the Manx grounds and for a short season in 1967 more attention was given to this area. In October the Scottish participation built up to a maximum of 28 pair-trawlers and 2 purse-seiners, their total catch amounting to 36,995 cwt which sold for £56,000.

Partly because of poor results in recent years through scarcity of herrings on the traditional grounds and the change-over to pair-trawling by Manx drifters, the fleet at East Anglia in 1967 was only 20 drifters, 3 English and 17 Scottish. As bad weather often interrupted operations and herrings were difficult to locate, some Scottish drifters spent only a few days in the area and all had left by the end of the first week in November. Demand for the small quantities landed was very keen and the average price for all landings at East Anglian ports was 58s 4d per cwt, the comparative figure for 1966 being 48s 1d per cwt.

In addition to their landings at East Anglian ports, Scottish drifters landed 609 cwt valued at £2,296 at Dutch ports.

4. Method of Capture

LANDINGS OF HERRING BY METHOD OF CAPTURE

TABLE 17 — *Thousand cwt*

	Total	Drifters*			Trawlers	Motor ring-netters	Motor seiners	Purse-seiners
		Steam	Motor	Sail				
1938 . .	2,800·5	1,578·0	503·0	3·7	120·4	595·4	—	—
1966 . .	1,997·5	—	882·6	—	331·4	731·1	0·8	51·6
1967 . .	1,735·0	—	575·8	—	447·5	623·2	0·5	88·0

*Includes small quantities taken by trammel nets and anchored nets.

The number of Scottish motor drifters mainly engaged in herring fishing dropped from 66 in 1966 to 42 in 1967. During 1967, 80 Scottish and 2 English drifters worked in Scottish waters, compared with 124 and 5 in 1966.

The number of vessels engaged mainly in ring-net fishing dropped from 73 in 1966 to 55 in 1967. The number which fished by ring-net at some time in 1967 was 97, compared with 116 in 1966.

The growth of pair-trawling and single boat trawling for herring continued in 1967. While trawling has not been successful on the summer grounds when the herring are active, it has proved satisfactory at other times and is less liable to interference by bad weather than some gears. Some 26 per cent of the Scottish landings were made by herring trawlers.

The experience of the Scottish purse-seiner and her partner vessel during 1966 encouraged other owners to equip with purse-seine gear. Five more Scottish vessels, ranging in length from 70 to 120 ft, began fishing in 1967. The smaller vessels operated with partners which were not themselves equipped with nets. Several more purse-seiners were under construction for Scottish owners at the end of the year. The English purse-seiner which fished in Scottish waters in 1966 gave up herring fishing in 1967 to re-equip for white fish trawling.

5. Disposal of Catch

The following table showing the main methods of disposal of the Scottish catch does not include imports or herring landed by foreign vessels. These are

DISPOSAL OF THE SCOTTISH HERRING CATCH

TABLE 18 *Thousand cwt*

	Total landed	Marketed fresh or quick-frozen*	Exported fresh or lightly salted (klondyked)	Kippered†	Marinated, bloaters, reds and buckling	Canned	Pickle-cured (gutted and ungutted)	Pet food	Oil and Meal
1938	2,800·6	461·9	366·0	522·1	3·9	117·5	1,319·6	—	9·6
1958	1,639·1	343·5	28·7	454·6	34·7	132·1	125·3	283·7	236·5
1959	2,218·1	362·7	22·2	432·3	68·7	213·3	317·2	316·1	485·6
1960	1,762·0	328·0	50·6	461·0	52·7	125·1	149·2	368·1	227·3
1961	1,359·7	256·3	31·8	568·5	42·6	116·2	60·2	192·6	91·5
1962	1,486·6	385·5	108·5	551·3	73·8	134·7	56·8	155·4	20·6
1963	1,567·1	309·2	49·2	552·5	79·1	152·1	78·3	208·4	138·3
1964	1,578·6	289·2	6·1	641·1	63·8	108·1	51·0	226·2	193·1
1965	1,627·5	402·3	69·2	496·5	65·8	115·9	61·5	242·2	174·1
1966	1,997·5	436·6	146·4	469·5	97·8	127·0	59·9	218·4	441·9
1967	1,735·0	371·0	208·8	460·1	70·7	98·8	57·7	210·1	257·8

*Includes certain quantities of herring kippered in England.
†Includes kippered and subsequently quick-frozen.

included in the details of disposals in the annual Scottish Sea Fisheries Statistical Tables published separately.

There was a slight decrease in the output of pickle-cured herring, about 20,000 barrels being produced compared with 22,500 barrels in 1966. Fourteen curing stations were operated in Scotland employing 55 crews of gutters and packers; 30 gutting machines were used.

The number of barrels of pickle-cured herring exported in 1967 totalled about 18,000 compared with 19,100 barrels in 1966. The main buyers were West Germany, Czechoslovakia, the Netherlands and South Africa.

For the third year in succession, the total exports of herring by the United Kingdom increased in both weight and value over the previous year. Total exports amounted to about 487,300 cwt valued at £1,994,000 compared with about 388,900 cwt valued at £1,965,500 in 1966. Exports of fresh, chilled or frozen herring increased by about 92 and 81 per cent in weight and value respectively, mainly because of larger purchases by Denmark, the Netherlands and West Germany. Pickle-cured exports to the Netherlands, Italy and West Germany increased considerably and offset decreases to other countries, resulting in overall increases of 22 and 13 per cent in weight and value respectively over 1966. Other cured herring exports increased by about 25 per cent in weight and value, mainly owing to larger purchases by Sweden, Denmark, Norway and West Germany. Kipper exports again showed decreases in weight and value amounting to about 5 per cent. Despite large purchases of redded herring by Belgium and Canada, exports of this commodity fell by 34 per cent in weight and value, as purchases by Australia, Cyprus, Italy and Switzerland decreased. Canned herring exports decreased by about 26 and 18 per cent in weight and value respectively. Smaller purchases by Australia, New Zealand, the United States and Canada were due more to lack of supplies than to any fall in demand.

6. Foreign Landings

The amount of herring landed in Scotland by foreign vessels in 1967 was 112,000 cwt valued at £60,000 compared with 38,000 cwt valued at £57,000 in 1966.

CHAPTER V

SHELLFISH

There was a further increase in the weight and value of shellfish landed in Scotland during 1967. The total catch of 230,998 cwt (11,738 metric tons) was some 4·2 per cent higher than the 221,776 cwt (11,269 metric tons) landed in 1966 and the value was £2·1 million compared with £1·9 million. The improvement in the overall return to fishermen was due almost entirely to an increase of 15 per cent in the value of the nephrops fishery. Lobster fishing continued to decline; the weight landed fell by 3·2 per cent and, contrary to the established trend, the average market price was marginally below the 1966 figure. Landings of escallops and of squid increased both in weight and in value but landings of most other species were smaller than in the previous year.

(*a*) Nephrops (Norway Lobsters)

The nephrops fishery continued to make the most valuable contribution to the Scottish shellfish industry and landings of 131,599 cwt, valued at £1,287,028, accounted for some 57 per cent by weight and 61 per cent by value of the entire Scottish shellfish catch.

The most efficient gear for taking nephrops is the light trawl, and the fishing is carried on mostly by full-time crews who fish at other times of the year for other species with seine or ring nets, although an increasing number are trawling for nephrops throughout the year. A few boats on the west coast are using creels for the capture of nephrops with considerable success.

The Firth of Forth, the Moray Firth, the Firth of Clyde and the Minches continued to be the most productive nephrop grounds. Landings in all west coast districts increased substantially. Those at Stornoway, Ullapool, Mallaig and Oban totalled 40,772 cwt compared with 32,177 cwt in 1966 and those in the Clyde, mostly at Ayr, totalled 34,948 cwt compared with 25,739 cwt in 1966. Total landings in east coast districts were lower than in 1966. Those in the Firth of Forth totalled 22,273 cwt compared with 31,812 cwt in 1966. The Anstruther landings, 8,737 cwt as against 18,657 cwt in 1966, reflect very poor catches on local beds in the early months of the year and a consequent switch of effort to white fish fishing. Landings in the Moray Firth, mostly at Buckie, totalled 19,787 cwt compared with 20,241 cwt in 1966. The average price received by the fishermen rose from 178s 8d per cwt in 1966 to 195s 7d per cwt in 1967.

Most of the landings were processed in factories at Berwick-on-Tweed, Eyemouth, Anstruther, Inverbervie, Aberdeen, Stornoway, Irvine and Annan but some catches were also sent to factories in England for processing.

In contrast to lobsters and escallops, the home market for processed nephrops provides the main outlet for this species. Their export in processed form is on a relatively small scale, for demand abroad is, in general, for whole fresh nephrops. There has been some export of live nephrops and also of extra-large frozen tails in shell. This specialised export market would appear to offer considerable scope for expansion.

The lobster fishery contributed 25 per cent of the value of the total shellfish catch but there was a further slight decline in lobster landings in 1967. The weight of lobsters landed was 3·2 per cent less than the comparable figure for 1966, which itself was 8·8 per cent below that for 1965, which in turn had been 19 per cent less than the figure for 1964. The average market price in 1967 did not

(*b*) LOBSTERS

WEIGHT AND VALUE OF LOBSTERS LANDED IN SCOTLAND

TABLE 19

	1938		1966		1967	
	Number	Value £	Weight cwt	Value £	Weight cwt	Value £
TOTAL	803,414	52,691	11,537	559,925	11,168	538,215
Eyemouth	50,071	2,499	717	35,256	1,036	49,136
Leith	54,209	3,144	643	30,190	925	46,467
Anstruther	40,853	2,050	748	34,016	895	43,880
Arbroath	43,897	2,098	633	34,096	558	30,222
Aberdeen	5,267	300	39	2,210	48	2,545
Peterhead	7,845	529	66	2,819	80	3,641
Fraserburgh	19,478	1,172	82	3,555	126	5,727
Macduff	6,291	432	95	3,911	118	4,966
Buckie	1,610	80	52	2,192	50	2,028
Lossiemouth	6,696	466	231	9,310	222	10,842
Helmsdale	16,713	1,061	—	—	—	—
Wick	50,094	4,562	856	42,776	870	40,546
Orkney	119,329	7,787	3,769	196,327	3,126	157,430
Lerwick	2,788	224				
Stornoway	170,019	12,661	980	43,990	1,163	45,309
Ullapool	41,575	3,089	301	15,261	162	9,262
Mallaig*	29,555	1,931	895	42,409	693	36,623
Oban	50,402	3,279	537	26,352	406	19,842
Campbeltown	35,265	2,221	544	21,256	393	15,372
Tarbert	14,085	1,064	—	—	—	—
Ayr	37,369	2,042	349	13,999	297	14,377

*Previously known as Kyle District.

respond to the drop in production and was marginally lower than in the previous year, i.e. 8s 7d per lb compared with 8s 8d. The combination of lower landings and lower prices resulted in a reduction of 3·9 per cent in the total value of the catch.

Landings decreased in Lerwick and in the west coast districts, with the exception of Stornoway, and the increased weights which were landed in most east coast districts were insufficient to offset this reduction. Despite the smaller landings there, Orkney and Shetland contributed almost 30 per cent of the total landings: the west coast contributed approximately the same proportion and the slightly improved landings in east coast districts represented a little over 40 per cent of the total. The bulk of the catches continued to be consigned fresh to Billingsgate but there was also a substantial trade direct with the Continent. The lobsters are refreshed en route to the market in storage tanks situated at Berwick-on-Tweed, Eyemouth, Johnshaven (Montrose), Helmsdale, Stromness, Scalloway, Lerwick, Stornoway, Mallaig and Troon.

(*c*) CRABS

Crab landings in 1967 dropped to 34,119 cwt valued at £102,983 compared with 37,465 cwt valued at £106,224 in 1966. The decline in the landings which occurred in the Fraserburgh, Macduff and Wick districts was largely offset by the increased landings in other east coast districts and on the west coast. The increased landings in 1966 in Orkney and Shetland, which reflected the setting up

on an experimental basis of a crab processing plant in Orkney, were not maintained following the closure of the plant, and the substantial decline there accounted for most of the total fall in both weight and value of crab landings.

The bulk of the crab landings continued to be made on the east coast at Fraserburgh and Peterhead (8,098 cwt valued at £29,300); at Arbroath (2,686 cwt valued at £7,993); at Wick (2,065 cwt valued at £6,195); and on the Firth of Forth and Berwickshire coasts (10,018 cwt valued at £32,056). Landings in Orkney and Shetland decreased during the year to 7,125 cwt valued at £16,245, compared with 10,325 cwt valued at £20,771 in 1966. Landings on the west coast, mainly in Ullapool and Mallaig districts, were relatively light. The average price per stone received by the fishermen rose from 7s 1d in 1966 to 7s 6d in 1967.

Most of the landings on the east coast were processed locally in factories at Berwick-on-Tweed, Inverbervie, Boddam (Peterhead), Thurso, Stromness and Lerwick. West coast catches also were processed in the east. Although Billingsgate continued to take some consignments of fresh fish, the demand in this market is for a larger type of crab than is generally available from Scottish sources.

(*d*) Escallops

Weight and Value of Escallops Landed in Scotland

Table 20

	Weight cwt	Value £
1938 .	2,648	3,452
1965 .	7,456	44,496
1966 .	12,092	78,611
1967 .	19,850	122,892

Although the average price fell from 130s per cwt in 1966 to 124s per cwt in 1967, increasing demand encouraged a further expansion of this fishery. The bulk of the landings were made in the Campbeltown district and came from beds at Gigha, Colonsay and the Firth of Clyde. Processing was carried out at Rothesay and at Port Ellen, Islay, and most of the catch was consigned, in a quick-frozen state, to markets in the south of England and the Continent.

(*e*) Oysters

The Scottish Marine Biological Association continued their experiments, in collaboration with commercial and other interests, in the rearing of oysters under Scottish conditions. Particular attention was given to the cultivation of oysters on ropes and in synthetic fibre bags suspended from rafts and floats.

(*f*) Other Shellfish

There was little change in the landing of mussels (used mainly for bait) but the results of experimental work on the west coast by scientists of the Department's Marine Laboratory, Aberdeen, on the cultivation of mussels on

TABLE 21

VALUE OF MUSSELS, SHRIMPS, SQUID AND PERIWINKLES LANDED IN SCOTLAND

	Mussels	Shrimps	Squid	Periwinkles
	£	£	£	£
1938. .	4,142	—[1]	336[2]	—[1]
1965. .	6,780	11,600	7,785	—[1]
1966. .	7,518	11,621	1,507	45,249
1967. .	7,937	9,742	11,290	42,602

[1] No figures available. [2]This value was included in the total for Demersal Fish in 1938.

suspended ropes were most encouraging and there appears now to be some prospect of this method being developed on a commercial basis with a view to supplying the very considerable market in England for mussels for human consumption.

The established fishery for brown shrimps in the Solway Firth conducted by a fleet of small boats operating out of Annan continued, but with decreased landings, i.e. 1,820 cwt as compared with 2,260 cwt. The experimental commercial pink shrimp fishing on the Fladden grounds by a Peterhead boat, which was noted in last year's report, was discontinued owing to marketing difficulties. Although the catches taken indicated that pink shrimps were present in commercial quantities in the area fished, the prices obtained were insufficient to sustain the venture.

The improvement in landings of squid (3,052 cwt as compared with 739 cwt last year) reflected an improvement in price (74s per cwt as against 40s 9d). Cockle gathering on a small scale was recorded in the Stornoway and Oban districts. Gatherings of periwinkles fell slightly from 22,795 cwt in 1966 to 19,961 cwt. These were consigned mainly to Billingsgate for Continental markets.

CHAPTER VI

HARBOURS

1. Assistance to Harbour Authorities

The Fisheries Act 1955 empowers the Secretary of State in certain circumstances to make grants or loans or both to harbour authorities towards the cost of works for the construction, improvement and repair of fishery harbours. The assistance offered during the year for works to be undertaken consisted entirely of grants, which totalled £217,668, and the payments of grant actually made on works in progress or completed totalled £132,933. Appendix I gives details of the offers and payments and also shows the stage reached on the individual works at the end of the year.

The main works completed during the year were the construction of a new pier at Kyleakin, the provision of an additional area of hardstanding at Culag Pier (Lochinver) and the strengthening of the Victoria Breakwater at Dunbar, the Lighthouse Pier at Lybster and the East and West Piers at Gardenstown.

The major deepening scheme at Pittenweem Harbour was begun in November. In addition, reconditioning works were put in hand at Buckie Harbour and minor works were carried out at a number of other harbours.

Grants were offered towards a number of new projects, including a scheme of improvement at Gourdon, further major reconstruction work at Mallaig and repairs to the sea wall at Whitehills.

Expenditure on the maintenance of Peterhead Harbour of Refuge was £185.

2. Dredging

The Department continued to maintain the bucket dredger *Dragon* and the grab dredger *Sandchime* for work at Scottish fishery harbours. The quantities of material dredged in 1967 are as follows.

TABLE 22

	Cubic Yards
Dragon	
TOTAL	28,050
Anstruther	1,760
Arbroath	8,680
Buckie	3,570
Girvan	1,860
Granton	1,400
Stornoway	5,000
Wick	5,780
Sandchime	
TOTAL	18,364
Anstruther	2,750
Arbroath	904
Buckie	430
Burghead	3,390
Girvan	6,600
Helmsdale	2,970
Lybster	1,320

Of the charges for dredging carried out during the year, amounting to about £46,500, some £36,000 was remitted.

In November an order was placed for the construction of a new vessel to replace the dredger *Dragon*.

CHAPTER VII

SALMON FISHERIES

1. Catch, Value and Employment

The 1967 catch of salmon and grilse by all methods, commercial and angling, as extracted from the returns submitted by proprietors and occupiers of salmon fisheries amounted to 2,132 tons (1624)[1], the number of fish caught being 604,131 (449,383). The catch of sea trout totalled 345 tons (252), the number of fish caught being 312,226 (244,778). The estimated value of the total catch was £2,052,700 (£1,780,000). It is worthy of note that the combined catch of salmon

[1]Figures in brackets are for 1966. These figures now quoted have been revised to include late returns received after the publication of the 1966 Annual Report.

and grilse and the total catch of salmon, grilse and sea trout were the highest recorded in any year since Departmental statistics were first collected in 1952. In this period the 1967 catch of salmon has been exceeded on only three occasions. A more detailed analysis of the catch by species and method of capture is given in the following tables:

TABLE 23

CATCH BY SPECIES

	1966		1967	
	Number	Weight in lbs	Number	Weight in lbs
Salmon:				
Rod and Line	64,208	625,629	62,898	609,966
Net and Coble	87,077	939,306	123,168	1,329,693
Fixed Engines	77,078	791,050	75,468	804,541
TOTAL	228,363	2,355,985	261,534	2,744,200
Grilse:				
Rod and Line	8,474	42,854	14,450	78,321
Net and Coble	95,202	542,376	161,227	936,171
Fixed Engines	117,344	637,891	166,920	942,290
TOTAL	221,020	1,223,121	342,597	1,956,782
Sea-trout:				
Rod and Line	73,504	133,060	63,107	112,592
Net and Coble	127,807	334,279	190,933	519,614
Fixed Engines	43,467	88,889	58,186	128,099
TOTAL	244,778	556,228	312,226	760,305

TABLE 24

CATCH BY METHOD OF CAPTURE

	1966		1967	
	Number	Weight in lbs	Number	Weight in lbs
Rod and Line:				
Salmon	64,208	625,629	62,898	609,966
Grilse	8,474	42,854	14,450	78,321
Sea-Trout	73,504	133,060	63,107	112,592
TOTAL	146,186	801,543	140,455	800,879
Net and Coble:				
Salmon	87,077	939,306	123,168	1,329,693
Grilse	95,202	542,376	161,227	936,171
Sea-trout	127,807	334,279	190,933	519,614
TOTAL	310,086	1,815,961	475,328	2,785,478
Fixed Engines:				
Salmon	77,078	791,050	75,468	804,541
Grilse	117,344	637,891	166,920	942,290
Sea-trout	43,467	88,889	58,186	128,099
TOTAL	237,889	1,517,830	300,574	1,874,930

The returns indicate that the number of men directly employed in commercial salmon fishing in Scotland was 1,514 (1,543). This does not include men engaged in ancillary trades such as twine, net and rope manufacture, boat building, box making, distributing and marketing: nor does it take into account the considerable number of men employed as ghillies and water bailiffs.

2. **Close Times**

A list of the close times is given in Appendix II.

3. **District Boards**

No new district boards were constituted during the year.

The total assessable value of the salmon fishings for levy by district boards where these operate, and including the Tweed, amounted to £277,323 (£252,347); the total assessment raised was £94,675 (£79,543). After making allowance for certain districts in which no assessment was made the average rate of levy was 9s 4d in the £; the lowest figure was 3d in the £, and the highest was £2 1s.

4. **Poaching and Illegal Fishing**

In the course of the year 250 persons were proceeded against for offences under the Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951 and 236 convictions were obtained. Of the persons convicted 159 were fined £10 or less and 53 more than £10; 9 were sentenced to terms of imprisonment without the option of a fine and 15 were admonished. In 78 cases gear and fish were forfeited.

5. **Salmon Disease**

The disease which was first observed in some Irish rivers in 1964 and which affected a number of rivers in the North of England in 1966, including the Esk which flows partly in Scotland, was present in a large number of Scottish rivers in 1967. Nearly all the major rivers in the area from the Tweed to the Nairn, with the exception of the Tay and the Forth, were affected, as well as a number of rivers in Ayrshire and on the Solway. District salmon fishery boards and proprietors of fisheries were advised of the action to be taken to try to control the spread of infection.

Reports of the number of diseased fish removed from rivers were received from district fishery boards, and a list of the rivers affected, showing the number of diseased fish removed up to the end of the year, is included in the report of the Inspector of Salmon Fisheries at Appendix II.

Investigations into the nature and cause of the disease were continued at the Marine Laboratory, Aberdeen and an account of this work is included in Appendix III.

6. **Seals**

Damage to salmon net fisheries by seals was again reported from many parts of the coast. The Department's scientific staff continued their investigations into the effects of grey seals on fisheries and a brief account of this work is included in Appendix III.

In terms of the Grey Seals Protection Act 1932, grey seals are normally protected during the annual close season which extends from 1st September to 31st December. Since 1962, however, the close season has been suspended each

year for certain areas of Scotland. In 1967 this was effected by the Grey Seals Protection (Scotland) (Suspension of Close Season) Order dated 3rd August 1967, and permits were issued to allow salmon netsmen to kill seals at their netting stations around the mainland and to allow seal hunters to shoot seals in Orkney, where a limited cull is controlled by the Department. Permits were also issued for the shooting of seals in the Shetland Islands and for the killing of a limited number of seals on the islands of Gasker and Coppay in the Outer Hebrides. Eighty-nine seals were killed in the close season in Shetland and 748 were killed by permit holders in Orkney. Neither the salmon netsmen on the mainland nor the permit holders in the Outer Hebrides killed any seals during the close season. The reason for this in the case of the Hebrides was the extremely stormy weather which prevailed during the whole of the breeding season.

7. Drift-Net Fishing for Salmon

The ban on drift-net fishing for salmon which was first introduced on 15th September 1962 was continued until 14th February 1969 to give further time for consideration of the recommendations of the Hunter Committee on Scottish Salmon and Trout Fisheries. The extension was effected by the Salmon and Migratory Trout (Prohibition of Drift-Net Fishing) (Extension) Order 1967 which came into operation on 15th February 1967 (S.I. 1967 No. 135).

8. Committee on Scottish Salmon and Trout Fisheries

The recommendations of the committee under the Chairmanship of Lord Hunter, which are contained in the final report published in August 1965 (Cmmd. 2691), were further considered and a series of meetings was held with representatives of the main interested organisations to discuss their written observations and to explore further the practical and financial implications of the recommendations in the report.

CHAPTER VIII

MARINE SUPERINTENDENCE

1. General

During 1967 superintendence of the Scottish inshore fisheries involving patrols of the entire Scottish coastline, which extends to more than 3,000 miles, was maintained by the Department's fleet of six motor and two steam vessels. H.M.S. *Belton*, assigned by the Ministry of Defence for protection duties in Scottish waters, together with other vessels of the naval fishery protection squadron based at Port Edgar, continued to assist with patrols of the offshore grounds.

Patrols were varied to suit the seasonal pattern of fishing and to deal with complaints of alleged illegal fishing received from time to time. In general, however, *Brenda*, *Minna* and *Ulva* patrolled the west and north-west coasts, including the Outer Hebrides, while *Rona* concentrated on the Firth of Clyde and south-west coast; *Norna* and *Vigilant* were mainly employed on the north coast and in Orkney and Shetland; *Longa* operated mostly on the east coast and

in the Moray Firth, while *Fidra* kept the Firth of Forth and Berwickshire coasts under surveillance. Assistance was given on a number of occasions to fishing boats and other vessels. In the course of their duties during the year the Department's vessels steamed a total of 164,939 nautical miles. Air patrols were also undertaken on occasion.

In 1967 there were 58 detections of alleged illegal fishing in close inshore waters. Forty-nine were made by the Department's vessels (one with the assistance of H.M. Coastguard), three by the naval fishery protection squadron, three by private individuals assisted by cruisers and three in the course of air exercises. Of these cases, 48 related to illegal trawling, eight to illegal seine-net fishing and two to infringements of British fishery limits by foreign vessels.

There were, in addition, 14 detections of alleged contraventions of other fishery regulations. Five of these were made by the Department's vessels and nine by the Fishery Inspectorate.

Eighteen cases arising out of the total of 72 detections remained outstanding at the end of the year.

2. Prosecutions for Illegal Fishing

Legal action was initiated in 57 cases of alleged illegal trawling (including 15 cases outstanding from the previous year) but in six of these prosecution proceedings were not taken. In 41 cases convictions were obtained; in 35 of these cases fines ranging from £10 to £100 were imposed; in five cases sentence was deferred for two years; in one case the offender was admonished. A verdict of 'not proven' was returned in one case. Fifteen cases were outstanding at the end of the year.

Proceedings for alleged illegal seine-net fishing were initiated in ten cases (including two cases outstanding from the previous year). Convictions were obtained in eight cases and fines ranging from £15 to £75 were imposed. In two cases charges were dropped.

Two convictions against foreign vessels for illegal fishing resulted in fines of £50 and £80. In neither instance was forfeiture of catch ordered but a net on one of the vessels was confiscated.

3. Prosecutions for Other Offences

Legal action was initiated in 35 cases of other alleged contraventions of the fishery regulations (including six brought forward from the previous year), 19 in conjunction with illegal trawling charges and three in conjunction with illegal seining charges. In two of these cases prosecution proceedings were not taken.

Eight cases (five relating to trawling charges) were outstanding at the end of the year.

Particulars of the 27 convictions are shown below:

Sea Fishing Industry (Nets on British and Foreign Fishing Boats) Orders 1965 and 1966	11
The Collisions Regulations (Ships and Sea-Planes on the Water) and Signals of Distress (Ships) Order 1965	11
Sea Fisheries Act 1883—Section 14(2)	2
Merchant Shipping—Fishing Boats Registry Order 1927	1
Sea Fisheries Act 1868—Section 26	2

In 23 cases fines ranging from £2 to £50 were imposed on skippers and in three cases the owners of the vessels were also convicted, one being fined £20 and two admonished. In one case sentence was deferred for two years and in three cases the skippers were admonished.

4. Trawling in Prohibited Areas (Prevention) Act 1909

In terms of this Act, any fishing vessel which engages in beam or otter trawling in a prohibited area, as defined in the Act, may not land or sell fish in the United Kingdom for a period of two months thereafter. In practice, this provision is used only in instances of trawling by foreign vessels within that part of the Moray Firth which lies outwith the fishery limits but within the area closed to British trawlers by Byelaw 10, i.e. west of the Duncansby Head/ Rattray Point closing line. It will be appreciated that the area in question is now much smaller than it was before September 1964 when the Fishery Limits Act came into force. During the past four years the only foreign trawlers reported as having been observed working in this area were Belgian. The numbers were as shown in Table 25.

FOREIGN TRAWLERS OBSERVED TRAWLING IN THE MORAY FIRTH

TABLE 25

	Number of trawlers	Number of occasions observed
1964 .	7	14
1965 .	8	16
1966 .	4	4
1967 .	1	1

Fish landed in the United Kingdom in contravention of the 1909 Act is liable to confiscation by the Customs Authorities. Thirteen such cases have come to notice since the passing of the Act but none in recent years.

5. The Scottish Inshore Fisheries Committee

Since the latter part of last century when the initial legislative measures for the regulation of Scottish fisheries were introduced, 79 Byelaws have been made. Of these, 25 were in force during the year. Four new Byelaws (three renewing, with amendments, existing regulations) were made late in the year and had not come into operation by its end. The increasing complexity of this legislative structure, the radical changes in the methods and means of fishing, the increase in scientific knowledge about the conservation of fish stocks, and the growing difficulty of enforcing the law led to the appointment, on 8th December, of a Committee of Inquiry under the chairmanship of Lord Cameron, D.S.C., Q.C., with the following terms of reference:

'To review the law governing the methods of sea fishing in Scottish coastal waters, having regard to the changing pattern of sea fishing, the requirements of fishing communities and the conservation of fish stocks; and the cost and method of enforcement, having regard to the value of the fisheries concerned, and the cost and effectiveness of alternative methods; and to make recommendations.'

CHAPTER IX

FISHERIES RESEARCH

1. Laboratory Facilities

The two main centres of fisheries research under the control of the Department are the Marine Laboratory at Aberdeen and the Freshwater Fisheries Laboratory at Pitlochry. During the year further progress was made with the plans for the Fish Behaviour Unit at Aberdeen and approval in principle was given for the construction of a major extension to the laboratory there. Arrangements were completed for the provision of an additional laboratory hut, primarily for salmon disease investigations. At Pitlochry a new laboratory, and a store, boilerhouse and workroom which were under construction in 1966 were completed during the year. A start was made also on the provision of a new water supply system for the fish tanks and laboratories at Pitlochry and plans were made for alterations to the existing library and chemical huts.

2. Vessels

There were no changes in the fleet during the year but a contract was placed with Messrs. Hall Russell and Company Limited of Aberdeen for the construction of a new research vessel, at a cost of approximately £190,000, to replace the *Clupea*. A start was made on a design study for a vessel to replace *Scotia*. The vessels at present in commission are listed below:

(*a*) *Explorer*—202 ft Arctic class trawler built in 1955. This vessel is engaged in general research, including hydrographic work, and is equipped to operate in any region of the North Atlantic.

(*b*) *Scotia*—164 ft minesweeper built by the Admiralty in 1943 and converted for use as a research vessel in 1948. It is now used in general fisheries research.

(*c*) *Mara*—74 ft motor vessel built in 1958. Designed for seining and trawling and the investigation of the performance of fishing gear.

(*d*) *Clupea*—75 ft motor vessel, mainly used on herring work and fitted for drift-net fishing.

(*e*) *Goldseeker*—50 ft motor vessel, used for shellfish research.

(*f*) *Navicula*—26 ft motor vessel, used on inshore work and loch surveys.

3. Staff

The table below gives details of the number of staff in post at the laboratories on 31st December 1967:

Class	*Marine Laboratory Aberdeen*	*Freshwater Fisheries Laboratory, Pitlochry*
Scientific Officer	33	6
Experimental Officer	32	10
Scientific Assistant	53	10
Executive, Clerical, Typing and other grades	62	12
	180	38

4. **Research Expenditure**

Provision was made for a total estimated expenditure of £614,000 in the financial year ending 31st March 1968. The largest item (£415,000) was for the salaries and wages of the staff employed at the laboratories and the crews of the research vessels. The cost of improvements and repairs and of maintenance of research vessels (including fuel and stores) was estimated at £73,000.

5. **International Research**

Members of the scientific staff again represented the Department in Working Groups organised by the International Council for the Exploration of the Sea, the International Commission for North West Atlantic Fisheries, the Food and Agriculture Organisation of the United Nations, the Inter-governmental Oceanographic Commission and other such bodies.

6. **Relations with Other Research Organisations**

Contact and collaboration have been maintained with other laboratories at home and abroad. Amongst the bodies at home with which there has been collaboration on particular projects are the Ministry of Agriculture, Fisheries and Food, the White Fish Authority and the Scottish Marine Biological Association.

7. **Research Programmes**

Appendix III contains an account of the work of the Department's laboratories and research vessels.

(a) *Marine Laboratory, Aberdeen*

The work of the laboratory is described in general terms in pages 57 to 61 and in more detail in pages 62 to 129.

(b) *Freshwater Fisheries Laboratory, Pitlochry*

The report of the officer in charge of the Freshwater Fisheries Laboratory is contained in pages 136 to 176, which provide a detailed account of the fundamental and applied research undertaken on salmon and freshwater fisheries at the laboratory and at research sites elsewhere in Scotland and on salmon at Greenland.

8. **Scottish Marine Biological Association**

Fisheries research is carried out by the Association with the assistance of grants provided by the Natural Environment Research Council. The Association, which has laboratories at Millport and Edinburgh, has collaborated with the Department on a number of research projects.

An account of the Association's work is contained in its Annual Report.

CHAPTER X

MISCELLANEOUS

1. **By-products**

The production of fishery by-products in Scotland declined during 1967. Complete information about the operations of Scottish factories engaged in the manufacture of fishery by-products is not available but the following tables

include approximate figures for the quantity of raw materials used and the quantity and value of the principal products:

RAW MATERIALS USED IN THE PRODUCTION OF FISHERY BY-PRODUCTS

TABLE 26 *tons*

	1938	1966	1967
TOTAL	63,533	145,686	119,401
Herring	—	21,758	16,566
Herring offal	9,531	14,906	14,958
Sprats	—	36,847	21,986
White fish	—	3,036	1,426
White fish offal	51,759	64,944	61,014
Livers	1,401	1,907	1,471
Oils	842	2,288	1,980

PRODUCTION OF FISHERY BY-PRODUCTS

TABLE 27

	1938		1966		1967	
	Tons	£	Tons	£	Tons	£
TOTAL	15,011	229,398	35,503	2,324,646	27,990	1,663,904
Guano	478	2,225	—	—	—	—
White Fish Meal	11,914	157,507	14,052	1,060,351	12,945	885,037
Herring and Sprat Meal	597	3,646	13,550[1]	947,334[1]	9,567[1]	576,622[1]
Herring Oil Cod Liver Oil Cattle-feeding Oil Halibut Oil	2,022	66,020	7,103	297,000	4,726	183,349
Industrial Oil			798	19,961	752	18,896

[1]It is estimated that of these amounts about 6,790 tons valued at £474,804 was attributable to sprats in 1966 and about 3,930 tons valued at £236,920 in 1967.

In addition, fish glue and shellfish meal to the value of about £38,000 were produced in 1967. Considerable quantities of white fish offal and surplus white fish were sold for mink food, some 24,000 tons being exported to Scandinavia from the Aberdeen district.

Of the twelve Scottish factories engaged in the production of fishery by-products during the year, five were engaged in the manufacture of white fish meal, one was almost wholly engaged in the manufacture of meal and oil produced from herring, while three others produced fish meal and oil from herring, sprats and white fish. Of the remainder, one processed shellfish offal, another produced fish glue and the third factory was engaged in rendering fish livers and refining crude fish oils.

Fish meal and oil production decreased compared with 1966, due to the smaller landings of sprats and herring which resulted in less whole fish and offal of these species being available. The amount of whole white fish available dropped by over 50 per cent compared with 1966. There was competition for offal from merchants interested in frozen mink food although the quantity of offal available was smaller than in 1966.

There was keen competition from overseas fishmeal producers in South Africa, Peru, Chile, Iceland and Norway. Over the year white fish meal prices fell by up to £14 per ton but recovered towards the end of the year and averaged about £69 per ton over the year. There was an improvement in home demand during the period of the dock strike but this fell again on the ending of the strike. Marketing conditions for herring and sprat meal were similar and the average selling price was about £61 per ton. The price of fish oils remained low during the year, averaging about £37 per ton for edible oil and £25 per ton for oil of industrial grade.

2. Meteorology

Fishermen are assisted by the weather forecasts and gale warnings for shipping issued by the Meteorological Office and broadcast by the B.B.C. and the coastal radio stations of the G.P.O. Late evening forecasts intended primarily for Scottish inshore fishermen were broadcast throughout 1967 on B.B.C. 4 (371 metres). In addition, special 24-hour forecasts were broadcast during the year for the fishing fleets working in the Minches and for the fleet at East Anglia during the October and November herring fishing season. A chart and weather bulletin for shipping in coastal waters are presented each evening on B.B.C Television immediately after the summary and chart for land areas.

The Gale Warning Board, on which the Department is represented, also issues warnings of approaching storms to 47 stations in Scotland, at 44 of which signals are hoisted for the benefit of passing ships.

The Department continued to co-operate with the Meteorological Office in arrangements for the loan of barometers and barographs to fishing communities for the benefit of fishermen. At the end of the year, 21 barometers and 30 barographs were exhibited at various points around the Scottish coasts.

3. Gun Firing, Bombing and other Ranges, and Dumping

During the year a number of proposals by Service Departments for the use of sea areas for training and other purposes, and arrangements for the deposit of materials which could conceivably adversely affect the fisheries, were examined in order to safeguard fishery interests.

APPENDICES

APPENDIX I

ASSISTANCE OFFERED AND PAYMENTS MADE DURING THE YEAR TOWARDS THE COST OF THE CONSTRUCTION AND IMPROVEMENT OF FISHERY HARBOURS

Harbour or Pier	Description of Work	Estimated cost at 31.12.67	Local contribution	Assistance Offered[1]		Already advanced	Grants advanced in 1967	Position at 31.12.67
				Pre-1967	1967			
	Total	£ 1,404,956	£ 259,153	£ 928,135 (31,000)	£ 217,668	£ 426,125 (29,240)	£ 132,933	
Arbroath	Dredging	2,300	575	—	1,725	—	1,664	Completed
Avoch	Repairs	8,423	500	7,300	623	4,257	3,303	Work completed
Avoch	Dredging	7,375	500	—	6,875	—	—	Not started
Buckie	Reconditioning works	32,200	8,050	24,150	—	—	468	In progress
Burghead	Repairs to inner face of North Pier	23,000	5,750	17,250	—	3,600	11,338	Work completed
Burghead	Concrete deck for South Pier	8,200	2,050	3,210	2,940	—	—	Not started
Burghead	Dredging	200	50	—	150	—	150	Completed
Burnmouth	Repairs	8,000	1,000	—	7,000	—	—	Not started
Carradale	Extension of breakwater pier	26,500	6,625	19,875	—	—	—	Not started
Crail	Storm damage repairs	822	206	300	316	—	616	Completed
Culag	Provision of additional hardstanding area	9,000	2,250	6,750	—	—	6,100	Work completed
Culag	Site investigation	2,000	500	1,500	—	—	889	Completed
Culag	Pier extension	76,000	19,000	57,000	—	—	—	Not started
Dunbar	Repair and reconstruction of Victoria Breakwater	23,000	5,750	17,250	—	—	13,929	Work completed
Eyemouth	Erection of spur wall	5,500	1,500	4,000	—	—	—	Not started
Fraserburgh	Strengthening sections of Balaclava Breakwater	20,000	5,000	15,000	—	—	966	In progress
Gardenstown	Strengthening of East and West Piers	7,245	800	6,445	—	—	4,850	Work completed
Girvan	Renewal of ladders and repair of concrete decking	1,296	324	972	—	—	935	Work completed
Gourdon	Repairs to whaleback breakwater	3,167	792	2,201	174	—	2,233	Work completed
Gourdon	Harbour improvements	67,000	16,750	—	50,250	—	—	Not started
Helmsdale	Repairs to North Pier	11,000	2,750	8,250	—	6,387	988	Completed
Kyleakin	Construction of pier	19,559	4,889	14,670	—	—	2,286	Work completed
Loch Bervie	Tidal gauge	645	161	—	484	—	—	Not started
Loch Clash	Repairs to pier	8,279	2,069	5,625	585	—	6,210	Completed

Lybster	Strengthening of Lighthouse Pier	18,300	250	18,050	—	—	14,743	Work completed
Macduff	Major development and deepening	191,899	29,279	162,620	—	151,043	11,577	Completed
Mallaig	Repairs to fishery pier	27,000	[2]	27,000	—	22,948	1,750	Work completed
Mallaig	Installation of service duct and renewal of piping	14,300	—	14,300	—	—	—	In progress
Mallaig	Reconstruction of fish curing stance area	24,126	—	—	24,126	—	—	In progress
Mallaig	Provision of crane, navigation light, etc.	9,393	—	—	9,393	—	9,393	Completed
Oban	Reconstruction and extension of South Pier	200,000	50,000	150,000	—	—	—	Not started
Peterhead	Repairs and renewals (2nd phase)	21,000	2,100	18,900	—	—	13,494	Work completed
Peterhead	Repairs and renewals (3rd phase)	25,725	—	—	25,725	—	—	In progress
Pittenweem	Harbour improvements	75,000	18,750	—	56,250	—	—	In progress
Portsoy	Repairs	5,816	1,454	4,362	—	—	3,180	Work completed
St. Monance	Repairs	3,916	200	3,515	201	—	3,520	Work completed
Scalpay	Test borings	1,380	345	—	1,035	—	—	Not started
Scrabster	Diving survey	300	75	—	225	—	—	Not started
Stornoway	Provision of fish market	4,750	1,188	3,562	—	2,803	310	Completed
Tarbert (Loch Fyne)	Reconstruction of fish quay and other improvements	60,000	—	60,000 (12,000)	—	51,201 (10,240)	2,100	Completed
Tarbert (Loch Fyne)	New supporting column for navigational light	630	315	—	315	—	—	Work completed
Tarbert (Loch Fyne)	Site investigation	900	450	—	450	—	—	Not started
Ullapool	Development scheme	77,300	8,300	69,000 (19,000)	—	49,108 (19,000)	11,288	Work completed
Whalsay	Construction of breakwater pier	170,800	42,700	128,100	—	121,103	—	Main works completed
Whalsay	Extension of spur jetty	37,000	9,250	27,750	—	—	—	Not started
Whalsay	Provision of bollards, ladders and electric lighting	1,235	309	—	926	—	—	In progress
Whitehills	Repairs to sea wall	31,000	3,100	—	27,900	—	—	Not started
Wick	Repairs to jetty and timber wharf	10,000	1,000	9,000	—	8,490	508	Completed
Wick	Repairs to slipway and appliances	5,975	597	5,378	—	5,185	—	Work completed
Wick	Improvement of jetty and new fishmarket	16,500	1,650	14,850	—	—	4,145	In progress

Explanatory note:—'Work completed' indicates schemes where the works are finished but financial transactions have not been concluded.
'Completed' indicates that both the works and all financial arrangements have been concluded.
[1]The figures in parenthesis show the loans included in the offers.
[2]Voluntary contribution of £2,700 received from the Mallaig and North West Fishermen's Association Ltd.

APPENDIX II

SALMON FISHERIES

1. Annual Close Times Applicable to the Salmon Rivers in Scotland

N.B.—In the following List the days fixed for the commencement and termination of the Annual Close Time for Net-fishing and for Rod-fishing respectively, are in all cases inclusive.

	Annual Close Time for Net-fishing	Annual Close Time for Rod-fishing
Add	Sept. 1 to Feb. 15	Nov. 1 to Feb. 15
Ailort (*Kinloch*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Aline	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Alness	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Annan	Sept. 10 to Feb. 24	Nov. 1 to Feb. 9
Applecross	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Arnisdale (*Loch Hourn*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Awe	Aug. 27 to Feb. 10	Oct. 16 to Feb. 10
Ayr	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Baa and Goladoir	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Badachro and Kerry (*Gairloch*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Balgay and Shieldaig	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Beauly	Aug. 27 to Feb. 10	Oct. 16 to Feb. 10
Berriedale	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Bervie	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Bladenoch	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Broom	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Brora	Aug. 27 to Feb. 10	Oct. 16 to Jan. 31
Carradale (*in Cantyre*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Carron (*W. Ross*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Clayburn, Finnisbay, Avennangeren, Strathgravat, North Lacastile, Scalladale and Mawrig (*East Harris*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Clyde and Leven	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Conon	Aug. 27 to Feb. 10	Oct. 1 to Jan. 25
Cree	Sept. 14 to Feb. 28	Oct. 1 to Feb. 28
Creed or Stornoway and Laxay (*Island of Lewis*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Creran (*Loch Creran*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Croe and Shiel (*Loch Duich*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Dee (*Aberdeenshire*)	Aug. 27 to Feb. 10	Oct. 1 to Jan. 31
Dee (*Kirkcudbrightshire*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Deveron	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Don	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Doon	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Drummachloy or Glenmore (*Isle of Bute*)	Sept. 1 to Feb. 15	Oct. 16 to Feb. 15
Dunbeath	Aug. 27 to Feb. 10	Oct. 16 to Feb. 10
Earn	Aug. 21 to Feb. 4	Nov. 1 to Jan. 31
Echaig	Sept. 1 to Feb. 15	Nov. 1 to Feb. 15
Esk, North	Sept. 1 to Feb. 15	Nov. 1 to Feb. 15
Esk, South	Sept. 1 to Feb. 15	Nov. 1 to Feb. 15
Ewe	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Fincastle, Meaveg, Ballanachist, South Lacastile, Borve and Obb (*West Harris*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Findhorn	Aug. 27 to Feb. 10	Oct. 1 to Feb. 10
Fleet (*Sutherlandshire*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Fleet (*Kirkcudbrightshire*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Forss	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Forth	Aug. 27 to Feb. 10	Nov. 1 to Jan. 31
Fyne, Shira and Aray (*Loch Fyne*)	Sept. 1 to Feb. 15	Nov. 1 to Feb. 15
Girvan	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Glenelg	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Gour	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Greiss, Laxdale or Thunga	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Grudie or Dionard	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Gruinard and Little Gruinard	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10

APPENDIX II—*Continued*

	Annual Close Time for Net-fishing	Annual Close Time for Rod-fishing
Halladale, Strathy, Naver and Borgie	Aug. 27 to Feb. 10	Oct. 1 to Jan. 11
Helmsdale	Aug. 27 to Feb. 10	Oct. 1 to Jan. 10
Hope and Polla or Strathbeg	Aug. 27 to Feb. 10	Oct. 1 to Jan. 11
Howmore	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Inchard	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Inner (*in Jura*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Inver	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Iorsa (*in Arran*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Irvine and Garnock	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Kannaird	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Kilchoan or Inverie (*Loch Nevis*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Kinloch (*Kyle of Tongue*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Kirkaig	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Kishorn	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Kyle of Sutherland	Aug. 27 to Feb. 10	Oct. 1 to Jan. 10
Laggan and Sorn (*Island of Islay*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Laxford	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Leven	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Little Loch Broom	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Loch Duich	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Loch Luing	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Loch Roag	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Lochy	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Lossie	Aug. 27 to Feb. 10	Oct. 16 to Feb. 10
Luce	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Lussa (*Island of Mull*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Moidart	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Morar	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Mullanageren, Horasary and Lochnaciste (*North Uist*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Nairn	Aug. 27 to Feb. 10	Oct. 1 to Feb. 10
Naver and Borgie, *see* Halladale		
Nell, Feochan and Euchar	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Ness	Aug. 27 to Feb. 10	Oct. 16 to Jan. 14
Nith	Sept. 10 to Feb. 24	Dec. 1 to Feb. 24
Orkney Islands (*River from Loch of Stenness, etc.*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Ormsary (*Loch Killisport*), Loch Head and Stornoway (*Mull of Cantyre*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Pennygowan or Glenforsa and Aros	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Resort	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Ruel	Sept. 1 to Feb. 15	Nov. 1 to Feb. 15
Sanda	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Scaddle	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Shetland Islands (*River of Sandwater, etc.*)	Sept. 10 to Feb. 24	Nov. 1 to Feb. 24
Shiel (*Loch Shiel*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Sligachan, Broadford and Portree (*Isle of Skye*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Snizort, Orley, Oze and Drynoch (*Isle of Skye*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Spey	Aug. 27 to Feb. 10	Oct. 1 to Feb. 10
Stinchar	Sept. 10 to Feb. 24	Nov. 15 to Feb. 24
Tay (except Earn)	Aug. 21 to Feb. 4	Oct. 16 to Jan. 14
Thurso	Aug. 27 to Feb. 10	Oct. 6 to Jan. 10
Torridon, Balgay and Shieldaig	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Tweed	Sept. 15 to Feb. 14	Dec. 1 to Jan. 31
Ugie	Sept. 10 to Feb. 24	Nov. 1 to Feb. 9
Ullapool (*Loch Broom*)	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Urr	Sept. 10 to Feb. 24	Nov. 30 to Feb. 24
Wick	Aug. 27 to Feb. 10	Nov. 1 to Feb. 10
Ythan	Sept. 10 to Feb. 24	Nov. 1 to Feb. 10

2. Report by S. Drummond Sedgwick, Inspector of Salmon Fisheries

Net Fishing

The returns received for commercial catches of salmon, grilse and sea trout for the 1967 season are the highest for any season since official returns were first made in 1952. There was a scarcity of early salmon in some districts, notably the Moray Firth, but this was amply compensated for by an abundance of summer salmon, and fish of all three groups generally continued plentiful up to the end of the season.

Rod and line fishing

Rod and line catches of salmon and grilse on rivers unaffected by disease were generally good and better than in the 1966 season. Sea trout catches were also up on the 1966 total in some rivers and were generally well up to average.

Prices

Salmon prices in the early part of the season up to the end of May were fairly keen, averaging in the region of 13s per lb. Salmon prices fell steeply during the summer owing to the large quantity of fish, including supplies from Ireland, coming on to the market, and the average price in mid-July for best quality fish was as low as 8s per lb. The price rose slightly but fell again in August when even large fish suitable for smoking were selling at 7s 6d per lb and medium fish for upwards of 1s less. Grilse prices were fairly well maintained but in some east coast fisheries prices paid for sea trout were as high as or higher than those for grilse. There was no shortage of sea trout.

The approximate wholesale prices paid for good quality, well-packed fish, averaged over the whole season for the main east coast fisheries and comprising approximately 80 per cent of the Scottish commercial catch, were as follows:

Salmon	*Grilse*	*Sea Trout*
10s per lb	4s 11d per lb	5s 3d per lb

The average salmon price for the season obtained by some coastal fisheries on the east coast was rather less than that for estuarial or river fisheries because of poor sea fishing in the early months of the season. Average prices made by fish from fisheries in the north and west, which depend upon summer runs, were in some cases considerably below the average for the east coast.

Salmon Exports

Most of the larger salmon fishing companies in Scotland and a number of the fish merchants dealing in salmon are now exporting part of their product. An increasing quantity of salmon and grilse is being deep-frozen, partly in order to overcome the problem of low prices during glut periods. This was particularly evident in the 1967 season when large runs of salmon reached the coastal netting stations during the summer and coincided with runs of grilse. There is now a two-way trade between Britain and Norway in the export and import of salmon. In the early part of the season, before salmon fishing has started in Norway, large salmon for smoking are exported to that country from Britain. Later on the situation is reversed when the large Norwegian fish make their appearance and a proportion of the catch is exported from there to Britain.

Fish Packing

There was little further development in salmon box design. The dense form of polystyrene has been successfully used for salmon boxes in Scandinavia and a box of this type has been developed for white fish in Scotland. The material is cheap, has a very high insulation co-efficient and is easily moulded to any shape. Standard types and sizes of dense polystyrene, non-returnable boxes for salmon, grilse and sea trout could usefully be developed by the salmon fishing industry and the plastics industry.

Nets and Gear

The increasing use of synthetic fibres for nets and other gear has improved the economic position of the commercial salmon fishing industry in Scotland and could in some instances have made the difference between profit and loss in smaller coastal fisheries. The earlier synthetic fibres were often too hard, particularly for use in bag nets, as they tended to injure fish. More recently, staple polypropylene has allowed the production of a softer net. Flat-stranded polypropylene has been used for cordage and largely avoids slipping. The main advantage of synthetic fibres in fixed coastal nets is longer life and resistance to storm damage. Synthetics also discourage the growth of algae on nets and cordage. Lead stranded rope for sole ropes is being increasingly used, the advantage being that the weight is built into the rope, thus avoiding the use of external leads which can tangle in the mesh of a net. Plastics are also used for floats and hard polystyrene is replacing cork. Inflated plastic buoys are used instead of wooden barrels.

Imports of Pacific Salmon

The import of deep-frozen Pacific salmon, mainly Coho (Oncorhynchus kisutch), has increased in recent years and is now reaching a level which can affect the wholesale price of 'Scotch' salmon. The flavour of Coho and other better quality Pacific salmon is different from that of Atlantic salmon but can become an acquired taste. The colour is generally good and the quality of the fish is consistent. Hotels and other catering establishments are making increasing use of imported Pacific salmon as they are attracted by the stable price which is not subject to short term fluctuations. This enables them to offer salmon dishes on the menu at predetermined cost. There has also been a marked increase in the use of Pacific salmon for smoking.

Salmon Disease

The disease which was first reported in Ireland and which for the time being is called by the descriptive name of Ulcerative Dermal Necrosis (U.D.N.), appeared in more Scottish rivers during 1967. The names of these rivers and the dates when outbreaks were officially confirmed are given in Table 28. A few fish with similar symptoms were received for bacterial examination from other rivers. The rivers in which epizootic disease was confirmed in 1967 were confined on the east to the area between the Moray Firth and the Tweed and on the west to the Ayrshire coast and the Solway. The Tay and Forth remained clear from epizootic disease throughout the year. At present the U.D.N. condition can be recognised only from external symptoms and these may be inconsistent. It is generally accepted that external symptoms similar to those associated with U.D.N. have been seen on fish in the past, and from time to time the numbers may have reached epizootic proportions in some rivers. The only realistic

method of assessing whether a serious outbreak has occurred in any river is to compare the total number of casualties with those in previous years, without attempting specific recognition of U.D.N. Bacteriological reports record the specific pathogenic bacteria found on fish sent in for examination, but only indicate that external symptoms are similar to those associated with the U.D.N. condition. This method of assessment may be superseded when the primary cause of U.D.N. is known and symptoms can be defined and are clearly recognisable.

Table 28 shows the numbers of fish of various species removed from rivers in the salmon fishery districts where epizootic disease was officially confirmed. The numbers shown are for all diseased fish removed from these rivers. It is not possible to give separate details for fish suffering from U.D.N. It is important to note that in every instance a proportion of the diseased fish taken out were kelts. Where separate figures for unspawned fish and kelts are available these are given separately in the table.

NUMBERS OF DISEASED FISH TAKEN FROM RIVERS IN SCOTLAND FROM MARCH TO DECEMBER 1967

TABLE 28

Fishery district	Date of outbreak	Salmon and grilse		Sea trout		Brown trout	Parr	Smolts	Other species
		Unspawned fish	Kelts	Unspawned fish	Kelts				
Annan .	Oct. 1966	234	6	132*	Not available	46	6	Nil	7
Ayr . .	May 1967	155*	Not available	6*	Not available	49	4	Nil	65
Dee (K) .	Oct. 1966	354	108	15*	Not available	5	Nil	Nil	2
Dee (A) .	Sept. 1967	1,901	4,596	267	414	27	23	Nil	13
Deveron .	June 1967	1,193	879	126	63	58	5	Nil	—
Don . .	Sept. 1967	220*	Not available	Not available	Not available	Not available	Not available	Not available	Not available
Doon . .	May 1967	319*	Not available	236*	Not available	Nil	14	Nil	11
Esk (North)	May 1967	1,168	508	26*	Not available	3	2	Nil	11
Esk (South) .	Oct. 1967	133	44	42	24	2	Nil	Nil	3
Findhorn .	Oct. 1967	390	275	9	25	2	1	Nil	Nil
Nairn . .	Oct. 1967	608	168	54	4	7	1	Nil	Nil
Nith . .	Oct. 1966	2,312	204	236	628	32	15	Nil	63
Spey . .	May 1967	5,936	1,089	3,840	328	56	15	Nil	20
Tweed .	Mar. 1967	13,694*	Not available	6,535*	Not available	Not available	Not available	Not available	1,541
	Totals	28,617	7,877	11,524	1,486				

Numbers bearing an * include the kelt total which is not returned separately.

There is no evidence to indicate that the diseased kelts had not succeeded in spawning although they may have been suffering from symptoms of disease prior to spawning. Nor is there any evidence that the disease has had any detrimental effect on combined catches of salmon, grilse and sea trout, which have in fact been higher during 1967 than at any time since 1952, when official returns were first made in their present form. Salmon and sea trout were reported as being reluctant to take and more difficult to catch in rivers where disease was confirmed, and rod catches on most of these rivers were below average. The reduction in rod catch may partly result from reduced fishing effort on rivers where diseased fish were to be seen in large numbers.

DISEASED SALMON TAKEN FROM REPRESENTATIVE RIVERS IN SCOTLAND FROM MARCH TO DECEMBER 1967, SHOWN AS A PERCENTAGE OF THE DISTRICT CATCH BY ALL METHODS FROM RETURNS RECEIVED BY 31ST DECEMBER 1967

TABLE 29

Fishery district	Salmon and grilse		Sea trout	
	Percentage with kelts	Percentage without kelts	Percentage with kelts	Percentage without kelts
Annan . . .	2	—	0·5	—
Dee (Aberdeenshire) . . .	21	6	2	1
Deveron . . .	9	6	5	4
Findhorn . . .	5	3	0·7	—
Nith	29	27	22	6
Spey	14	11	16	15
Tweed . . .	10	Not available	6	Not available

Table 29 shows the percentages of diseased fish removed from rivers in a representative group of salmon fishery districts in which epizootic disease was confirmed. Each district covers only one river, but includes the catch made by estuarial nets and sea nets operating for a distance along the coast outside the estuary of the river. The total run of migratory fish belonging to any river is made up of the catch by all methods and the number of fish which escape to spawn. No direct information is available as to the number of fish which escape to spawn compared to the catch made in any Scottish salmon fishery district, with the exception of the Kirkcudbright Dee. The figures for disease casualties compared to total counted runs in that district are shown in a separate paragraph of this report (page 50). The percentage of casualties from disease shown in Table 29 would be considerably less in each case if the total run of migratory fish for these rivers was known and could be used for the calculation.

Investigations continued to ascertain the cause of the disease but this has not so far been established. Some salmon were found with ostensible symptoms of U.D.N. from which no pathogenic bacteria could be isolated, and the view came to be held that the disease might be caused by a virus. A virus infection may cause stresses in the fish or in some other way make them more liable to general systemic infection by bacteria which they might otherwise be able to

resist. The final cause of death might be secondary bacterial infection complicated by external attack from parasitic fungi.

The rivers in which epizootic outbreaks occurred during the year (and those involved in the outbreak of disease with similar symptoms which occurred in the latter years of the last century) are nearly all in areas where the geology and geography tend to produce less acid or alkaline waters. The pathogenic bacteria most commonly isolated from fish sent in for examination belong to groups which are less viable in acid waters. Acid rivers tend to occur in the north and west of Scotland and their waters are comparatively sterile, whereas rivers in less mountainous areas are more eutrophic and may be polluted. Accordingly, there would seem to be a greater risk of secondary bacterial infection occurring, with the appearance of the symptoms associated with U.D.N., in less acid rivers flowing through richer agricultural land in the more populated areas of the country.

A number of features emerged from reports made by district salmon fishery boards. There was evidence of fish coming in from the sea with initial symptoms of the disease, but other fish were observed with no external symptoms which subsequently developed symptoms in fresh water. The spread of the disease and the number of casualties increased rapidly when adult migratory fish were temporarily held up by an obstruction. Very few casualties were reported among salmon and sea trout parr and numbers of healthy parr were seen in sections containing concentrations of diseased adult fish. It was shown that eggs and milt taken from diseased fish can produce viable ova and that the fry from these ova were healthy with no apparent signs of weakness evidenced by an increase in mortality.

Spawning reports were received from district salmon fishery boards in districts where epizootic disease has been confirmed. A summary is given in a separate paragraph of this report (page 46). The effect on spawning stocks in different rivers seems to have been variable, but this may in part be due to inconsistencies in assessment. In rivers where the sex of dead kelts was distinguished and separately recorded, an increase was observed in the proportion of females. The sex of all diseased fish removed from the River Dee (Aberdeenshire), including kelts, was distinguished and recorded separately by the superintendent for the district salmon fishery board. His report for the 1967 spawning season includes the following information:

1967 Death rate owing to disease:

Male casualties	...	63·7 per cent
Female casualties	...	36·3 per cent

In the twentyfour years prior to 1967—death rate owing to disease:

Male casualties	...	95·2 per cent
Female casualties	...	4·8 per cent

Casualty Rate from Disease

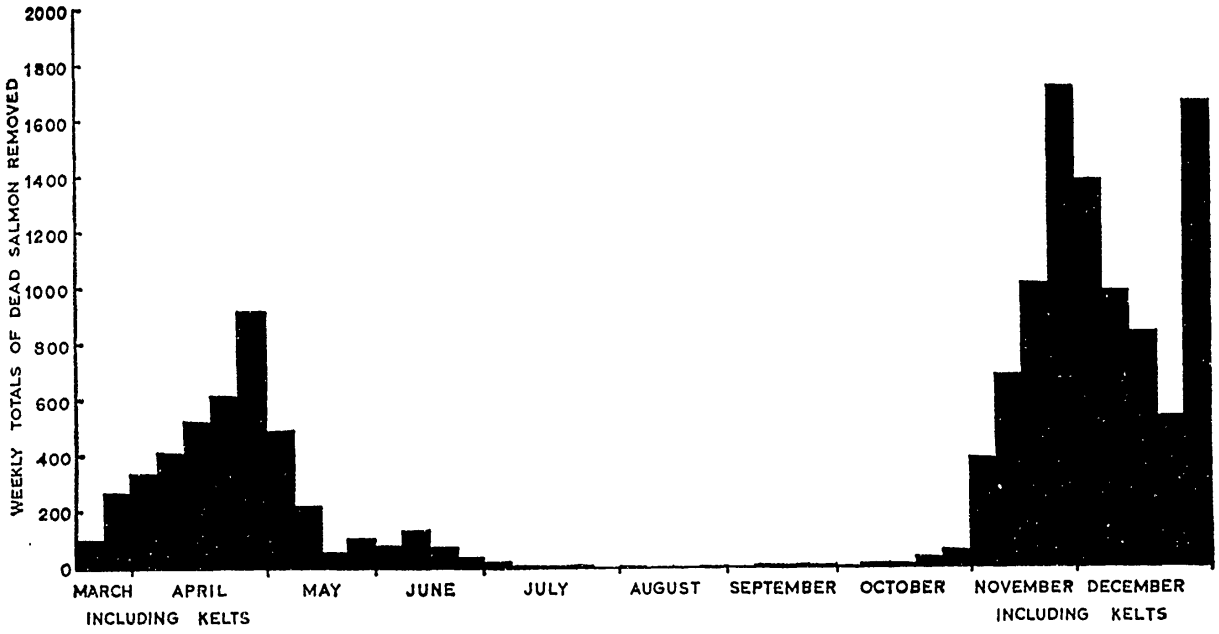
The following histograms show the weekly totals of dead fish removed from rivers in three representative salmon fishery districts in Scotland where epizootic disease has been confirmed for the period 19th March to 31st December 1967.

Note—the totals shown include both unspawned fish and kelts.

RIVER TWEED

FIG. 1

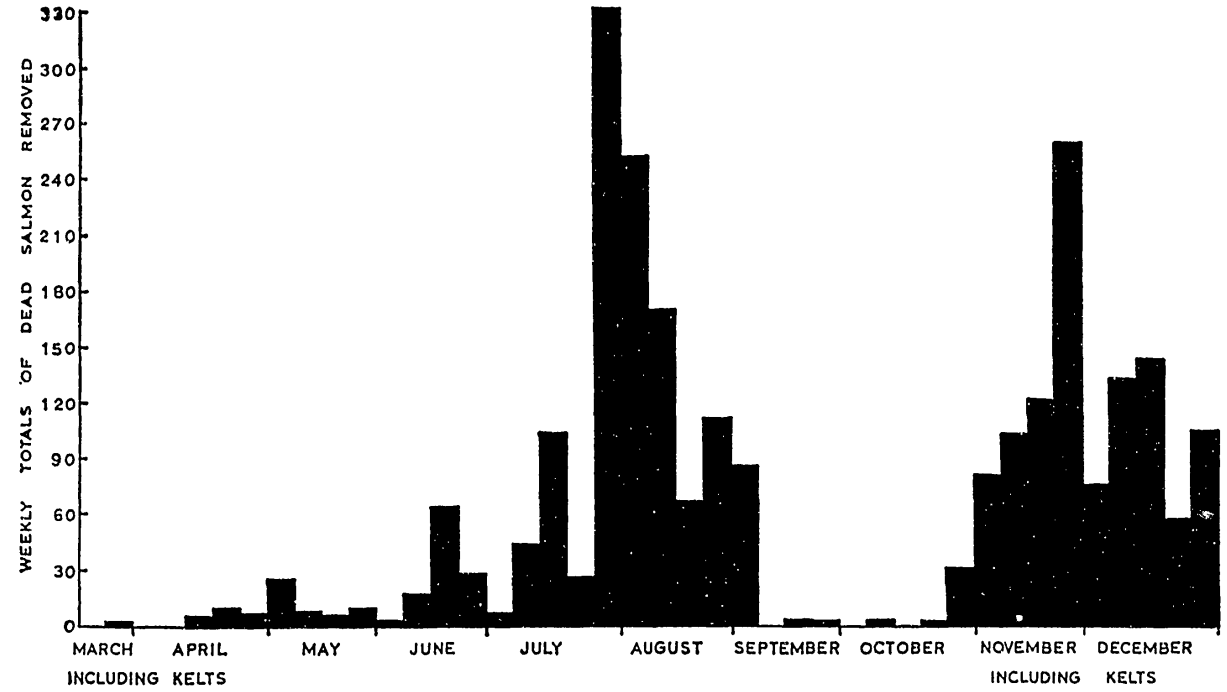
TOTALS FOR SPRING AND AUTUMN

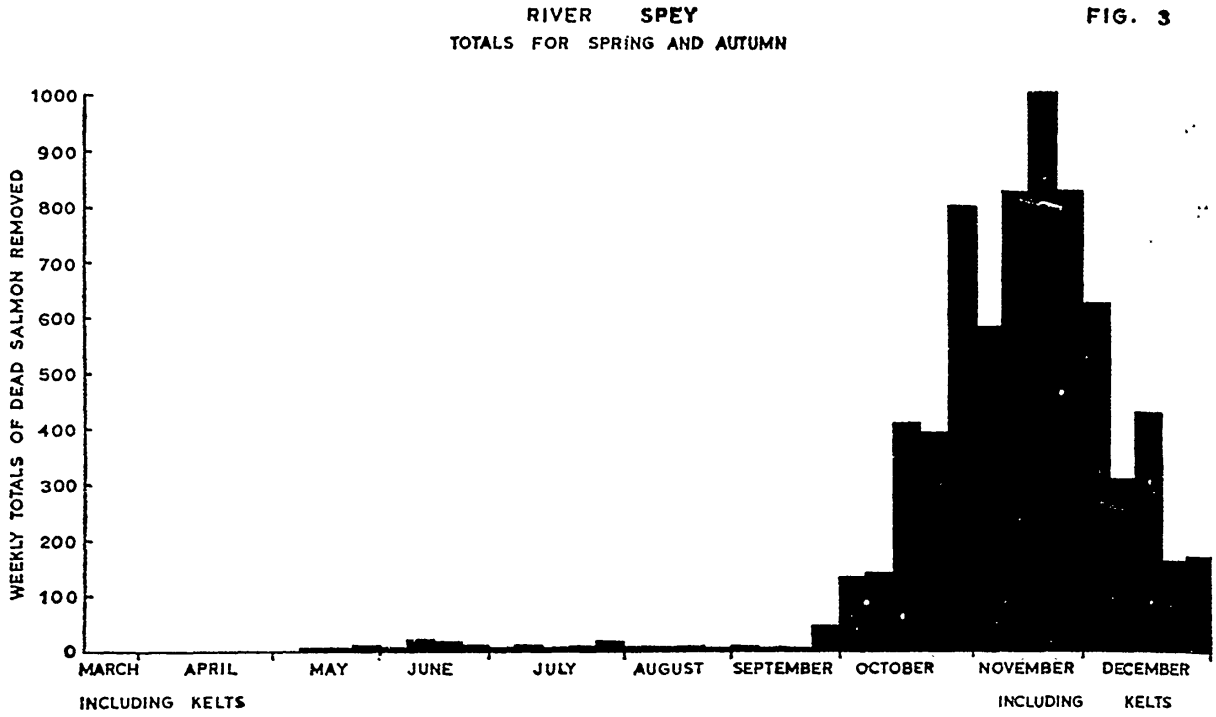


RIVER NITH

FIG. 2

TOTALS FOR SPRING AND AUTUMN





Epizootic and Normal Disease

Most district salmon fishery boards in Scotland complete a section of an annual report made to the Inspector of Salmon Fisheries giving details of dead fish removed from their rivers. A comparison of the number of dead fish removed in previous years compared with that in 1967 is shown in Table 30 for rivers in which a serious outbreak was confirmed.

TABLE 30

Fishery district	Average yearly casualties prior to 1967 Salmon and grilse Unspawned	Kelts	Casualties March–December 1967 Salmon and grilse Unspawned	Kelts
Dee (A) . . .	84	1,131	1,901	4,596
Dee (K) . . .	4	29	108	354
Deveron . . .	15	447	879	1,193
N. Esk . . .	109	345	508	1,168
Nith	16	61	204	2,312
Spey	12	1,309	1,089	5,936

Kirkcudbright Dee

The total run of salmon entering the Kirkcudbright Dee is counted electronically in a fish pass at the head of tide. The counted run of salmon and grilse during the period 1st June to 30th November 1967 was 10,136. Runs of salmon and grilse entering this river had fallen to a very low level due to malfunctioning

of fish passes constructed in connection with the development of the Galloway Power Scheme in the mid-1930s. Modifications to the fish pass at Tongland were initiated in 1960. Modifications were subsequently made to other similar fish passes at Earlston and Carsfad during 1961 and 1962. These modifications involved the conversion of the existing underwater orifice pools to overfall type. An electronic fish counter was installed in the Tongland fish pass in 1962. The electronic counter has recorded counted runs of salmon and grilse as follows:

1st June—30th November 1962	...	...	2,408
1st June—30th November 1963	...	...	4,698
1st June—30th November 1964	...	...	6,031
1st June—10th November 1965	...	...	6,528
1st June—1st October 1966 ...	...	...	4,789*
1st June—30th November 1967	...	...	10,136

*The figure for 1966 is low because the fish pass and fish counter were closed in October in order to prevent the spread of disease.

A total of 354 unspawned, diseased salmon and grilse and 108 kelts was removed from the river in the period 19th March to 31st December 1967. The total of 354 unspawned fish represents 3·5 per cent of the run during the 1967 counting period and 4·7 per cent of the spawning escapement.

Brood Fish with Disease

It has been shown that it is possible to produce healthy eggs and fry from brood fish with symptoms of disease. The problem lies in keeping diseased fish alive in captivity until they are ripe to spawn. It is not advisable to capture fish for hatchery purposes which are about to spawn on their natural spawning grounds, but fish captured earlier in the year may already have symptoms of disease or develop symptoms in captivity. Various methods have been tried in order to prolong life and to prevent a spread of infection. The fish should be stored in ponds or tanks with a good through-flow of clean water. The ponds or tanks should be long and narrow and divided in such a way as to prevent the fish from becoming closely packed together. It has been reported[1] that inoculation with a broad spectrum antibiotic (Chloromycetin) has been successful in treating secondary bacterial infection. Brood fish with symptoms of U.D.N. and heavy infestation with fungus, held for hatchery purposes by one English river authority, were treated with a solution of Malachite green. This appeared to cure the fungus condition and the fish remained alive in captivity for a period of six weeks until they were stripped of their eggs.

Spawning Season—Autumn 1967

Exceptionally heavy spawning took place in most Scottish rivers. Special reports were obtained from salmon fishery districts in which there had been an outbreak of salmon disease. Summaries of these reports are as follows:

(a) *River Annan*

Reports indicate that disease had very little effect on spawning stocks or their distribution in this river.

---

[1]Leaman, A. C., 1965, 'Control of furunculosis in impounded adult salmon'. *Nature, Lond.*, 208 1344.

(b) *River Ayr*

At the close of the fishing season the spawning escapement was considerably greater than in the previous year but very few fish were unaffected by disease. Throughout November the stock diminished considerably. Observations of gravid fish indicate a preponderance of males and a corresponding lack of females, and collections of dead fish indicated that females were dying in greater numbers than males, without having spawned. Distribution of fish was normal. No changes were noted in normal spawning behaviour.

(c) *River Dee (Kirkcudbright)*

The spawning escapement and number of dead fish on this river can be correctly assessed from electronic counts and has been discussed in a separate paragraph. The distribution of spawning fish was normal and all spawning areas were fully utilised, including some not used for many years. No abnormalities were noted in spawning behaviour.

(d) *River Dee (Aberdeenshire)*

The spawning escapement to upper tributaries and the main river above Aboyne Bridge was estimated to be well below average before an outbreak of epizootic disease had been confirmed. This was probably due to a lack of spring salmon rather than the effect of disease. There were no disease casualties in these areas until after the fish had spawned. There was some evidence of disease prior to spawning in the lower tributaries joining below Aboyne but this was on a small scale except in the Feugh. No abnormalities were observed in spawning behaviour.

(e) *River Nith*

The spawning escapement to some upper tributaries was reported to be slightly below average but this was not the case in the headwaters of the main river where more spawning pairs than usual were seen. The spawning stock in the middle reaches was fully up to average and the fish were well distributed to all their usual spawning areas. There was no apparent reduction in the number of spawning pairs on the redds and no spawning areas without fish. The spawning stock in the lower reaches was well below average and certain spawning areas were denuded of fish.

(f) *River Nairn*

There was an absence of spawning fish in the upper reaches but no great reduction in the overall stock in the river although most of the fish were reported to be diseased. Casualties were mainly among unspawned fish.

(g) *River Findhorn*

The total spawning stock may have been slightly below average but appeared generally good although a few spawning areas held no fish. The fish were fairly well distributed up to the headwaters. There was no noticeable change in the spawning behaviour. Approximately 90 per cent of the casualties which occurred among gravid fish were female.

(h) *River South Esk*

The spawning stock in the river was reported to be much reduced, particularly in the headwaters and tributaries. The highest incidence of casualties occurred among gravid fish shortly before spawning time.

(i) *River North Esk*

The estimated spawning stock was well above average and well distributed. There was a reduction in the number of spawning pairs in the lower reaches, but this should be more than compensated by the excellent spawning in the rest of the river and its tributaries.

(j) *River Spey*

An inspection of this river was made at the time of the normal peak of the spawning period. The number of spawning fish present in some of the main spawning tributaries was very much below average. There were few redds and most of the gravid salmon and grilse seen were infected with disease. The Spey has the greatest length of water, in main river and tributaries, accessible to natural spawning of any river system in Scotland. It was, therefore, not possible to form a complete assessment of the situation in some spawning tributaries and in many of the main river spawning areas. Spawning may have been more successful in the head waters and upper tributaries, as a larger percentage of the spawning stock may have survived to spawn in the cleaner and more sterile water. It is, however, reasonable to conclude that there was heavy mortality among gravid fish and that normal distribution to spawning grounds, particularly in the lower tributaries, did not take place. The run of salmon and grilse, as reflected by commercial catches, was exceptionally large and the initial spawning escapement was probably well above average. Sufficient fish may therefore have survived to spawn to stock the available rearing areas at a productive density. The Spey district salmon fishery board constructed a new hatchery and had approximately one million ova under incubation. It was intended to distribute fry in potential rearing areas which are not at present accessible to natural spawning and it was also proposed to plant artificially any tributaries or stretches of tributaries where fish failed to spawn naturally.

(k) *River Deveron*

This river was also inspected during the 1967 spawning season. Spawning stocks did not appear to have suffered very severely as a result of disease, although there were fairly heavy casualties among gravid fish. There was an exceptionally large run of fish into the river. Rod catches of both salmon and grilse were higher than those for the 1966 season, in spite of the outbreak of disease which was officially confirmed in June. The initial spawning escapement is therefore likely to have been well above average and the loss of gravid fish should be tolerable. Fish were distributed up to the head water spawning areas. Most of the sea trout seen with symptoms of disease were kelts. The natural deposition of ova in this river should be up to the density required to maintain production.

Live holding of salmon in saline water

An obstacle to increasing hatchery production, either as a means of distributing salmon eggs to potential rearing grounds which are inaccessible for natural spawning, or to offset the effects of epizootic disease, is the difficulty of keeping brood fish alive in holding ponds or tanks for long periods. Evidence has been accumulating in recent years which indicates that there may be racial differences between salmon in different rivers and possibly between different runs of salmon in the same river. These differences may be reflected in the time when the fish return to the river, the time when smolt migrate to the sea, growth

rate both in fresh water and in the sea, and in other ways relating to the behaviour and physiology of the fish. Grilse may also prove to have genetic factors which distinguish them from salmon. These considerations will have increasing relevance to hatchery management and the selection of brood fish. It may be necessary to capture brood fish early in the year and hold them for long periods in captivity. The Norwegian salmon fisheries authorities have developed a method of keeping salmon in saline water and this could have application in Scotland, particularly if it becomes necessary to increase hatchery production in order to offset the effects of salmon disease.

Salmon Hatcheries

The total of salmon eggs under incubation in the larger Scottish salmon hatcheries on rivers free from disease is given in Table 31.

TABLE 31

Location of Hatchery	Number of Ova (Thousands)
Conon	10,500
Garry (Inverness-shire) .	5,500
Thurso	500
Borgie	700
Polly	750
Awe	1,045
Tay	1,030

The total of salmon eggs under incubation in hatcheries on rivers with disease is given in Table 32.

TABLE 32

Location of Hatchery	Number of Ova (Thousands)
Spey	1,000
North Esk	372
South Esk	167
Dee	420
Tweed	250
Others	50

Planting of Salmon Eggs or Fry

It has been generally recommended that planting should not be carried out in parts of rivers or tributaries which are already stocked with the progeny of

naturally-spawning salmon. This principle should be adhered to even in the case of rivers where spawning stocks may have been reduced by disease, except in instances where a complete absence of spawning fish from recognised spawning grounds has been observed.

Eel Fishing

The average wholesale price per lb paid for 'Silver' eels (eels on their seaward migration) is now often higher than for fresh salmon. There has been increasing interest in the eel-fishing potential of Scottish lochs and rivers. Most of the lochs and rivers in the Highland area are not sufficiently rich to produce any great weight of eels. Eel fishing, mainly with fyke nets, has increased in a number of rivers on the east coast and in low lying lochs in the central lowlands and border areas. An eel fishery has also been developed in the Orkney Islands. The Scottish potential for eel production has not as yet been fully realised and it seems likely that further development will take place in future. Under the Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951, the proprietor or occupier of the adjacent land has the right to fish for eels by net or trap in any inland water. There is no specific restriction on the design or setting of nets or traps intended for the capture of eels. Set lines (long lines) are not permitted and their use would constitute an offence. There is no close season for eels in Scotland.

Commercial Fish Culture

There was further progress in the development of rainbow trout farming for the table market. A trout farm in central Scotland is now producing approximately 20 tons per annum of 'portion' size fish (6–8 oz). Another larger unit in the south-west, with an annual capacity of approximately 40 tons of 'portion' size fish, will be in full production during the summer of 1968. Both these farms are on standard Danish lines. One large unit, with an eventual expected production of 200 tons per year and several smaller units were set up on the Shetland Mainland. These farms will produce larger rainbow trout up to 5 lb in weight and the growing fish will be kept in cages in salt or brackish water.

APPENDIX III

REPORT OF THE DIRECTOR OF FISHERIES RESEARCH

CONTENTS

I. MARINE RESEARCH

REPORT OF THE DIRECTOR OF FISHERIES RESEARCH

C. E. LUCAS, C.M.G., D.SC., F.R.S.E., F.I.BIOL., F.R.S.

Marine Laboratory, Aberdeen

INTRODUCTION

1. The work of the Marine Laboratory at Aberdeen is directed to supplying the Department with information necessary for determining policy in relation to the regulation and conservation of the fisheries, both nationally and internationally, and to assisting the industry in the maintenance and development of the existing fisheries.

2. Accordingly, research is primarily concerned with (*a*) the population dynamics of the exploited fish and shellfish stocks, in relation to fishery exploitation, forecasting and regulation; and (*b*) methods of fish location, detection, behaviour and capture in relation to fishing tactics and the efficiency of fishing operations. Related work involves investigation of the ecology of the fish species concerned, their food supply, health and disease, together with studies concerned with pollution and fisheries improvement, and the various aspects of the biological and physical environment which influence both fish and the fisheries. In this programme, senior members of the staff work closely with various international bodies, the International Council for the Exploration of the Sea, the North-East Atlantic Fisheries Commission, the International Commission for the Northwest Atlantic Fisheries, the Food and Agriculture Organisation of the United Nations, the Intergovernmental Oceanographic Commission, and the Scientific Committee on Oceanic Research of the International Council of Scientific Unions.

The Commercial Fisheries

3. The principal fish species with which the laboratory's research programme is concerned are herring, haddock, cod and whiting, together with the flatfish, plaice, halibut and lemon sole. For the existing fisheries on these stocks, the laboratory maintains a sampling programme of landings at the principal fishing ports and also conducts research vessel sampling surveys. The results contribute to both national and international assessments of the state of the stocks, and provide short and long-term predictions of changes in yield resulting from regulatory measures and natural factors.

4. The laboratory's annual forecasts of the prospects for the U.K. haddock and whiting fisheries are familiar examples of the short-term predictions. In the international field, the laboratory has continued to collaborate with specialists of other countries in stock assessment work and over the next few years will contribute to longer-term assessments of exploited demersal stocks in the North Sea and Arctic waters. Much of the herring work also must continue to be pursued in very close collaboration with other European countries, as part of the programme organised by the International Council for the Exploration of the Sea (ICES). Initially this was focussed on the southern North Sea and now, since the development of intensive purse-seine fishing by Norwegian fishermen, it has extended to the northern and central North Sea, where the laboratory's chief effort has been concentrated for many years. The forecasts for the herring fisheries during 1967 (paras. 99, 106 and 107) all proved reasonably accurate

and work is already under way in preparation for the 1968 forecasts (paras. 99, 106 and 107).

Industrial Fisheries

5. While fish offal and surplus herring and sprat are converted in the UK to fish meal (and oil), the quantities produced are only a fraction of the national demand, especially for meal, for which the country has to meet an import bill of more than £20 million (equivalent to a total of well over one million tons of fish). Therefore, research effort has recently been diverted to studies of fish stocks which might be fished to reduce these imports. In addition to considering the possibility of further tapping local stocks of herring and sprat, the laboratory has been making preliminary surveys of unfished stocks of sandeel, and especially of blue whiting, which their earlier work (in conjunction with that of the Continuous Plankton Recorder Survey of the Edinburgh Laboratory) suggests must be extremely abundant to the west of Scotland. Intensive surveys during 1967 suggest that the spawning stock of blue whiting is a large one, at least of one million tons. Work in 1968 will be directed to assessing more precisely the size of this stock in order to evaluate the possibilities of economic returns from this, as well as those of other suitable fish stocks nearby (paras. 78–97).

Shellfish

6. Similar scientific problems to those of the more conventional fisheries are presented by the shellfish fisheries, which are of increasing importance to Scotland every year. Research is conducted principally on the lobster, crab and *Nephrops* (scampi) stocks, as well as on scallops and other local molluscs which, given the processing centres, could be of much greater value to Scottish fishermen. Recent work in Scotland has been directed to the possibilities of reviving the Scottish oyster fisheries (mainly in conjunction with the Scottish Marine Biological Association laboratory at Millport), and of developing the shrimp, mussel and cockle fisheries. The results of the experimental cultivation of mussels on ropes, suspended in Scottish sea lochs, and of the experimental transportation of cockles to more productive sites, are already promising and will be continued. If staff can be provided, preliminary experiments on the rearing of Crustacea will be developed (paras. 122–158).

Fishing, Fish Behaviour and Fish Detection

7. An essential element in the programme is experimental work on fishing gear (paras. 241–261), which is designed to elucidate the hydrodynamics of existing gears (trawls and seines), with a view to improving their efficiency, and to designing new gears; its practical value is shown by the increasing extent to which the present small, gear-technology unit's advice is sought by owners and fishermen.

8. Various research projects have, however, shown the dangers of attempting to improve fishing gear without taking into account both the natural behaviour of the fish and their reactions to the gear itself. A closely related section of the laboratory's research programme is, therefore, concerned with fish behaviour studies (paras. 212–240), at present especially in the fields of fish vision, the reactions of fish to sounds and the sounds produced by fish. As soon as facilities are available, this programme will be extended to include olfaction studies. The programme involves work at sea as well as in the laboratory and is conducted

in close co-operation with the gear unit; in addition to observation under water by camera, television and sonar, this work involves direct observation by a team of research divers, which from time to time assists in other aspects of the laboratory's work.

9. In all this complex work, the laboratory has been a pioneer, and it is hoped that considerable advances will follow when a towed underwater observation vehicle and a specially commissioned ship-borne data logger and computer are available. The former will be manned, and is for studying the reactions of the fish to the gear; the latter is for continuously monitoring the various sensors (electronic and mechanical measuring devices) now being fitted to the gear itself; an associated development is a multi-channel system for telemetering information through the water, without wires, from the gear to the research vessel (paras. 254–259). With these aids it is hoped to obtain more precise and continuous measurements of the effects of altering different elements of trawls, seines and other gears.

10. The laboratory's instrumentation section (paras. 262–270) has always maintained close contact with developments in the field of fish detection, both for research purposes and for advising the fishing industry on developments and the manufacturing industry on requirements. The laboratory pioneered the use of echosounders to study the operation of fishing gear on the sea bed, and is at present developing electronic scanning techniques for studying the behaviour of fish, as well as quantitative echosounding for population surveys.

Biochemistry and Physiology

11. Just as behaviour studies are relevant to the gear programme, so biochemical and physiological studies (paras. 179–211) are relevant to the behaviour and other programmes. The major biochemical effort is in endocrinology, where a unit transferred fom the Torry Research Station is finalising work on hormone synthesis etc., mainly on dogfish, while reorientating their programme towards fish of greater economic value and the practical problems of fisheries biology. Special objectives include the sites of synthesis of various hormones, together with analysis of their seasonal variations. Thyroid studies are directed to problems of growth and behaviour, to the development of hierarchies in fish communities and to locomotion and migration. Investigations of the effects of stress during capture and tank adaptation in haddock will be developed into a more general study of the factors governing the condition and survival of fish on capture, with a view to obtaining fish in good condition for tagging and other experimental work.

12. Serological and immunological studies have been concentrated recently on the Greenland salmon, but have also been applied to the identification of races of cod, herring and other species.

Parasitology and Disease

13. The parasitology unit is especially concerned with determining the nature of various fish parasites and their effects on the fish, and the possible identification of fish belonging to different stocks by the use of parasite tags. In particular, a detailed study of the parasites in young plaice, and their effects on condition and survival, is being made at Loch Ewe, which should be relevant to fish farming projects. Other work includes studies of the incidence of larvae of the nematode, *Porrocaecum decipiens*, in the flesh of cod in relation to the

increase, since the last war, in the number of seals which act as the definitive or adult hosts of these parasitic worms (paras. 159–178 and 358–361).

14. In addition to its statutory obligation to diagnose and maintain records of furunculosis and other salmon diseases, much of the effort of the small bacteriological unit is at present devoted to an investigation of the ulcerative dermal necrosis now affecting salmon in certain rivers in Scotland. It is hoped to expand this side of the laboratory's work to include investigations of bacteriological diseases affecting other fish and shellfish (para 367).

Pollution

15. The spread of industry, and developments in the nature of industrial chemicals released into estuaries and inshore waters (including chemical pesticides), have necessitated the establishment of a small pollution group. Scotland is relatively fortunate, however, in that most of its rivers are not too badly troubled with pollution. Therefore, with a view to prevention rather than cure, relatively unpolluted areas are being investigated as well as polluted ones. Also, the longer-term effects of pollution, not simply in killing organisms but in diverting them from their usual habitats, are being considered where possible (paras. 368–376).

Environmental Studies

16. The work of the small plankton unit continues to be planned in relation to that of the SMBA Oceanographic Laboratory in Edinburgh (Continuous Plankton Recorder Survey). Particular projects include the monitoring of crops of zooplankton in the northern North Sea, especially in relation to the distribution, food and abundance of the herring. Other investigations include the effects of planktonic predators on the survival of young fish and on fish food supplies. Assistance is given to the Loch Ewe and industrial fishing projects and on pollution problems. The bottom fauna group is mainly concerned in the Loch Ewe project, mentioned below (paras. 329–353).

17. On the hydrographic side (paras. 271–296), the availability of new types of current meters and automatic sensing systems, together with data processing facilities, are making it possible to extend the direct study of current systems and the chemical constitution of sea water, especially in the areas over the continental shelf which maintain the principal fisheries. Development of radio beacons, for use with current meters and parachute drogues, is being applied to studies of water movement in relation to the movement of herring shoals. Studies of dye diffusion assist in understanding the drift of fish larvae and the effects of water movements in relation both to pollution, and to fish behaviour. More conventional hydrographic work includes a special study of the 'slope' current through the Faroe-Shetland Channel and across the North Sea to the Norwegian Deeps, as well as a watch on the main movements of waters through the Faroe-Shetland Channel, which the laboratory has maintained for many years.

Productivity and Improvement

18. Work on productivity continues in collaboration between the environmental and other teams in the laboratory, and is at present concentrated on the Loch Ewe project, with the voluntary co-operation of members of the staffs of several other laboratories. Recent work in Loch Ewe was designed to continue the experimental study of food chains in the sea, and incidentally to examine

problems that are likely to arise in fish farming when young fish are concentrated in restricted areas of the sea or in tanks. Attention has been focussed on (*a*) the physical and ecological effects produced by enclosure, (*b*) the effects of nutrient enrichment on the benthic food of young plaice and (*c*) the density interrelations of plaice and plaice food. It is planned to extend the study and to progress from the sandy and muddy bays of Loch Ewe to a deeper loch, with a food web including roundfish, and permitting studies of some of the factors causing mortality in young fish. On the one hand this will provide information of relevance to fish cultivation, and on the other provide methods and ideas for obtaining a better understanding of the biological systems which govern fish production in the open sea (paras. 297–328).

Freshwater Fishery Investigations

19. Salmon and the salmon fisheries have already been mentioned and this is appropriate in so far as the salmon is a marine fish during its main growing phase. But it returns to spawn in the rivers and the bulk of Scottish research on the salmon is done at the Department's Freshwater Fisheries Laboratory in Pitlochry. Here the objectives are essentially the same as at Aberdeen, and the work little less complex, although modified in general by the more restricted nature of the river environment in which the chief fish species investigated—salmon, sea trout and brown trout—live. The research conducted from the Freshwater Fisheries Laboratory, covering many Scottish rivers and lochs and even including Greenland waters, is described in detail in the report on Freshwater Fisheries.

I. MARINE RESEARCH

STAFF

Appointments, Promotions and Resignations, etc.

20. Owing to competition for first-class men, recruitment of scientists with special qualifications for fisheries research continued to present problems. Further, although fresh calls on the laboratory during 1966 demanded staff increases in several directions, it was not found possible to authorise any increases until late in 1967, and then only a very limited number. It was nevertheless possible to increase slightly the strength of the Scientific Officer class although, as a result of resignations, promotions to posts elsewhere, etc., the numbers of the Experimental Officer and Assistant classes were slightly down. At 31st October 1967, the staff in Aberdeen comprised 32 Scientific Officer class, 31 Experimental Officer class and 50 Assistant class, together with two Research Fellows and two NERC* Research Students.

Visiting Workers

21. As usual, a number of guest workers were welcomed from other laboratories, in this country and abroad. While some of them were in the laboratory for only a few days, others stayed for varying periods collaborating with one or another member of the staff. Among these were: Dr. Reuben Lasker of the U.S. Bureau of Fisheries, temporarily doing research in the University of Aberdeen and collaborating with the productivity group; Dr. Giese of the Woods Hole Oceanographic Institution, U.S.A., working with Dr. Steele; Mr. Careno of the Fisheries Development Institute in Santiago, Chile, working with the fish teams; Mr. Okera of the University College, Dar-es-Salaam, Tanzania, working with various units; and Mr. van Banning of Rijksinstituut voor Visserijonderzoek in Ijmuiden, Netherlands, working with the plankton group. In addition, as part of a special exchange arrangement, Mr. Sankaranarayanan of the Oceanographical Institute in Ernakulam, South India, visted the laboratory to work with the productivity group, and the laboratory was also glad to welcome Professor Kurian, University of Kerala, Ernakulam for a short visit.

Publications

22. Over the year, some 120 scientific papers were published or accepted for publication and/or presented to scientific meetings in this country and abroad. A complete list of these is given at the end of this report.

RESEARCH VESSELS

Departmental

23. *Explorer* continued to give excellent service during the year, in which she completed eleven cruises, five of them in the Atlantic Ocean and including three unusually long cruises when she was engaged in surveys of the unexploited stocks of blue whiting on Rockall Bank and neighbouring regions (paras. 78–90).

24. *Scotia* completed twelve cruises during the year, plus a special three-day trip on work for the Institute of Geological Sciences. Since she was built over

* Natural Environment Research Council.

25 years ago, and is well beyond the age at which a research vessel ceases to be efficient, the nature of the work *Scotia* can now usefully do is distinctly limited. Accordingly it is a pleasure to record that a contract has been placed with Yarrow Admiralty Research Department (YARD), for the design of a vessel of some 200 ft b.p. to replace her.

25. *Clupea* undertook eleven cruises, mainly in connection with herring research, including two jointly on purse-seining exercises with *Mara*. It was reported last year that arrangements were in hand for the design of a replacement, and a contract was placed with Messrs. Hall Russell for a new vessel of some 106 ft in length. The new vessel will accommodate four scientists and a crew of ten, and again will be primarily designed for herring research. She will, however, also be able to undertake work on the development and testing of new fishing gears, and will be equipped with a stern gantry for towing a submarine vehicle (para. 252) from which the behaviour of fish and fishing gear can be observed.

26. *Mara* completed thirteen research cruises during the year (including two in conjunction with *Clupea*), mainly within local waters, on exercises ranging from shellfish investigations to purse seining.

27. An important event was the commissioning of the new shellfish research vessel *Goldseeker* (Plate 1) in February 1967. *Goldseeker* proved to be a satisfactory vessel during her first year of service, having had relatively few teething troubles. Because of her length (some 50 ft) her work has necessarily been mainly inshore, but she covered during the year a wide range of shellfish investigations, extending from Shetland to Berwickshire and the Firth of Clyde.

28. The two motor boats *Navicula* and *Maid* (both transportable over land) have been in use in waters around Aberdeen, in the inner Moray Firth and as far afield as various west coast lochs, including Loch Ewe and Loch Ainort.

Other Organisations

29. A number of foreign research vessels visited Aberdeen during the year. These included the Danish research vessel *Dana*, the French vessels *Thalassa* and *l'Agile*, the *Gauss* from the Federal Republic of Germany and the *Karl Liebknecht* from East Germany. The highlight of the year occurred during September when *Dana*, *Thalassa* and *Karl Liebknecht* were all in port, together with *Explorer*, a gathering which has previously been equalled only during the course of international research cruises in the North Atlantic.

30. There was close collaboration with the Scottish Marine Biological Association, both in the Loch Linnhe—Loch Eil surveys (para. 370) and in the Loch Ewe project (para. 297), and also in several fields with the Association's Oceanographic Laboratory in Edinburgh. From time to time the laboratory's vessels were able to assist in the Association's work, and also in that of the Institute of Geological Sciences and several universities. A very welcome collaboration has been with members of the staff of the National Institute of Oceanography, on underwater acoustic investigations from the laboratory's research vessel *Mara* in Loch Torridon.

Buildings

31. Although staff increases were slight during the year, some vacancies remained to be filled, and the range of work being undertaken continued to expand. Accordingly, the authority which had recently been received to plan for a new general purposes block on the eastern side of the laboratory site was es-

pecially welcome. This block should not only provide the existing staff with more space and some very necessary modern and specialised facilities, but should also provide some scope for expansion of activities in the future. At the end of the year work had not yet begun on the urgently required experimental behaviour unit, although authority had been given for a contract to be placed in 1968, subject to approval of plans, etc. Meanwhile, a second demountable wooden hut (comprising six small research rooms) was in process of erection. This was originally requested for general purposes, while authority was sought for the more permanent extension, but most of it was being adapted to the research urgently being developed on the salmon disease which recently affected Scottish rivers (para. 367). Another hut was, therefore, requested for general purposes, as it was likely to be some years before the new permanent building could be available for use.

Library

32. As an essential component in the laboratory's research programme, it is appropriate that the library should receive mention in this section of the report. It is a large and long-established library, and is, indeed, one of the principal libraries on fisheries and oceanographic research in Europe.

33. Through the national inter-library lending organisation its book stock is available on loan to other libraries in this country and abroad. Each year, from 400 to 500 volumes are lent through the Scottish Central Library or the National Central Library and, more frequently now, on direct application from the borrowing library. The range of scientific information relevant to fisheries research has also made necessary the borrowing from other libraries of some 500 or 600 volumes. This represents a valuable supplement to the library's own resources just as its lending activities are important contributions to the library services of the nation.

34. Additions to the stock in one year may amount to 200 books and between 1,000 and 1,500 pamphlets, offprints, etc. Current serial publications being taken include 915 titles. Of these, 201 are purchased journals; the others are received by exchange or gift.

Various series of publications, containing 50 or so scientific publications by members of the staff, are sent in exchange each year to other libraries and scientific organisations. In addition, the cataloguing and classification of the library's own stock and the exploitation of bibliographies of works relevant to fisheries research and oceanography represent a considerable body of work.

Relations with other Organisations

Visitors

35. The laboratory again welcomed a number of visitors from this and other countries, some individually (see also para. 21) and others in groups.

36. First should be mentioned three scientific meetings. One was the combined laboratories' meeting of the Challenger Society (organised in conjunction with the Natural Environment Research Council), over 26th–28th April, when more than 80 representatives of the various laboratories concerned in this country met to hear about and discuss research in progress. Members of the staff contributed fifteen papers to this meeting. On March 6–8, the Sixth Annual Meeting of the International Fishing Gear Research Group (IF) was held at this laboratory to discuss progress in individual laboratories and especially the results of a conjoint underwater investigation into the operation of trawls, in

the Mediterranean last year. The third meeting was that of the FAO/ICES/ ICNAF Working Party, concerned with the improvement and standardisation of fishery statistics in the North Atlantic Ocean.

37. Visits of other groups (in date order) were made by Professor Grieve and members of the Highlands and Islands Development Board; two technologists from the Russian Experimental Trawler, *Kaliningrad*; senior officers of the White Fish Authority (including the then Chairman, Sir Roy Matthews, the Chairman Designate, Mr. C. E. M. Hardie and the Chairman of the Scottish Committee of the Authority, Sir John Ure Primrose); a party of Polish fishery technologists (under arrangement by the British Council); a party from the Annual Conference of the Inspectors of Weights and Measures meeting in Aberdeen; another group of Polish fishery officials headed by Mr. J. Soltan (Director General, Polish Fisheries Central Board); and a party of surgeons (the Gray Turner Club) led by Mr. S. G. Davidson of Aberdeen. Parties of scientists from the foreign research vessels mentioned above, and a group of scientific journalists (from 'Nature', 'The Guardian', 'The Telegraph' and the Central Office of Information in London) were also welcomed.

Lectures, etc.

38. Some forty lectures were given by laboratory staff to outside organisations, in this country and abroad. These included lectures to Aberdeen University post-graduate students and to members of the public as part of the University's programme of extra-mural studies. Lectures, by invitation, were also given to the Conference on the Technology of the Sea and the Sea Bed (sponsored by the Ministry of Technology at Harwell); to the Conference on Future Developments in the Fishing Industry (held in the Grimsby College of Technology); and to the Conference on Shellfish Fisheries held during the World Fishing Exhibition. As usual, a number of scientific papers were presented to the Challenger Society. Lectures abroad included contributions to meetings of the International Council for the Exploration of the Sea, the Second European Symposium on Marine Biology, held in Bergen and the FAO Symposium on Fish Behaviour in Relation to Fishery Techniques and Tactics, also held in Bergen.

39. In addition to continuing the series of evening discussions between members of the staff and the Scottish fishing industry, fisheries research talks were given at fishing ports as well as on BBC radio and television. Members of the staff assisted with demonstrations of research work at several exhibitions.

40. The long-standing association which the laboratory has had with the University of Aberdeen continued to develop in several ways, especially with the Natural History Department and its ecological research stations. Under a new scheme developed by the University, in relation to post-graduate students working in the local research institutions, Mr. B. B. Parrish, Dr. J. H. Fraser, Dr. B. B. Rae, Dr. J. H. Steele, Dr. H. J. Thomas, Mr. A. D. McIntyre and Dr. T. H. Simpson were appointed as Honorary Research Associates on the staff of the University. The Director continued to serve as Honorary Lecturer in Fisheries and Oceanography.

International Organisations

41. The laboratory was again represented at a number of international fisheries and oceanographic meetings during the year at governmental level, including meetings of the International Council for the Exploration of the Sea

in Hamburg; the International Commission for the Northwest Atlantic Fisheries in Boston, Mass.; the Northeast Atlantic Fisheries Commission in Paris; the Intergovernmental Oceanographic Commission in Paris; and the Scientific Committee for Oceanic Research of the International Council of Scientific Unions in Rome. Dr. Lucas continued to serve as the Chairman of the FAO Advisory Committee on Marine Resources Research and Mr. Parrish as Convener of its Working Party on Direct and Speedy Estimation of Fish Abundance. The Director, Mr. Parrish, Dr. Fraser and Dr. Steele variously served as consultants to FAO, UNESCO and SCOR, while Messrs. Dickson and Raitt were on loan as project leaders to FAO.

42. Many members of the staff are actively concerned with the work of the International Council for the Exploration of the Sea, and the Director, with several colleagues, attended its annual meeting in Hamburg, where 14 papers were contributed to meetings of the Council's scientific committees. At that meeting, the Director completed his five-years' period as Chairman of the Council's Consultative and Liaison Committees, and the laboratory noted with pleasure the appointment of Mr. B. B. Parrish as his successor in these posts, on completion of his term of office as Chairman of the Council's Statistical Committee. Dr. Fraser continued as Chairman of its Plankton Committee and also as Editor of the Council's Plankton Sheets. Meanwhile, Dr. Lucas was appointed as the Council's special representative on the committee appointed by the Secretary General of the United Nations Organisation to make recommendations for action on UN Resolution 2172 (XXI) on the Resources of the Sea, concerning international co-operation in research and exploitation of the oceans. Mr. Parrish continued as Chairman of the Assessments Sub-committee of ICNAF and served as Chairman of the joint ICES/ICNAF Working Party on North Atlantic Salmon Problems.

43. The scientific papers contributed at the various international meetings are listed at the end of this report.

Other Bodies

44. With various other members of the staff, the Director represented the Department or the laboratory on a number of governmental and institutional committees, and he continued to serve as Chairman of the Buckland Foundation and as Joint Editor of the Bulletins of Marine Ecology.

45. Committees not previously mentioned and on which members of the staff had served (other than standing committees of governmental and intergovernmental bodies) were the British National Committee for Oceanic Research; the Royal Society UNESCO Committee; the Councils of the Marine Biological Association of the UK and the Scottish Marine Biological Association; and the Research and Development Policy Committee of the White Fish Authority. Dr. Hemmings was elected Chairman of the newly formed Underwater Association of Malta, 1965.

Acknowledgements

46. The laboratory gratefully acknowledges a wide range of assistance from fishermen, Fishery Officers, scientists and others both in this country and abroad, and was glad to extend hospitality and assistance to outside workers both in Aberdeen and on research vessels at sea.

DEMERSAL FISH INVESTIGATIONS

Staff

Principal Scientific Officer	... ...	R. JONES
Senior Scientific Officer	... ...	D. F. S. RAITT
Scientific Officer	... ...	J. R. G. HISLOP

47. As in past years, a major part of the laboratory's demersal fish research programme in 1967 was concerned with the continuation of long-term investigations of the abundance, composition and population dynamics of the stocks of haddock, whiting and cod exploited by Scottish fisheries in the northern North Sea, off the Scottish west coast and at Faroe. The principal objectives of these investigations are:

(*a*) to determine the short-term changes in stock abundance, due mainly to fluctuations in year-class strength, which provide a basis for the production of fishery forecasts. Such forecasts were prepared for the haddock and whiting fisheries in the northern North Sea in 1967 and were published in the Scottish Fisheries Bulletin and the U.K. Fish Stock Record. Assessments of the likely trends in production of these and other demersal species by the Scottish fisheries up to 1972 were also made for the Interdepartmental Committee on the Review of Fisheries Policy;

(*b*) to assess the state of the exploited stocks in relation to changes in fishing, both national and international. The results of these assessments form the basis of scientific information supplied to the Department, the International Council for the Exploration of the Sea and the North-East Atlantic Fisheries Commission on matters concerning fishery regulation and management.

48. The basic data for these investigations were collected, as in previous years, by routine sampling of the commercial trawl and seine-net landings at the major Scottish ports, and by research vessel trawling surveys, with small-meshed trawls, over the northern North Sea (in March and June), off the Scottish west coast (in January) and at Faroe (in October) to provide information especially on the strength of haddock and whiting year-classes prior to their recruitment to the commercial fisheries. An exchange of market and research vessel sampling data was continued with the Lowestoft Laboratory on the cod and haddock stocks at Faroe.

State of Fisheries and Exploited Stocks

(a) *Haddock*

49. In the North Sea, the landings of haddock per 100 hours' fishing by trawlers landing at Aberdeen tended throughout the first nine months of 1967 to be higher than during the first nine months of 1966. This continued the increase in Aberdeen trawler catch rates that has occurred since 1964, and was due to the extremely strong 1962 year-class. It had been expected that the catch rates of this year-class would decline during 1967, but even by September there was no real indication that they were doing so.

50. In contrast with those of the trawlers, the haddock catch rates of seiners tended to be lower in 1967 than in 1966, as expected. Seiner catch rates, which

were also increased by the strong 1962 year-class, reached their peak in 1965 when the fish of that year-class were three years old. The reasons for this difference between the seiners and trawlers were being investigated with special reference to regional differences in fishing by the two types of gear and other possible explanations.

51. On west coast grounds the haddock catch rates by both trawlers and seiners tended to be lower in 1967 than in 1966, as predicted. However, as in the North Sea, there was a difference between trawlers and seiners in that the decline in the seiner catch rates was greater than that in the trawler rates.

52. The prospects for the North Sea and west coast haddock fisheries in 1968 and 1969 depend mainly on the strengths of the 1963–1966 year-classes. It is known that the 1963, 1964 and 1965 year-classes are weak, so that in 1968, the catch and catch-per-unit-effort of the older fish are likely to fall from their recent high levels. On the other hand, the data from the research vessel trawling surveys in the North Sea in 1967 indicated that the 1966 year-class was a relatively strong one. This year-class would begin to enter the fishery in strength during the second half of 1968 and thus lead to an increase in the landings of small haddock.

53. At Faroe, the catch-per-unit-effort of haddock of Aberdeen trawlers was slightly lower in 1967 than in 1966. This was in accordance with expectation, as a result of the relatively low strength of the 1965 year-class.

(b) *Whiting*

54. In 1966, the Scottish landings and catch-per-unit-effort of whiting from the North Sea were higher than in 1965, owing mainly to the abundance of the strong 1962 year-class. In 1967, however, this year-class had passed its maximum abundance, with the result that the catch-per-unit-effort for the first nine months of the year was smaller than for the corresponding period in 1966. No improvement took place during the remainder of the year and this is likely to continue in the first half of 1968, because of the relatively weak 1963–1965 year-classes. However, research vessel records indicate that the 1966 year-class of whiting is fairly strong and this should bring about some improvement in the catches of small whiting towards the end of 1968.

55. In the Scottish west coast fishery, seiner landings of whiting and catch-per-unit-effort were somewhat higher in the first nine months of 1967 than in the corresponding period of 1966, especially in the Clyde winter fishery. In the Minch, the strong 1962 year-class continued to be dominant in the catches, but in the Clyde, where the catch is largely composed of whiting in their second year of life, the relatively productive fishery was owing to the higher-than-average strength of the 1965 year-class there. It was expected that this year-class would appear in strength on other parts of the west coast during 1968, providing good supplies of small and medium-sized fish, to compensate for the decreasing abundance of the 1962 year-class.

(c) *Cod*

56. In 1966 and the first half of 1967, the Scottish landings and catch-per-unit-effort of cod from the northern North Sea were substantially higher than in 1965, despite a considerable decrease in the amount of fishing effort by both trawlers and seiners. This resulted from the higher landings of 'small' and 'medium' cod contribution by the above-average-strength 1964 and 1965 year-classes. Although no data were yet available on the strength of the 1966 year-

class, which would begin to enter the fishery in 1968, it seemed likely that these two year-classes would sustain the cod fishery at a relatively high level during that year.

57. An analysis has been made of the changes in the Scottish North Sea cod fishery since 1920 for publication in the Scottish Marine Research series. This indicates that since 1950 cod landings have increased markedly above the average pre-war level. Yet, despite the fact that the estimated total fishing effort has remained fairly steady at a lower level than pre-war, the catches of 'large' cod have decreased steadily throughout the post-war period from their high level in the immediate post-war years. The post-war rise in landings has been almost entirely due to an increase in the catches of 'small', and to a less extent 'medium', cod.

58. This suggests that the increase in total catch was not the direct conservation effect of a reduction in fishing intensity but was due to a higher overall level of recruitment than pre-war. This is supported by estimates of mortality rate from the Scottish sampling data, which point to a high post-war rate of exploitation, comparable with published estimates for pre-war years.

59. Recent data on the relative abundance of year-classes of cod in the Scottish and English fisheries in the North Sea suggest that the stocks exploited by the two fleets may be distinct. Whereas the successful 1961 year-class dominated the stock exploited by the Scottish fishery in the northern North Sea in 1963 and 1964, it was not particularly strong in the stock exploited by the English fishery in the southern North Sea. The English fishery, however, had a very good 1963 year-class of cod which was not reflected in the Scottish catches. The apparent separation of these two stocks is supported by the lack of evidence of any significant interchange of tagged fish between the two areas. Further studies of the identification of distinct cod stocks in the North Sea are in progress.

Tagging Experiments on Cod, Whiting and Haddock

60. Liberations of tagged cod, whiting and haddock were made during 1967 from research vessels and commercial fishing vessels in the northern North Sea, off the west coast of Scotland and at Faroe (haddock only), as part of the long-term studies of the distribution, movements, population sub-division and rates of exploitation of these species. Experimental work was also continued on the problem of reducing tagging mortality, especially in haddock, and of elucidating the factors governing it (see para. 64).

Cod tagging

61. The cod tagging programme in 1967 was directed principally to the offshore cod stocks in the northern North Sea, to supplement the extensive inshore taggings carried out in previous years. A total of 250 cod were tagged in this area during the year, from which 21 recaptures have so far been obtained. At the end of the year it was still too early to assess these results, but an analysis of the returns from experiments in coastal areas in earlier years was completed. The most striking feature of these preliminary data was the small degree of interchange of tagged cod between the different fishing areas in which the liberations were made (Moray Firth, east coast of Scotland, east coast of Orkney and north coast of Scotland) and between these areas and the open North Sea. This might have been due to the fact that these experiments were conducted principally on one-, two- and three-year-old adolescent cod prior to their main migrations

at the onset of first maturity, and because of the relatively high rate of exploitation within the tagging areas. In one experiment off the Scottish east coast in 1966, over 50 per cent of the 500 fish liberated were recaptured in the local fishery within two months of liberation.

Whiting tagging

62. In May 1966, 874 whiting were released in the Bell Rock area and by 31st October 1967 125 tags (14 per cent) had been recovered. The movements showed a southerly trend which was unlike the general direction of movement shown by haddock tagged in the same area. To investigate this further, 988 seine-net caught whiting were tagged and released off Eyemouth in August 1967, but by 31st October 1967 only ten tags had been returned. A further 283 fish were tagged in other parts of the North Sea during 1967, 23 tags having been returned up to the end of September.

Haddock Tagging

63. The principal liberation areas for tagged haddock in 1967 were the north coast of Scotland (959 fish in June), the Shetlands (935 fish in July-August), the Moray Firth (775 fish in August), the south east coast of Scotland (150 fish in August) and the Faroes (857 fish in July). In general, the rates of recapture from these and earlier experiments point to a high tagging mortality rate, which limits their usefulness for estimating fishing and natural mortality rates, but they have provided further information on the growing picture of the pattern of movement of haddock in the northern North Sea and at Faroe.

Estimation of initial tagging mortality of haddock

64. The programme of experimental work, aimed at determining the initial tagging mortality of haddock caught by seine-net and trawl, reported on last year, was continued. In an experiment in Broad Bay on seine-net caught fish in the autumn of 1966, groups of haddock were treated in the following ways:

(i) brought to the surface in the normal way, tagged on board ship and then returned to the sea-bed by divers and placed in a cage;
(ii) taken out of the codend of the seine on the sea-bed by the divers, tagged and placed in the cage;
(iii) taken from the codend on the sea-bed and placed in the cage without tagging.

65. The percentage survival, after five days, of the groups treated in these three ways was as follows:

Tagged at surface	= 16%
Tagged on sea-bed	= (a) 93% (b) 96%
Untagged on sea-bed (controls) ...	= 80%

66. These results confirm earlier indications that haddock tagged at the surface suffer a high initial tagging mortality and that it is caused by factors associated with the hauling and handling on board ship rather than with the tag itself. Observations of the fish during the experiment again showed that at the rates of decompression generated during the normal handling of the seine-net (and trawl) gear, the incidence of swim-bladder rupture is high. The results of this work, which have been written up for publication, point to the desirability

of developing a technique for underwater tagging on a large scale, and in 1967 some preliminary trials were made. An underwater tagging bench was designed and tested on hand-line caught saithe in Loch Torridon. A satisfactory tagging method was worked out and a tagging rate of one fish per minute and a half was achieved. At the end of the year, further larger scale experiments, using seine caught fish, were in progress.

Capture of Live Fish

67. In addition to the development of an efficient underwater tagging technique, to be used in relatively shallow water, work was also continued on methods of bringing haddock and whiting from deeper water to the surface in good condition for tagging and for use in aquarium studies. To achieve this, one of the main requirements is to regulate the rate at which the fish are brought to the surface so as to avoid swim-bladder rupture and embolisms from too rapid decompression when raised to the surface. This is not usually practicable during normal fishing operations, so for this purpose a detachable codend has been developed which can be raised to the surface at any desired rate after being released from the trawl. Satisfactory preliminary trials were made with this equipment. A cage for bringing handline-caught fish to the surface slowly was also successfully developed.

Feeding and Digestion Studies on Cod, Haddock and Whiting

68. Our knowledge of the food of fish, and hence of the place of fish in the food-web of the sea (but see also para. 297) is mainly derived from analyses of the stomach contents after capture. Valuable information can be obtained from these, as work on the food of cod and dogfish, described in paras. 361–363, shows. This value is, however, limited. Quite apart from any risks of loss by regurgitation on capture, the contents depend on rates of digestion under different conditions, and yield no information on feeding rates.

69. In previous years, to obtain more precise information on the rates of digestion, cod and haddock kept in the aquarium were given weighed meals and killed after various time intervals, to determine how much food remained in the stomach. In these experiments, the fish had first to be maintained until they began to feed; they were then isolated and kept for 3–4 days to ensure that their stomachs were empty before they received the experimental meal.

70. This year the procedure changed. The fish were again kept until they were feeding well, and each fish was then fed at a constant rate for a period. After 4–5 days, by which time it was judged that their stomach content weights should have reached equilibrium, the fish were killed. Each fish was killed at the middle of its feeding interval and in this way it was possible to obtain a direct relationship between rate of feeding and mean stomach content weight.

71. Three food organisms were used—young saithe, *Nereis* and *Crangon*. The experiments were done at 12–13°C and cod, haddock and whiting were all used as experimental animals. The results show that *Nereis* is digested more quickly than either saithe or *Crangon*, for which the digestion rates are approximately the same. For instance, a stomach content of 1 per cent of the body weight indicates a daily food intake of 2·2 per cent in the case of saithe or *Crangon*, but 3·1 per cent in the case of *Nereis*. They also show that where cod, haddock or whiting have been fed the same food organisms the results fall to a first approximation on the same curves.

72. Of interest is the fact that the food organisms in these experiments were passing through the stomach appreciably faster than they did in the previous year's experiment. This could have been because the fish used were physiologically fitter fish than those used before, as a result of a progressive improvement in the techniques used for capture and handling. Alternatively, there could have been a difference because the fish used in the earlier experiments were starved for three days prior to an experiment whereas those used in the current year's experiments were not.

73. In addition to recording the stomach content weights of the experimental fish, the condition of the ingested food was also noted, with special reference to the quantities of intact to non-intact food. Preliminary results, with *Nereis* as a food organism, suggest that these quantities may be influenced by the size of meal and by the feeding interval. The conclusion is that, in nature, if meals are large and the interval between meals is long, the stomach contents range from stomachs 'full' of mainly fresh food (intact) to stomachs that contain small quantities of well-digested (non-intact) food. The natural distribution of stomach contents of cod that have been feeding on fish in the sea frequently show this type of distribution. If, on the other hand, the meals are small in nature and taken more frequently, there is less variation due to digestion in the stomach content weights, from any one ground. The fuller stomachs are more likely to have come from a different ground and can then contain as high a proportion of non-intact food as the nearly empty ones. The aquarium experiments suggest that, under these circumstances, the fuller stomachs may even contain a higher proportion of non-intact food although further experiments are required to confirm this. The examination of haddock stomachs from many areas shows in fact that the fuller stomachs contain as high a proportion of non-intact food as the nearly empty stomachs. This suggests, therefore, that the natural feeding habits of cod and haddock differ, the haddock browsing to a much greater extent than does the cod, which tends to take larger, less frequent meals.

Cod Spawning and Larval Investigation

74. From a study of the laboratory's earlier collections of cod eggs and larvae from the North Sea and off the north coast of Scotland, it has been possible to extend pre-war information on the distribution of cod spawning in the North Sea to include a wide area off the Scottish east coast and Orkney Islands. Considerable spawning areas were also found off the Butt of Lewis, on the north Scottish coast and to the west of Shetland. However, the analysis of Gulf III net samples taken in the Moray Firth from February to May in 1959–64 yielded no cod larvae, and only very few were identifiable in two surveys carried out in the central Moray Firth by *Clupea* in April 1967, although in the latter quite large numbers of gadoid eggs at an early stage of development were found which could not be definitely identified as cod or haddock.

Haddock Courtship and Spawning

75. Original studies on these processes are described in the section on Behaviour Studies (para. 222).

Flatfish Investigations

76. Little work was done on flatfish during the past year, owing to staffing problems, which it is hoped will be resolved in the near future. Meanwhile, the paper on 'The age composition and growth of plaice in Scottish waters' (by Mr. J. M. Lamont, recently retired) has now been published.

77. Research papers concerning demersal fish, published or in the press, are: 17, 18, 25–30, 33, 50–52, 54, 74, 90, 92, 95, 101, 117, 119, 120, 121, 131.

Industrial Fish Investigations

[Members of the Pelagic and Demersal Fish Teams, with the co-operation of members of other units as required.]

78. Although large industrial fisheries are conducted by a number of European countries in areas within easy reach of the British fishing fleets, hitherto this country has not developed such a fishery on any substantial scale, despite a large annual import of fish meal, now costing well over £20 million. Attention is, therefore, being paid by the Fishery Departments, in association with the White Fish Authority and the Herring Industry Board, to the possibilities of developing such a fishery. In 1967, a substantial part of the laboratory's research programme was directed towards the study of aspects of this problem, with special reference to the assessment of the distribution, composition and size of potential industrial fish resources in waters off the Scottish coast. This new programme was directed principally to the stocks of blue whiting off the Scottish west coast and sandeels off the east and north coasts, while the small programme already under way on the other industrial species, Norway pout and sprats, was also continued.

Blue Whiting

79. Earlier work of the laboratory, together with information obtained by the Plankton Recorder Survey of the Oceanographic Laboratory in Edinburgh, had for some time suggested the potential importance of the stocks of blue whiting (*Micromesistius poutassou*) off our western shores. A major research effort in 1967 was devoted to exploratory studies of the distribution, abundance, composition and accessibility to capture of these stocks over the oceanic banks to the west of the British Isles, especially Rockall Bank, and along the edge of the continental shelf. In addition to the study of the fish stocks themselves, investigations were also made of the distribution and abundance of blue whiting larvae in this area during the late spring.

80. Three cruises by F.R.S. *Explorer* were made in April–May, June–July and August–September, respectively. The areas covered by the three cruises were Porcupine Bank (cruise 1), Rockall Bank (cruises 1, 2 and 3) and the edge of the continental shelf to the west of Scotland, between latitudes 54°30′N and 60°30′N (cruises 2 and 3). The main trawling operations on these cruises were conducted with a high-headline SARO-type bottom trawl, fitted with a small-meshed codend and worked with bobbins and large, curved otterboards. A limited amount of fishing was also done with a pelagic trawl, which yielded low catches, although mid-water fish echo traces were scarce during all three surveys.

81. The results of the three surveys showed that there were large concentrations of blue whiting in the area surveyed, accessible to capture by bottom trawl. The best catches of blue whiting were taken on Rockall Bank in depths between 95 and 155 fathoms. It was the dominant industrial fish species in this area, and catches of between 30 and 70 baskets per hour's tow were obtained at a number of different trawling positions. Substantial catches of silver smelts (*Argentina* sp.) of between 10 and 20 baskets per hour were also taken in this area, but generally in other localities than those yielding the largest catches of blue whiting.

82. The catches of blue whiting on the limited trawling survey on Porcupine Bank and the more extensive survey along the edge of the continental shelf were substantially lower than those at Rockall. Except for three hauls of between 22 and 44 baskets per hour to the west and north-west of St Kilda, the blue whiting catches were in general less than 5 baskets per hour. Two catches of silver smelts, of 24 and 40 baskets per hour, were taken to the east of Porcupine Bank, but no substantial catches of this species were taken in the continental shelf area on these occasions.

83. Some quantities of conventional 'commercial' species were also taken during the surveys, but on average they formed a small proportion of the total catch. On Porcupine Bank they averaged about 1 basket per hour (6 per cent of the total catch), on Rockall 4–10 baskets (15–24 per cent of the catch) and on the edge of the continental shelf $3\frac{1}{2}$–$4\frac{1}{2}$ baskets (32–39 per cent of the total catch). It was noteworthy that undersized fish of the commercial species formed less than 1 per cent of their total, and less than 0·1 per cent of the whole catch.

84. In general, the largest catches of industrial fish species taken during the survey were taken in localities where the density of echo-traces obtained, close to the sea bed, was highest. Preliminary investigations were made of the diurnal variations in catches of blue whiting. These showed that catches in daylight were higher than in darkness, suggesting that blue whiting may exhibit some degree of diurnal vertical migration. This was confirmed by echo-sounding records.

85. During the first *Explorer* cruise an extensive plankton sampling survey was made to provide detailed information on the distribution, particularly in depth, and abundance of blue whiting larvae, to supplement the information obtained at 10 m. depth by the Edinburgh laboratory. Substantial numbers of larvae were caught on Porcupine Bank and at several positions over deep water to the west of Scotland but the largest concentrations were encountered on Rockall Bank. By means of replicate series of stepped oblique Gulf III hauls, it was established that in daylight the larvae were distributed down to some 75–100 metres depth; they exhibited some vertical migration towards the surface at night.

86. The total area within which the main concentrations of blue whiting larvae were encountered on Rockall Bank was about 9,000 square miles, approximately to the area bounded by the 200 fm depth contour (Fig. 1). Within this area, there was a small one of about 1,800 square miles, over that part of the bank with a depth of less than 100 fm, where the biggest larval concentrations were encountered, in estimated numbers of about 14×10^8 under each km^2. This area of high concentration was associated with a well-defined mid-water, layer-type echo-trace which extended, on average, from just below the surface, down to about 100 m. The edge of this larval concentration was clearly delimited, both in the plankton samples and on the echo-trace.

87. On the basis of these data, information from the continuous plankton recorder survey and estimates of the average fecundity and sex ratio, the average stock of adult blue whiting in the area to the west of Scotland was conservatively estimated to be not less than one million tons. In 1967, it must have been much greater.

88. In addition to the presence of dense concentrations of blue whiting larvae over Rockall Bank, the plankton samples there also contained quantities of other planktonic organisms not usually associated with open Atlantic conditions, such as *Calanus finmarchicus*, decapod larvae (eupagurids) and

euphausid furcilia. The 'clear' water outside this area contained a typical oceanic plankton community, including *Sagitta maxima*, *Aglantha* sp. *Euclio* sp. and diphyids and physonectids (siphonophores).

89. In the area of highest abundance on Rockall Bank, the larvae sampled on the first survey were from 2 to 6 mm in length and on average were not very much bigger than the size at first hatching; some of the smaller individuals still possessed traces of the yolk-sac. Towards the edge of the bank the larvae were

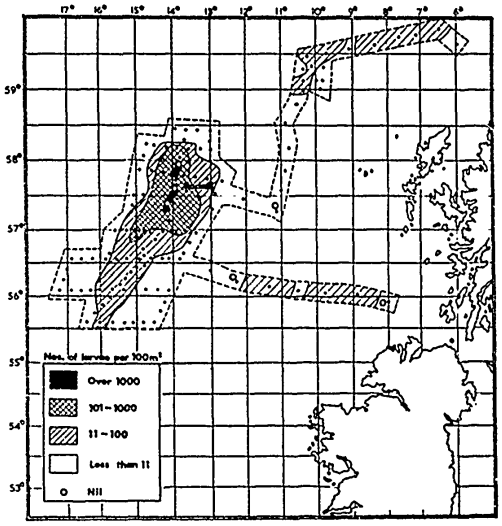


Fig. 1. Distribution of blue whiting larvae, May 1967.

larger (6–12 mm) and over deep water specimens of up to 25 mm were encountered. It seems possible that the latter could have been derived from an earlier spawning, perhaps to the south of Rockall Bank.

90. A further echo-plankton survey of Rockall Bank was made on the second cruise in June. The plankton population on the bank was of similar composition to that in April–May but the numbers of blue whiting larvae caught were much smaller. On the third cruise, in September, however, the neritic-type plankton species had disappeared from the bank and it was completely covered by Atlantic plankton species. This suggests that an eddy circulation system which persisted over the bank during spring and early summer may subsequently have broken down. More detailed studies of this system would be started in 1968.

Norway Pout (Trisopterus esmarkii)

91. Routine sampling of the Norway pout population in the northern North Sea, and to a less extent off the west coast of Scotland and at Faroe, was continued in 1967 on research trawling surveys, to provide further data on the abundance and composition of the stocks in these areas. An analysis of the age composition and abundance data from 1960 to 1966 shows that after 1963 there was a large decrease in the abundance of Norway pout in the northern North Sea, owing to poor recruitment, especially in 1963 and 1965. The preliminary results from the trawling surveys in 1967 indicate an increase in abundance from the low level in 1966, owing to a relatively stronger 1966 year-class. The decrease in stock abundance in the years after 1963 was reflected in a fall in the yield of the European industrial fishery for Norway pout in the North Sea from 185,000 tons in 1963 to 78,000 tons in 1965.

92. An analysis of length, maturity and fecundity data collected during the period of decreasing abundance indicates significant changes in certain biological features of the stock which may be important in the control of population numbers in Norway pout. For example, the mean length at a given age of the 1964 year-class, which grew up at a time of low stock abundance, was significantly higher than in the earlier, more abundant year-classes and a substantially higher proportion of its members reached maturity at one year of age. Further, a comparison of the fecundities of 2-years-old pout of the 1962 and 1964 year-classes, at the same length, showed that the fecundities of the latter were 2–2½ times higher. These apparent density-dependent changes must all have tended to maintain the egg production potential of the Norway pout stock at a relatively high level during a time of low stock abundance. Further studies of these biological features of the stock will be made in subsequent years.

Sandeels (*Ammodytes* spp.)

93. Three exploratory trawling surveys in April–May, June–July and September respectively, were made by F.R.S. *Mara* off the Scottish east and north coasts in 1967, to assess the distribution, composition and abundance of sandeels in these areas as potential industrial fish supplies. The principal area surveyed was the Moray Firth (1st and 2nd surveys), but a survey was also made along the north coast and along the east coast between Cruden Bay in the north and St. Andrews Bay in the south. Fishing was done with a wing trawl having a small-meshed codend and extension piece.

94. In the Moray Firth, sandeels were widely distributed on grounds with a sandy substrate, but catches were generally low from a commercial fishery standpoint. The densest concentration of sandeels was located on the south-western edge of Smiths Bank, but this patch of relatively high density covered only a small area, and throughout the remainder of the survey the concentrations were much less dense.

95. No sandeels were caught in the area surveyed off the east of Scotland in September. Off the north coast, the largest catch taken was a half basket in an hour's tow, although the grounds chosen proved to be very unsuitable for towing with fine-meshed gear. It is possible, moreover, that this survey took place after the main summer aggregation of sandeels had broken up.

96. The sandeels caught over the whole area surveyed were relatively small fish with a modal length of 14–16 cm, consisting principally of *Ammodytes marinus*; only occasional specimens of the larger *A. lanceolatus* species were taken.

97. Research papers concerned with 'industrial' fish species, published or in the press, are: 35, 44, 53, 104, 122, 123.

PELAGIC FISH INVESTIGATIONS

Staff

Principal Scientific Officer	A. SAVILLE
Senior Scientific Officer	I. G. BAXTER
Scientific Officer	N. P. E. LANGHAM
Senior Experimental Officers	G. MCPHERSON
	D. P. SHARMAN

98. Studies of the abundance and composition of the herring stocks exploited by the Scottish fishery in the northern North Sea and off the west coast of Scotland (Minch and Clyde) were continued in 1967 along the same general lines as in past years. Particular attention was paid to the north-western North Sea fishery and stock and to the elucidation of the effects on stock abundance and future fishery yields of the recent large increase in fishing in the northern North Sea, referred to in last year's report.

North Sea Herring

99. The total Scottish herring catch from the northern North Sea in 1967 was slightly greater than in 1966. Following the trend of recent years, the main, and most productive, fishery took place in the Shetland area, the fishery on the Buchan grounds again being very poor. These events were in close agreement with the forecast issued for these fisheries. The failure of the Buchan fishery was largely due, as expected, to the weakness of the recruiting, 1964 year-class, while the relatively high productivity of the Shetland fishery was due to the presence of an abundant adult stock in which the 1963, 1960 and 1956 year-classes featured prominently.

100. Estimates of survival rates for the exploited stock in the north-western North Sea were at about the same level in 1966–67 as in previous years, being high in the Shetland area and low in the Buchan area. Estimates for the north-western North Sea as a whole since the middle 1950s show no significant changes in survival rate during this period, despite the large increase in fishing which took place in 1965.

101. A striking feature of the Shetland fishery in 1967 was its high level of productivity in August and early September, which maintained the trend of recent years. Whereas in the 1930s and 1950s the catch-per-unit-effort averaged around 10 crans per shot, in the 1960s it increased to about 25 crans per shot; during the same period, the Buchan spawning fishery in August–September has declined drastically.

102. These events point to a shift in recent years of the main distribution of the pre-spawning and spawning components of the herring stock in the north-western North Sea to the north. This is supported by the results of larval surveys conducted each year over the north-western North Sea since the mid 1950s. These show that in recent years the main concentrations of larvae have been located in the Orkney–Shetland area rather than, as in earlier years, off the Scottish east coast. In 1967, the larval surveys conducted by the laboratory in the north-western North Sea formed part of a continuing, international co-operative programme covering all of the major spawning areas in the North Sea, aimed at providing additional information on the changes in spawning stock size following increases in the fishing intensity of the North Sea fisheries.

103. In addition to the analyses of the adult stocks, reported above, investigations continued on the exploited stock of adolescent, 'halflin' herring in the upper Moray Firth. As well as routine sampling of the commercial drift-net and pair-trawl fishery, research vessel trawling surveys were also made throughout the Moray Firth. These analyses showed that the 'halflin' stock in the upper Moray Firth during the 1966–67 winter fishing season was much smaller than in the previous year, and the fishery yielded only 16,000 crans, compared with 112,000 crans in 1965–66. This was due principally to the low strength of the 1964, autumn spawned year-class compared with the relatively

strong 1963 year-class in 1965–66. A feature of the fishery in 1966–67 was the relatively high proportion of the O-group (1965 year-class) in the catches.

104. In addition to the studies of young herring in the Moray Firth the *Explorer* also took part in March 1967 in an international, co-operative trawling survey on the stocks of adolescent herring throughout the North Sea, aimed at providing detailed information on their main centres of distribution, their biological characteristics and estimates of year-class strength prior to their recruitment to the adult stocks, for use in fishery forecasting. The results of a preliminary analysis of data from these surveys point to the strength of the 1965 year-class in the North Sea being a weak one, comparable with that of 1959, which appeared as an extremely poor one in all of the adult autumn-spawning stocks in the North Sea. It was planned that these conjoint surveys would be continued in subsequent years so that their full value for fishery forecasting could be assessed.

105. Mr. Saville also participated in the work of the international Working Group set up to analyse the data collected during the North Sea young herring trawling surveys in 1960 and 1961. The discriminant function analysis of these data by computer was completed and the results from it, giving relative proportions of Downs, Dogger and Buchan spawners in the young herring concentrations in the North Sea in those years, were in general keeping with what is known of the subsequent relative strengths of the year-classes in these stocks. Other characters, not used in the discriminant function analysis, were also being examined.

West Coast Herring

106. The winter fishery in the Minch in 1966–67 was a very productive one, with total landings from November to February of 265,000 crans, compared with 184,000 crans for the same period in 1965–66. While this large increase in catch was partly due to the increase in fishing by pair-trawlers and purse-seiners, all sections of the fishery had a productive season, the catch-per-unit-effort of the drift-net fishing being the highest ever recorded in this area. The success of this fishery was due, as forecast, to the strong 1963 year-class, which constituted over 60 per cent of the catches. In contrast, the summer fishery in the Minch in 1967 with a total catch of 25,000 crans was less successful than in 1966, when 40,000 crans were landed. This decrease in catch was largely due to a decrease in fishing effort, although the catch-per-unit-effort of the drift-net fishery also fell in 1967 to less than two-thirds of its 1966 level. On the other hand, the catch-per-unit-effort of the ring-net fishery increased slightly. As in the winter fishery, the 1963 year-class was the dominant age-group in the catches, while three-year-olds (1964 year-class), which normally predominate in the catches in the summer fishery, were relatively scarce. However, two-year-olds (1965 year-class) were quite abundant, which augured well for the summer fishery in this area in 1968.

107. The spawning fishery in the Clyde from January to March 1967 was very much less successful than in 1966, as forecast, with landings down from 23,000 crans to 12,000 crans and with an appreciable decrease in catch-per-unit-effort. In the fishery in the remainder of the year, catch and catch-per-unit-effort were at about the same relatively low level as in 1966. Most of the catch in this fishery consisted of the 1965 year-class but this, like the 1963 and 1964 year-classes, was a weak one so that the prospects for the spawning fishery in 1968 were not good.

108. In addition to the study of the exploited herring stocks in the Minch and Clyde, samples of herring were obtained from grounds to the west of the Hebrides to supplement the data collected during more extensive research vessel trawling surveys in this area in 1962–1966. As in previous years, the autumn-spawned component was the dominant one in the samples from this area, within which, as in the Minch, the 1964 year-class was poorly and the 1963 year-class well represented. The spring-spawned component of the samples was composed principally of five- and nine-year-old members of the 1962 and 1958 year-classes respectively. Further analysis of the data collected in the trawling surveys in 1962–66 suggests that recruitment of individual year-classes to the stock in this area may extend over a number of years, thereby producing a relatively stable stock.

109. As in previous years, the data obtained for the routine herring sampling programmes in the northern North Sea and off the west coast in 1967 are being prepared for publication in the UK Fish Stock Record and the ICES Annales Biologiques and Statistical News Letter. Forecasts for the northern North Sea and west coast fisheries in 1967 were prepared and published in the Scottish Fisheries Bulletin.

Racial Investigations

110. The identification of distinct stocks of herring in the exploited populations in the North Sea and of their rates of mixing is of major importance in assessments of the causes of changes in their abundance and composition, and of the effects of fishing on them. Therefore, considerable effort has again been devoted to the investigation of this problem in the northern North Sea and off the Scottish west coast. In this work, in addition to the routine collections of data on vertebral counts, keeled scale units, 1_1 distributions and otolith types, increasing attention has been paid to gill-raker counts as a racial character in the light of results by German workers. A large sample of ripe Buchan spawners was also collected for detailed morphometric study as part of current international investigation of the value of these characters for racial discrimination in North Sea herring.

111. The programme of fecundity studies in relation to stock discrimination problems was also continued, with special reference to:

(*a*) the fecundities, in relation to length, of herring in maturity stages III–V in autumn (August and September), from grounds to west and south of the Hebrides for comparison with those of North Sea autumn spawners and west coast spring spawners. This analysis showed that the fecundities of the stage III fish were similar to those of Clyde spring-spawners of similar lengths; those of the stage IV fish indicated a mixture of spring and autumn-spawning fish, the relative proportion of which could be easily determined from the fecundity counts (good agreement was obtained between fecundity counts and otolith characters in separating the two groups), while the fecundities of the stage V fish were similar to those of Buchan spawners from the northern North Sea;

(*b*) the study of mixing rates of herring with high and low fecundities in the pre-spawning concentrations in the northern North Sea;

(*c*) the analysis of fecundity data for herring, in maturity stages III and IV

sampled around the coasts of Iceland in November and December 1965. The fecundities of these herring were similar to those of Norwegian spring spawners of similar lengths; there was no evidence of a mixture of low (spring spawners) and high (summer spawners) fecundity herring in the samples examined.

112. The investigation of the relationship between the stock of adolescent herring in the Moray Firth and the recruits to the adult stocks in the north-western North Sea and the Scottish west coast was continued. It was reported last year that a comparative study of 1_1 distributions of adolescent herring in the Moray Firth and of adults of the same year-class in the north-western North Sea showed little overlap, whereas the 1_1 distribution of Moray Firth adolescents and adults from the Minch fisheries showed a close correspondence. Other characters have, therefore, been examined to attempt to substantiate the evidence from 1_1 data of a link between Moray Firth adolescents and the adults in the Minch. Differences in keeled scale and vertebral counts between Minch and Buchan fish are rather small, and these characters, therefore, are unlikely to give a clear answer as to which of these stocks the Moray Firth fish recruit, but it is perhaps significant that in all the year-classes for which data are available the Moray Firth meristic counts were closer to those of the Minch stock than to those of Buchan fish. Better evidence was supplied by relating year-class strength as measured by the catch-per-unit-effort in the Inverness 'halflin' fishery to year-class strength in the Minch and Buchan stocks. There was a significant relation between the year-class strengths in the Inverness fishery and in the Minch but no such relationship between Inverness and Buchan. A paper on this topic was presented to the Challenger Society meeting in Aberdeen in April 1967.

Herring larval studies in the Clyde

113. An investigation in March 1967 of the dispersion of herring larvae from the spawning ground on Ballantrae Bank in relation to water movements in that area, using Rhodamine B dye and parachute drogues to trace the movement of the water masses, was hindered by persistently bad weather, which prevented the monitoring of larval hatching, with the result that the dye release had to be made without reference to larval distribution. However, the results on dye dispersion rates and of water movements in relation to winds (see para 286) suggest that such hydrographic techniques, in conjunction with larval surveys, could provide valuable information on the factors governing larval dispersion from the spawning grounds and permit more accurate studies of growth and mortality rates of larvae.

114. Experiments were also started in 1967 on keeping herring larvae in cages in the sea, to obtain information on growth and survival rates at different stages of development and under different environmental conditions. A pilot experiment was conducted on Ballantrae Bank during February and March, using a series of 10 cylindrical, perspex cages, 2 ft long by 6 in. in diameter, moored in mid-water with 60 mesh plankton silk netting at either end to permit the free circulation of water and the smaller planktonic organisms through them. The arrangement used for mooring the cages is shown in Fig. 2. This system worked very satisfactorily but the weather conditions encountered in this area in the spring prevented a detailed study of the larval growth and survival. Further experiments are being planned for the spring of 1968.

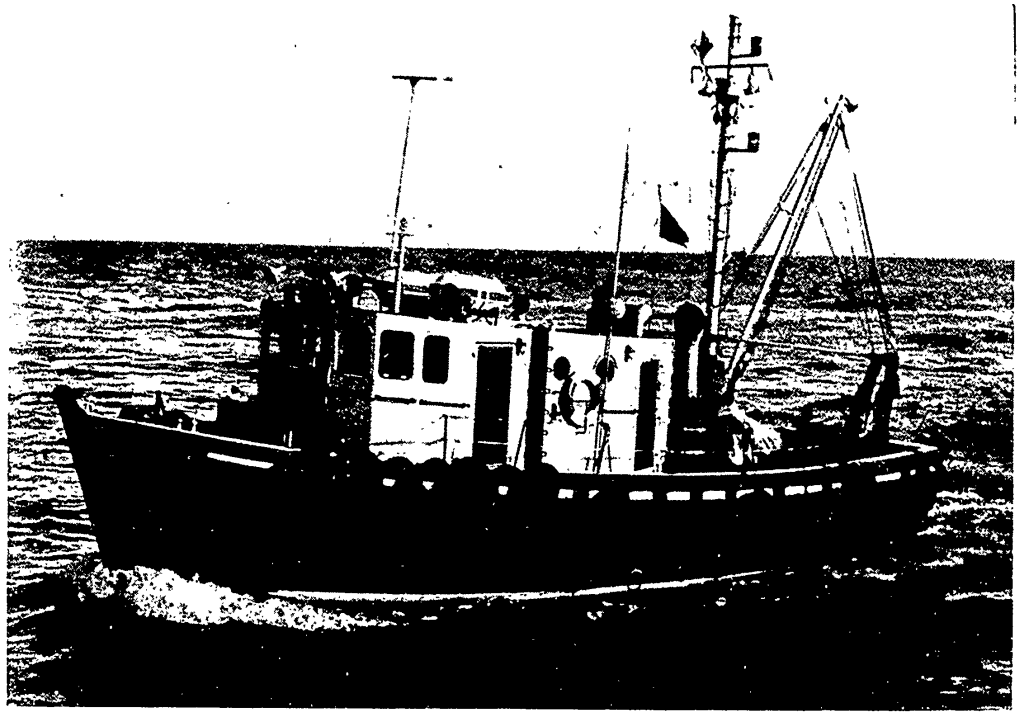


PLATE I
Shellfish research vessel 'Goldseeker'.

PLATE II
Mussel growth on rope.

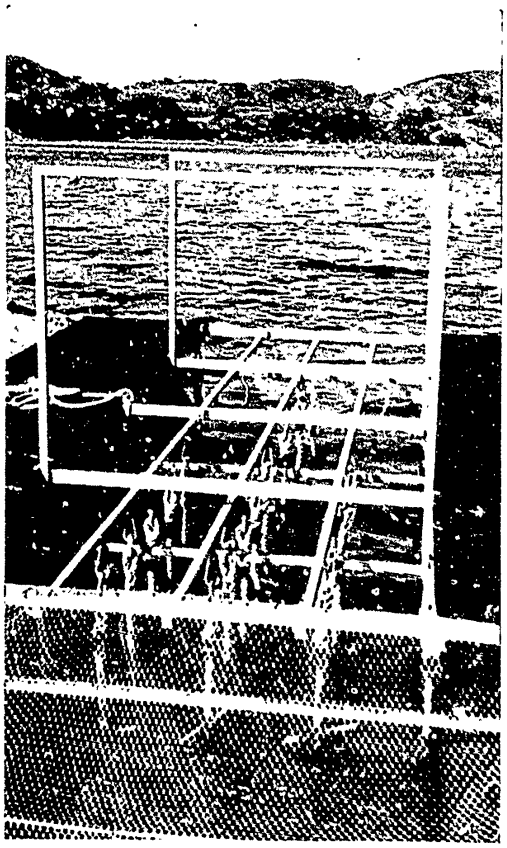


PLATE III
Mussel raft.

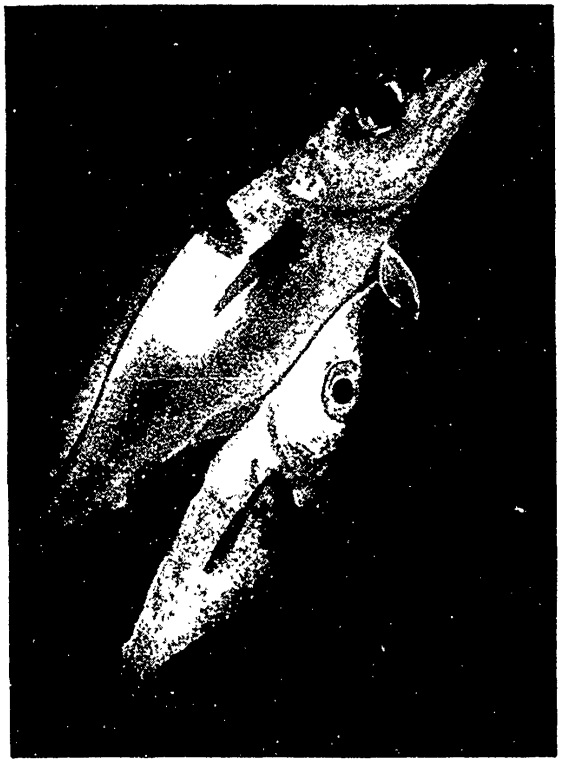


PLATE IV

Mating of haddock in aquarium of Marine Laboratory, Aberdeen, April 1967.

PLATE V
Gear research instruments on F.R.S. 'Explorer'.

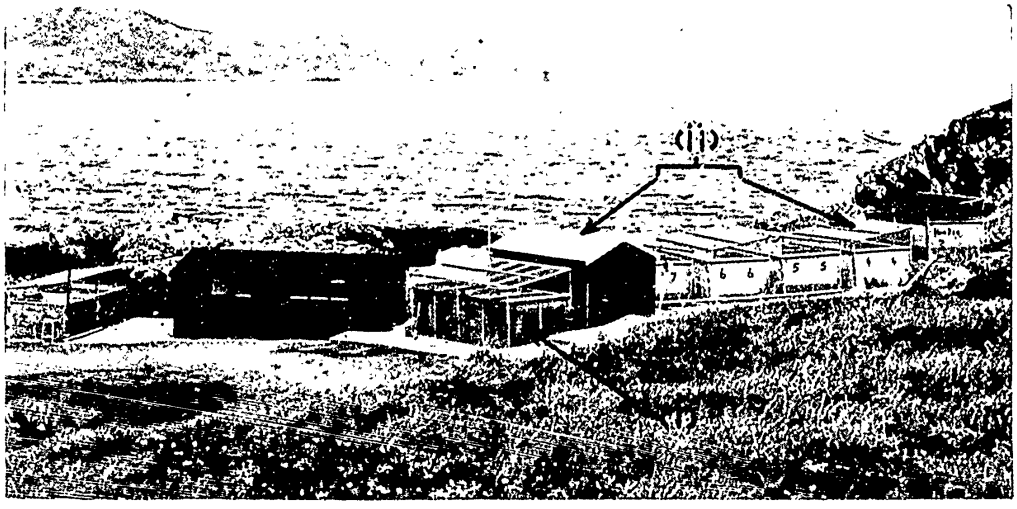


PLATE VI
Aquarium site at Loch Ewe
(i) 4 compartment tank used in enrichment studies.
(ii) 5 tanks used in plaice-*Tellina* experiments.

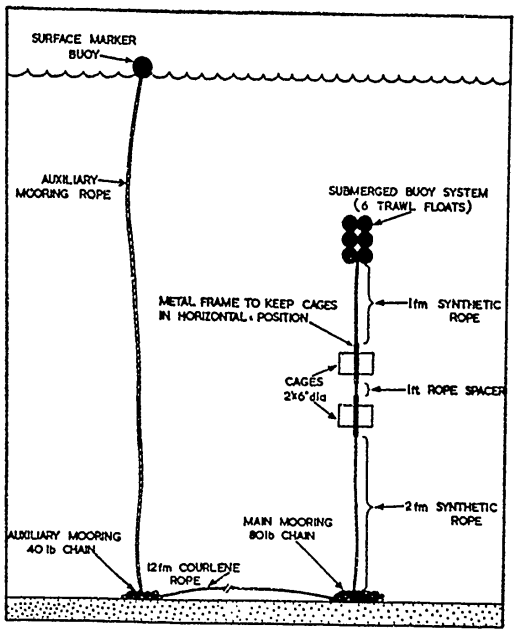


Fig. 2. Arrangement for mooring of mid-water cages.

Studies of Herring and Water Movements

115. Investigations were started in the northern North Sea in August 1967 into the local movements of herring in relation to the water masses in which they live, an understanding of which is of importance in, for example, purse-seine fishing for herring. The water movements were measured from a research vessel by plotting the movements of parachute drogues, set at the depths of fish shoals, monitored by echosounder from a small boat, while the fish movements were measured by again plotting from the research vessel the movements of the small boat whilst it kept over the fish shoals. The results from these preliminary experiments suggested that shoals close to the sea-bed maintained their geographic position (presumably by stemming the tidal current); shoals in mid-water showed active horizontal movement unrelated to the observed water movements, while shoals at or near the surface moved with the water current.

Biochemical Studies of Starved Herring

116. Mr. Wilkins' studies on the tissue of starved herring, referred to in last year's report (and mentioned here for convenience), were completed and the results were written up for publication. They show that prolonged starvation results in the depletion of fat and protein with, possibly, long-term effects on reproductive capacity. Samples of various tissues were examined histologically to determine whether large-scale loss of protein was reflected in tissue breakdown. Although the material was not suitable for detailed histological study, examination of the tissues under low power magnification showed no differences from those of normal, unstarved individuals. This result is well in keeping with the biochemical results which indicate that structural protein—such as makes up cell walls and inclusions—is not readily utilised under starvation conditions.

Sprat Investigations

117. The laboratory's limited investigation of the exploited sprat stocks in Scottish coastal waters was continued in 1967. Attention was paid principally

to monitoring the changes in the abundance and composition of the sprat stocks in these areas and in the fluctuations in the fisheries based on them.

118. At 420,000 cwt, the total Scottish sprat catch in the 1966–67 winter fishing season was little more than a quarter of that in 1965–66, when over 1,600,000 cwt were landed. The total Scottish sprat landings and those for the main fishing areas in each season since 1960–61 show that landings increased suddenly in 1962–63, and after a decline in most areas in 1963–64, the landings from one area, the inner Moray Firth, shot up to give the record landings of the season 1965–66. This was followed by a marked decline in the landings, especially in the Moray Firth, although the grand total is still appreciable in comparison with earlier years.

119. This large decrease in landings was due partly to a fall in the abundance of sprats, as indicated by a decrease in catch-per-unit-fishing-effort in each of the principal fisheries, and partly to a decrease in total fishing effort in the Firth of Forth: because of the counter-attraction of a very productive sprat fishery off North Shields, and in the Moray Firth because of the high proportion of juvenile (O group) herring in the catches, which conflicted with the existing HIB 'minimum count' direction for herring. A scientific assessment was made of the effects in the Moray Firth sprat fishery of the present rate of exploitation of O group herring on the future yields of 'halflin' and adult herring and, on the evidence provided, the HIB decided to waive this direction for the east coast of Scotland as from 2nd October 1967.

120. The age compositions of the exploited stocks varied somewhat between the different fishing areas. At Shetland, one-year-old sprats made up 98 per cent of the sampled catch while in the Moray Firth and Firth of Forth a wider range of ages was represented in the catches, with three-years-old fish dominant in the Moray Firth and two-years-old in the Firth of Forth. In both of these areas one-year-old fish were more abundant than in the 1965–66 season. Samples from the productive fishery off North Shields also showed a prominence of one-year-old sprats, which suggests that a strong year-class may join the east coast sprat stocks in 1967–68.

121. Research papers, concerning pelagic fish, published or in the press, are: 1, 22, 38, 45, 55, 56, 74, 106, 124, 125.

SHELLFISH

Staff

Principal Scientific Officer	...	...	H. J. THOMAS
Senior Scientific Officer	...	...	J. MASON
Senior Experimental Officer	...	...	C. DAVIDSON

Advisory

122. Information has been furnished to the industry on lobster storage and the potential exploitation of shrimps, cockles and mussels. Three papers were given at the Shellfish Conference of the World Fishing Exhibition. A number of other talks were given to fishermen in Scottish centres and a supplement was issued to 'Scottish Scallop Fishery' and contributions made to the Scottish Fisheries Bulletin.

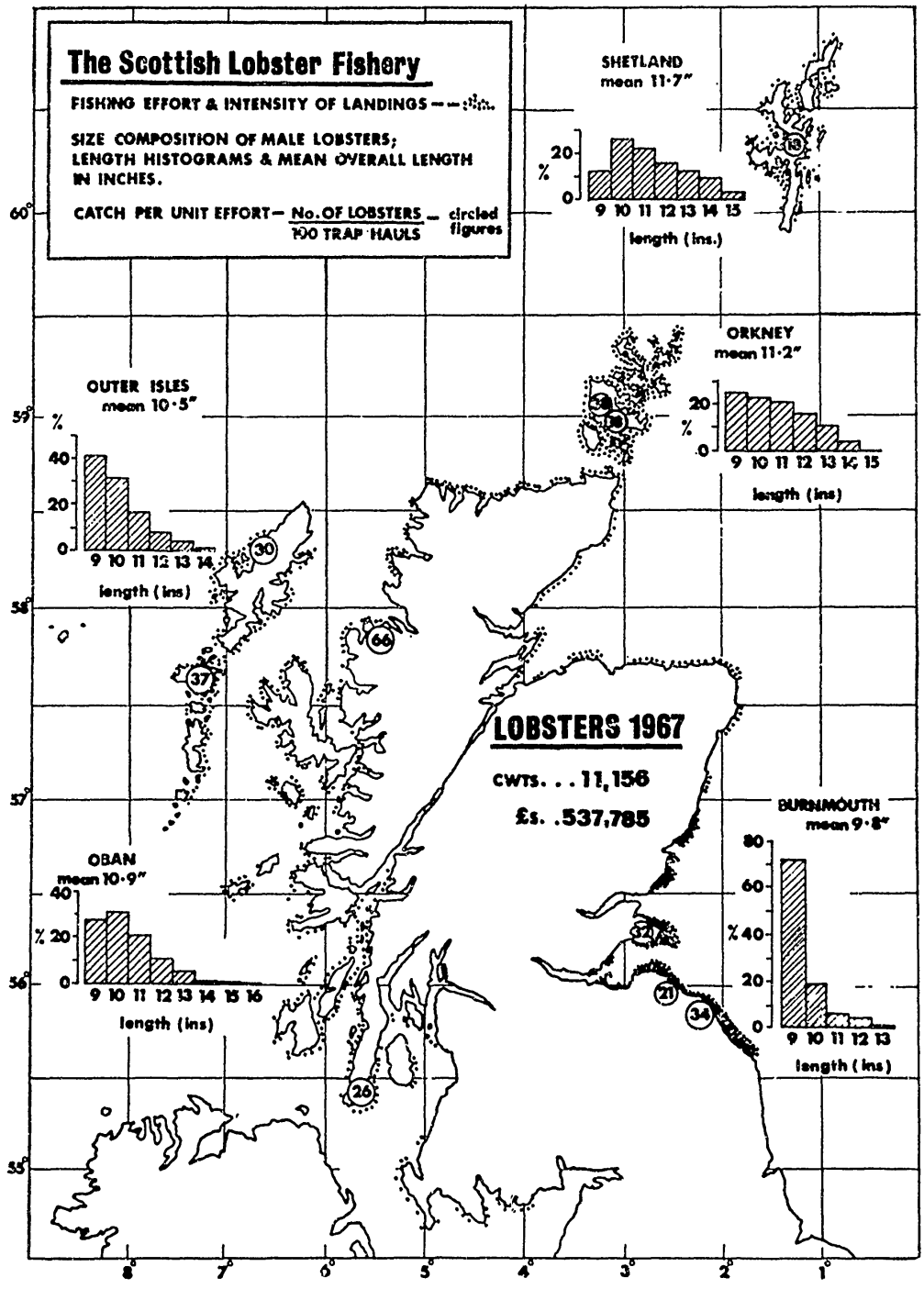


Fig. 3. The Scottish lobster fishery, 1967.

Crustacea

123. *Lobsters.* Fishermen have reported finding lobsters increasingly scarce and annual landings have decreased by some 8,000 cwt from the peak of about 19,500 cwt reached in 1961. The length composition of the commercial catch reveals a very considerable difference between the east coast and other parts of Scotland (Fig. 3). Off the south-east coast of Scotland, the average size of male lobsters taken in the commercial catch was about 9·8 inches overall length, and

well over 60 per cent of the lobsters landed are in the 'smalls' category which commands a lower market price per lb than the prime lobster weighing between 1½ and 2 lb each. Elsewhere around Scotland, the catch comprises a much higher proportion of larger lobsters. Around Orkney the average size is 11·2 in., at Shetland 11·7 in., and off the west coast a sample of the commercial catch of lobster from the Outer Isles averaged 10·5 in. and at Oban 10·9 in.

124. The laboratory has gathered data weekly from fishermen observers covering the main fishing areas around Scotland. This information includes the catch by number of lobsters per 100 trap hauls. These data, which have been gathered since 1963, indicate that the catch-per-unit-effort on the west coast has been maintained, although there has been some decrease in catch-per-unit-effort around Orkney. Catch-effort data are available from the south-east Scottish coast yearly since 1949. These show that the catch of lobsters per 100 trap hauls decreased progressively after 1960 and that during the last few years it has been lower than in 1952, the year after the minimum legal landing size was raised from 8 to 9 in. More recently, however, there has been a welcome increase from 22 lobsters per 100 trap hauls in 1965 to 23 in 1966 and to 33 in 1967—all sampled in September.

125. During 1967, tagging experiments were undertaken off the east coast of Scotland and around Orkney In the former area, 930 tagged lobsters were released on the fishing grounds. Results to date suggest a high level of fishing mortality (over 50 per cent) which is reflected in the size-composition of the stocks. In this area, even allowing for a natural mortality as high as 15 per cent (which is very unlikely) and a growth rate of 15 per cent per annum for lobsters of 9 in. overall length, decreasing with increasing size as indicated by previous growth experiments in the area, it would seem that the weight of lobsters recaptured by the fishery after growth would be 30 per cent up on the weight of 9 in.–9¼ in. lobsters if they were returned to the sea at that size. Furthermore, a higher proportion of the lobsters thus caught would then come into the prime market category and realise a higher price per lb.

126. Around the Orkney Islands, 754 lobsters were tagged and released during July/August of this year. Returns suggest a lower fishing mortality than on the Scottish east coast. Although the catch-per-unit-effort has decreased over the year 1964 to 1966, the average size has been maintained at a level above 11 in., which is well beyond the minimum legal landing size. It seems likely that the Orkney lobster stocks are not threatened by overfishing, but that the reduced level of landings in recent years has been the result of a diminished growth rate resulting in a low recruitment to the stock of marketable sized lobsters, as well as a lesser growth amongst the marketable sizes. It is also encouraging to note that the catch-per-unit-effort in 1967 is above that for 1966.

127. Observations were undertaken monthly from February 1967 on the composition of the commercial catch of lobsters landed around Orkney. The average size of male lobster from February to July was 11·2 in. and from August to October the average was 11·0 in. In conjunction with the recent increase in catch-per-unit-effort this may reflect a somewhat better recruitment to the stock of marketable-sized lobster arising after the main casting season in July/August. The percentage of females in the total catch showed a considerable increase over the months April to July.

128. Off the west coast generally, fishing as indicated by the chart is not intense in relation to the area of fishable ground. Furthermore, the catch-per-

unit-effort and the average size of lobster landed suggest that in this area the stocks may be capable of withstanding some increase in fishing.

129. *Crabs.* Routine sampling of the catch of edible crabs and the collection of catch/effort data were maintained at Burnmouth, Crail and Fraserburgh. The catch per 100 creel-hauls was less in all areas in 1966 compared with 1965:

	Catch/100 creel hauls		
	Burnmouth	*Crail*	*Fraserburgh*
1965	114·0	70·2	381·2
1966	107·0	63·5	324·7

There has been little change in mean size of crabs landed:

	Burnmouth	*Crail*	*Fraserburgh*
1965	144·5 mm	146·3 mm	154·0 mm
1966	135·6 mm	150·6 mm	145·3 mm
1967 (to September 1967)	136·4 mm	147·8 mm	149·9 mm

130. No further tagging experiments were carried out during the year. Returns continued to come in from the previous releases, and gave further information on movements and growth at the moult. Of 131 recaptures from the 1966 release off Burnmouth, 23 (10 males and 13 females) had moulted. The percentage increase in shell breadth ranged from 9·4 to 33·8 per cent. The movements conformed to the normal pattern of moulting, females moving northwards and males moving little.

131. *Norway lobsters* (*Nephrops*). The main Norway lobster grounds were sampled by F.R.S. *Scotia* in July. On the west coast, after the steady decline for 1959 to 1965, the average size of male Norway lobsters has risen marginally. In this area it may well be that the stock composition has reached equilibrium in terms of the present intensive level of exploitation. On the east coast grounds the mean size is markedly less than in 1965 (the last year of sampling) but commercial catches, equally in the Firth of Forth, are exceptionally high. It seems likely that the present low average size results from a very good recruitment to the catchable stocks.

Mean size mm carapace length of male Norway lobsters taken in F.R.S. Scotia *on specified* Nephrops *grounds*

	1959	1960	1961	1962	1963	1964	1965	1967
Firth of Clyde	—	36·5	35·8	33·9	30·2	30·1	34·8	33·5
South Minch	43·5	41·9	41·0	32·5	30·2	29·6	31·7	36·3
North Minch	45·2	42·4	41·1	39·6	37·0	36·2	36·7	38·6
Noup Deep	—	—	—	—	—	36·4	35·1	37·9
Moray Firth	—	38·4	39·7	32·0	31·6	29·2	35·0	29·4
Firth of Forth	47·7	47·4	42·4	38·3	35·9	35·9	38·7	33·7

132. Measurements were made monthly on board commercial vessels in the Firth of Forth area. The catch composition data confirm previous results on the seasonal variation in sex ratio. Females are fewer in relation to males during October to April. During May, Norway lobsters of both sexes are caught in very small numbers. External eggs are in a green condition in August to October. Females bearing eggs in the stage immediately prior to hatching are taken mainly in April.

133. Further study has been made in the aquarium on egg development and feeding rates in Norway lobsters. Papers on this work were presented to the Challenger Society and to the Shellfish Committee of ICES. Observations on the behaviour of *Nephrops* in nature are described in para. 233.

134. *Brown shrimps (Crangon).* Collection of catch/effort data for the Annan brown shrimp fishery was maintained. The average catch per boat per day was higher in 1966 (11·5 stones) than in 1965 (9·4 stones).

135. *Pink shrimps (Pandalus).* The Department continued its attempts to promote interest in the larger pink shrimps (sometimes known as prawns), *Pandalus borealis* and *P. bonnieri.* Research ship cruises were devoted to searching for stocks. Good catches of *P. bonnieri* were taken in the Clyde, in the Sound of Jura and west of Gigha, in the Inner Sound.

136. These shrimps were of a good average size, which compared favourably with the similar *P. borealis* from the Fladen Ground in the North Sea, where it is exploited commercially by Scandinavian fishermen. The mean carapace lengths were:

Pandalus bonnieri	Clyde	18·7 mm
	Sound of Jura	18·4 mm
	West of Gigha	14·9 mm
	Inner Sound	18·5 mm
P. borealis	Fladen	17·1 mm

137. In addition, fair catches of the smaller *P. montagui* were obtained in the Moray Firth.

138. The present state of our knowledge of the prospects for the future were summarised in an article in the Scottish Fisheries Bulletin.

Mollusca

139. *Escallops (Pecten).* Catch-per-unit-effort data were collected from both sides of the Firth of Clyde and from the rapidly expanding west coast fishery to the west of Kintyre. A cruise on *Goldseeker* was devoted to a study of the scallop stocks in the Clyde, and other sampling was carried out on the catches of commercial vessels.

140. During the season 1966–67, catches from the west side of the Clyde (Campbeltown District) again contained a low proportion (some 60 per cent) of 'large' ($\geqslant$115 mm) scallops. The mean length of commercial-sized scallops taken in January–March, when growth had stopped, was 121·2 mm. During this season 5-ring scallops constituted the most abundant year-group and only some 28 per cent had seven or more rings.

141. In contrast, 94 per cent of the scallops sampled from the more lightly fished east side of the Clyde (Ayr District) were 115 mm in length, and the mean length of commercial-sized scallops sampled during the cessation of growth was 131·1 mm. Seven-ring scallops were the most abundant year-class and 75 per cent had seven or more rings.

142. The catch-per-unit-effort in 1966–67 showed a further decline on both sides of the Clyde compared with the previous two seasons, though too much emphasis should not be placed on the figures for the Campbeltown district owing to the paucity of the data. Estimates of the adductor muscle meat yield per 100 hours' fishing per foot of dredge width were as follows:

Muscle weight (g) per 100 hours per foot width

	1964–65	1965–66	1966–67
Ayr District	38,400	35,100	25,200
Campbeltown District	23,000	18,500	16,000

143. The fishery on the west coast has continued to expand; several boats from the Clyde have transferred their attention to the beds west of Kintyre,

partly because of the poor catches being obtained in the Clyde. Most of the fishery has been in the Gigha area. Samples of the commercial catch revealed that 91 per cent of scallops were $\geqslant$ 115 mm in length. The mean length of scallops landed commercially in January–March 1967 was 127 mm. Of the catch, 75 per cent had seven or more rings while 32 per cent had ten or more. The muscle yield per 100 hours' per foot dredge width was 110,500 g.

144. As a result of the expansion of the west coast fishery, landings of scallops in Scotland in 1967 appeared certain to reach their highest ever value, exceeding the £79,000 of 1966.

145. *Queens* (*Chlamys opercularis*). An interesting development is the commercial exploitation of the beds of queens in the Clyde area which were reported in last year's annual report. They are being frozen and sold in family-size packs.

146. *Cockles* (*Cardium edule*). A further transplantation experiment was carried out on Traigh Mhor, Barra, and a further year's growth and survival data are available from the first experiment. The results confirm that cockles taken from an area of abundance high on the shore and transplanted to an area of scarcity low on the shore survive as well as undisturbed cockles in the area of abundance. Furthermore, the transplanted cockles grew much more quickly, probably owing to the greater time each day during which they were covered by the tide.

147. The results of these experiments were written up for presentation at the symposium on Mollusca to be held by the Marine Biological Association of India in January 1968, and would subsequently be published.

148. *Mussels* (*Mytilus*). Preliminary experiments in rope cultivation of mussels were started in the spring of 1966 in two places on the west coast, Loch Ewe, where the Department already had facilities for field work, and Linne Mhuirich. Linne Mhuirich was known to have temperatures higher than those of the adjacent open sea and to be suitable for growing and fattening oysters. The results so far are most encouraging.

149. Sisal ropes, 2½ in. in circumference, were suspended from a system of buoys in Loch Ewe in March 1966. The first settlement of mussel spat probably occurred in June 1966, and the growth of the spat was studied. By February 1967 they had attained sizes of up to 38 mm, with a mean of 28 mm. By September 1967, only 15 months after settlement, they had increased to 59 mm, with a mean of 42 mm. Mussels of the 1965 settlement, which were tied on ropes and suspended in Loch Ewe, grew from a mean size of 31 mm in May 1966 to 45 mm in May 1967 and 52 mm in September 1967. The flesh of these mussels was good, attaining a condition factor (meat volume as a percentage of total internal volume) of over 50. The ropes acquired further settlements of mussels, particularly in the autumn of 1966 and the spring of 1967.

150. The results in Linne Mhuirich have been even more impressive. Ropes and netting sleeves hung out there at the end of May 1966 acquired a dense settlement of mussel spat resulting from the spring spawning. Growth was rapid. In January 1967, eight months after the ropes were put out and seven months after settlement, the mussels formed a mass almost a foot (30 cm) thick. Individual mussels from the spring settlement had attained sizes of up to 57 mm, with a mean of 43 mm. After such a short time, the largest of the mussels were of a marketable size. In September 1967, about 15 months after settlement, these mussels measured up to 75 mm with a mean of 67 mm, and were almost all marketable. These growth rates are far greater than any recorded for naturally growing mussels in Britain.

151. The flesh of the Linne Mhuirich mussels was excellent. The condition factor reached a peak of 60·4 in May 1967, fell to a minimum of 40·2 in June after spawning, and had risen again to 58·2 in September. Estimates based on the yield of sample lengths of rope suggest that a 10 ft (3 m) long rope should yield at least ½ cwt (25·4 tg) mussels within 18 months of settlement (Plate 2).

152. In the spring of 1967, an experiment was commenced in Linne Mhuirich which was designed to study the seasonal settlement and growth of mussels on ropes and also their distribution by depth. Ropes 10 ft long are being attached to and removed from a fleet of buoys at intervals of time. A heavy spatfall occurred in May–June and settlement has continued to a smaller extent in subsequent months. Settlement has occurred at all depths on the ropes.

153. Ropes of four different kinds, 2½ in. courlene, 2½ in. coir, 2½ in. sisal and 1 in. sisal were suspended from a raft (Plate 3) in order to compare their relative suitabilities for settlement. The best settlement was obtained on coir and the worst on courlene. Sisal ropes of 2½ in. hung 2 ft apart did not attract more mussels than similar ropes 1 ft apart.

154. It has been established that conditions in Linne Mhuirich favour the settlement and rapid growth of mussels and the production of flesh of excellent quality. Summer temperatures in Linne Mhuirich were high in 1967, attaining almost 19°C.

155. *The mussel parasite Mytilicola.* Samples of mussels from Gareloch and the Firth of Forth, areas which had a heavy infestation in 1961 and a very light one in 1966, showed that the level has remained low in 1967.

156. *Squid.* Very few squid were taken on the research vessels or by commercial boats during 1967. The data on commercial landings were maintained.

Rare Invertebrates

157. A note of recent records of the crab *Geryon* sp. in waters of Britain was prepared and submitted for publication in 'Crustaceana'.

158. Shellfish papers published or in the press are: 10, 11, 39, 40, 41, 42, 48, 83, 97, 109, 110, 113.

Fish Parasites, Diseases, etc.

Staff

Unit Leader—vacant;

159. During the year, the laboratory lost the services of Dr. Kabata, the leader of the small fish parasite section, who moved to the Canadian Fisheries Research Board's laboratory at Nanaimo. His post has not yet been filled, but the laboratory was fortunate in having available the valuable assistance and advice of Dr. H. H. Williams of the Department of Natural History of Aberdeen University on aspects of the laboratory's fish parasite work.

160. With Dr. Kabata's departure the programme of detailed studies on the morphology, systematics and general biology of marine parasitic copepods was discontinued, and work was concentrated principally on:

(*a*) the investigation of the parasites infecting young plaice at Loch Ewe, as part of the detailed tropho-dynamics investigations there;

(*b*) studies of the possible use of parasites as biological tags in Atlantic salmon (with special reference to the determination of the origin of salmon exploited in the West Greenland fishery), whiting and Norway pout.

Parasites of Young Plaice

161. The analyses of parasitological data from the tank experiments with 0+ plaice in Loch Ewe in 1965 were completed and the results written up for publication. Samples from the natural population of 0+ plaice in Loch Ewe were used as a basis for comparison with the tank material. Nineteen parasite species were recorded from the 263 fish examined and some valuable information on the ecology of these parasites has emerged from this work, which should also be relevant to experimental fish farming.

162. Further studies have been made of the parasites infecting members of the 1965 and 1966 year-classes of plaice. Twenty species of parasites, consisting of 8 digeneans, 1 monogenean, 2 nematodes, 1 acanthocephalan, 3 larval cestodes, 4 protozoans and 1 copepod, have been recorded from the natural population of young plaice up to one and a quarter years old. Several of these parasites are undoubtedly harmful to young plaice, and in the past year much of the work in this field has centred around the following three trematode species which fall into this category:

163. *Cryptocotyle lingua* (*black spot*). Experiments carried out in the aquarium with infested *Littorina littorea* and 0+ plaice have shown that these fish can be killed in 10 to 14 days by continuous exposure to large numbers of cercariae of this species. The provision of a layer of sand has been shown to be an important factor in determining the site of infestation due to the habit of young plaice of burying themselves in sand with only parts of the head exposed. When sand was provided, the principal sites of infestation were the gills, whereas in tanks without sand trematodes were found throughout the flesh, skin and fins, and to a significantly lesser extent on the gills.

164. A closely related species found infesting a specimen of *Littorina littoralis* at Loch Ewe is to be investigated.

165. *Stephanostomum baccatum.* This trematode is present in plaice in an immature form and has been specifically identified by infesting *Cottus bubalis* with specimens from naturally infested plaice and allowing them to develop to an identifiable stage. Further experiments involving *C. bubalis*, *C. scorpius* and *Buccinum undatum*, the suspected mollusc host, are in progress.

166. One specimen each of *C. bubalis* and *C. scorpius* has been found naturally infested in Loch Ewe. In 90 specimens of *Buccinum undatum* from Loch Ewe in June and July 1967, one was found infested with a larval trematode suspected of being *S. baccatum.*

167. *Rhipidocotyle sp.* During the period April to September 1967, 19 out of 70 specimens of the lesser weever, *Trachinus vipera*, caught in Firemore Bay, were found to be infested with the adult form of *Rhipidocotyle galeata.* As larval stages in the group to which *Rhipidocotyle* belongs are easily identifiable and are found only in lamellibranch molluscs, several hundred specimens from 10 lamellibranch species in Firemore Bay were examined. The only species infested with a parasite belonging to this group was the mussel, *Mytilus edulis.* The possibility of these trematodes in mussels, plaice and weevers being stages in the life cycle of *R. galeata* is being investigated.

168. Two samples, each of 10 first-year plaice, were provided by the White Fish Authority from the fish pond at Ardtoe in November 1966 and in April

1967 for parasitological examination. The outstanding features of these samples were the extremely heavy infestations with the same *Rhipidocotyle sp.* Further evidence of the link between mussels and plaice in the life cycle of this trematode is provided by the fact that mussels were the only lamellibranchs known to be present in the fish pond at the time of sampling.

Parasites as Biological Tags

Salmon

169. Studies on the parasite fauna of salmon in the West Greenland area and in Scottish rivers were continued in association with tagging and serological investigations into the geographical origins of the salmon population exploited in the West Greenland fishery. Close contact was maintained with Mr. J. H. C. Pippy of the Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B., who is also examining salmon parasites as potential biological tags.

170. Fifty-seven deep-frozen salmon from the 1966 West Greenland fishing season, 20 fresh salmon from the 1967 West Greenland fishing season, 16 salmon and 16 grilse from the estuary of the North Esk at Montrose and 111 smolts from 4 Scottish rivers (Bran, North Esk, Teviot and Polly) were examined for parasites.

171. Preliminary knowledge of the parasite fauna present in salmon at West Greenland was gained from an examination of the deep-frozen salmon caught there in 1966, and a more detailed study was then made of the fresh material collected in 1967. The parasites, recorded in this study, and their rates of infection, were as follows:

	Parasite	*Percentage Infection*
Trematoda	*Diplostomulum* (larvae)	20·0
	Tetracotyle (larvae)	5·0
	Derogenes varicus	90·0
	Brachyphallus crenatus	35·0
	Lecithaster gibbosus (+?*L. confusus*)	35·0
Cestoda	*Eubothrium crassum*	15·0
	Tetraphyllidean (cestode) larvae	35·0
	Other cestode larvae	15·0
Nematoda	*Anisakis* (larvae)	85·0
	Contracaecum (adults and larvae)	100·0
Acanthocephala	Acanthocephala	5·0
Copepoda	*Lepeophtheirus salmonis*	95·0

172. From the examination of the smolt, grilse and salmon samples from home waters, 10 parasitic genera were recorded, all but one of which were also recorded in the fish from West Greenland.

173. The full value of the parasite fauna as indicators of the origin of the salmon at West Greenland cannot be assessed until the results of the Canadian studies on smolts and salmon from North American rivers are completed, so that comparisons can be made of the parasitic fauna in the two home-waters areas. In this regard, it is encouraging that the results obtained to date point to differences in the parasite fauna of smolts in Canadian and Scottish rivers.

Gilquinia squali infestation of whiting

174. The large amount of data on the infestation of whiting by *Gilquinia squali* collected in 1964 and 1965 has been almost fully worked up and at the end of the year was being prepared for publication. So far, analysis of the

records of infestation of more than 10,000 whiting in the northern North Sea has shown:

(*a*) the incidence of infestation is related to length rather than to age of the host fish, probably arising from changes in the diet of whiting with growth;

(*b*) the chances of the parasite developing to infest the final host are much greater in younger fish (the possibility of whiting developing partial immunity to this parasite as a result of an earlier infestation is to be investigated);

(*c*) the incidence of infestation is higher in northern and offshore areas than in southern and coastal areas, ranging from 15·5 per cent on the Coral Bank to 2·4 per cent off the Firth of Forth.

Diclidophorid on the gills of Trisopterus esmarkii

175. This diclidophorid (monogenetic) trematode of Norway pout has received very little attention since it was originally described by T. Scott in 1901 (Dr. J. Llewellyn of the University of Birmingham is currently comparing it with other known diclidophorids from other gadoid fish). Nearly 900 Norway pout from 12 localities in Scottish waters have been examined, revealing new information on the parasite's general ecology. The results of these investigations indicate that the parasite appears to be absent or very rare in the parts of the northern North Sea from which material has so far been obtained, but relatively common off the west coast of Scotland and at Faroe.

Studies on the Blood Flukes of Fish

176. Investigations were continued on the blood flukes of fish. A new species, *Aporocotyle margolisi*, four specimens of which were found in the bulbus arteriosus of three of 26 specimens of the Pacific hake, *Merluccius productus* (Ayres), caught off Vancouver Island, B.C., Canada, has been described. This species differs from the other three known species of the genus mainly in the wider distribution of the cuticular spines, in the ratio of the length of the oesophagus to the length of the body, in the number of testes, and in the shape of the cirrus sac and ovary. The examination of poorly fixed specimens of an aporocotylid found in the heart of *Merluccius hubbsi* from Argentinian waters suggests that the creation of another new species of the genus may be warranted.

Porrocaecum decipiens

177. Work on the 'cod worm' is described in para. 357, in relation to seal studies.

178. Research papers on parasitology, published or in the press, are: 31, 32, 60, 61, 93.

Physiology and Biochemistry

179. Just as problems of fish behaviour underlie the seasonal changes in the distribution, density and quality of fish, as well as their reactions to fishing gear, so do the internal biochemical patterns of hormone control underlie the patterns of behaviour. It is such problems that are being tackled by a small group of

endocrinologists recently appointed to the staff, whose work is described below. Another aspect of fisheries biochemistry is included in the programme concerning the serological and immunological aspects of fish stock identification. Yet others are described elsewhere, mainly in the section on Productivity.

Endocrine Studies

Staff

Senior Principal Scientific Officer	...	Dr. T. H. Simpson
Principal Scientific Officer ...	...	Dr. R. S. Wright

180. Hormones must be expected to control, in fish as in mammals, the primary patterns of animal distribution and behaviour, upon which changes in the environment impose their own modifications. Since successful commercial fisheries are based on a knowledge of the predictable distribution and behaviour of fish, it is important that the underlying mechanisms of these be understood.

Studies of Hormone Biosynthesis

181. Since it cannot be assumed that the endocrine glands of fish produce the same hormones as the corresponding glands of mammals, or even that within the range of commercially important fish, the hormones are substantially similar, studies to determine the identities of these biologically important compounds are essential.

182. Experiments on the incubation of the testis of lemon sole with simple steroid precursors were completed. The major products of the testis have been confirmed as being testosterone and androstenedione; these are accompanied by 3α-hydroxy-5β pregnane and audrostane derivatives. Similar experiments on the ripe ovary of lemon sole, though not yet complete, indicate that the female reproductive organ has the capacity to synthesise the common mammalian hormones oestradiol 17β, oestrone and testosterone, together with a number of as yet unidentified steroids.

183. Incubations of the inter-renal gland (the homologue in fish of the mammalian adrenal cortex) of lemon sole with appropriate radioactive precursors have shown that the gland is capable of synthesising the familiar hormones cortisol, cortisone, 11-deoxycorticosterone, Reichstein's substance S and 17α-hydroxyprogesterone together with their reduced derivatives. No difference in the biosynthetic capacities of inter-renals taken from male or female fish was observed. Similar experiments on the inter-renal gland of the haddock are now almost completed, and have shown that this organ synthesises substantially the same hormones as in lemon sole, but differ in not forming detectable quantities of cortisone.

184. Although the structures of the mammalian thyroid hormones are now firmly established, the evidence of the chemical identity of the thyroid hormones of fish has hitherto been unsatisfactory. Experiments were, therefore, carried out in which live plaice were injected with radioactive iodine (^{125}I) and the resulting labelled compounds were submitted to chemical examination. Chromatographic analysis of the free iodoamino acids and of three chemical derivatives provided

unequivocal evidence of the accumulation of thyroxine, 3: 5: 3'-tri-iodothyronine, mono-iodotyrosine and di-iodotyrosine in the thyroid follicles and of the appearance at the first two of these compounds in the blood plasma.

185. The results of a preliminary study, by a double isotope technique, of the details of thyroxine biosynthesis in young plaice and lemon sole suggest that mono-iodotyrosine is formed before di-iodotyrosine and that tri-iodothyronine is a precursor of thyroxine. They indicate moreover an apparent circadian rhythm in the uptake and release of iodine by sole larvae and suggest that, in this organism, the rate of turn-over of thyroglobulin in the thyroid gland is greater at 15°C than at 10°C.

186. An examination of the metabolism of radioactive thyroxine in the plaice is now nearing completion. The main excretory pathway has been shown to be via the liver and bile. Chemical identification of the iodine-containing constituents of the bile and of their co-occurring sulphates and glucoronides indicate that thyroxine breakdown occurs, as in the dog, by non-specific de-iodinating enzymes and by deaminases.

Blood Plasma Analysis

187. Studies of the relationship between the behaviour and physiological status of fish have necessarily, hitherto, relied solely on histological evidence in assessing the activity of endocrine glands; such evidence is frequently difficult to interpret and impossible to express quantitatively. In contrast, chemical determination of the concentrations of hormones circulating in the blood and free to affect the target organs constitutes a direct method of assessing endocrine status.

188. The method of determining individual thyroid hormones in blood, reported last year, was further refined; its sensitivity is now such that 0·1 ml samples of blood may be satisfactorily analysed. Use of this method to determine thyroxine and tri-iodothysonine concentrations in the blood of tank-held plaice has given results of 0·05μg/ml and 0·01μg/ml respectively.

189. A double isotope method was developed for the analysis of steroid hormones in blood plasma; the size of sample required is approximately 1 ml. Cortisol and cortisone concentrations in the plasma of tank-held plaice were found to be of the order of 0·15μg/ml and 0·02μg/ml respectively.

190. The employment of these methods in relating the endocrine status of fish to seasonal and environmental changes was delayed by the difficulty in securing time on the liquid scintillation spectrometers in other laboratories. Delivery of a suitable machine to the laboratory is expected in January 1968.

Histochemical Studies

191. Although histochemical procedures have, as indicated above, certain limitations, they offer the easiest way of determining the cellular sites of hormone synthesis and of observing changes in the structure of the endocrine gland.

192. Observations, reported last year, on seasonal changes in the cellular distribution of a steroid synthesising enzyme in the testis of the spurdog were related to seasonal changes in the relative quantities of the various hormones produced in incubation experiments, and the results were published.

193. The sites of steroid synthesis in the gonads and inter-renal tissue of the haddock were examined. Synthesis of hormones in the testis appears to be limited to the strands of connective tissue which divide the testis into lobules.

In the ovary, steroid biosynthetic enzymes are localised in the cells of the granulosa layer which invests the ripening ovum. The inter-renal gland of the haddock has been found to be less discrete than that of flat fish and to be located as a surround to the cardinal veins which meet in the head kidney to form the Cuverian ducts. No sites containing steroid biosynthetic enzymes could be discovered in other regions of the head kidney.

194. A complete series of seasonal samples of gonads, inter-renals and pituitaries of haddock was collected and either fixed or frozen. These samples will be examined in order to discover whether in haddock, as in spurdog, there are periods of pituitary and gonadal disfunction.

Studies of Stress Reaction

195. Investigations of stress in plaice following trawl capture and tank adaption were extended. Analytical techniques have been improved by the introduction of a specific enzymatic method for the determination of blood and muscle lactate. A series of experiments was carried out in which plaice, which had been held in tanks for various periods after trawl capture, were forced to exercise and the levels of glucose, glycogen and lactate in muscle and blood were determined at various intervals after this activity. The results indicate that muscle lactate rises and then falls, apparently stoichiometrically with falling and rising levels of muscle glycogen, the sum of the two levels remaining approximately constant at 250–300 mg/100g of muscle (expressed as glucose). In contrast, blood lactate levels show a slight fall after exercise. These results suggest that trawl or tank stressed plaice suffer an impairment in the circulation to the muscle, a hypothesis which is in accord with observations of the behaviour of plaice when hunted. It is tempting to speculate on the evolutionary advantage of such an adaption.

196. The changes, following capture, in the laematocrit values and freezing point of haddock blood and the onset of diuresis in this fish were found to follow similar patterns to those described in the plaice. Samples of blood plasma, collected from haddock at various stages of tank adaption, were collected for determination of their hormone levels; these will be related to the physiological status of the fish.

197. The results of these investigations and of the endocrine studies of the section were communicated at a recent meeting of the Challenger Society.

198. A member of this unit (Mr. C. S. Wardle) took part in the cruise (July 14–August 26) of R.R.S. *Discovery* to investigate the physiology of deep sea fish. Haematocrit values of these animals were almost invariably low (5–15 per cent) and blood sedimentation rates were high. It is not yet clear whether these features were the result of the release of pressure in bringing the fish to the surface. Samples of the gonads and semen of six species of deep-sea Squalidae were collected for laboratory examination.

Analytical Techniques

199. The quantities of hormones present in the endocrine glands and blood of fish are probably at least one order of magnitude lower than in human subjects. For this reason, accentuated also by the physically smaller size of fish, it was expected that fish endocrine studies would demand vastly more sensitive techniques than those available to the medical endocrinologist.

200. A limit to the sensitivity of radiochemical methods in hormone analysis is the intrinsic background counting rate of the detector system. A low back-

ground detector system has, therefore, been developed for the location of trace quantities of ^{125}I labelled thyroid hormones on thin layer chromatograms and a cosmic guard assembly has been designed, the use of which gives a twenty-fold increase in the sensitivity of detection of radio-active materials on a gas chromatograph. Mass detection by G.L.C. is currently being improved by modification to the flow control and injection systems.

201. Difficulties in analysing nanogram (10^{-9}g.) quantities of steroid hormones by gas chromatography have been traced to contamination of the sample by minute quantities of sebum originating in fingerprints. An apparatus has been described for the elution of hormones from thin layer chromatograms without risk of contamination.

202. A method has been devised for the removal of certain components of blood plasma which interfered with the analysis of thyroid hormones.

Serological Investigations, etc.

Staff

Senior Scientific Officer ... ... N. P. Wilkins

Salmon (Salmo salar)

203. The main effort in the laboratory's programme of serological and related studies was again directed towards the investigation of the racial composition and home-river origins of salmon exploited in the coastal fishery off the west coast of Greenland, in accordance with recommendations of the ICES/ICNAF joint working group on North Atlantic salmon. Material for analysis was collected from salmon at West Greenland, during the course of the fishing seasons there in 1966 and 1967, from parr, smolts and salmon in a number of Scottish rivers and from salmon in Canadian rivers.

204. Analyses were made of red-cell agglutinogens, polymorphisms of the enzymes, lactic hydrogenase, liver esterases, and serum protein variants. The following results have so far been obtained from the analyses conducted:

(a) The analyses of red cell agglutinogens indicate that salmon from Scottish and Canadian rivers can be distinguished by the strength of their reactions, and that the salmon population at West Greenland in 1966 contained a mixture of fish from different origins. It was not possible, however, from the material available to estimate the mixing rates of salmon of different origins. Further analyses of these characters were being made on blood samples collected at West Greenland during the 1967 fishing season, using more specific anti-sera.

(*b*) An analysis of lactic dehydrogenase from the muscles, heart and other tissues of over 60 salmon from West Greenland and from Scottish rivers provided no evidence of polymorphism which could be attributed to racial differences. Further studies of this enzyme are, therefore, being discontinued in relation to the identification of salmon stocks at West Greenland.

(*c*) Following claims by Swedish workers that salmon of different origins can be identified from the electrophoretic patterns produced by their

liver esterases, an analysis was started on this character on salmon from Scottish rivers and from West Greenland. Preliminary results of an analysis of material from 20 salmon from Scottish rivers showed no differences in the esterase patterns in these fish, but differences were observed in material from West Greenland salmon sampled during 1967. Further studies of this character were, therefore, proceeding.

(*d*) Studies of the serum protein variants, using anylamide gel disc electrophoresis, were started, but insufficient material was analysed for the value of this character in salmon stock identification to be assessed.

205. It is evident from the above that this work has not proceeded sufficiently for the full value of these serological methods in the elucidation of salmon stocks at West Greenland to be fully assessed, but it is clear that some of the characters exhibited polymorphism, which was promising.

206. In addition to the above investigations relating to the problem of stock identification in salmon, further investigations were made of the changes in the electrophoretic patterns of salmon haemoglobin during growth and maturation. This work was conducted in collaboration with Professor Koch of the University of Louvain, and the complete sequence of changes in pattern was worked out. This study was also extended to sea trout for which similar but smaller ontogenetic changes in haemoglobin pattern were established.

207. Work on other marine species was also continued during the year as time permitted.

Cod (*Gadus morhua*)

208. Studies of haemoglobin types of cod in Scottish waters were completed. Evidence has accumulated that the gradual cline noted in cod haemoglobin types along the Norwegian coast is also present in the north-western North Sea, along the coast of Scotland and to the north of Shetland. The haemoglobin type frequency of cod in the Minch does not differ significantly from that outside the Minch, e.g., around the Flannan Isles. Abnormal haemoglobin types have been observed from all the Scottish areas sampled, although the highest frequency of abnormal types is in the Moray Firth and along the east coast.

Lythe (*Pollachius pollachius*)

209. A hitherto undescribed haemoglobin polymorphism has been observed in the lythe *Pollachius pollachius*. The observed electrophoretic patterns can be explained by a simple two allelle genetic system governing the extression of three distinct haemoglobin types.

Blue Whiting (*Micromesistius poutassou*)

210. Haemoglobin of *Micromesistius poutassou* was analysed in the course of an Atlantic survey cruise of F.R.S. *Explorer*. No evidence of polymorphism of racial-segregation value was observed.

211. Biochemical research papers published or in the press are: 23, 59, 100, 107, 112.

Fish Behaviour Investigations

Staff

Deputy Chief Scientific Officer	...	B. B. Parrish
Senior Scientific Officer ...	...	C. C. Hemmings
Scientific Officers	...	C. J. Chapman
		A. D. Hawkins

212. The programme of fish behaviour research in 1967 was mainly concerned with a continuation of basic investigations of the parts played by visual and acoustic stimuli in the behaviour of fish both as regards their natural life and in response to the stimuli generated by fishing gear. Attention was paid particularly to:

(*a*) problems of underwater visibility and factors governing it in Scottish coastal waters;

(*b*) further studies of the reactions of fish to sound stimuli;

(*c*) sound production by fish and its biological significance especially in relation to spawning behaviour.

213. Owing to the lack of experimental tank facilities for some projects, especially those concerning the reactions of fish to sound stimuli, most of the work was again conducted in the field. For this purpose, a temporary shore-based laboratory was set up in Loch Torridon, Wester Ross, where much of the programme of work on the reactions of fish to sounds was conducted.

214. Progress with the development of the towed, dry underwater vehicle for observing fishing gear and fish behaviour was slower than had been hoped, but the half-scale model has now been built and is currently being tested under controlled tank conditions (see also para. 252). It was hoped that the electronic sector scanning sonar equipment, currently under development, would also become available for use in this programme of work in 1968.

Diving in the Research Programmes

215. The use of diving techniques figured prominently in the laboratory's behaviour programme, and further diving training for members of the laboratory staff was provided by Dr. Hemmings and Mr. J. Main. In all, there are now six fully trained divers in the behaviour unit and twelve in other units.

Underwater Visibility Studies

216. Further investigations of underwater visibility were made in Scottish coastal waters. Particular attention was paid to the influence of slight changes in turbidity and surface light distribution such as the effect of the movement of clouds in front of the sun on underwater visibility. The standard range of visibility targets, which are perspex rectangles painted black through grey to white, was used for all this work. The effect of varying light distribution and turbidity has a great effect on the distance at which the middle range of greys can be seen. It is the visibility of these low contrast targets which is most closely related to the problem of how far one fish might be able to see another fish, which is similarly a low contrast target, or an element of a fishing gear.

217. Observations with polaroid analysers attached to divers' faceplates

continued and a number of sightings of targets obtained with 100 per cent cloud cover confirm the significance of polarisation of underwater space-light by scattering in turbid water. Preliminary results were also obtained with magenta (minus green) filters in face masks, to parallel work done in the Mediterranean with yellow (minus blue) filtered face masks. These colour filters have the effect of changing the luminance of the water background and thus the contrast of objects seen against it. Some fish do have yellow filters but as yet none have been found with magenta filters.

Laboratory Work on Fish Vision

218. Work on the development of a perspex circular tank and its ancillary apparatus, for studying optomotor responses of fish, proceeded intermittently during the year. A 9 ft diameter perspex ring was installed and a 6 ft diameter circular mirror erected above it for cine camera viewing. A motor and chain drive for the movement of the backgrounds which result in the optomotor response of the fish in the tank was installed; this will achieve a speed of approximately 3 knots in the centre of the tank.

Sound Production by Fish

219. Studies proceeded on various aspects of the sound-producing behaviour of fish. These were mainly concerned with examination of the acoustic repertoire of different species of Gadidae and Triglidae, and investigation of the mechanism of sound production in these fish. Particular attention was paid to acoustic measurement of sounds produced by different species in aquarium tanks and in the sea.

220. It is now clear that the sounds produced by different species of both the Gadidae and Triglidae are composed of trains of short, similar pulses, repeated at different rates. Variation in the repertoire of the sounds is based on changes in the rate at which these pulses are produced. Thus, for the haddock, sounds produced in aggressive and defensive behaviour consist of low frequency pulses, reiterated slowly to give a repetitive knocking. By contrast, however, the sounds produced by male fish during courtship (see below) consist of similar pulses produced at a much faster rate, giving a quite different, continuous, humming sound.

221. This use of amplitude-modulated sounds by marine fish is of great interest. Though many workers have suggested that fish can distinguish between sounds of different frequency, this ability does not appear to be utilised in the sounds that fish produce themselves. Previous studies on the hearing of fish have invariably been concerned with pure tone stimuli, or sounds of long duration, with no variation in amplitude. The use of amplitude variations by fish in their own sounds suggests that future work on fish hearing should also concern stimuli showing amplitude modulation.

Spawning Behaviour of Haddock

222. Hitherto, little was known of the spawning behaviour of haddock, but an opportunity to observe and study it in detail was presented in April 1967, when haddock spawned in the laboratory's aquarium. Detailed observations were maintained on the group of fish concerned, and true courtship behaviour and a 'spawning embrace', were demonstrated and recorded for the first time.

223. The behaviour prior to spawning was also striking, involving aggressive displays between male fish, and courtship displays between one of the males and

the mature female. Throughout this preliminary behaviour, all the male fish produced intense sound (see para. 220), and these sounds were accompanied by pronounced visual displays.

224. Courtship behaviour involved the leading of the female fish about the tank by the male (the latter showing greatly exaggerated swimming movements), a marked change in pigmentation of the male, and the production of a characteristic humming sound. This prolonged courtship culminated in a sexual embrace, where the male adhered to the female (ventrally), as shown in Plate 4. With the two fish held together in this embrace, they then swam upwards, releasing eggs and milt. The same two fish spawned repeatedly at intervals of about 26 hours, some 14 spawnings occurring in 19 days. The number of eggs shed at each spawning was estimated on five occasions. These ranged between 7,500 and 16,500 with a mean of about 12,000. Estimates were also made of the fertilisation rate by examining random samples of eggs taken from the tank at intervals after spawning. These observations showed that fertilisation took place within 25 minutes of the eggs and sperm being released. The fertilisation rate was high, ranging from 86 to 94 per cent. These observations were of value in suggesting that the reproductive behaviour of haddock in the sea is complex, involving aggressive and courtship displays, pigment change and sound production, and culminating in a sexual embrace. They have obvious implications for population dynamics studies and even for the commercial fisheries.

225. A report on these observations was presented to the Challenger Society meeting in Aberdeen in April, and short papers describing them were also published in Nature and in the Scottish Fisheries Bulletin.

Responses of Fish to Sounds

226. In 1967, experiments were conducted at Loch Torridon on the sensitivity and reactivity of lythe (*Pollachius pollachius*) and saithe (*Pollachius virens*) to pure tone sound stimuli of different frequencies, using an 'avoidance' conditioning technique. The experimental procedure consisted of placing a fish in a small tank, partially divided into two halves by a barrier, which the fish could cross with some difficulty. It was then presented with the sound stimulus, followed, if it did not cross the barrier, by an electric shock. Conditioned responses were successfully established to sound stimuli in the frequency range 140–500 c/s. The intensity of the stimulus was varied for each frequency so that the threshold intensities for each could be determined. The estimated thresholds for three specimens of lythe, 23 cm in length, for different frequencies, were as follows:

Frequency c/s	*No. of determinations*	*Mean threshold dB/1 μB*	*G dB*
140	3	−4·2	2·2
200	2	−6·9	3·6
300	6	−8·9	3·8
400	7	−2·2	6·5
450	4	4·9	6·3
500	4	14·3	2·0

227. These results show that the lowest intensity threshold occurred for sounds at a frequency of about 300 c/s. No fish exhibited conditioned responses to sounds of frequencies above 500 c/s. The results obtained for saithe of the same size were similar.

228. The results of the experimental work on the effects of noise on herring,

carried out in tanks at Cairnryan in 1966 were analysed during the year. In these experiments, herring were tested singly by placing them in a linear canvas tank measuring 12 ft × 2 ft. This was immersed in sea water (depth 1½ to 2 ft) contained inside a large concrete tank. 'White' noise was introduced into the canvas tank through an underwater loudspeaker placed outside it at one end. A gradient of noise corresponding to a cylindrical spreading law was found to be present along the length of the canvas tank and the movements and positions of the fish in relation to this gradient were recorded by time-lapse photography. Before and after the periods of stimulation by noise the positions of the fish in the tank were recorded as controls for comparison.

229. Statistical analysis of the results showed that there were significant differences between the frequencies of occurrence of the fish in different parts of the tank during control and noise stimulation periods respectively. These differences were due to an avoidance of the region of the tank nearest to the source where the intensity gradient was steepest. There was some evidence that the magnitude of the response was related to some function of the sound intensity (i.e. rate of change of intensity or an absolute intensity change). Further work is planned to elucidate this problem.

230. Echosounder observations on the reactions of whiting to intense, low frequency sound pulse, from a compressed air source were made from F.R.S. *Mara* in Loch Torridon in April 1967. The fish were first observed from the stationary ship as a thick, layer trace on the echosounder, extending in depth from 15 to 30 fathoms, but on production of the sound pulses at 10 second intervals the upper part of the echotrace quickly disappeared and a denser, more compact trace, 3 fathoms thick, appeared about 30 fathoms. It was not possible to determine whether the fish in the upper part of the trace dived to the lower level or whether they moved laterally out of the beam of the echosounder, but the change in the density of the echo-trace at the lower level suggests that at least part of the concentration moved downwards in response to the sound stimulus. The observations also showed that when the bursts of sound pulses were produced over successive periods of about 5 minutes, with silent intervals of 2–3 minutes, the top of the echotrace rose towards its original depth; this suggests that the fish were becoming habituated to the sound stimulus.

Echo Detection of Fish Using Low Frequency Sound

231. The laboratory again co-operated with the National Institute of Oceanography on low frequency echo detection of fish, using F.R.S. *Mara* in Loch Torridon, where special moorings had been laid by the Admiralty, which enabled *Mara* to maintain station over a deep water position suitable for the experiments.

232. Echoes were obtained from individual haddock (at 47 cm), whiting (at 39·5 cm), saithe (at 32 cm) and lythe (at 39 cm, 39·5 cm and 55 cm) in polythene containers at a depth of 30 m below the ship. Prior to testing, the fish had been held in keep cages to allow equilibration of their swim-bladders to working depth. A variety of transducers were used which operated in the frequency range 3 to 50 kc/s and included the new wide-band system designed and built by Birmingham University. The records taken during these experiments are being analysed to provide much-needed data on the target strengths of these species of fish at low frequencies and on the acoustic properties of swim-bladders.

Observations on Aspects of the Behaviour of Nephrops

233. During the course of the programme of behaviour work at Loch Torridon, fairly detailed observations were made by means of a still camera with electronic flash, and by underwater television, kindly supplied by the Lowestoft Laboratory, on aspects of the behaviour of *Nephrops*, particularly in relation to their burrowing habits. The observations were made over a small area in the loch at a depth of 100–110 ft. In this locality the density of burrows averaged 9 per square metre.

234. Prolonged observations of individual, tagged *Nephrops* and their burrows over a period of 11 days showed that each *Nephrops* was associated with the same individual burrow throughout this period. During daylight, individuals left their burrows at least once each day for periods of up to 4 hours, presumably for feeding, but they always returned to them at the end of the foraging period. 'Strangers' were often observed inspecting and sometimes entering the empty burrows of other *Nephrops* during the periods of absence, but on all occasions they left them again almost immediately. This suggests that the location of burrows after foraging may be by a combination of random search and home burrow recognition.

235. Aggressive fighting behaviour between individual *Nephrops* was observed on a number of occasions. It appeared to be a highly ritualised type of behaviour, involving sparring with the main claws held out at right angles to the body. Such behaviour was observed to last for periods of up to 20 minutes, before one of the contestants would break off the encounter and retreat by flicking its tail. The clashing of the claws during sparring actions produced sharp, snapping sounds which could be easily detected by hydrophone.

236. A difference was observed between the behaviour of large and small *Nephrops* when in their burrows. The larger individuals (over 50 mm carapace length), which were found to be mainly males, were observed lying in the entrance of the burrows with their claws protruding and, on the approach of a diver they would leave it and advance towards him, when they could be easily caught. The smaller *Nephrops*, on the other hand were generally well concealed in their burrows by day and were seldom seen, but their presence was made evident by tracks in the mud at the burrow entrance and by observations on their burrows at night, when their foraging activity was greatest.

Power Station Studies

237. The laboratory's small programme of work on the assessment of the quantities of fish taken in with the cooling water at power stations around the Scottish coast has been continued. In the summer of 1966, the Carolina Port power station, Dundee, experienced difficulties through the smolt screens becoming blocked with debris, and it was arranged that measurements should be made of the quantity of fish entering the cooling water intakes when the smolt screens were raised during the off season for smolts. A routine sampling programme was worked out with the power station personnel and the weekly catches of fish, shrimps and trash were recorded. The results showed that the fish catch was small, the weekly catch never exceeding 55 lb. The principal species caught were viviparous blenny, flounder, armed bullhead and pipefish; only small numbers of the commercially important species, herring, sprat, whiting and saithe, were taken. This sampling programme was continuing.

238. There has been no further routine sampling of the fish catch taken at the Kincardine power station since last year's report was prepared, but further

experiments on the behaviour of fish in the vicinity of the intake culverts were made in October 1966, in collaboration with the Department of Electrical Engineering at Birmingham, who once more made their sector scanning sonar equipment available for these studies. Further experiments at Kincardine were also made in November 1967, in collaboration with the N.I.O. and Birmingham University, on the possible scaring effects of high intensity, pulsed sounds on fish in the vicinity of the intake culverts. No marked effects on the numbers of fish entering the culverts during periods with and without sound production were evident from records of catches and the band screens, but a more detailed analysis of sector scanning sonar records is being made to detect possible behaviour changes during these times.

239. A final report on the routine sampling and experimental work done at Kincardine in 1961–65 was prepared.

240. Research papers on behaviour etc., published or in the press, are: 2, 3, 17–21, 37, 82, 90, 91, 132–136.

Fishing Methods, Fisheries Engineering, Etc.

Staff

Principal Scientific Officer	...	...	J. J. Foster
Senior Scientific Officer	...	...	D. N. MacLennan

241. Although the appointment of a Senior Scientific Officer at the beginning of the year has considerably advanced the work of this unit, it has not yet proved possible to fill the other Scientific Officer vacancy owing to lack of suitable candidates, and the unit is seriously under-staffed at other levels in relation to the development of the programme and the increasing liaison with the industry. Indeed, the latter is developing so rapidly that there is now a real need for an advisory section of the unit to be developed, and additional staff has been requested accordingly.

Demersal Trawling Gear

242. The staffing problem meant that some of the work originally planned in this field had to be postponed, but considerable progress was made, especially as regards the performance of otterboards. A combination of the results obtained during experiments from *Mara* and *Clupea*, with various otterboard types, are providing a much better understanding of otterboard performance. Cambered, 'V' type and standard boards of various sizes were used with standard nets and rigging and comparison of otterboard spreads over a wide range of speeds and ground conditions was obtained. The full-scale results clearly indicate that the cambered otterboards have a spreading power more than 30 per cent greater than the standard flat boards, while the 'V' type boards have between 5 and 10 per cent less when frontal area is taken as the standard for comparison. By altering the up-pull on the boards by the warps, or by changing board size or shape, headline heights of a wide range can now be predicted and achieved according to requirements, which is providing a sound basis on which decisions for commercial applications, and for scaling up to the sizes of larger boats, can be based.

243. Measurement of towing speed is vitally important in this work, and has still to be achieved with the desired degree of accuracy, although the laboratory's speed log used together with Decca readings has given considerable improvement over past work.

244. During the year, the section participated in all three of the cruises directed to the exploration of the blue whiting stocks to the west of the British Isles, an appreciable part of this programme being allocated principally to developing a suitable trawl for the programme. The necessity for small mesh (to avoid escape of this relatively small fish) presented design problems, but an effective gear was obtained by the use of a SARO-type trawl, with special modifications.

245. On completion of the modifications made to *Explorer*, in order to allow her to trawl from both sides, a cruise was undertaken to establish any differences in performance between trawling on the two sides. The results showed no statistically significant difference, and this has permitted a further conjoint programme with the *Ernest Holt*, on comparative fishing and development of the SARO gear, to be designed accordingly. Should this test suggest that a better optimum performance is not found with the longer bridle lengths, then it seems likely that the associated pressure fields, etc. are even more important than has been anticipated, and appropriate experimental work will be designed accordingly.

246. In addition to the handling experience gained with the programmes concerning otterboards, and the industrial exploratory fishing, a series of trials with different fishing arrangements on *Goldseeker* considerably advanced understanding of the interrelationship between gear and ship for handling purposes. There is no doubt that gear handling is a most important aspect of fishing, and accordingly considerable thought has been given to this aspect in preparing the final specification for the new *Scotia*; this necessitated a detailed study of the handling problems experienced by commercial firms with stern trawlers of various sizes and powers.

Pelagic Trawling Gear

247. Under this head, two small single-boat midwater trawls were tested on *Clupea* and, although she has neither adequate winch nor engine power for this technique, a considerable amount of useful data was obtained; net mouth openings of 30 ft (vertical) were obtained with a board spread of approximately 70 ft. This system proved to be very stable and, at speeds of three knots, it was possible to control the gear to fish in any position from one fathom off the bottom up to and including the surface.

248. In addition to designing a bottom trawl for exploratory voyages on blue whiting, the design and testing (with full instrumentation) of a pelagic trawl for this project was also completed, and two versions, with wide openings but relatively low drag, were provided. Specially designed Sübercrüb type boards were used. Unfortunately, there was little success on the odd occasions when it was possible to fish this gear during the exploratory voyages, although this may have been due to the absence of fish at the depths tried; the echo-traces on which fishing was directed were never in fact identified and may have represented smaller organisms which could escape through the meshes.

249. Meanwhile, a considerable amount of theoretical work and analyses of published work on pelagic pair trawling was begun; although no practical work has yet been possible on research vessels, the results were used in liaison with the industry.

Seine Nets

250. Unfortunately, the work planned on the Danish seine for this year had to be postponed owing to pressure of work in other fields, although studies on the development and application of synthetic floats and bobbins as well as metal core warps continued, as did discussions with and advice to the industry.

Underwater Work and Model Nets

251. Following the analysis of the results of the successful international Mediterranean project (last year's report), the members of the IF Group met in Aberdeen to consider their various contributions to the project. As a result, planning is in progress for another such project in 1968, if circumstances permit, incorporating relevant design modifications in the experimental gears.

252. The acquisition of a towed underwater vehicle suitable for observing fishing gears, and the behaviour of fish in relation to them, was held up through design and other problems encountered by the manufacturers. With the kind assistance of Ship Division of the National Physical Laboratory, a series of further model tests is now well under way, for which assistance the laboratory is extremely grateful. The tests so far completed indicate that the design philosophy of the vehicle should ultimately be successful.

Materials

253. The routine investigations on twine materials were continued, and the effects of different treatments during manufacture on strength, durability, etc., were studied in detail. Sets of graphical representations, showing diameter against runnage, are now available.

Instrumentation

254. Undoubtedly one of the most important problems tackled during the year was the extensive preparatory work in advance of tendering for a ship-borne, on-line data logging system for *Explorer*, with all the relevant component studies, consultations with other sections and planning for integration with this instrument of the net telemeter already under construction. A final report on discussions with computer manufacturers was completed, on the basis of which HMSO will be inviting tenders.

255. *Ship-borne, on-line, data-logging system.* As part of the feasibility study, a comparative costing between alternative systems was made, which clearly showed the advantages of the system in mind, not only for improved quality of research, but also for planning and use of ship's time in research operations, etc. This report is an extensive one, specifying the minimum performance necessary, with details of a model system, so that manufacturers' proposals could be measured against this. The operational requirement was issued to manufacturers in May, with initial discussions taking place during the following weeks (during which the number of manufacturers interested was reduced). These discussions were completed by the middle of August, when a suitable configuration of equipment was agreed, in close collaboration with representatives of Treasury O & M 2 and the Technical Support Unit of the Ministry of Technology.

256. Most of the instruments used at present on *Explorer*, both on board (Plate 5) and under water, will require modification before they can be con-

nected to the on-line system or, in some instances, replaced with more suitable or up-to-date equipment. All the interface connections for these were specified or, where necessary (e.g. with the Decca Navigator) agreed with the company concerned.

257. Acoustic links or separate cable connections are the more conventional techniques for transmitting real-time data from the underwater parts of the gear and, as the latter is inconvenient because of the likelihood of damage, the most suitable method is likely to be by acoustic link, even though sea water is by no means an ideal medium for the transmission of information. Theoretical work and experimental investigation is, however, proceeding in collaboration with firms and other Government establishments, into the possibility of transmitting data via a conductor contained within one of the towing warps and, if this technique should prove practicable within a fishing environment, its expected reliability and high data-transmission rate should enable more of the power of the computer-based system to be utilised.

258. While obtained primarily for monitoring the various sensory elements in connection with fishing gear investigations, the ship-borne computer will also be available for other scientific work at sea, especially logging and analysis of hydrographic data. The system has, however, been designed so that the computer can be used ashore when it is not required at sea (perhaps for 50 per cent of its time), where the main applications will be off-line. There are, in fact, many off-line scientific applications for such an instrument which urgently require a readily available medium-sized computer. Advance consideration was given to these possibilities when the computer specification was prepared to ensure that word-length and peripheral equipment will be adequate for at least those applications which can be defined in advance.

259. *Net telemeter.* Meanwhile, the design of the net telemeter under construction at the laboratory was being modified, so that it could be used mainly as an on-line input to the computer (rather than an independent system as was the first intention). Associated modifications should improve the telemeter in respect of signal-to-noise ratio, reliability and operating speed (not an easy task as the first and last requirements are to some extent incompatible). The most important modifications to the prototype concern reductions in the acoustic coupling to the water in other than the transmitting direction, the introduction of frequency shift-keying in the acoustic link circuits to overcome multipath effects in the medium and some re-design in the encoder unit to overcome 'cross-talk' between the logic elements. Other investigations and modifications suggest that the engineering of the whole system has been considerably improved, and it has been successfully tested although, owing to limited test facilities, only over a very short range. Full-scale testing at sea was scheduled to take place.

Other Work

260. Other work concerned a component study to devise a stock of electronic spares sufficient to prevent delay between design and construction stages of various jobs, further consideration of improvements of measuring speed through the water, and of course, consultations with and assistance to other sections, perhaps especially in designing small-scale fishing gear for the Freshwater Fisheries Laboratory at Pitlochry.

261. Research papers concerning fishing gear, etc., published or in the press are: 12, 13, 21, 43, 85, 127–130, 132–136.

Staff

Principal Scientific Officer	...	...	R. E. CRAIG (part time)
Senior Experimental Officer	...	...	R. G. G. LAWRIE

262. This unit continued to work under strength throughout the year, owing to the difficulty of recruiting a suitable Scientific Officer candidate, but one was appointed (at the Senior Scientific Officer level) towards the end of the year. Meanwhile, every opportunity was taken for appropriate members of the unit to undertake training or refresher courses in the various aspects of instrumentation with which they were, or were likely to be, concerned.

263. Collaboration with other laboratories was continued, very close relationships being maintained with Professor Tucker's Department in the University of Birmingham on all acoustic matters, with the University of Aberdeen on underwater light measurements and with NIO on the development of moored buoy and drift techniques.

264. The head of the unit was especially concerned during the year with final planning and the selection of tenders for a vessel to replace *Clupea*, and with the second stage of planning for a vessel to replace *Scotia* by means of a design study undertaken by YARD.

Moored Buoy Systems and Drogue Tracking System

265. Moored buoy systems were developed to carry the Plessey recording current meters, and various snags in the meters themselves are in process of being overcome. These systems are already being applied to the work of the hydrographic section in a preliminary way. Owing to the similarity in the radio equipment, these developments can be associated under the same head as the radio marker system for tracking drogues, which system has already been in use and confirms the adequacy of the foundations laid last year.

Transistorised Sector Scanner

266. The firm concerned had been unable to finish the contract to produce one or more transistorised sector scanners, and the incomplete instrument was hired from the firm as from the beginning of 1967. It proved to be even less near to completion than had been expected, but with the assistance of the Electrical Engineering Department of Birmingham University, and the advice of the consultant originally concerned, sufficient progress was made to provide grounds for hoping that the instrument might be tested out in the spring of 1968. This work was, however, taking much longer than expected, with consequent effects on other aspects of the unit's programme.

Fish Counting

267. Partly for this reason and partly because of the problem of recruiting an additional Scientific Officer, progress was also not quite as rapid as had been hoped in the development of the fish counting project. For this purpose, it proved necessary to build a completely new 400 Kc/s echosounder and match it to the 'Laben' pulse height analyser. At sea, interference levels from the ship's electrical installation at first were found to be severe, and no real progress was made until this had been reduced. Results obtained thereafter suggested that

with further modifications practical results should be attainable. This project would, therefore, be one of the major items for completion in 1968.

Other Instrumentation

268. Light meters were maintained and provided as required by other teams, while a comprehensive underwater photographic service was provided for various gear and biological projects. An 8 mm time-lapse camera was constructed and used in research projects at Loch Torridon and Loch Ewe. Designs for a new 16 mm camera for use by divers were begun.

269. The workshop continued to give support to the scientific staff in many fields. Among the major tasks (in addition to those mentioned above) were those in association with the behaviour investigations and those at Loch Ewe, together with occasional assistance to the Freshwater Fisheries Laboratory at Pitlochry. Another major project was the development of codend release systems (para. 67).

270. Research papers concerning this section, published or in the press, are: 5, 6, 24.

Inorganic Environment

Staff

Senior Principal Scientific Officer ...	J. H. Steele (part time)
Principal Scientific Officers	R. Johnston (part time) R. E. Craig (part time)
Scientific Officer	H. D. Dooley
Senior Experimental Officers	R. B. Burns J. H. A. Martin

271. Many of the requirements for hydrographic data in connection with fisheries problems are in terms of direct estimates of currents or of turbulent diffusion. During 1966–67 much of the effort of the section was involved in the continued development and testing of such methods as well as in their application to particular problems.

272. At the same time, the study of long-term changes in the physical environment is necessary, and some of the conclusions from a continuing study of the effects of variations in oceanic conditions near Scotland are summarised in this report.

Associations between Hydrographic and Climatic Factors

273. It is usually assumed that the Gulf Stream system has a direct and beneficial effect on the British climate, so that increased strength of the system would result in warmer, more saline water to the west of Britain with consequent increase in air temperature. This hypothesis has been questioned in the past by American oceanographers but a direct test using data from the north-east Atlantic appeared necessary.

274. The percentage of hydrographical stations in a defined area to the west and north of Scotland where high salinity water in excess of 35·45 per cent was present was used as a measure of the varying strength of the North Atlantic

current, which is the north-easterly extension of the Gulf Stream system. Salinity was used because, unlike temperature, the seasonal variation was small. High salinity data are available from 1930 to 1966, with the exception of the war years.

275. The period for assessment each year was from March to November, since few samples were taken from December to February.

276. Air temperature data was based on the average daily maximum and minimum temperature from nine reporting stations dispersed over Scotland and compared with the hydrographic data. Significant correlations existed only when the periods for high salinity data preceded those for air temperature and when the latter were for a period of at least six months, the greatest significance occurring when the air temperature periods were for nine to twelve months. Then the medial χ^2 test gave correlations significant at the 1 per cent level.

277. Thus these results give evidence of a long-term association between high salinity water and air temperature over Scotland. The time difference implies the dependence of the latter on the former and further, because of this time lag, the salinity data have some predictive value for the general climatic conditions in succeeding years.

278. Given this correspondence there remains the question of the relation of hydrographic events to the north-west of Scotland with circulation in the Atlantic. As a general index, the yearly average of sea surface temperatures to the west of Scotland has been used and, for the years 1902–1964, this was found to have a negative correlation (significant at the 0·1 per cent level) with changes in the mean sea level along the Florida seaboard, which is a measure of the Florida current and so of the Gulf Stream system. This result supports the concept that flow of warm water to the north-east occurs mainly when the Gulf Stream is weak and, conversely, when the Gulf Stream system is strong, air and sea temperatures around the British Isles are below normal.

Tracking of Parachute Drogues

279. Although moored current meters are the best method for obtaining information on water movement past a fixed location, biological investigations often require knowledge of the path taken by a water mass. For this purpose parachute drogues are most suitable and have been used for several investigations in 1966–67. This technique, however, has suffered from the disadvantage that the ship must remain in close proximity to the surface marker. To overcome this drawback small transponding radio dhans have been developed which can be interrogated individually so that ten drogues can be used simultaneously. The system was tested under severe weather conditions (force 9–10 winds) and it was shown that after intervals of 48 hours the bouys could be detected and so re-located from distances of 15 miles.

280. This system will permit not only the use of drogues on much larger time and distance scales but also great flexibility for associated biological sampling from the tracking ship.

Recording Current Meters

281. During winter 1966–1967, the mooring system (Fig. 4) for use with current meters was developed, particularly a surface 'spar' buoy which contains a transponding radio of the same design as that used with the drogues but with greater transmission power, that can be triggered and located by D.F. from our research ships. Trials of this radio show that it can be detected at a range

of 50 miles and located within 30 miles. This system was then tested at sea at a position approximately three miles off the Fraserburgh coast in a depth of 70 metres from February to July 1967. The initial tests without current meters showed that it could survive severe storms. Some minor faults with the sub-surface buoy were corrected at this time.

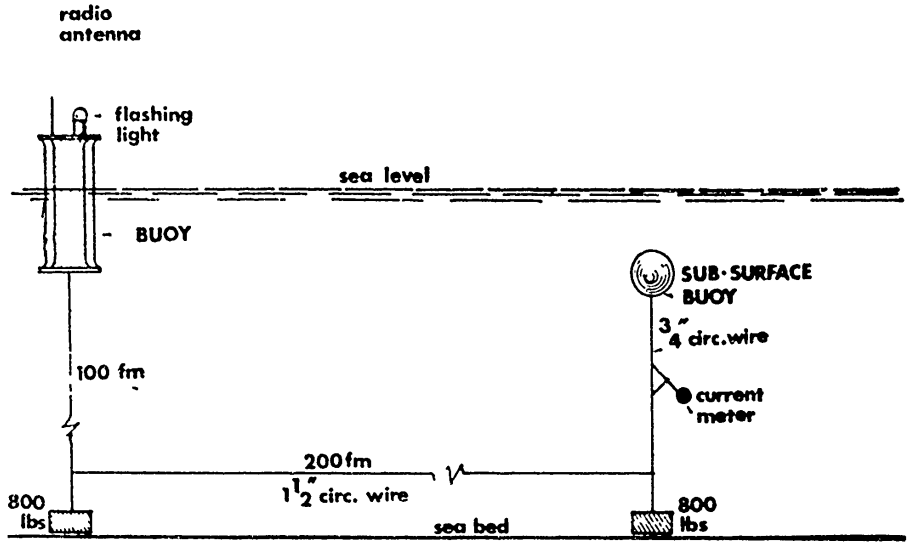


Fig. 4. Diagram of buoy mooring system.

282. During June and July, single current meters were included in the system and one successful run of 28 days was made with a meter at a depth of 25 metres recording every six minutes. Although this was intended as a test run, the data are of interest for the understanding of near shore circulation in the Moray Firth.

283. Fig. 5 shows the polar histogram of hourly mean direction indicating the predominantly easterly flow of the water. Using 25 hour means to eliminate diurnal tidal effects, the residuals were tested for correlation with local geostrophic wind and tidal height at Aberdeen. Sixty per cent of the variability of these residuals was associated with the easterly component of the wind, but this still

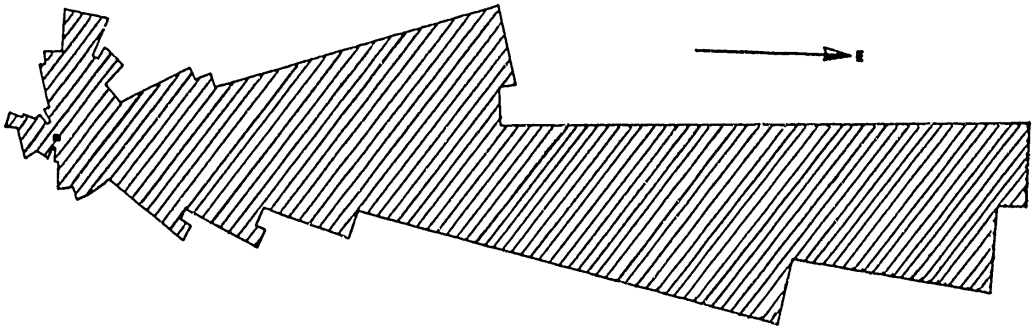


Fig. 5. Current pattern.

left an easterly current of 12–18 cm/sec., which was found to be correlated with tidal height. This latter component is important since it suggests that, apart from transient wind effects, the current is determined by the interaction of tide and local topography, perhaps by an eddy set up on the ebb tide past Rattray Head.

284. Since mid-August, a current meter station has been set up in the centre

of the northern North Sea (58° 33′N 1° 34′E). Firstly, a short-term mooring was made for detailed studies of variability of readings on two closely spaced meters and for comparison of results with a parachute drogue in the same area. The latter comparison showed an agreement with one meter within 10 per cent of the vector velocities over a 12·5 hour period. This meter also showed a narrow range of fluctuations in readings. The readings on the second meter were highly erratic even over 30-second intervals, and it was obviously not functioning properly. A second mooring was set up, but 30 days later, in mid-September, the surface buoy had been carried away. The remainder of the mooring, including the current meter, was recovered and the loss was seen to be due to a faulty shackle.

285. Thus, in summary, although the system can work well and produce useful results, further experience in moorings will be needed and, especially, an improvement in the reliability of the meters is required.

Diffusion and Water Movement on Ballantrae Bank

286. This work was undertaken in collaboration with the herring section (para. 113) to find how far measurements of currents and diffusion can explain observed larval herring concentrations.

287. A release of Rhodamine B dye to study turbulent diffusion, combined with tracking of parachute drogues, was undertaken between 9th and 12th March 1967. Exceptionally strong winds severely curtailed this work, but also had the consequence of providing measurements under conditions normally avoided. These provided evidence not only on the movement of water as a result of wind stress, but also showed that the dye patch after 25 hours (Fig. 6) was not severely

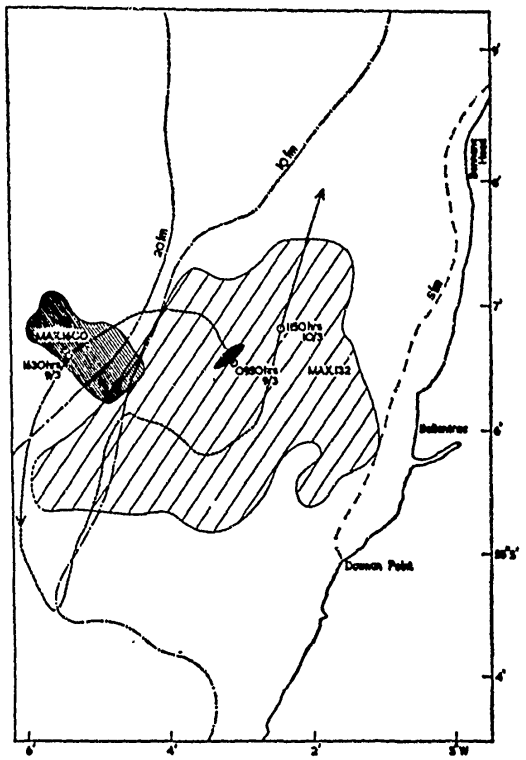


Fig. 6. Approximate size of the dye patch shortly after release and on two subsequent surveys; the broken line shows the path of a drogue released near the dye at the start of the experiment.

elongated as is usually found in near shore waters, and this may be a consequence of the effect of strong winds and tide being at angles between 45° and 90° to each other.

288. In general, however, the results are in agreement with previous observations. On this basis, an attempt was made to analyse larval data for 1958–1960. These, necessarily preliminary and inexact comparisons with wind data and diffusion theory, suggest that the physical parameters may be sufficient explanation of changes in larval concentration. In particular, there is no evidence of catastrophic mortalities during the first five to ten days of larval life.

Chemistry

289. A major part of the work of the section was concerned with development of automation of chemical analysis using a Technicon analyser. This provides for continuous monitoring of several possible parameters. The methods for phosphate and nitrate worked satisfactorily and techniques for silicate and ammonia are being tested.

290. There is wide range of application of these methods. During 1966–67, the apparatus was used at Loch Ewe for study of detailed changes associated with nutrient enrichment. They can be used at sea, particularly for the study of areas where rapid hydrographic changes may be expected to have associated chemical fluctuation. Also, in the laboratory, these methods permit more efficient utilisation of staff for routine analysis.

291. The Loch Ewe results and also the chemical aspects of pollution investigations are described in other sections of this report.

Other Studies

292. The analysis of the hydrographic sections from the mainland to Rockall is continuing jointly with the Lowestoft Laboratory.

293. The analysis of the data collected in the Norwegian Deeps in July 1966 as part of the ICES Skagerrak Expedition is complete and a paper was presented to ICES in 1967.

294. The work on computer processing of serial hydrographic data and current meter observation is proceeding. The main programmes are now written and should be used for data processing in 1968.

295. The hydrographic section has been collaborating in studies of shoal movements of herring; in relations between haddock catching and bottom currents; and in pollution studies.

296. Research publications concerning inorganic aspects of the environment, published or in the press, are: 4, 24, 62, 64, 65, 81, 118, 126.

Staff

Senior Principal Scientific Officer ...	J. H. STEELE (part time)
Principal Scientific Officer	R. JOHNSTON (part time) A. D. MCINTYRE
Senior Scientific Officer	A. L. S. MUNRO (part time) A. ELEFTHERIOU
Scientific Officer	Mrs. A. G. RALPH R. R. C. EDWARDS
Senior Experimental Officer	R. B. BURNS (part time)

Loch Investigations

297. The work at Loch Ewe in the third year of this project concentrated on experimental approaches to three major problems revealed by the work in the past two years—the sand ecosystem, the effect of variable food supply on the growth and reproduction of a dominant beach invertebrate *Tellina tenuis*, and the effect of variable density of *Tellina* on the growth of O-group plaice. For the latter two projects, further tank facilities were erected at the aquarium site (Plate 6).

298. Certain aspects of the natural ecology of the beach, however, required continued study and these are reported on first.

Beach Ecology

299. *Interstitial water movement and oxygen consumption.* Dr. G. Giese of Woods Hole Oceanographic Institution has developed a method for measuring the motion of interstitial water using a liquid, Cynogum-41, which gels after a predetermined period. He visited the laboratory and used this method on the littoral beach during July and found, generally, downward and seaward velocity components of 1–2 cm/hr for the period from three hours before to three hours after low water. Thus there was a net downward movement of 5–8 cm per tidal cycle. This, together with the high rates of oxygen uptake by sand reported previously, agrees well with observations made this year that below 5–10 cm the oxygen concentration is very low and the sand at these depths may be, periodically, in an anaerobic environment. It seems probable that the bacteria in the sand are facultative anaerobes and the periodic occurrence of anaerobic conditions may account for an increase in the soluble organic content of the interstitial water below 5 cm which differs from conditions in the sand columns (described later) where, under aerobic conditions, soluble organic carbon decreases with depth.

300. *Tellina and Plaice Populations.* As a consequence of the absence of successful spatfall of *Tellina* since the surveys started there has been a regular decrease in *Tellina* populations from 625/m^2 in 1965, to 364 in 1966, and 201/m^2 in 1967. In 1964 and 1965 *Tellina* was the dominant food during May and June for the plaice population. In 1966 it had declined in importance but in 1967 it was totally absent from the food and tentacles of *Magelona* and mysids were eaten by the plaice. The switch in feeding was much more marked than the decline in *Tellina* numbers, and suggests that there is some threshold density effect.

301. *Carbon budget for the beach.* More detailed analysis and some further

experiments are needed to provide an accurate description of the transformations on and within the beach. The following summary gives only an approximate and preliminary picture of reality. The values in Table No. 1 represent conditions in 1965 at about low water mark, except for the plaice for which mean density is used over an area extending above and below low water mark.

TABLE 1. CARBON AVAILABLE AND CARBON REQUIREMENT (gC/m^2. YEAR). FOR THE BEACH NEAR LOW WATER MARK BASED ON POPULATIONS IN 1965.

A. Primary production in water (for column 10 m deep)	95
B. Input to sand	
(1) Primary production by attached benthic diatoms	5
(2) Soluble organic carbon (by water flow)	40
(3) Particulate organic carbon (into sand)	8
C. Carbon requirement of sand	
(1) Total requirement (based on oxygen data)	50
(2) Meiobenthos requirement (based on respiration experiments)	5
D. Carbon requirement of benthic in-fauna	
(1) *Tellina tenuis* population	1·3
(2) Other benthos (respiration data only)	1·1
E. Carbon requirement of O-group plaice	0·3
(Yield expressed as population density at end of first year of life	0·006)

302. A comparison of Sections B and C of Table 1 shows that only the utilisation of the soluble organic carbon can meet the requirement within the beach. The size of the meiobenthos requirement suggests two possible pathways. Either they feed directly on the particulate carbon or on the bacteria utilising the soluble component. Investigation of the natural environment cannot answer this.

303. The macrofauna (D) utilise only a small fraction of either the primary production in the water or of the organic matter entering the sand. The plaice, however, because of their high conversion rates (described in a later section) utilise efficiently the portion of the benthos on which they feed, so that probably over 10 per cent of the input of food to the benthos appears as growth in the plaice. The very high plaice mortality, however, results in a low yearly production of plaice remaining for further growth and this is negligible in terms of the total energy turnover of the beach.

304. *Sand Columns.* As described in previous reports, the benthic diatoms appear to play a very minor role in the energetics of the beach and the high oxygen demand is the result of bacterial action on organic matter, soluble and particulate, taken from the interstitial water. The complexity and variability of the natural environment precluded more detailed study of this ecosystem and so sand columns, with slow flow of natural sea water downwards, have been used. The interstitial water can be sampled at 5 cm depth intervals to a depth of 25 cm for oxygen, soluble organic carbon and nutrients in the interstitial water. The column can be cored to provide data on chlorophyll *a*, carbon and meiobenthos.

305. After preliminary tests, a long-term run was begun in May 1967 and was still continuing at the end of the year. A summary of some of the results is given in Fig. 7. There is no significant decline in the carbon content of the sand but there is a slow decrease in chlorophyll *a*, with no degradation of the remaining pigment. (A similar change on the beach was observed in deep sand which remained unmixed from January to July). The oxygen decrease over the top 15 cm of the column does not show marked trends and provides a measure of the total utilisation by the column.

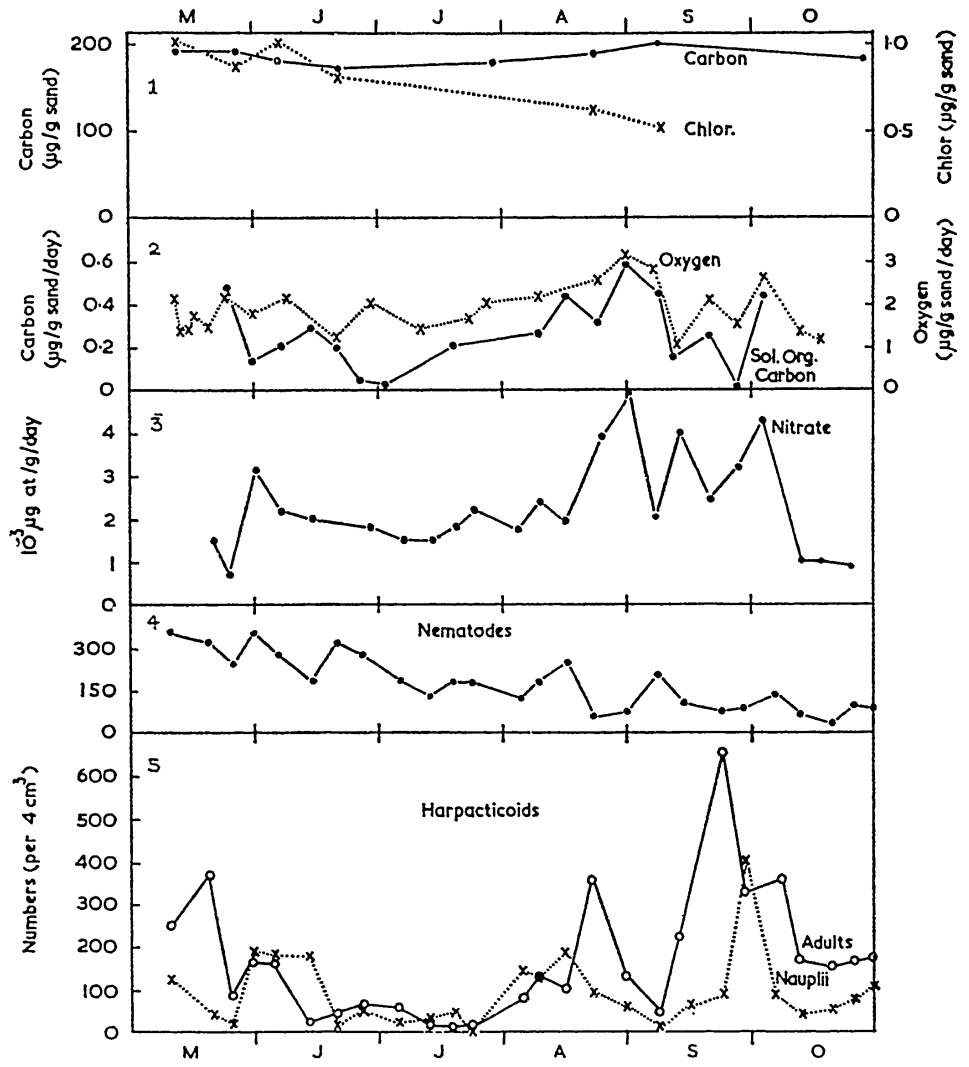


Fig. 7. Graphical representation of results from sand column experiments.

306. One of the main features is the uptake of soluble organic carbon which demonstrates that this is probably the major source of organic matter for the sand column. Unfortunately, the uptake is not sufficient to explain the total oxygen demand. This may be an analytical problem due to incomplete oxidation of the carbon by wet oxidation as used in the method of determination, and further work on this method is needed. There is a significant increase of nitrate in water flowing through the column but no increase in nitrate or ammonia.

307. Lastly, the meiobenthos survive well in these conditions and the ability of the crustacean component to reproduce under controlled conditions should provide data to estimate their population dynamics.

308. The effluent from this column was run through a second column, where there should be negligible input of particular matter since this is filtered out by the first column: but, since there is still oxygen consumption within this second column, there is some soluble utilisation. The data present several interesting features but the main aspect is the existence of meiobenthos populations with features generally similar to those in the first column. Thus, the meiobenthos must be feeding mainly on bacteria. Although this benthic system is, necessarily, a special case, it suggests that in such systems bacteria may be essential as an

intermediate step in the supply of food to benthic animals. In deeper areas, where the benthos is dependent on the residual organic matter from production in the upper waters, this intermediate step would decrease considerably the yield from these residues available to fish.

Enrichment Experiments

309. Experiments previously reported showed that *Tellina* benefited by nutrient enrichment of the water. More detailed experiments were required to determine the optimum conditions. In particular, this needed not only stricter control of enrichment procedure, but also more detail in estimating nutrient and phytoplankton concentration under a range of enrichments. A large fibre glass tank was divided into four compartments (Plate 6) and four daily enrichments, nil, 3, 10, 30/μg at N/1, were added after a daily exchange of 10 per cent

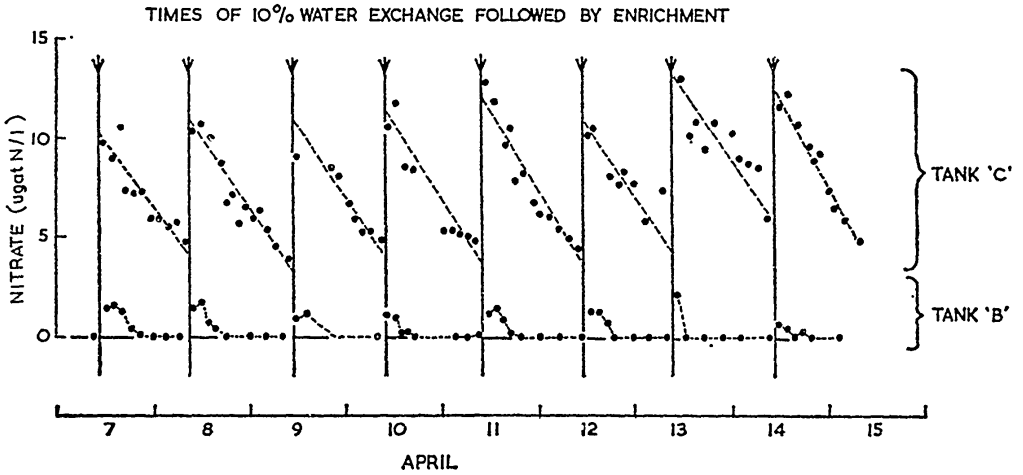


Fig. 8. Enrichment experiments: nitrate changes in tank compartments B and C.

of the water. Phosphate was added in excess so that nitrate was limiting. (The four compartments were labelled A, B, C and D respectively, but D was accidentally drained during the experiment and its results are reported more briefly).

310. *Environmental monitoring.* This experiment formed a useful introduction for the development of methods for the continuous analysis of nutrients and plant pigments. The estimation of nitrate was particularly valuable in demonstrating the detailed changes that occurred. Fig. 8 shows a section of the records typical of the environment in tanks B and C for most of the experiment. A gave continuous low values around 0·4/μg at N/1, D ranged about 30/μg at /1.

311. The *in vivo* pigment fluorescence data showed that the method, although useful for showing the major changes and diurnal fluctuations, did not calibrate with chlorophyll *a* with great accuracy under these conditions and more work is being done on this method. The results for the tanks showed a pattern in A similar to that in the bay, in B an April peak of 17/μg/m^3, and in C a peak of 65/μg/m^3. The major effect of excessive nutrient addition in C and D, however, was a rapid growth of *Enteromorpha* on the walls of the tank while B had a much slighter growth, mainly blue green algae, and growth on A was negligible. As a consequence C and D became very polluted and the sand in the bottom was anaerobic by August.

312. *Tellina.* Sand in the bottom of each compartment was seeded with a 1,000 Tellina of the same size range as on the beach to give a density of 590/m². The growth and mortality were followed by monthly sampling. Also the numbers of lamellibranch larvae in each compartment were estimated monthly. The growth curves, Fig. 9, show quite decisively that B gave the optimum conditions for growth. Further, the mortality by August in A-D was respectively 50 per cent, 60 per cent, 80 per cent and 100 per cent. (These mortalities are

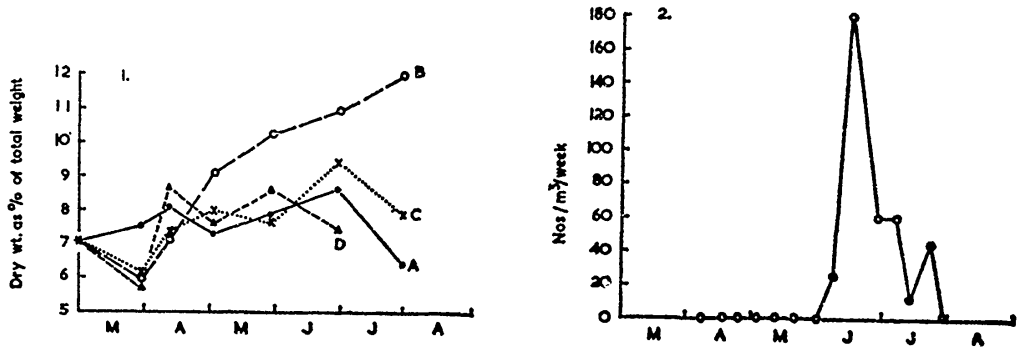


Fig. 9. Enrichment experiments:
(1) Growth of *Tellina.*
(2) Production of larvae in tank B.

generally higher than in Firemore Bay and this may be due to parasites in these *Tellina* which were collected from another bay, Gruinard).

313. These experiments were intended also to study the conditions for successful reproduction. The data on larvae show that apart from small pulses of lamellibranch larvae probably introduced by water exchange (< 5/m³). the only large production of larvae occurred in B (Fig. 10) at a time immediately following gonad development.

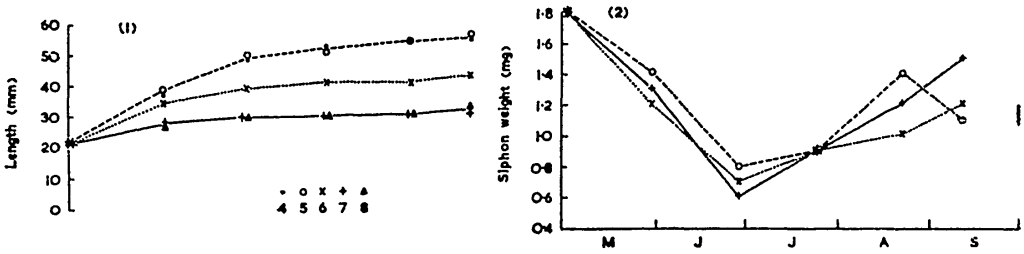


Fig. 10. Plaice-*Tellina* experiments in tanks 4–8:
(1) Length increase in plaice.
(2) Changes in *Tellina* siphon weights.

314. The conclusion from these small-scale experiments is that a low rate of enrichment, in which the nutrient is added daily and is utilised within six hours, provides optimum conditions for weed control, for bivalve growth, and for their reproduction. These conclusions are also relevant to problems of pollution control involving eutrophication.

Plaice-Tellina Experiments

315. Earlier experiments with plaice in underwater tanks containing the natural range of food organisms have shown changes in growth rate dependent on fish density. To study these relationships under more controlled conditions,

five tanks were stocked with plaice and *Tellina* in sand beds 10 cm deep. Each day 25 per cent of the water in the tank was replaced by water pumped from the bay and filtered to remove the larger zooplankton. Table 2 gives the initial numbers, the initial plaice-*Tellina* ratios and the ratios as a result of plaice mortality at the middle and end of the experiment. Fig. 10 shows the growth rates of the plaice in all the tanks and the changes in weight of *Tellina* siphon on which the plaice were feeding, in three tanks where the *Tellina* density was the same.

316. The Plaice growth rates show direct dependence on the plaice-*Tellina* ratio and appear to be independent of density. The maximum growth rate (in tanks 4 and 5) during the first 50 days is, in terms of weight, about twice that found on the beach, but this may be due, partly, to higher temperatures in the tanks compared with the sea. Table 2 shows that during the last half of the experiment there was significantly higher mortality in the tanks where food was most limiting, but during the first half mortality did not greatly alter the relative predator/prey ratios.

TABLE 2. INITIAL NUMBERS OF PLAICE AND *Tellina* IN TANKS AND THE PLAICE/*Tellina* RATIOS DURING THE EXPERIMENT.

Tank	*Plaice*	*Tellina*	*Predator-Prey Ratio*		
			May	July	Sept.
4	30	9,000	1:300	1:480	1:530
5	10	3,000	1:300	1:375	1:500
6	30	3,000	1:100	1:125	1:231
7	100	3,000	1:30	1:42	1:100
8	30	900	1:30	1:50	1:150

317. A significant feature of the growth rates is the effective cessation of growth after 50 days. This corresponds exactly to the minimum in siphon weight which decreased rapidly during the growth phase (the residual weight of about 0·5 mg represents the portion of total siphon within the valves and so not available to predation). Thereafter siphon weights increased but the rate of increase is only about one-fifth of the rate of regeneration found experimentally when there is no predation. Thus the plaice continued to eat siphons but at a low rate, just sufficient to meet maintenance requirements. This is not a function of size of fish since the same pattern occurred in tank 7 where the fish remained small, as in 5 where they were much larger. Thus, although the results for the first 50 days, in conjunction with the metabolic data for plaice and *Tellina*, will permit estimates of efficiency under a range of semi-natural conditions, it seems likely that an understanding of the responses during the later period depends on knowledge of behavioural as well as metabolic responses. In the natural environment in 1964 and 1965 when *Tellina* was dominant in the benthos, and in the food for the first one or two months, the same severe cropping probably occurred but was followed by a switch to other foods. In 1967, although there was still an appreciable *Tellina* population, no predation on them occurred, suggesting a threshold density for predation. In the tanks such a threshold density of siphons would be crossed as a result of predation and it would appear, therefore, that even though other sources of food are not available, the plaice do not graze so actively on siphons. Such behavioural patterns are important in understanding prey-predator relations, particularly for the survival of prey populations diminishing under predation pressure.

Conversion Efficiency and Nitrogen Balance of Plaice

318. O-group plaice were kept in pairs in containers at 10°C and fed every second day on oligochaete worms. The faeces of the fish were collected for analyses but these in fact formed less than 1 per cent of the food eaten. The growth of fish was measured monthly. Monthly samples of the fish and the worms were taken for proximate biochemical analysis and the average values, together with data for *Tellina*, are given in Table 3. Estimates were made of the excretion rate of soluble organic nitrogen (including ammonia). Groups of 20 fish were fed at three levels—maintenance, intermediate and excess. The following results are based on a preliminary analysis of the data. With adequate feeding the gross conversion efficiency (fish growth/food assimilated) was 35 per cent

TABLE 3. PERCENTAGE COMPOSITION OF THE ORGANIC CONTENT OF PLAICE AND OF FOODS USED IN LABORATORY AND TANK EXPERIMENTS.

	Protein	*Carbohydrate*	*Lipid*
O+ Plaice	84	2	14
Oligochaete	69	17	14
Tellina siphon	84	9	7

during the first 30 days, falling to 23 per cent during the second interval. Thereafter, the results were very erratic and this may be due to build up of bacterial contamination even though the water was changed every two days.

319. There was very good agreement between the nitrogen content of the food and the sum of nitrogen assimilated by the fish, the faecal and the excreted soluble nitrogen. These latter components are given as percentages in Table 4. The major fraction is the soluble component and this can be explained by combining the information in Table 3 with the conversion efficiencies. As a result of the high protein content of the food, after incorporation by the fish of the protein fraction necessary for growth, the remainder is utilised for metabolism with consequent excretion of soluble nitrogen compounds. Based

TABLE 4. PERCENTAGE DISTRIBUTION OF NITROGEN IN THE FOOD BETWEEN FISH, SOLUBLE EXCRETIONS AND FAECES.

	Growth	*Sol. Exc.*	*Faeces*
0–30 days	43	56	1
30–54 days	22	77	1

on the chemical composition the calculated percentages going into fish and excreted are 39 per cent and 61 per cent for the first 30 days and 27 per cent and 73 per cent for 30–54 days. This agrees reasonably with the observations. Thus an understanding of the nitrogen balance depends on knowledge of food composition and gross conversion efficiency. The high excretion is a consequence of the high protein content of the oligochaetes.

320. For a food such as *Tellina*, with an even higher protein content, it would appear that the natural diet is wasteful in protein and the fish should grow rapidly on a food with much lower protein content.

Rate of Plaice Metabolism under Natural Conditions

321. Work has continued on respiration rates under laboratory conditions to provide data on 'basal' and 'active' respiratory rates for different sizes of fish

at a range of temperatures. The active rate is found to be 3–4 times the basal or resting rate. The major problem in applying such results to natural conditions is that we do not know where the natural activity of the fish will lie within the laboratory-defined resting-active range. Thus, although there is extensive literature on laboratory studies of fish respiration, the conversion to natural conditions has been, effectively, guesswork.

322. There have been various reports in the ecological literature that the rate of elimination of the isotope zinc-65 may be related to respiration rate. It was decided to test this relation for O-group plaice by measuring these two factors under a range of temperatures and feeding regimes. These provided an oxygen-zinc relation, Fig. 11, which is independent of temperature. On this basis, plaice

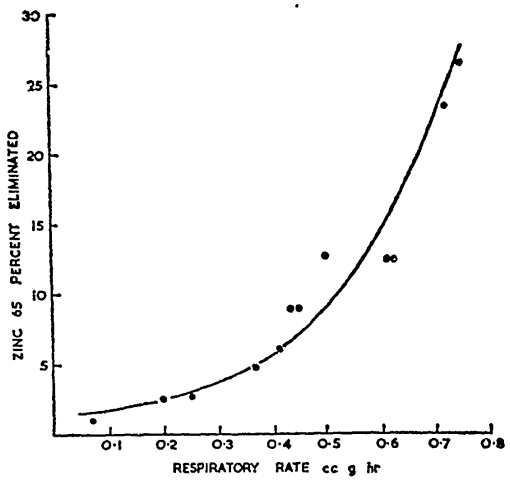


Fig. 11. Relationship between respiratory rate and elimination of zinc-65 for O-group plaice.

labelled with zinc-65 were put in large underwater tanks (30 plaice/tank = 4/m^2) where they could feed naturally. Later sampling of the tanks provided a rate of zinc elimination which from Fig. 10 could be converted to respiration rate. For the given size of fish and ambient temperature, this rate was exactly twice the basal rate for such conditions. This value can now be used in calculation of metabolic rates of the natural stocks but further work will be done on possible variations seasonally and for different densities of fish.

Ardtoe

323. Benthic studies at the W.F.A. fish pond at Ardtoe are continuing, but it seems useful to summarise here some of the results from 1965 and 1966.

324. The pond was formed by damming off the upper part of a beach which had a poorly sorted sediment with very fine mud mixed with gravel, stones and shell fragments. The initial flooding of this area took place in July 1965.

325. As a result of the enclosure, the upper part of an inter-tidal shore, carrying a normally rich fauna, was converted suddenly into an area of permanent submergence equivalent to a region below low water mark. This change in itself might be expected to result in the elimination of a considerable portion of the fauna, and the combination of this permanent submergence with the fresh water conditions which followed the initial filling was probably responsible for the mass mortality of this fauna, resulting in a decrease from nearly

41,000 individuals to less than 300/m² between June and September 1965 (see Table 5).

326. The pond was empty for much of the winter of 1965–66, so that when it was again filled in the summer of 1966, the bottom was comparatively barren and clean. After the 1966 filling, favourable conditions of salinity and oxygen were maintained in the pond water and the August survey showed a modest

TABLE 5. SUMMARY OF BENTHOS NUMBERS AND WEIGHTS AT ARDTOE, 1965–1966.

	Time of Sampling			
	June 1965	*September* 1965	*August* 1966	*October* 1966
Mean biomass in gm/m² (wet weight excluding shell)	159·16	0·17	2·13	4·17
Mean number of individuals per m²	40,936	273	1,800	244
Number of species	28	7	12	15

increase in number of species, number of individuals and weight of benthic animals, suggesting that colonisation was beginning. In October, although the number of individuals had again fallen, yet the number of species was still higher and the fauna was more marine in character, with the appearance of such polychaete worms as *Nephthys* and *Spio*. The reduction in numbers between August and October 1966, which was largely due to a fall in the oligochaete worm population, may be partly explained by the increase in marine conditions in the pond, but probably also partly by the introduction into the pond of a large number of young plaice before the benthic fauna had developed sufficiently to withstand extensive predation. Examination of plaice stomachs certainly showed that oligochaetes were being eaten.

327. Although analysis of the most recent surveys in 1967 had not been completed by the end of 1967, it was apparent that the general improvement in physical and biological conditions in the pond, although slow, was being maintained, and it seemed possible that in time increased natural repopulation of the pond benthos could be expected to take place.

328. Research papers concerning Productivity etc., published or in the press, are: 9, 36, 63, 66, 76, 77–80, 84, 95, 96, 98, 99, 105, 108, 111, 119.

PLANKTON AND BOTTOM FAUNA

Staff

Senior Principal Scientific Officer ...	J. H. FRASER
Principal Scientific Officer	A. D. MCINTYRE
Senior Scientific Officers	J. A. ADAMS A. ELEFTHERIOU
Scientific Officers	Mrs. A. G. RALPH R. R. C. EDWARDS

Plankton

329. *Equipment.* The high speed sampler 'Gulf III' has now been in satisfactory use over ten years for quantitative sampling. During the past year, in attempts to secure greater accuracy in the results, various improvements were

made in the control of shooting and hauling speeds. Studies were also made on the flow-path of the water inside the Gulf III so that flow-meters can be fitted in the most reliable position in the tail unit; one revolution of the Currie-Foxton depth flow-meter has been calculated to represent 4·6 m^3 of water filtered.

330. Further, experiments using bags of fluoroscein to check for leakages in the jointed sections of this instrument show that losses here are very small and are unlikely to exceed 5 per cent.

331. The internationally recommended nets WP2 and WP3 were introduced experimentally during the year. Differences in the catch taken by the nets compared with those already in use at Aberdeen indicated that further comparative trials are desirable.

332. *Phytoplankton (chlorophyll estimations)*. The amount of chlorophyll present, estimated from chemically extracted samples, is a convenient way of obtaining a quick overall assessment of the amount of plant life in the water. Figures from the Moray Firth in early April ranged from 0·5–3·1 mg/m^3, and along a line of stations to the Norwegian Deep they ranged from 0·4–0·8 mg/m^3, which is about average. During May more extensive data were obtained. East of Orkney and in the northern North Sea south of 57° 45′ values were low while east of 2°E the values ranged from 2·0–5·0 mg/m^3; an isolated sample gave 6·4 mg.

333. By June, values greater than 2 mg/m^3 were present only in two main areas, between 2°E and 3°E north of 58°N, and east of the Fair Isle Channel. In general, west of 2°E the areas which had a high chlorophyll content in May had low figures in June and vice versa, but east of 3°E the chlorophyll content had decreased. In general, the 1967 conditions so far were fairly normal.

334. *Phytoplankton (net samples)*. For more specific analysis than is given by chlorophyll estimations, it is necessary to examine collections microscopically. During the winter months, sampling was confined to the west coast and the phytoplankton population, then at its lowest level, nevertheless contained a remarkable variety of species especially in the oceanic water to the west of the Hebrides. By March, the spring increase was evident in the central North Sea with *Chaetoceros* spp. and patches of *Rhizosolenia var. semispina.*

335. The spring increase was well established by April and continued through May. *Thalassiosira gravida* was dense in the outer Moray Firth with *Skeletonema* in the central North Sea and *Chaetoceros* in oceanic water. Diatoms were distinctly less abundant in areas rich in *Calanus.*

336. By June, a tongue of *Rhizosolenia styliformis var. oceanica* extended south between Shetland and Norway, and dinoflagellates showed the summer increase except in neritic waters.

337. *Zooplankton (biomass)*. Biomass determinations are made to obtain an assessment of the total standing crop of zooplankton. In May 1967, these gave values of greater than 20 grams wet weight in 100 m^3 over most of the area examined. Only one position gave a value greater than 65 grams/100m^3, as compared with 1966 when there was an extensive area greater than this in the eastern North Sea. Values greater than 20 grams wet wt/100 m^3 nevertheless represent a high standing crop of zooplankton.

338. In June there was an area of high and very high biomass off the north-east of Scotland and off Norway. The details of these surveys will be used in comparing herring migration routes in 1967 with those in 1966.

339. *Zooplankton (Rockall Area)*. The samples taken by the 1 metre and Gulf III nets strongly support the inference, drawn from previous years sampling,

that over Rockall Bank a large but rather unstable eddy system exists. The timing, extent and breakdown of this eddy may have considerable bearing on the fate of larval blue whiting spawned in this area and, therefore, on the fate of the resulting adult stock.

340. In May 1967, the Rockall area within the 200 fm contour contained a very rich crustaceous plankton, especially *Calanus*, euphausiids and decapod larvae, and the centre of this community coincided with the area of maximum abundance of blue whiting (Fig. 1). Over the deep water on either side of Rockall Bank, the number of crustacea and larval blue whiting were dramatically lower and oceanic plankton, particularly siphonophores and medusae, were numerous.

341. In May, Atlantic species, such as *Salpa fusiformis* were more abundant to the east of Rockall Bank than west. This condition was reversed in September when the salps were more abundant to the west and Lusitanian forms were found to the east of the Bank. By this time the eddy system had broken down and the whole Bank area was flooded by oceanic plankton, the crustacean plankton and fish larvae present during the period of the eddy having, presumably, drifted away towards the north.

342. *Indicator species.* Plankton can be used to indicate changes in the distribution of water masses which can affect the fertility of the water. Oceanic species brought into the northern North Sea in 1966 were still to be found there in the spring of 1967, especially in the area north of 57°N and east of 0°. In the northern part of the North Sea the indigenous species, *Sagitta setosa* occurred only east of about 2°E and in the Skagerrak.

343. As expected from the Rockall studies mentioned above, oceanic plankton continued along the edge of the Scottish continental shelf towards Orkney and Shetland and there was some overflow into the South Minch. The Lusitanian part of this oceanic fauna (e.g. *Muggiaea, Rosacea, Vogtia,* etc.) was closer to the shelf than the Atlantic forms although by the time the Orkney waters were sampled in September the communities had become well mixed. Only a few species had penetrated into the northern North Sea as far as 58°N by then and no later data are at present available.

344. *Pleurobrachia.* The analysis of the 1966 samples confirmed that the distribution of this important predatory species was similar to the normal, with an autumn peak only, whereas in 1965 there was also a summer peak. No data for the autumn of 1967 are yet available but a summer peak occurred in the Moray Firth area. Examinations of the stomach contents confirmed the previous findings that in the Scottish area *Pleurobrachia* feeds very largely on crustaceans and that young fish are negligible in their food. For all that, as the Crustacea are the dominant food of larval fish, predation by *Pleurobrachia* could still have a serious effect on brood survival, particularly of autumn spawning fish. Parasites of *Pleurobrachia* increased from 17 per 1,000, in the period March to August, to over 3,000 in the period September to February.

345. *Nephrops* (scampi or Norway lobster) larvae were most abundant in 1967 in June, the normal peak period occurring over April, May and June. The greatest numbers were found in the Moray Firth, north of Fraserburgh, but they were widely scattered over a wide area east of the Moray Firth.

346. *General.* In addition to the unit's programme proper, assistance continued to be given to the work at Loch Ewe and to pollution and other problems.

347. Dr. Fraser continues to serve as Chairman of the Plankton Committee

of ICES and as editor of the Plankton Identification Sheets. He is also Convenor of the ICES/SCOR/UNESCO group on the Standardisation of Zooplankton Sampling Methods at Sea; reports arising from the activities of this working group are now at the printers.

348. One of the working visitors to the section was Dr. P. van Banning of Amsterdam, who worked through many of the Scottish plankton samples in search for nematode larvae, particularly of the parasite *Anisakis* which is of considerable concern for the Dutch herring fisheries.

Benthos

349. The work of this section was mainly devoted to the *Loch Ewe* project, as reported in pages 112–120. It includes several surveys of the benthos at the WFA fish farming project at *Ardtoe* and the changes following on enclosure; a report was circulated to interested parties.

350. A general survey was made of the ecology of the inter-tidal zones of the coast near *Dounreay*. The bays surveyed were Dunnet, Strathy and Sandside, each worked with one main traverse sampling for macro- and meio-fauno, soil type, salinity and (at low water) chlorophyll and carbon. Two secondary traverses were made at Dunnet and one at each of the other two bays.

351. Beach fauna there was sparse, with molluscs almost entirely absent and amphipods scarce. The common species were the isopod *Eurydice pulchra* which was widely distributed on all the beaches and the polychaete *Nerine cirratulum* which was locally numerous. Considerable differences were observed in the distribution of empty lamellibranch valves cast up on the various beaches, probably associated with prevailing currents and different offshore distributions, which might well repay further study. Other material is in progress of being worked up.

352. The sorting of *tropical benthos* samples from Porto Novo, India, was completed and a report was being prepared. At the end of the year the leader of the unit was preparing drafts for several sections of a handbook on methods for studying marine benthos.

353. Research papers concerning plankton and bottom fauna, published or in the press, are: 14, 15, 57, 58, 75, 78, 79, 86–89, 105, 114–116.

Inshore Problems, Seal Damage, Salmon Disease, Pollution, etc.

Staff

Senior Principal Scientific Officer ... B. B. Rae

Seal Damage, Codworm, Rare Fish, etc.

354. *Seals.* During the year, fourteen grey seals and six common seals were received at the laboratory for identification and examination. The stomach contents included the remains of gadoid, salmonid and clupeoid fishes, thus providing further evidence of the predation of seals on commercially important fish. Final adjustments were made to a paper on the food of seals in Scottish waters.

355. An analysis of the returns of seals sighted by salmon fishermen during the 1967 fishing season suggests a marked increase in the numbers of these animals on the Scottish east coast (Table 6). The thirteen stations making returns show that 911 (702) seals were sighted around the nets in 1967 compared with 551 (481) from 16 stations in 1966 and 575 (493), also from sixteen stations,

in 1965. These figures give a minimum estimate of 3·2 (2·5) seals present per working week in 1967 compared with 1·7 (1·5) in 1966 and 1·5 (1·3) in 1965. (The figures in brackets represent even more conservative estimates if it is assumed that only one seal was present near the nets when there were two or more 'sightings').

1967

TABLE 6. SUMMARIES OF SALMON FISHING STATION RETURNS ON SCOTTISH EAST COAST (THE FIGURES IN BRACKETS REPRESENT NUMBERS OF SEALS, ASSUMING THAT ONLY ONE WAS PRESENT WHEN TWO OR MORE WERE REPORTED AS SEEN).

	Period of observations	*No. of working weeks*	*No. of seal sightings*	*No. of seals with salmon*	*No. of salmon heads, etc.*	*Average no. of seals per working week*
Goswick	20/2–9/9	22	218(126)	—	6	9·9(5·7)
Boddam	21/2–31/8	23	29(29)	9	—	1·3(1·3)
Rossie	21/2–31/8	26	21(21)	3	14	0·8(0·8)
Watermouth	22/3–31/8	17	16(16)	2	11	0·9(0·9)
Charleton	26/4–31/8	15	29(29)	—	4	1·9(1·9)
Woodston (fly-nets)	21/2–31/8	26	40(40)	25	33	1·5(1·5)
Woodston (bag-nets)	21/2–31/8	23	27(27)	—	—	1·2(1·2)
Rockhall	23/2–31/8	22	316(232)	27	8	14·4(10·5)
Johnshaven	22/2–31/8	20	22(17)	—	—	1·1(0·9)
Auchmedden (Pennan)	8/3–26/8	24	27(24)	—	—	1·1(1·0)
Nairn	27/2–26/8	25	5(5)	—	—	0·2(0·2)
East Delnies	13/3–26/8	21	93(75)	4	22	4·4(3·6)
West Delnies	15/3–26/8	22	68(61)	—	12	3·1(2·8)
Totals 1967	20/2–9/9	286	911(702)	70	110	3·2(2·5)
1966	11/2–2/9	325	551(481)	59	64	1·7(1·5)
1965	15/2–14/9	373	575(493)	124	57	1·5(1·3)

356. The proportion of seal-clawed salmon on Aberdeen fish market over the fishing season, from February to August, was 2·5 per cent. This compares with 1·8 per cent in 1966 and 2·9 per cent in 1965. A resumé of seal damage to fish and fisheries was prepared for a NERC working party and, in a slightly revised form, was submitted to the Marine Mammals Committee of ICES.

TABLE 7. INFESTATION OF COD BY LARVAE OF *Porrocaecum decipiens*; BASED ON SAMPLING OF COD IN RESEARCH VESSEL CATCHES. NUMBER OF FISH EXAMINED (N) AND PERCENTAGE INFESTED (%I) (1958–61 RESULTS ALREADY PUBLISHED IN MAR. RES. 1963 No. 2)

Region	*Period of Sampling*	*Size-group of Cod* 31–50 cm N	%I	51–70 cm N	%I	over 70 cm N	%I	*Total* N	%I	*Progress of Infestation Size-Groups* +	−	*Total*
Firth of Forth	1958–61	922	13	405	33	48	67	1,375	21			
	1964–65	245	17	34	35	5	100	284	21	3		=
Southern North Sea	1959–61	122	0	40	0	13	0	175	0			
	1964–67	149	1	74	11	62	15	285	7	3		+
Aberdeenshire Coast	1958–61	420	1	141	16	142	47	703	13			
	1964–67	40	5	22	23	33	45	95	23	2	1	+
Moray Firth	1958–61	322	6	184	21	75	28	581	14			
	1964–67	290	15	127	45	71	65	488	30	3		+
East Orkney	1958–61	143	10	51	28	14	64	208	18			
	1964–67	59	29	15	60	2	100	76	37	3		+
East Shetland	1958–61	268	11	120	38	96	64	484	28			
	1964–67	159	33	102	50	33	48	294	40	2	1	+
Northern North Sea	1958–61	389	1	167	5	128	12	684	4			
	1964–67	106	8	55	15	42	24	203	13	3		+
North of Scotland	1958–61	180	13	84	16	54	37	318	18			
	1964–67	106	8	123	32	110	47	329	29	2	1	+
North Minch	1958–61	47	38	202	38	138	45	387	41			
	1964–67	73	59	114	45	83	65	270	55	3		+
South Minch to Irish Coast	1958–61	20	15	81	57	43	70	144	55			
	1964–67	5	60	52	65	19	79	76	68	3		+
West of 7°W Long.	1959–61	12	17	74	28	47	40	133	32			
	1964–67	53	23	214	36	265	40	532	37	2	1	+
Firth of Clyde	1959–61	98	46	74	47	25	56	197	48			
	1964–67	62	39	22	59	1	0	85	44	2	1?	−

357. *Codworm.* Attention has been focussed mainly on the examination of cod caught by research vessels during the past four years. The proportions of fish with parasitic larvae of *Porrocaecum decipiens* have been calculated for various regions and localities of Scottish fishing grounds from 1964 to 1967 and are reproduced in Table 7, in which comparable figures for the years 1958–61 are also included.

358. A comparison of the two periods shows that, in ten of the twelve regions and localities from which samples were examined, the overall infestation of marketable cod and codling is now higher than in 1958–61, in some instances considerably higher. In one locality, the Firth of Forth, the proportions of infested fish are the same in the two periods, while in only one area, the Firth of Clyde, is the infestation in 1964–67 less than in the earlier four years period. It should be noted, however, that in both the Forth and the Clyde few cod of 71 cm and over were examined, and since the infestation of the larger fish is generally heavier than that of the smaller fish, this would undoubtedly affect the overall percentage of infested fish.

359. These results confirm those of recent years, derived mainly from commercial sampling, and show that infestation of cod flesh by larval *Porrocaecum decipiens* is increasing on all Scottish fishing grounds in the North Sea and on the west of Scotland. Although the growth of this problem is greatest in the North Sea area, the increase on western grounds is quite remarkable in areas in which infestation has been abnormally high for many years.

360. It is interesting to refer here to research on another nematode worm, *Anisakis*, found in the flesh of herring, at present being undertaken by Dutch scientists. Since it is believed that seals represent the definitive host of this parasite as well as of *Porrocaecum decipiens*, a number of seal and porpoise stomachs were preserved for examination by Mr. P. van Banning, of Ijmuiden, who also spent a month at the Marine Laboratory investigating the occurrence of larval *Anisakis* in plankton organisms. It is understood that the incidence of this parasite of herring has also increased greatly in recent years.

361. *Food of cod.* Observations on the stomach contents of 15,000 cod caught by Scottish research vessels in the North Sea and on west of Scotland grounds from 1922 to 1965 show that feeding takes place over the entire year but reaches its highest intensity during June and July and its lowest in March and April and again in September. The food consists predominantly of decapod crustaceans and fish, with much smaller quantities of molluscs, echinoderms, worms and coelenterates, etc. In general, the smaller cod of 21–50 cm feed mainly on decapods and to a less extent on fish, but as the cod increase in size their diet changes gradually from crustaceans to fish. In some localities, the Minch and the Firth of Clyde, however, the larger cod, 51 cm and over, continue to feed heavily on decapods, particularly on Norway lobsters, which in these areas must be regarded as the chief food type. In most of the other areas, the larger cod feed predominantly on fish and in some localities, for example off the north of Scotland and in the Moray Firth, sandeels constitute the outstanding food item, in 50 to 80 per cent of the stomachs. Charts showing the incidence of Norway lobsters and sandeels in the food of cod are of particular interest in view of the current importance of the former to Scottish fisheries and of the potential value of the latter as a likely species for industrial exploitation.

362. The food of cod has also been studied on Faroese grounds. Although the feeding cycle resembles that of cod in Scottish waters, the various phases all appear to be about a month later at Faroe. Sandeels again form the outstanding

item in the stomach contents and, although in general the food resembles that of cod in Scottish waters, there are nevertheless some remarkable differences. For example, no Faroese cod were found feeding on Norway lobsters and the shrimp *Pandalus* proved to be the commonest crustacean in their food. Haddock were also prominent in the stomachs at Faroe but herring, mackerel, whiting (all important types in Scottish waters) were rarely eaten.

363. *Dogfish food.* The proportion of dogfish with empty stomachs throughout the year (60 per cent) is higher than in any other species so far examined at the Marine Laboratory. This is in agreement with the results of similar investigations on this dogfish in other parts of the world. The food consists chiefly of fish with small but variable proportions of crustaceans, molluscs, annelids, tunicates and coelenterates. The herring is the most important single species in the dogfish's diet in Scottish waters, although sandeels, mackerel and small gadoids are also prominent locally. The dogfish was found to be predominantly a pelagic feeder, preying mainly on pelagic fishes, cephalopods, and occasionally, and somewhat spasmodically, on planktonic organisms such as ctenophores, salps and jellyfishes.

364. A review of evidence of the impact of dogfish shoals on Scottish fisheries over the past 200 years indicates predation on fish stocks and damage to catches and fishing gear, particularly in drift-net fisheries for herring.

365. *Food of shags and cormorants.* An analysis of the stomach contents of shags and cormorants in the estuary of the River Dee and in the Montrose area is now in hand. This shows that although these birds prey on salmonid smolts, this does not appear to be a serious problem in the two areas investigated.

366. *Rare fish records.* Rare fish records during the year included a number of interesting features. Since 1st January 1967, seventeen deal-fishes were recorded from grounds stretching from south-east Iceland to Montrose—the highest total ever listed for any one year. In July and August, five opahs, again a record for any one year, were reported from south-east Iceland to Skye. In the latter half of the year, Ray's bream were again recorded in higher than average numbers, and finally, two pink or hump-backed salmon were caught, the first in a sweep net at Bonar Bridge, Sutherland, on 7th July, and the second, also in a sweep net, near Whiteness, Shetland, on 29th August.

367. *Salmon Diseases, etc.* A. L. S. Munro, H. J. Ball. Although primarily the concern of the Department's Freshwater Fisheries Laboratory at Pitlochry, the diagnostic work on salmon and other fish diseases is undertaken for convenience at Aberdeen. Previously this was concerned in the main with furunculosis, but during 1967 there were outbreaks of U.D.N. disease in Scotland, and work was necessarily concerned principally with that problem, and in attempting to determine its cause. Details are given in the Report on Freshwater Fisheries Research. (page 136).

368. *Pollution Problems.* The 'pollution' group, at present led by Dr. Rae, includes representatives of the various relevant sections, as follows:

B. B. Rae, R. Johnston, R. E. Craig, J. A. Adams, D. P. Sharman.

369. While various problems have arisen, work (*ad hoc* and anticipatory) proceeded under three main headings.

370. *Effluent from Pulp Mill near Fort William.* The most striking feature of the Loch Linnhe-Loch Eil surveys during the past year was the increase in the amount of suspended fibres evident in net hauls and in particulate carbohydrate analyses. At the same time, there was a progressive increase in B.O.D.

at the surface and at depths of 1, 2, 5 and 10 metres, and to a less extent in bottom samples. The increase extending from one to two miles on either side of the effluent pipe is 1·0 to 1·5 ppm for the upper waters. The oxygen content remains satisfactorily high. Average pulp fibre in the effluent amounts to 24 tons per day which at 60 per cent planned output anticipates 40 tons per day on full production. This level exceeds the present limit of 30 tons per day. While the presence of fibres obscures the phyto- and zooplankton organisms in net hauls, on close examination the numbers and species of organisms remain steady. One small set of dye experiments was worked along with the University of Strathclyde, involving two dye releases into the effluent pipe. The first was made to determine the dilution obtained near the diffusers. The second, during flood tide, was used to measure effluent movement into Loch Eil.

371. *Cromarty Firth Survey.* A report has been prepared on the hydrographical and plankton surveys of Cromarty Firth. Detailed lists of the organisms found in the phytoplankton and zooplankton were made; this should assist in the detection of any future changes arising from the effects of pollution.

372. *Surveys of Inverness and Beauly Firths.* Two surveys of the narrows at the junction of the Inverness and Beauly Firths were carried out by Mr. Craig. The first of these was concerned with a study of temperature, salinity, oxygen and B.O.D. measurements associated with the plankton, and the second to measuring tidal currents. A third survey will be devoted to a study of dispersion by the release of Rhodamine-B dye.

373. Complaints about an obnoxious odour in the Inverness area were investigated and the cause was found to be abnormal accumulations of the green seaweed *Enteromorpha* during 1966. The weed had accumulated at high water mark where there was little opportunity for its dispersal. As decay set in, anaerobic conditions resulted before all organic matter had been broken down, with the consequent production of hydrogen sulphide by anaerobic bacteria.

374. *Experimental.* Towards the end of 1966, some experiments were carried out to establish the toxicity of condensate from the evaporating plant at a distillery in Kincardineshire. Three concentrations of condensate in sea water were tested—one in fifty, one in ten and one in two. In the first two concentrations, plaice, sticklebacks and blennies were used as the test species, while sticklebacks alone were employed in the highest concentration. No evidence was found that the condensate was toxic, over a period of about three days, to any of the species at the concentrations tested.

375. Arrangements were made to provide more suitable facilities for testing the possible toxic effect of substances suspected of causing pollution.

376. Tests were made on the use of dry powdered peat as an aid to the clearing of oil from the surface of the sea. The results showed that though peat was moderately successful, it was nevertheless inferior to straw, since it was more readily wetted and had only one-half the oil-retaining capacity of straw.

Staff

Principal Scientific Officer	J. A. POPE
Scientific Officer	J. A. URQUHART

377. The complement of this section remained at the same level as in 1966/67, although several staff changes occurred during the year and the unit operated under complement because of difficulties in replacing assistants who secured promotion elsewhere.

378. The work of the section necessarily continues mainly along lines similar to those of recent years, with the important exception of the relatively large amount of time now being devoted to computer programming.

Market Sampling and Commercial Statistics

379. As indicated in last year's report, several changes in the processing of market samples were planned for 1967, and these were introduced at the beginning of the year, to coincide with the production of revised statistical tabulations of landings and effort, for processing in the Department's computer in Edinburgh. The charting and tabulation of commercial statistics for fish population studies continued, with a slight increase in the amount of data handled. The processed data from these routine censuses, together with biological statistics derived from the various samplings, were used in compiling the UK Fish Stock Record and supplied to ICES for publication in the Bulletin Statistique and the Council's Statistical News Letters, and for use by its various Fish Stock Assessment Working Groups.

Advisory Work

380. A most important element of the unit's work concerns assistance to various sections in connection with their investigations: this year in the fields of shellfish investigations, population dynamics of cod, the abundance estimation of herring, racial analysis of whiting, salmon tagging and salmon rearing, plankton and bottom fauna, parasitology, productivity, waste disposal and pesticide research, together with analysis of the results of various comparative fishing experiments.

381. A particular example concerned samples collected in different depth zones in two parts of Loch Ewe, with the objectives of (*a*) assessing the sampling error in the data, (*b*) determining optimum sampling schemes for future work and (*c*) determining the minimum sorting and identification required to provide a clear picture of variation in the bottom fauna in future sampling. Another was to determine the relationship in the O-group plaice population of Loch Ewe between growth in weight on the one hand, and food availability and food intake on the other. Yet a third concerned the fitting of reasonably simple models to the curves of embryo and alevin growth obtained from the experimental investigations proceeding at Pitlochry.

Computer Programming

382. Progress under this head was somewhat slow, during the first year of the new arrangement under which projects are prepared for processing on the Head Office IBM 360 computer.

383. By the end of the year various programmes were, however, in different stages of processing, especially for the fish teams and the hydrography unit. A particular project has been to fit asymptotic regression curves to unequally spaced and unequally weighted observations, the curves including a number of special cases, notably the Bertalanffy growth curve. This in turn involves the inversion of a 3 × 3 matrix and the re-writing of an available but not quite appropriate library programme.

Comparative Fishing and Gear Testing

384. This section continued to be heavily committed in the design, execution and analysis of comparative fishing experiments, especially those arising from the Saro project and involving comparative fishing experiments between *Explorer* and the MAFF research vessel *Ernest Holt*. One feature of the results obtained in recent years has been the hint of a real interaction between ships and gear which, with the experimental design so far employed, has precluded the determination of gear effects uncontaminated by a combination of ship and gear effects, and a recent experiment has been designed to remove this defect.

Search Theory

385. Preliminary research has been proceeding into the theory of searching for moving targets, and especially the problem of locating herring shoals by means of echosounding. The interim results suggest that a particular type of rectangular spiral search path (the Russian box design) has advantages over search patterns previously used. The optimum dimensions for such a pattern were evaluated, on certain assumptions relating to swimming speeds of fish, which should cover the largest area and at the same time avoid repeated detection of the same target, and this pattern was employed on a cruise although the data collected have not yet been fully analysed.

386. Owing to the heavy pressure of other demands on the unit's time, work proceeded only slowly on the economic analysis of fishery statistics and the preliminary investigation of a new method of forecasting, in numerical terms, catch-per-unit-effort indices. It is known that the forecasting methods employed so far are relatively crude and this was confirmed; more sophisticated methods will be attempted in the coming year.

PUBLICATIONS AND CONTRIBUTIONS

REPORTS, ETC., PUBLISHED

1. BAXTER, I. G. 1966. Trawling survey for adult herring West of Scotland. *Annls biol., Copenh.*, **21** (1964), 121–124, 1966.
2. BLAXTER, J. H. S. 1966. The effect of light intensity on the feeding ecology of herring. *Brit. ecol. Symp. no. 6 Light as an ecological factor: ed. by R. Bainbridge*, 393–409, 1966.
3. BLAXTER, J. H. S. and JONES, M. P. 1967. Development of the retina and retinal motor responses in the herring. *J. mar. biol. Ass. U.K.*, **47**, 677–697, 1967.
4. BURNS, R. B. and JOHNSTON, R. 1966. Near northern seas. Chemical observations. *Annls biol., Copenh.*, **21** (1964), 29–36, 1966.
5. CRAIG, R. E. 1967. Developments in fish detection. *Scott. Fish. Bull.*, no. 28, 11–12, 1967.
6. CRAIG, R. E. and LAWRIE, R. G. G. 1966. Undersea observations for fishery problems. *Proc. I.E.R.E. Conf. on Electronics in Oceanography, Southampton Univ.*, Sept. 1966, Pap. no. 2, 1–3, 1966.
7. DUNTHORN, A. A. 1966. Gamma-radiography of fusion welded pressure vessels. *J. Sci. Technol.*, **12**, 173–178, 1966.

8. EBLING, F. J., HAWKINS, A. D., KITCHING, J. A., MUNTZ, L. and PRATT, V. M. 1966. The ecology of Lough Ine 16. Predation and diurnal migration in the *Paracentrotus* community. *J. Anim. Ecol.*, **35** (3), 559–566, 1966.
9. EDWARDS, R. R. C. 1967. The estimation of the respiratory rate of young plaice (*Pleuronectes platessa* L.) under natural conditions using zinc-65. *Nature, Lond.*, **216**, 1335–1337, Dec. 30, 1967.
10. FIGUEIREDO, MARIA JOSE DE, and THOMAS, H. J. 1967. On the biology of the Norway lobster, *Nephrops norvegicus* (L.). *J. Cons. perm. int. Explor. Mer*, **31**, 89–101, 1967.
11. FIGUEIREDO, MARIA JOSE DE and THOMAS, H. J. 1967. *Nephrops norvegicus* (Linnaeus 1758) Leach—A review. *BARNES, H. ed. Marine Biology and Oceanography—An Annual Review*, **5**, 371–407, 1967. [Reprinted in] *Notas Estud. Inst. Biol. mar., Lisb.*, no. 33, 1967.
12. FOSTER, J. J. 1967. European fishing gear research. *Scott. Fish. Bull.*, no. 28, 17–21, 1967.
13. FOSTER, J. J. 1966. Data collection in fishing gear research. *Proc. I.E.R.E. Conf. on Electronics in Oceanography, Southampton Univ.*, Sept. 1966, **1**, 19/1–19/5, 1966.
14. FRASER, J. H. 1966. Atlantic area. Plankton Investigations from Aberdeen 1964, between Northern Ireland and Rockall. *Annls biol., Copenh.*, **21** (1964), 69, 1966.
15. FRASER, J. H. 1967. Siphonophora in the plankton to the north and west of the British Isles. *Proc. R. Soc. Edinb.*, **70B**, 1–30, 1967.
16. FRASER, J. H. 1967. Marine fisheries research in the United Kingdom. [Descriptive Brochure for World Fishing Exhibition, London, 1967.]
17. HAWKINS, A. D., CHAPMAN, C. J. and SYMONDS, D. J. 1967. The spawning of haddock in captivity. *Scott. Fish. Bull.*, no. 28, 7–10, 1967.
18. HAWKINS, A. D., CHAPMAN, C. J. and SYMONDS, D. J. 1967. Spawning of haddock in captivity. *Nature, Lond.*, **215**, 923–925, Aug. 26, 1967.
19. HEMMINGS, C. C. 1966. Olfaction and vision in fish schooling. *J. exp. Biol.*, **45**, 449–464, 1966.
20. HEMMINGS, C. C. 1966. The mechanism of orientation of Roach *Rutilus rutilus* L. in an odour gradient. *J. exp. Biol.*, **45**, 465–474, 1966.
21. HEMMINGS, C. C. 1967. Divers observe the Danish seine net. *Scott. Fish. Bull.*, no. 27, 17–20, 1967.
22. HEMPEL, G. and BLAXTER, J. H. S. 1967. Egg weight in Atlantic herring (*Clupea harengus* L.) *J. cons. int. perm. Explor. Mer*, **31** (2), 170–195, 1967.
23. HUNT, SHEILA V. 1967. Apparatus for the elution of steroids in thin layer chromatograms. *Lab. Pract.*, **16** (5), 601, 1967.
24. JOHNSTON, R. and STEELE, J. H. 1966. The need for automation of observations in fisheries oceanography. *Proc. I.E.R.E. Conf. on Electronics in Oceanography, Southampton Univ., Sept.*, 1966, **1**, 14/1–14/4 1966.
25. JONES, R. and CROSS, D. G. 1966. Scottish investigations of the North Sea haddock stock. *Annls biol., Copenh.*, **21** (1964), 95–96, 1966.
26. JONES, R. and CROSS, D. G. 1966. Scottish investigations of the West Coast stock of haddock. *Annls biol., Copenh.*, **21** (1964), 92–93, 1966.
27. JONES, R. and CROSS, D. G. 1966. Scottish investigations of the stock of haddock at Faroe. *Annls biol., Copenh.*, **21** (1964), 93–94, 1966.
28. JONES, R. and HISLOP, J. R. G. 1966. Scottish investigations of the North Sea whiting stock. *Annls biol., Copenh.*, **21** (1964), 99–100, 1966.
29. JONES, R. and HISLOP, J. R. G. 1966. Whiting—Scottish investigations of the West Coast whiting stock. *Annls biol., Copenh.*, **21** (1964), 98–99, 1966.
30. JONES, R., HISLOP, J. R. G. and RAITT, D. F. S. 1967. Haddock, whiting and cod prospects. *Scott. Fish. Bull.*, no. 28, 2–3, 1967.
31. KABATA, Z. 1966. Copepoda parasitic on Australian fishes, VI. Some caligoid species. *Ann. Mag. nat. Hist.* Ser. 13, **9**, 563–570, 1966.
32. KABATA, Z. 1967. Whiting stocks and their gall-bladder parasites in British waters. *Mar. Res.*, 1967 no. 2, pp. 9. Edinburgh, H.M.S.O. Price 4s. 6d.
33. LAMONT, J. M. 1967. Plaice investigations in Scottish waters 2. Age-composition and growth. *Mar. Res.*, 1967, no. 3, pp. 51, Edinburgh, H.M.S.O. Price £1 1s. 6d.
34. LUCAS, C. E. 1967. Report of the Director of Fisheries Research. *Rep. Fish. Scotl.* (1966), 58–116, 1967.
35. LUCAS, C. E. 1967. Investigations of the stocks of the blue whiting by the Marine Laboratory. *Aberdeen Press and Journal Fishing and Shipping* Review, p. 12, 7th Nov., 1967.
36. LUCAS, C. E. 1967. Problems in fish farming and large-scale ecological control. *Proc. Conf. Tech. Sea & Sea-bed, Min. Tech. 1967*, **1**, 44–54, 1967.
37. LYTHGOE, J. N. and HEMMINGS, C. C. 1967. Polarized light and underwater vision. *Nature, Lond.*, **213**, 893–894, Mar. 4, 1967.
38. MCPHERSON, G. and SAVILLE, A. 1966. Scottish herring fisheries 1964. *Annls biol., Copenh.*, **21** (1964), 125–135, 1966.
39. MASON, J. 1967. Shrimps around Scotland. *Scott. Fish. Bull.*, no. 27, 13–16, 1967.
40. MASON, J. 1967. Money from old rope. *Scott. Fish. Bull.*, no. 27, 26–27, 1967.

41. MASON, J. 1967. Developments in the scallop fishery 1963–1966. *Scott. Fish. Bull.*, no. 28, 21–22, 1967.
42. MASON, J. 1967. Cockles in Scotland. *Scott. Fish. Bull.*, no. 28, 4–7, 1967.
43. MOWAT, M. J. D. 1966. A digital acoustic telemeter for fishing gear research. *Proc. I.E.R.E. Conf. on Electronics in Oceanography, Southampton Univ.*, Sept. 1966, **1**, 20/1–20/3, 1966.
44. PARRISH, B. B., RAITT, D. F. S. and SAVILLE, A. 1967. Industrial fisheries. *Scott. Fish. Bull.*, no. 27, 5–13, 1967.
45. PARRISH, B. B. and SAVILLE, A. 1967. Changes in the fisheries of North Sea and Atlanto-Scandian herring stocks and their causes. *Oceanogr. mar. biol.*, **5**, 409–447, 1967.
46. PAYNE, R. and CRAIG, R. E. 1966. Near northern seas. Temperature and salinity in Scottish waters 1964. *Annls biol., Copenh.*, **21** (1964), 26–27, 1966.
47. PAYNE, R. and CRAIG, R. E. 1966. Near northern seas. Monthly releases of current indicators from four stations in the North Sea. *Annls biol., Copenh.*, **21** (1964), 28–29, 1966.
48. POPE, J. A. and THOMAS, H. J. 1967. Some biometric observations on *Nephrops norvegicus* (L.) *J. Cons. perm. int. Explor. Mer*, **31**, 265–271, 1967.
49. RAE, B. B. 1967. The significance of the observation of haddock spawning. *Scott. Fish. Bull.*, no. 28, 10–11, 1967.
50. RAE, B. B. 1967. The food of cod in the North Sea and on west of Scotland grounds. *Mar. Res.*, 1967, no. 1, pp. 68. Edinburgh, H.M.S.O., Price 24s. 0d.
51. RAE, B. B. 1967. The food of the dogfish, *Squalus acanthias* L. *Mar. Res.*, 1967, no. 4, pp. 19. Edinburgh, H.M.S.O., Price 7s. 0d.
52. RAITT, D. F. S. and SYMONDS, D. J. 1967. The Scottish cod fishery in the North Sea. *Mar. Res.*, 1967, no. 5, pp. 24, Edinburgh, H.M.S.O., Price 8s. 6d.
53. RAITT, D. F. S. 1967. Blue whiting. *Scott. Fish. Bull.*, no. 28, 12–16, 1967.
54. RAITT, D. F. S. and HALL, W. B. 1967. A note on the fecundity of the redfish *Sebastes marinus* (L.). *J. Cons. perm. int. Explor. Mer.*, **31** (2), 237–245, 1967.
55. SAVILLE, A. 1967. Forecasts for Scottish North Sea and West Coast herring fisheries in 1967. *Scott. Fish. Bull.*, no. 27, 2–4, 1967.
56. SAVILLE, A. 1966. Scottish fisheries on adolescent herring. *Annls biol., Copenh.*, **21** (1964), 124–125, 1966.
57. SEATON, D. D., FRASER, J. H., ADAMS, J. A. and BAIRD, I. E. 1966. Plankton investigations from Aberdeen 1964 in the Near Northern Seas Area. *Annls biol., Copenh.*, **21** (1964), 61–65, 1966.
58. SEATON, D. D. and FRASER, J. H. 1966. Plankton investigations from Aberdeen 1964 in the Distant Northern Seas. *Annls biol., Copenh.*, **21** (1964), 56, 1966.
59. SIMPSON, T H and WARDLE, C. S. 1967. A seasonal cycle in the testis of the spurdog *Squalus acanthias*, and the sites of 3β-hydroxysteroid dehydrogenase activity. *J. mar. biol. Ass. U.K.*, **47**, 699–708, 1967.
60. SMITH, J. W. 1967. *Aporocotyle margolisi* n. sp. (Digenea: Aporocotylidae) from *Merluccius productus*. *J. Fish. Res. Bd. Canada*, **24** (8), 1763–1773, 1967.
61. SMITH, J. W. and WILLIAMS, H. H. 1967. The occurrence of the blood fluke *Aporocotyle spinosicanalis* Williams, 1958, in European hake, *Merluccius merluccius* L., in British waters. *J. Helminth.* **41** (1), 71–88, 1967.
62. STEELE, J. H. 1967. Current measurements on the Iceland-Faroe Ridge. *Deep-Sea Res.* **14** (4), 469–473, 1967.
63. STEELE, J. H. 1967. Problems in fish farming. *Scott. Fish. Bull.*, no. 27, 21–24, 1967.
64. TAIT, J. B. *ed.* 1967. The Iceland-Faroe Ridge International (ICES) 'Overflow' Expedition May–June, 1960. An investigation of cold, deep water overspill into the North-Eastern Atlantic Ocean. *Rapp. P.-v. Cons. perm. int. Explor. Mer*, **157**, 1–274, 1967.
65. TAIT, J. B. 1967. Introduction. List of station positions. Horizontal temperature and salinity distributions. Vertical temperature and salinity distributions. [in] Iceland-Faroe Ridge International 'Overflow' Expedition. *Rapp. P.-v. Cons. perm. int. Explor. Mer.*, **157**, 7–15, 38–100, 1967
66. TREVALLION, A. 1967. An investigation of detritus in Southampton Water. *J. mar. biol. Ass. U.K.*, **47** (3), 523–532, 1967.
67. WILKINS, N. P. 1967. Polymorphism of whole blood proteins in the cod (*Gadus morhua* L.). *J. Cons. perm. int. Explor. Mer*, **31** (1), 77–88, 1967.
68. WILKINS, N. P. 1967. Immunology, serology and blood group research in fishes. *Polymorphismes biochemiques des animaux, 10th Congr. européen sur les groupes sanguins et le polymorphisme biochemique des animaux. Paris, 5–8 juillet 1966*, 355–359, 1967.
69. WILKINS, N. P. 1967. Starvation of the herring *Clupea harengus* L.: survival and some gross biochemical of changes. *Comp. Biochem. Physiol.*, **22**, 503–518, 1967.

The following relevant publications have also been issued by the Department:

70. Fisheries of Scotland, Report for 1966, Cmnd. 3460, pp. 148, Edinburgh, H.M.S.O., 1967, 11s. 0d.

71. Scottish Sea Fisheries Statistical tables, 1966, pp. 54, Edinburgh, H.M.S.O., 1967, 8s. 6d.
72. Scottish Fisheries Bulletin, no. 27, June, 1967.
73. Scottish Fisheries Bulletin, no. 28, December, 1967.
74. Fish Stock Record 1966. (Jointly with Ministry of Agriculture, Fisheries and Food.) 1967.

REPORTS, ETC., IN PRESS

In addition to the contributions to *Annales Biologiques* for 1965 and 1966 and *Statistical Newsletter* of ICES, the following scientific marine papers have been accepted for publication and are in the press.

75. ADAMS, J. A. Plankton studies with the Gulf III sampler [Abstract] *Rep. Challenger Soc.*
76. ANSELL, A. D. and TREVALLION, ANN. Studies of *Tellina tenuis* da Costa on the Scottish west coast. 1. Growth and biochemical composition. *Expl mar. Biol. Ecol.*
77. BAIRD, I. E. and WETZEL, R. G. A method for the determination of zero thickness activity of C14 labelled benthic algae in sand. *Limnol. Oceanogr.*
78. BENTLEY-MOWAT, J. A. and REID, S. M. Effect of gibberellins, kinetin and other factors on the growth of unicellular marine algae in culture. *Bot. mar.*
79. BENTLEY-MOWAT, J. A. Do plant growth substances affect the development and ecology of unicellular algae? [Abstract] *Int. Con. on Plant Growth Regulators, Oct.* 1966.
80. BENTLEY-MOWAT, J. A. and REID, S. M. Investigation of the radish leaf bioassay for kinetins, and demonstration of kinetin-like substances in algae. *Ann. Bot.*
81. BURNS, R. B. Drift bottle recoveries at Orkney. [Abstract]. *Rep. Challenger Soc.*
82. CHAPMAN, C. J. Acoustics and fish behaviour. [Abstract]. *Rep. Challenger Soc.*
83. DUNTHORN, A. A. Observations on development of *Nephrops norvegicus*. [Abstract]. *Rep. Challenger Soc.*
84. EDWARDS, R. R. C. and STEELE, J. H. Relations between density, growth and food requirements of O-group plaice. [Abstract]. *Rep. Challenger Soc.*
85. FOSTER, J. J. and MOWAT, M. J. D. Shipboard handling of scientific data with special reference to fishing gear research and hydrography. [Abstract]. *Rep. Challenger Soc.*
86. FRASER, J. H. The history of plankton sampling. *UNESCO Manual of sampling methods—Introductory chapter.*
87. FRASER, J. H. Report of the International Working Group on the Standardisation of Zooplankton Methods at Sea. *UNESCO Manual on Sampling Methods.*
88. FRASER, J. H. Variability in the oceanic content of plankton in the Scottish area. *SCOR Symp. Variability in the Oceans.*
89. FRASER, J. H. Plankton resources. *Reinhold Encyclopedia of marine resources.*
90. HAWKINS, A. D. Observations on spawning behaviour of haddock. [Abstract]. *Rep. Challenger Soc.*
91. HEMMINGS, C. C. Underwater vision and fish behaviour. [Abstract]. *Rep. Challenger Soc.*
92. JONES, R. Some aspects of feeding and digestion in cod and haddock. [Abstract]. *Rep. Challenger Soc.*
93. KABATA, Z. *Nicothoë* Audouin and Milne-Edwards, 1826 (Copepoda), a genus parasitic on *Nephrops* Leach, 1816 (Decapoda). *Zoöl. Meded., Leiden.*
94. KABATA, Z. The genus *Haemobaphes* (Copepoda: Lernaeoceridae) in the waters British Columbia. *Can. J. Zool.*
95. MCINTYRE, A. D. and ELEFTHERIOU, A. E. The bottom fauna of a flatfish nursery ground. *J. mar. biol. Ass. U.K.*
96. MCINTYRE, A. D., LASKER, R. and WELLS, J. B. J. The role of meiofauna in the sand ecosystem. [Abstract]. *Rep. Challenger Soc.*
97. MASON, J. Boats, gear and bait. *Wld Fishg.*
98. MUNRO, A. L. S. and BROCK, T. D. Distinction between bacterial and algal utilisation of soluble substances in the sea. *J. gen. Microbiol.*
99. MUNRO, A. L. S. and STEELE, J. H. Some problems concerning production on a sandy beach. [Abstract]. *Rep. Challenger Soc.*
100. OSBORNE, R. D. and SIMPSON, T. H. Gel filtration of iodoamic acids. *J. Chromat.*
101. RAE, B. B. 1968. The food of cod on Faroese grounds. *Mar. Res.*, 1967, no. 6, pp. 23, Edinburgh, H.M.S.O., 1968. Price 8s. 6d.
102. RAITT, D. F. S. and NIVEN, D. R. Exploratory prawn trawling in the waters off the Niger Delta. *UNESCO/FAO/OAU Symposium on Oceanography and Fisheries Resources of the Tropical Atlantic. Abidjan, October,* 1966.
103. RAITT, D. F. S. and SAGUA, V. O. Preliminary investigations on the biology of *Brachydeuterus auritus* (Val. 1831), in Nigerian waters. *UNESCO/FAO/OAU Symposium on Oceanography and Fisheries Resources of the Tropical Atlantic. Abidjan, October, 1966.*

104. RAITT, D. F. S. Synopsis of biological data on the blue whiting (*Micromesistius poutassou*) (Risso) 1810. *FAO Fish. Biol. Synops.*
105. REID, S. M. and MOWAT, J. A. The effect of kinetin and gibberellins 1, 2, 3 and 4 on the growth of marine algae. [Abstract]. *Trans. Bot. Soc., Edinb.*
106. SAVILLE, A. The biology of young herring in the Moray Firth and their recruitment to the adult stocks. [Abstract]. *Rep. Challenger Soc.*
107. SIMPSON, T. H. Hormones in fish—a review. [Abstract]. *Rep. Challenger Soc.*
108. STEELE, J. H. and BAIRD, I. E. Production ecology of a sandy beach. *Limnol. Oceanogr.*
109. THOMAS, H. J. 1967. Stock availability of crabs and lobsters in Scotland. *Wld Fishg.*
110. THOMAS, H. J. The Scottish shrimp and prawn fisheries. *Wld Fishg.*
111. TREVALLION, ANN and ANSELL, A. D. Studies of *Tellina tenuis* da Costa on the Scottish west coast. 2. Growth in tanks. *Expl mar. Biol. Ecol.*
112. WARDLE, C. S. Physiological response of fish to capture and captivity. [Abstract]. *Rep. Challenger Soc.*

CONTRIBUTIONS TO INTERNATIONAL MEETINGS

The following contributions by members of the Marine Staff were presented at the meeting of ICES in Hamburg October, 9–19, 1967.

113. DUNTHORN, A. A. Some observations on the behaviour and development of the Norway lobster. K.5.
114. FRASER, J. H. *Pleurobrachia* in Scottish waters in 1966. L.2.
115. FRASER, J. H. and HANSEN, Vagn Kr. Plankton Identification Sheets. L.3.
116. FRASER, J. H. Overflow of oceanic plankton to the shelf waters of the North-East Atlantic. L.13.
117. HISLOP, J. R. C. and HEMMINGS, C. C. A preliminary assessment of the survival of haddock (*Melanogrammus aeglefinus* (L.)) tagged underwater. F.28.
118. JOHNSTON, R. Notes on analytical methods and problems. C.38.
119 MCINTYRE, A. D. and ELEFTHERIOU, A. The bottom fauna of a flat fish nursery ground. K.18.
120. RAE, B. B. Seal damage to fish and fisheries. N.7.
121. RAITT, D. F. S. Cod spawning in Scottish waters—preliminary investigations. F.29.
122. RAITT, D. F. S. Further observations on the population dynamics of Norway pout: the effect of the poor 1963 year class in the North Sea. F.30.
123. RAITT, D. F. S. Scottish blue whiting investigations in 1967. Preliminary report. F.31.
124. SAVILLE, A. Report on the international trawling survey for immature herring in the North Sea in 1967. H.28.
125. SAVILLE, A. The Scottish herring fishery and exploited stock in the northern North Sea in 1966 and 1967. H.29.
126. STEELE, J. H. and H. DOOLEY. Current studies in the Norwegian Deeps—June–July 1966. C.37.

Papers by the Marine Staff were presented at other international meetings as follows:

INTERNATIONAL FISHERIES MEETING, ABERDEEN, MARCH 6–8, 1967

127. FOSTER, J. J. Shipborne computer applications with special reference to fishing gear research.
128. FOSTER, J. J. Developments in fishing gear research instrumentation.
129 FOSTER, J. J. Direct observations of the performance of fishing gear.
130. HEMMINGS, C. C. Diving and photographic methods in the Corsica gear project 1966.

ICNAF BIO-ECONOMICS WORKING GROUP

131. PARRISH, B. B. North-eastern Arctic fisheries, biological aspects.

FAO CONFERENCE ON FISH BEHAVIOUR IN RELATION TO FISHING TECHNIQUES AND TACTICS, BERGEN, OCTOBER 19–27, 1967

132. CHAPMAN, C. J. and HAWKINS, A. D. The importance of sound in fish behaviour in relation to capture by trawls.
133. FOSTER, J. J. The influence of fish behaviour on trawl design, with special reference to mathematical interpretations of observations on the swimming speeds of fish and results of C.F. experiments.

134. HEMMINGS, C. C. A discussion of the principles of observing fish behaviour in relation to fishing gear.
135. HEMMINGS, C. C. Observations on the behaviour of fish during capture by the Danish seine net and their relation to herding by trawl bridles.
136. PARRISH, B. B. A review of some experimental studies of fish reactions to stationary and moving objects of relevance to fish capture processes.

INTERNAL REPORTS AND MINOR PUBLICATIONS

137. [CRAIG, R. E.]. 1967. 'Goldseeker' to study shellfish. *Scott. Fish. Bull.*, no. 28, 1967.
138. CRAIG, R. E. and ADAMS, J. A. The Cromarty Firth [Part 1. A study of the estuarine circulation with reference to water pollution]. Mimeogr. pp. 20.
139. ELSON, K. G. R. Furunculosis. *Fish Disease Leaflet*, no. 1, pp. 6. 1967, Mimeogr.
140. ELSON, K. G. R. Disinfection of salmonid eggs. *Fish Disease Leaflet*, no. 2, pp. 3, 1967, Mimeogr.
141. FOSTER, J. J. A report on the feasibility of acquiring a computer based shipborne data logging system for the Marine Laboratory, Aberdeen, April 1967.
142. [LUCAS, C. E.]. 1967. United Nations resolution on the resources of the sea. *Scott. Fish. Bull.*, no. 28, 1–2, 1967.
143. POPE, J. A. 1967. Fish measuring on the market. *Scott. Fish. Bull.*, no. 27, 24–25, 1967.
144. RAE, B. B. Seal damage to fisheries in 1967. Typescript. December, 1967.
145. SAVILLE, A. 1967. Marine fish farming. *Aberfar.*, no. 5, 10–12 Sept. 1967.
146. WILKINS, N. P. Scottish biochemical studies on salmon. *ICNAF Res. Doc.* 67/99, Ser. no. 1898. Mimeogr. pp. 3.

II. SALMON AND FRESHWATER FISHERIES RESEARCH

CONTENTS

II. SALMON AND FRESHWATER FISHERIES RESEARCH

Officer in Charge: K. A. PYEFINCH, M.A., F.R.S.E., F.I.BIOL., *Freshwater Fisheries Laboratory, Pitlochry*

INTRODUCTION

1. In most of the recent annual reports of freshwater fisheries research, some reference has been made to the fact that much of the work described is a continuation of the investigations of previous years. That this is true is inherent in the nature of this work but the continuation of many of the main projects may mask the amount of change that takes place.

2. Many of the changes are linked with important developments which affect the salmon fisheries. Some developments, such as the offshore drift-netting for salmon which occurred over the period 1960–62, call for limited investigations which last for a year or two; others, such as the effect of seal damage on coastal salmon fisheries, necessitate maintaining routine observations and records over long periods; but sometimes the developments require major research programmes which extend over many years and which may come to affect many parts of the research programme.

3. One such development has been the rapid growth of the Greenland salmon fishery. Details are given later in the report of the progress made in the investigation of this fishery; the whole study not only involves work directly connected with this fishery, such as tagging smolts from as many Scottish rivers as possible and participating in tagging experiments on the Greenland coast, but also calls for the intensification of the study of the salmon fishery in home waters. Indeed, one of the salutary features of a major development of this kind is that it focuses attention on aspects of salmon biology which may have been inadequately studied, or even neglected, in the past.

4. The investigation of the Greenland salmon fishery will require the fullest co-operation between all those countries which are thought to contribute fish to this fishery, but the other recent major development, the outbreak of salmon disease (which at present has been given a descriptive name, ulcerative dermal necrosis, or UDN) is rather more domestic in its impact. Twelve months ago it was possible to say that no major outbreak of this disease had occurred in Scottish rivers and it is to be regretted that it is no longer possible to make this statement now. Some of the Solway rivers were affected during the late autumn and early winter of 1966; in the spring of 1967 a more serious outbreak occurred in the Tweed, and the disease spread to the Spey and a number of other east coast rivers later in the year. A full account of all the work carried out on this disease is given later in this report (paras. 126–143), but unfortunately it is not yet possible to identify the causative organism. Present indications are that the causes of this disease are complex and that both a virus and one or more pathogenic bacteria may be responsible for the symptoms which have been observed.

5. Investigations of pesticide residues, particularly but not wholly in the freshwater environment, have formed an important part of the programme of the chemistry section for some years past. Part of these investigations has been concerned with the acute effects of pesticides, e.g., fish mortalities produced by pollution from sheep dips, but a more important part of this problem is that which arises from more chronic effects produced, perhaps, by the addition of

sub-lethal quantities of pesticides to the aqueous environment over long periods of time. The latter is a serious problem and an account is given later in this report (paras. 178–182) of the results of a preliminary study of the occurrence of organochlorine residues in four species of wildlife—earthworms, mussels, pike and starlings—in twelve European and North American countries. These first results make it clear that there is still much to be learned about the estimation and evaluation of pesticide residues and that it is important that work should be started on the investigation of the effects which such pesticide concentrations as may be present might have on the animals in which they occur. The actual effects produced may be small but, as they may well affect fundamental processes, their delineation is a task which is of vital significance and not merely a useful complement to the chemical investigations which have now been started.

6. Requests for advice on the management of salmonid fisheries, particularly brown trout fisheries, continue to be received and the laboratory is becoming increasingly involved in giving advice about management operations extending over long periods. This is a welcome development in that it reflects an increasing awareness of the fact that, in many cases, the adjustment or improvement of a fishery can only be done slowly. In this connection, the account given later (paras. 97–111) of the rehabilitation of the trout fishery of the Lake of Menteith is of particular importance because this is an operation which is being carried out by the local proprietors under direct guidance from the laboratory. It is hoped that this investigation will prove useful as a guide to similar operations elsewhere, particularly as records are being kept of the cost of the management operations involved and of the returns received from the improved fishery.

7. Most of this report concerns investigations which have been in progress for a number of years and these have, in general, developed along expected lines. The full complement of traps on the Girnock burn have now been in commission for over a year; these have already produced useful information (paras. 26–41) the value of which will undoubtedly increase as the observations are continued. The transfer of two members of staff to Montrose made it possible to give more regular attention to the work on the North Esk (paras. 64–81) and the laboratory's share in the Loch Leven investigations (paras. 112–125) is developing as expected. The work on the bottom fauna of salmonid nursery streams (paras. 153–157) continues to explore the relationship between this fauna and plant detritus on the one hand and to trout and salmon on the other continued.

8. Specific acknowledgement is made at a number of places in this report of help received in carrying out particular investigations but this is only a small part of the debt which the laboratory owes to those who have provided facilities for field work or who have helped in other ways. This help, which is much appreciated, is gratefully acknowledged.

Staff and Facilities

9. Dr. D. M. Witcomb resigned her post of Scientific Officer on appointment as a lecturer in the Department of Biology, University of Salford. Her place on the Pitlochry staff was taken by Dr. D. A. Cadwalladr. Mr. H. J. Ball was appointed as a Scientific Officer to work at the Marine Laboratory, Aberdeen on bacterial diseases of fish. The Experimental Officer complement was filled during the year and the Sandwich Course students and University students

employed for shorter periods during the summer provided useful additional assistance.

10. Mr. Norman F. Buchan, M.P., Parliamentary Under Secretary of State, visited the laboratory in April and the laboratory was also visited by a number of other persons and organisations from at home and abroad, including angling clubs, university societies and schools. In particular, those attending the OECD/NERC[1] Conference on 'Pesticide Residues in Wildlife' visited the laboratory in September.

11. Mr. K. A. Pyefinch attended the meetings of the ICES/ICNAF[2] Joint Working Party on Atlantic Salmon and of the Anadromous and Catadromous Fish Committee of ICES which were held in Hamburg in October. Mr. A. V. Holden visited Sweden and Norway in November 1966, at the invitation of the Swedish Royal Commission on Natural Resources, to discuss pesticide problems affecting wildlife and also attended the meeting of the Sub-Commission on Fish in Polluted Water of EIFAC[3], which was held in London in October 1967. Mr. W. R. Munro visited Norway in August to study kilenot fishing.

12. Mr. Holden and other members of staff organised the Conference on 'Pesticide Residues in Wildlife' which was held at Taymouth Castle, Perthshire during September. This conference, which was arranged by OECD and sponsored by NERC, was convened to discuss the results of the preliminary study of pesticide residues in selected species of wildlife, which had been planned following the Paris meeting noted in the report for 1966. Members of staff again read papers to a number of angling clubs, natural history societies and other organisations.

13. In order to facilitate the work in progress on the River North Esk, a small laboratory was established at Montrose during the spring and two members of the Pitlochry staff were stationed there. At the end of May the remaining member of the laboratory's staff was withdrawn from the Salmon Research Laboratory at Contin, which was then closed. The work still in progress on the Conon River system is now staffed from Pitlochry.

14. A fourth laboratory hut and an additional store and boiler house came into use during the early spring, and work on improvements to the water supply began during the autumn. The work on the water supply was scheduled for completion early in 1968: the improved water supply should allow important research projects, which have been hampered by the inadequacy and uncertainty of the present system, to go forward.

15. A list of the papers published, or accepted for publication, is given at the end of this report, together with a sketch map showing the location of most of the sites where work is in progress.

RESEARCH

Fish Investigations

Growth of Young Salmon

16. Dr. D. H. A. Marr and Mr. J. E. Thorpe made further observations on the survival and growth of the early feeding stages of salmon fry which were

[1]Organisation for Economic Co-operation and Development/Natural Environment Research Council.

[2]International Council for the Exploration of the Sea/International Commission for the Northwest Atlantic Fisheries.

[3]European Inland Fisheries Advisory Commission.

reared, during the alevin stage of development, on grooved surfaces in tanks with rates of turnover of water of once every 8·3, 11·7, 15·4 and 22·3 minutes. These observations confirmed that both growth and survival during the early fry stage of development is influenced by the rate of turnover of water in the alevin rearing tanks. The best survival and growth was obtained in fry which had been reared in tanks with a rate of turnover of water of once every 15·4 minutes.

17. They also tested designs of grooved surfaces which require less hatchery space than that required by glass tubes. These tests showed that the growth of salmon alevins on a grid of parallel perspex strips, 6 mm in width and 12 mm in depth, separated by 4 mm gaps, was as good as that of salmon alevins on a grooved surface formed by laying $\frac{3}{4}$ in. outside diameter glass tubes side by side.

18. In connection with plans for a smolt rearing station, some studies were made on circular rearing ponds. The main requirements in design seem to be (*a*) that rotational displacement of water in the horizontal plane, such as occurs in Swedish-type ponds, should be prevented, (*b*) that the flow of water over the bottom of the pond should be radial so as to carry food to fish in contact with the floor of the pond and (*c*) that provision should be made for the introduction of fish food with the inflowing water supply. The latter should be at the centre of the pond so that the food is carried in the radial flow of water directly towards, and at the correct height for, fish in contact with the floor of the pond.

19. Trials with a prototype pond, 5 ft 6 in. in diameter, showed that young salmon from the fry to the pre-smolt stage remained in contact with the floor of the pond and stemmed the radial water flow over all parts of the pond floor with the exception of a small area under the inflow pipe. Except for the times when food was carried in with the water supply, the behaviour of fry and parr in the prototype pond was closely similar to that described by Kalleberg (Kalleberg, H. 'Observations in a stream tank of territoriality and competition in juvenile salmon and trout (*Salmo salar* L. and *Salmo trutta* L.)', Rep. Inst. Freshwat. Res. Drottningholm, 39, 55–98 (1958)) for fry and small parr at stations in the large stream tank at the Drottningholm Institute of Freshwater Research. Since this tank provided an environment that was very similar to that of a natural stream or burn it is reasonable to assume that the behaviour of young salmon in the prototype pond is very similar to that of young salmon in their natural environment.

20. Salmon, at all stages of development from fry to smolt, fed extremely well in the prototype pond on a proprietary dry salmon food that was carried in the radial water flow across and just above the floor of the pond. The feeding behaviour of fish in the pond was, however, different from that of fish in the Drottningholm stream tank because in the pond food was frequently carried very close to the fish. In consequence fish did not have to swim up into open water from the floor of the pond in order to obtain food particles, although this behaviour was sometimes observed. Often it was necessary only for a fish to open its mouth to ingest food while at other times a slight depression of the pectoral fins was sufficient to raise the fish to the level of an approaching food particle. Fish were also capable of taking food particles that were rolling across the floor of the pond. In such cases the head and anterior end of the body were rapidly flexed downwards in order to place the mouth in the correct position to intercept the food particles. Lateral deflections of the head and anterior end of the body were also employed to effect interceptions.

21. Fifty salmon, which were reared for 11 weeks from the late alevin stage at a density of one fish per square inch in two small tanks incorporating the principles described in paragraph 18, survived without loss. These fish were fed entirely on a proprietary dry fish food which was automatically distributed in the inflowing water supply, and they attained an average size of 4·6 cm with a range of 3·1 to 5·7 cm.

22. A paper on the factors which affect the growth of salmon alevins and their survival and growth during the fry stage of development was prepared for the ICES meeting in Hamburg (13) and a report on 'The Standardization of Research Techniques' was published jointly with Professor H. S. Swingle and Dr. S. E. D. El-Zarka in the Proceedings of the World Symposium on Warm-water Pond Fish Culture (6).

23. Further experiments were carried out to test the hypothesis that the number of feeding channels available to a population of salmonid fry has a greater effect on the amount of aggressive behaviour in the population than the area available to the population, where a feeding channel is defined as a localised region of flowing water which carries particles of food either continuously or for limited periods, and is distinguished from regions of slack or flowing water which never convey food.

24. Experiments carried out in 1966 showed that the number of sequences of overt aggressive behaviour by the dominant fish in a population of four trout fry, in a population of two trout and two salmon fry, and in a population of four salmon fry which were maintained in tanks and fed a limited quantity of food, was not significantly altered if the area of the tank was reduced from 250 to 125 sq. in. However, aggressive behaviour by the dominant fish in the trout and in the mixed populations was significantly lower when a fixed quantity of food was distributed by two food channels than when it was distributed by one food channel, although particles of food were present in the food channel for only two hours in each 24-hour period. Aggressive behaviour was recorded only at times when food particles were absent from the food channels. Observations on a population of four salmon fry, however, showed that neither the overt aggression of the dominant fish nor the total overt aggression of the population was significantly altered by increasing the number of food channels from one to two. This result was confirmed in 1967.

25. Since there is no *a priori* reason for assuming that the mechanism regulating aggressive behaviour in salmon fry is fundamentally different from that in trout fry, it is likely that there is some other reason for the difference, for example, the food channels were unsuitable for salmon fry because they contained food only for very short periods of time but were suitable for trout fry. To test this assumption a further experiment was conducted with three tanks, each of about 250 sq in. in area, which were fitted respectively with one, two and three food channels, each continuously supplied with food in such a way that each tank received the same amount of food. The sequences of aggressive behaviour in each population of three salmon fry in each tank were recorded on two consecutive eight-minute periods on three separate days. The results are given below.

No. of food channels	1	2	3
No. of sequences of fighting ...	111	59	29

The differences in the number of sequences of fighting are significant, $p < 0{\cdot}001$.

26. Mr. W. R. Munro and Mr. R. J. G. Buck report that the traps for upstream and downstream migrants near the mouth of the Girnock Burn, Aberdeenshire, worked very satisfactorily throughout the year and withstood severe flooding without damage. Their successful operation at night was greatly improved by the installation of flood-lighting which has allowed more precise attention to be paid to the trapping of descending migrants and has markedly facilitated the handling of ascending adult migrants. Leaves, however, continued to present difficulty to maintaining the traps in operation during autumn floods and, despite every effort, spillage was unavoidable for short periods on occasions. Experience gained under a variety of difficult conditions, however, provided enough evidence to suggest that during peak flood conditions little movement of fish appears to take place and the numbers of fish which by-pass the downstream traps when spillage is occurring may, therefore, not be significant.

27. During the year ended 31st October 1967, 119 salmon kelts, 6,416 salmon fry (6,029 of this year's brood), 3,317 salmon parr, 18 trout fry and 884 older trout passed through the descending trap. During this period 700 eels also passed downstream. From early March onwards all salmon parr and trout measuring over 10·0 cm in length, totalling 2,388 and 695 respectively, were tagged before release. The trout were tagged to try to obtain further information on the migratory and non-migratory composition of the stock of this species in the burn.

28. Although the recorded adult salmon spawning stock which entered the Girnock Burn during 1966 was similar to the estimated stock entering in 1965, only small numbers of salmon fry entered the descending trap during the autumn of 1967 and there was no repetition of the large, distinctive movement downstream recorded in 1966. Earlier in the year, towards the end of May and during the first half of June, a definite movement downstream of over 3,500 post-alevin fry took place. This migration, small in relation to the estimated number of ova deposited in the burn, was confined to the hours of darkness and occurred during varying water levels. It was not sustained and possibly resulted from the dispersal of fry from redds near-by.

29. In contrast with the movement of salmon fry, the movement of salmon parr was clearly defined, occurring mainly during two periods, the spring silver parr and smolt migration which takes place from early March to early May and the autumn migration which appears to take place from mid-October to mid-November. Although the latter migration is reminiscent of the migrations of parr observed in the tributary burns at the same season in previous years, only 3·5 per cent of the parr captured were precocious males, whereas precocious males have always formed a high percentage of the tributary migrants and, in 1966, 92 per cent of the parr in the East Burn and 36·5 per cent of those in the South Burn showed signs of sexual maturity. Substantial numbers of salmon parr have again been moving into the main descending trap this autumn and indications are that the percentage of precocious males is similar to that recorded last year. Results obtained so far indicate that approximately one-third of all salmon parr captured during the year in the descending trap in the main burn enter in late autumn and early winter.

30. A total of 269 adult salmon (156 females and 113 males) and a total of 24 adult sea trout (13 females and 11 males) entered the main ascending trap during 1966. Six of the female salmon entered in an almost completely spent

condition. All adult salmonids were allowed to move upstream to the spawning areas after the salmon had been measured and tagged and the sea trout measured. As far as possible this work was carried out during the high water conditions which had induced the fish to enter the Girnock Burn, thus allowing them to proceed further upstream whilst conditions remained suitable. Regular observations were made over the entire burn during the autumn and early winter and some interesting information on the dispersal of the salmon stock over the spawning areas and its subsequent history was obtained. Some of these findings are tabulated below.

	Females	*Males*
Killed by otter, unspawned	20 (13·3%)	1 (0·9%)
Found dead, unspawned	3 (2·0%)	0
Killed by otter, as kelt	0	8 (7·3%)
Found dead, as kelt	11 (7·4%)	35 (31·2%)
Recorded through trap as kelt	96 (64·0%)	24 (21·2%)
No record after tagging	20 (13·3%)	44 (39·4%)

31. Recoveries of tagged fish show that 127 of the 150 unspawned female salmon originally passed upstream could have survived to spawn in the burn.

32. The number of adult salmon which have entered the burn during the autumn of 1967 so far has been below that recorded for 1966, and a total of 138 (66 females and 72 males) was recorded up to the end of October. However, as a substantial number of fish enter the burn in November, this count is almost certain to be increased before the spawning run ends. In contrast, over twice as many adult sea trout have entered the burn in 1967 as in 1966 and a total of 47 (27 females and 20 males) was recorded up to the end of October.

33. The traps in the two tributary burns continued to operate efficiently throughout the year and, although on occasions attention to them was limited by priority given to the main traps, spillage occurred only twice during the year and lasted only for a short time. Fewer adult salmon entered the two burns in 1966 than in 1965 and the final totals were 3 (1 female and 2 males) in the East Burn and 13 (5 females and 8 males) in the South Burn. In 1965 10 adult salmon (5 females and 5 males) entered the East Burn and 24 (15 females and 9 males) entered the South Burn. No sea trout entered either of the tributaries in 1966 and none has so far been recorded this autumn.

34. The final trap counts of juvenile salmonids for both burns in 1965 and 1966, as well as the totals to 31st October 1967, are given in the following table.

Year	*Salmon Fry*	*Salmon Parr*[1]	*Trout Fry*	*Trout*[1]
		East Burn		
1965	2	72(6)	27	375(9)
1966	41	50(30)	5[2]	335(34)
1967	181	20(12)	0	115(38)
		South Burn		
1965	0	78(4)	13	225(9)
1966	192[3]	210(112)	13[3]	237(39)
1967	109	137(91)	0	91(40)

[1] Figures in brackets indicate numbers of fish silvering.
[2] Excluding 82 fry which could not be identified to species.
[3] Excluding 224 fry which could not be identified to species.

35. As in previous years a small but well-defined downstream migration of salmon parr occurred in each burn during the late autumn and early winter of 1966 and larger numbers were recorded than during the corresponding period of

1965. Although the numbers of salmon parr moving out of the burns during the spring migration period in 1967 were rather less than those in 1966, the figures for trout over the corresponding period show a pronounced decrease from the substantial totals recorded in previous years and, in both burns, only about one-third of the usual numbers were recorded. All salmon parr and trout moving out from each burn were tagged during 1967 and some interesting information on the movement of fish between the point of release and the main descending trap was obtained. The record of recaptures during the spring migration period shows that, despite considerable variation in the time taken to do so, a very high percentage of silvering salmon parr reached the main trap; the record of trout recaptures shows that many of them also appear to be migrating out of the system after leaving the burns. Some details of the recapture of fish at the main trap are given in the tables below.

Salmon Recaptures

	Girnock East Burn	*Girnock South Burn*
Number tagged	12	90
Number recaptured	12	79
Percentage recaptured	100	88
Average number of days to main trap	23	14
Time range (days)	1 to 58	1 to 56

Trout Recaptures

	Girnock East Burn	*Girnock South Burn*
Number tagged	85	63
Number recaptured	61	44
Percentage recaptured	73	70
Average number of days to main trap	6	6
Time range (days)	1 to 23	1 to 17

36. Small numbers of the current brood of salmon fry moved out of each burn during 1967 but no significant pattern of movement of this stage was apparent. In the East Burn only one female salmon spawned in 1966 and the progeny of this single fish, moving out as fry during the summer of 1967, show some interesting size variations, which are shown in the table below:

	Number	*Length range*
May	47	2·9–3·0
June	68	3·0–3·2
July	3	4·0 (no variation)
August	54	4·0–5·5
September	4	4·8–5·9
October	4	4·9–5·8

37. During the year a good deal of time was devoted to the development of an accurate method of assessing the composition and size of the total stock of juvenile salmonids in the Girnock Burn by means of electro-fishing. Because it was not always possible to have satisfactory electro-fishing equipment available this investigation did not progress as far as had been hoped. Nevertheless, some valuable results were obtained and a system of sampling devised which can be developed, it is hoped, to serve as standard practice for yearly assessment of the number of fish in the burn.

38. Early in 1967, in preparation for this survey, the Girnock Burn was divided into five habitat types, each defined according to gradient and substrate. The whole of the main burn was then measured and its area calculated. It had

been hoped that it would be possible to extend the measurements to the tributary burns this year, but this part of the survey was not carried out, though it should be completed early in 1968. For the purpose of electro-fishing the burn was then divided into three main sections (lower, middle and upper) all of which contained areas of the five habitat types, and samples were taken at least once from each type within each section. Each sample was taken from an accurately measured area, enclosed by stop nets, which was intensively fished three times, with an interval of approximately one hour between each fishing. As the distribution of fish within any one area might have been affected by electro-fishing, no area was re-visited for sampling subsequently. In order that sampling could be carried out with comparable efficiency these electro-fishing operations were concentrated into a relatively short period during the summer, during low water conditions. The number of fish within four length ranges was recorded for each area sampled in each of the five types of habitat and the total population of each section was then calculated on a proportional basis. The separate results thus obtained for each section were added together to give an estimate of the total number of fish in the stream.

39. The classification of habitat types was as follows:

Type 1 Rather deep, rapid flowing current; bottom consisting of large boulders and rough stones; little gravel or silt.

Type 1A Current similar to Type 1, but water relatively shallow; bottom consisting of smaller boulders and rough stones; small amounts of gravel and silt deposited.

Type 2 Rather deep, slow flowing current; bottom consisting of boulders, coarse gravel and silt.

Type 3 Medium to fast current, shallow; bottom gravelly, typical of salmon spawning area.

Pool Deep, slow flowing current; bottom generally containing some large stones but substantial silt deposits.

40. The following table shows the area of each type of habitat present in each of the three sections into which the stream was divided for census work and the total area of each habitat in the main stream. Figures in brackets give the actual areas fished electrically during the census.

Area in sq. ft. x 1000

Type of Habitat	*Lower Section*	*Middle Section*	*Upper Section*	*Total*
1	143·5(3·3)	80·9(4·8)	35·2 (1·8)	259·6(10·0)
1A	50·9(3·6)	130·0(4·1)	42·7(4·1)	223·6(11·8)
2	30·0(1·1)	8·8(1·3)	11·4(1·8)	50·2(4·2)
3	3·2(—)	46·0(1·9)	10·1(1·8)	59·3(3·7)
Pools	2·2(0·8)	7·4(0·5)	4·1(—)	13·7(1·3)
Totals	229·8(8·8)	273·1(12·6)	103·5(9·6)	606·3(31·0)

41. All the fish caught during electric fishing were measured and scales were also taken from all fish, except the current year's fry. When these scales have been read it will be possible to make estimates of the numbers of each age group in the stream but for the present, preliminary unadjusted estimates of the numbers of fish in various length groups present in each section, and in the main stream as a whole, are given in the following table.

Estimations of Salmonid Fish Populations, Main Girnock Burn

		Salmon Size Range (cm)			*Trout Size Range (cm)*
	<6·0	6·0–7·9	8·0–9·9	>10·0	5·8–10·0
Lower Section	13,750	4,300	2,350	1,700	1,150
Middle Section	12,200	2,350	750	1,200	600
Upper Section	8,000	1,650	150	400	600
	33,950	8,300	3,250	3,300	2,350

Investigations of Fry Survival in the Bran System

42. Dr. D. H. Mills, of the Department of Forestry and Natural Resources, University of Edinburgh concluded his observations on fry survival in tributaries of the River Bran, Ross-shire and is now preparing the results of this investigation for publication. Unfed salmon fry were again added to Allt a' Chomair and Allt dos Mhuicarain this spring, at similar densities to those used in 1964 and 1965, and fry survival and other characteristics of the fish populations of these streams were assessed by fishing the streams electrically during the early autumn. Details are given in the table below.

43. In Allt a' Chomair, although the population density of salmon parr and trout was lower this year than in any of the preceding three years, there was no consequent increase in the survival of fry. The population density of fry this year was of the same order as that occurring in 1964 when the population density of older fish was five times higher. The low population density of fry this year may have been due to the flood conditions which prevailed at the time of their liberation, which might well have displaced many of the fry from the stream. There is no indication that the addition of fertiliser to this stream last year has had any beneficial effects.

44. The results for Allt dos Mhuicarain are similar to those for 1966 except that the population density of fry is lower than might have been expected in relation to the population density of older fish present. This is probably also due to the flood conditions which prevailed at the time of fry planting.

	Allt a' Chomair				*Allt dos Mhuicarain*			
	1964	1965	1966	1967	1964	1965	1966	1967
Stocking density (unfed fry/m²)	3·09	3·00	3·02	3·21	3·43	3·53	3·65	3·42
Density of salmon and trout at census (no./m²)	0·15	0·10	0·07	0·03	0·18	0·15	0·11	0·14
Density at census (fry/m²)	0·15	0·22	0·39	0·17	0·80	0·36	0·39	0·21
Wt. of fish present (g/m²)	1·18	1·34	1·66	0·65	4·25	2·81	2·83	2·32
Av. length of fry at census (cm)	4·0	4·9	4·9	4·7	5·7	6·1	5·7	5·4

Rearing Salmon Parr and Smolts in Lochs

45. Mr. G. Struthers, who was in executive charge of this project, points out that, as anticipated in last year's report, no further survivors from the 40,000 fry planted in 1963 have been recorded in the trap in the outflow from Loch Kinardochy and it was clear that the results from the first stocking experiment were complete. The 7,007 fish which migrated out of the loch following this first planting represented a survival of 17·5 per cent and their total weight of 786 lb gives a crop of 19·2 lb/acre spread over three years. Over 86 per cent of these migrants were 10 cm or longer when trapped and almost 63 per cent migrated as true smolts, the remainder mostly moving out of the loch as parr or silvering parr.

46. Migrants from the 1965 planting of a similar number of fry continued to enter the trap throughout the year and details of the monthly counts are given in the following table.

Period	1965 *Planting* Numbers Trapped[1]	*Av. Length (cm)*[1]	*Range (cm)*
May 1965–October 1966	1,587(4,447)		
1966			
November	3(99)	13·9(15·2)	11·0–19·0
December	13(27)	16·1(16·7)	13·5–19·2
1967			
January	9(5)	17·1(12·9)	12·4–28·5
February	5(0)	17·0(—)	14·0–24·6
March	8(65)	25·6(20·4)	14·2–31·6
April	2(35)	12·2(19·4)	9·1–15·3
May	140(178)	18·0(16·0)	13·6–30·1
June	56(749)	18·2(18·5)	13·3–20·7
July	0(729)	—(20·0)	—
August	243(190)	25·3(20·9)	16·6–30·8
September	6(263)	24·0(24·5)	13·6–29·5
October	170(88)	27·8(25·3)	17·4–33·0
Total	2,242(6,875)		

[1] Figures in brackets indicate corresponding numbers or values following the 1963 planting.

47. From this table it will be seen that, as in previous years, there was little activity during the winter months although water levels were often high from December to March. During April water temperatures rose rapidly around the middle of the month but water levels were very low and it was not until May that a smolt run developed, reaching a peak towards the end of May and the first week of June. This movement occurred following a relatively small rise in water level to values much lower than those often occurring during the winter.

48. During the second half of June, all of July and the first fortnight in August water levels were low but, following a small rise of only 3½ in. in water level on 15th August, a very clearly defined movement of 243 fish occurred in five days. Water levels were again low in September but were high in October when further movements of fish occurred throughout the month. As at the corresponding stage in the first experiment, a very high proportion (almost 98 per cent) of the autumn migrants were smolts and, of those which migrated in September and October, 17 per cent and 25 per cent respectively, were ripe males. To date over 1,500 (70 per cent) of the migrants from this planting have entered the trap as smolts.

49. In last year's report attention was drawn to the rather slower growth rate exhibited by the migrants from the second stocking and to the fact that, up to October 1966, a much smaller number of fish had migrated out of the loch than at the corresponding stage in the first experiment. From a comparison of average lengths at corresponding stages, shown in the table above, it appears that survivors from the 1965 planting have now reached average lengths which are at least comparable to those obtaining during the first experiment, but that the number of migrants is still only about a third of that recorded at the equivalent stage in the first experiment. Although some further survivors may be expected to migrate as smolts next spring, it now seems probable that the final survival rate from this second experiment will be substantially lower than the

exceptionally good one recorded from the first experiment. Nevertheless, the survival to date, of over 5·5 per cent, is satisfactory in that it compares favourably with published reports of survival rates to the smolt stage in streams.

50. It had been intended to carry out a third experiment by stocking at a different rate in the spring of 1967 but, because of the different results obtained from the first two plantings with similar numbers of fry, it was decided to carry out a third stocking at the same rate and a further 40,000 unfed fry were accordingly distributed around the shores of the loch on 1st May 1967. Only a small number of fish from this recent planting has entered the trap so far. Details of movement over the first six months are compared with the corresponding figures for the 1963 and 1965 plantings in the following table.

	No. of Migrants			*Average Length (cm)*		
Month	1963	1965	1967	1963	1965	1967
May	—	4	31	—	2·8	2·8
June	9	213	31	4·5	3·6	3·3
July	59	103	5	5·3	4·3	5·2
August	13	11	4	7·4	5·2	6·3
September	693	23	26	10·0	6·4	7·0
October	862	34	47	9·8	7·6	8·3
Total	1,636	388	144			

51. From this table it will be seen that the pattern of movement following the most recent planting was rather more like that of the 1965 stock than that of the 1963 stock, particularly in the absence of any marked autumn movement. The total number of migrants to date is distinctly lower than in 1965 but this is mainly due to a considerable and probably involuntary movement of very small fish during June and July 1965 which were much wetter months than the corresponding months in 1967.

52. The growth rate for the 1967 stocking seems rather better than that for 1965 but does not quite equal that of 1963 and this may explain the absence of an autumn run following stocking this year, since the results from the first experiment indicate that the faster growing fish migrate earlier and that most fish leave the loch after they have attained a length of about 10 cm or more.

53. Many of the migrants which left Loch Kinardochy did so at unusual times of the year and a high proportion of them were larger, often very much larger, than the average size of smolts migrating in the Tummel system. The decision to carry out smolt tagging at Clunie Dam in 1967 provided an opportunity to begin an experiment which should permit a comparison of returns as adults from these Kinardochy migrants with those from the normal run and so, since April, migrants over 10 cm in length at Kinardochy were tagged with the same type of tag as that used at Clunie Dam. To date a total of 566 fish from the 1965 stocking have been tagged, of which 352 were transported and released below Pitlochry Dam, as were the smolts tagged at Clunie Dam, while the remainder were released below the trap at Kinardochy. During October a small number of the larger migrants from the most recent planting were also tagged and released below Pitlochry.

Smolt Tagging

54. Considerable effort was again devoted to tagging smolts on a number of river systems in Scotland as a contribution to the programme of investigations into the significance of the salmon fishery on the west Greenland coast. Following unproductive attempts during 1966 to catch smolts in mill lades on the

Rivers Tay and Tweed, it was decided that the staff available for smolt tagging could be used most efficiently if tagging were confined to sites where traps were already in operation, or where traps had been used in the past and could easily be reinstated. Mr. W. M. Shearer, Mr. P. E. Shackley, Mr. Struthers and Mr. R. J. G. Buck were in charge of the various parts of these operations.

55. During 1967, therefore, smolt tagging was carried out at the Meig and Bran traps on the Conon, at the trap in the Kinnaber lade on the North Esk, at the smolt trap on the Girnock Burn (Aberdeenshire Dee) and at traps at Loch Kinardochy and at Clunie Dam on the Tummel system. At all but one of these sites, that at Clunie Dam, the traps were already in use and the smolt tagging programme formed part of wider studies. At Clunie Dam, the trap in the fish ladder, which had been used from 1961 to 1963 during a study of smolt migration, was reinstated on 13th March and maintained in operation until 5th June. All the smolts tagged at Clunie Dam and most of those tagged at Loch Kinardochy were transported downstream and released below the lowest power station on the river, i.e., below Pitlochry. The smolts tagged on the River Bran were released below Torr Achilty power station (see paras. 59–63). In addition to the wild fish tagged at these sites, smolts from Invergarry Hatchery were tagged and released in the River Ness.

56. Details of the numbers of tagged smolts released during 1967 are given in the following table.

Site	*Main River System*	*Number Tagged*
Bran Trap	Conon	2,700
Meig Trap	Conon	4,179
Girnock Burn	Aberdeenshire Dee	2,058
Kinnaber Lade	North Esk	8,825
Clunie Dam	Tay	3,042
Loch Kinardochy	Tay	189
Invergarry Hatchery	Ness	4,451
		25,444

57. Although the total tagged during 1967 was only about 2,000 more than in 1966, the numbers of wild smolts tagged, which on present results give a much better return, rose from approximately 15,000 in 1966 to over 20,000 in 1967. This distinction is important because previous work has shown that virtually all the hatchery smolts from Invergarry return as grilse and, as the fish which return to Scottish waters as grilse do not seem to be caught on the west Greenland coast, tagged smolts from Invergarry are probably not a significant contribution to the problem being investigated.

58. Most of the smolts were tagged with the standard Scottish silver tag but on the North Esk over 4,000 were tagged with the tag used by the Fisheries Research Board of Canada for smolts. Returns of this tag from a recent international tagging test suggest that it may give a better recovery rate than other smolt tags currently in use and, if so, its adoption as a standard tag, by those countries with interests in the west Greenland fishery, could do much to eliminate one source of variability in the returns of smolt tags from that fishery.

Smolt Transport

59. As in 1966, most of the migrating parr and smolts from the River Bran were caught in the trap installed in the lower reaches of the river and transported

to Moy Bridge, which lies below all the hydro-electric installations on the Conon River system. Mr. Shackley was in charge of this operation.

60. Between 13th April and 26th May, 6,282 parr and smolts were caught in the trap, of which 6,176 were transported and, of the latter, 2,700 were tagged. The condition of the migrants was generally good and, throughout the period, the number of dead or dying fish was 28 (0·45 per cent of the total transported) and most of these mortalities occurred on 8th and 9th May, when the water temperature of the Bran rose sharply. The percentage mortality was similar to that of previous years.

61. The proportion of the total catch transported this year (98·3 per cent) was virtually the same as that in 1966, when 98·4 per cent of the smolts caught were transported, but the proportion of the transported fish which was tagged this year (43·7 per cent) was rather higher than that for 1966 (36·8 per cent). The numbers caught this year were, however, only about two-thirds of those caught last year. The run of migrants from the Bran may have actually been smaller in 1967 than in 1966, but trapping operations this year were interrupted by floods on four occasions.

62. During 1967, 77 recaptures were made of fish which were tagged as smolts and transported during 1966, giving a proportionate recapture to date of 2·30 per cent. Nearly two-thirds of the tagged fish recaptured were taken in the Meig and Luichart traps and, of this trap catch, roughly one-third was caught in the Meig trap and the remainder in the trap below Luichart Dam.

63. Six further recaptures were recorded of smolts tagged and transported in 1965, bringing the total recaptures from this experiment to 13, or 2·7 per cent of the smolts tagged and transported. Smolts have been transported from the River Bran each year from 1963 and the proportionate recaptures as adults (1963–2·8 per cent; 1964–2·2 per cent; 1965–2·7 per cent and 1966–2·3 per cent, to date) are encouraging evidence of the success of this way of avoiding some of the problems created by obstructions on salmon rivers.

North Esk Investigations

64. During 1966 it became increasingly evident that these investigations could no longer be carried out efficiently on the basis of regular visits by staff based at Pitlochry and it was therefore decided to station the two members of staff concerned with this work at Montrose, on a full-time basis, from April onwards. Simple but adequate laboratory accommodation was provided. This arrangement proved very satisfactory and extra help from Pitlochry was required only during the smolt tagging programme in April and May. Mr. Shearer was in executive charge of these investigations.

65. *Downstream movements of young salmon.* The transfer of full-time staff to Montrose has made it possible to make these observations on a more systematic basis and the trap in Kinnaber lade has been in operation, virtually continuously, since 25th March. During the smolt season, two box traps were also fished, one in the Westwater, a tributary of the North Esk, and the other on the north side of Morphie dyke, i.e. on the opposite bank to the intake to Kinnaber lade. The catches in these traps served to augment the number of smolts caught for tagging and, in the case of the Westwater trap, also provided a site for the release of tagged fish well above the Kinnaber lade trap. Recoveries of these fish in the latter served as a check on the results obtained from the second recaptures at Kinnaber of fish which, as in the last three years, were trapped and tagged at Kinnaber and then released upstream again. The data

from these transport experiments during the last four years is now being analysed statistically to provide estimates of the size of the smolt run in the North Esk each year.

66. Up to the end of June a total of 8,277 smolts were tagged, a proportion with the standard Scottish silver tag and the remainder with Canadian tags (see para. 58). In addition, every tagged smolt was also marked by the removal of the adipose fin. Of the total tagged, 7,239 were taken in the Kinnaber trap and 122 and 862 in the box traps in the Westwater and at Morphie Dyke respectively. Unlike previous years, most of the smolts were caught during April, rather than during May, and this may partly account for the relatively poor performance of the Westwater box trap which was not installed until mid-April. During the smolt migration 257 salmon parr and 983 sea trout smolts were also trapped. The average length of all the tagged salmon smolts was 13·5 cm, slightly greater than the corresponding figure for 1966. The daily average varied from 12·3 to 14·3 cm.

67. From time to time there have been reports from various rivers of an autumn migration of young salmon, and trap records on three tributaries of the Aberdeenshire Dee, the Lui Water, the Beltie Burn and the Girnock, have confirmed that there is a downstream movement at this time. On the North Esk, during the autumn and early winter of 1965 and 1966, about 100 young salmon were caught in the Kinnaber lade smolt trap. During these periods, however, this trap could only be operated sporadically because of difficulties with autumn leaves, but there was strong circumstantial evidence that the actual number of fish moving downstream in the lade was much greater, e.g. during the autumn and early winter of 1966 approximately 900 young salmon were caught in the lade while removing adult salmon from the adult trap by electric fishing. The average size of these fish was just over 13·0 cm and three age groups (0+, 1+ and 2+) were present in the sample. Some of these fish were tagged immediately and the remainder were held in a hatchery tank until mid-April, by which time the majority had 'silvered'. The water supply to this tank was pumped from the tidal reaches of the river and it is interesting to record that these fish were able to withstand the daily changes in salinity which must have occurred. Only one of the fish died during the period of impoundment.

68. Because it has been possible to maintain the smolt trap in operation almost continuously this year, more details are now available about this movement. Since the end of the smolt migration in June, some juvenile salmon have been recorded during each month; 7 in July, 53 in August, 188 in September and 851 in October. The same three age groups were again present in the samples and the size range extended from 5·0 to 16·0 cm. Approximately 5 per cent of the total were infected with fungus and two were ripe male parr. Unlike the majority of smolts migrating during the peak of the smolt run, these fish appear to move almost entirely during the hours of darkness and do not form shoals.

69. These results suggest that particularly as the trap was sometimes out of commission and the lade takes only a proportion of the total flow in the river, the downstream movement of young salmon in the North Esk during the autumn may be substantial.

70. Over 1,500 of these fish, including some caught by electric fishing in the lade downstream of the trap, have now been tagged and it is hoped that recaptures of these fish as adults may help to explain two puzzling aspects of the results of the smolt tagging experiments on the North Esk. These are, (*a*) that there is an almost complete lack of tagged fish among the spring catches

PLATE (A)

Smolt trap in Kinnaber Lade, Montrose, looking downstream. Smolts are diverted by the screens into one of the filter beds of the waterworks, which is used as a temporary holding pond.

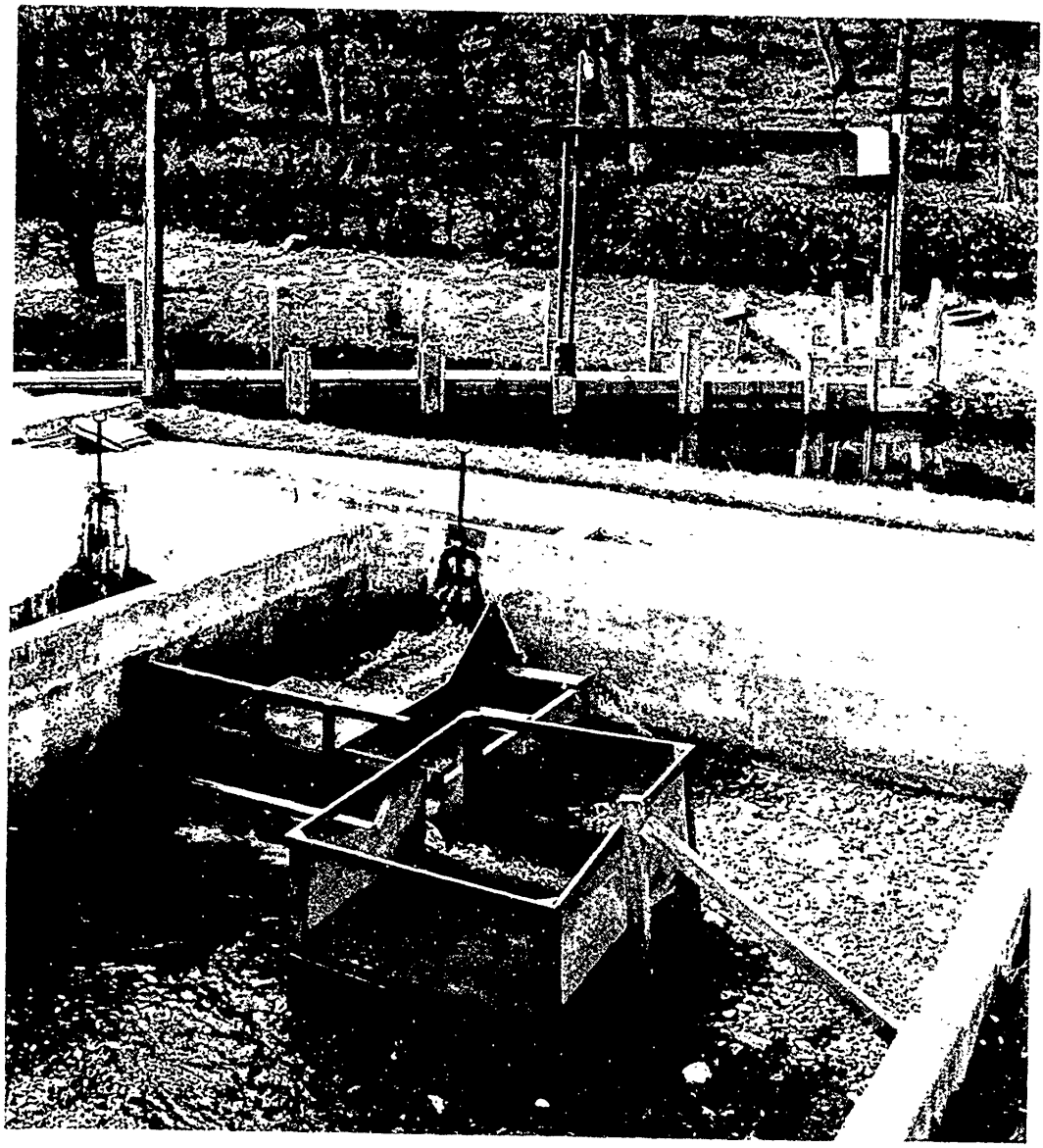


PLATE (B)

Smolt trap in Kinnaber Lade, Montrose, showing the arrangements for trapping smolts in the filter bed (in the foreground) when only small numbers of migrants are moving. During the peak of the migration the smolt trap is removed and the whole filter bed used to accommodate the trapped fish.

in the river and, (*b*) that estimates of smolt production, based on the proportion of tagged to untagged adults in the commercial catch, are always higher than those obtained from the recaptures of tagged smolts transported upstream and subsequently caught for a second time in the Kinnaber trap. Both these facts suggest that, in previous years, a proportion of the juvenile salmon leaving the river has not been sampled and it may be that these autumn migrants, which at least move into the lowermost reaches of the river, will provide the answer.

71. During the period covered by this report a total of 412 recaptures of tagged hatchery-reared and wild smolts released in the North Esk each year from 1963 to 1966 were recorded. In addition, three of the 4,000 tagged hatchery-reared smolts released in the Catterline burn in 1966 were recaptured. The percentage recapture rates for tagged wild smolts released in the North Esk during 1963 and 1964 are now 6·0 and 5·6 respectively and are much higher than the corresponding figures (0·1 and 1·1) for hatchery-reared smolts released during the same years.

72. Most of these recaptures were again made close to the River North Esk but, as in previous years, a small number were recaptured on the Greenland coast during the autumn of 1966 and some were recaptured in home waters distant from the North Esk, e.g. single fish were recaptured at Ackergill near Wick, off Amble in Northumberland and in the River Tweed. All these recaptures were of fish tagged as wild smolts.

73. *Close season salmon runs.* Sampling of these runs was continued during the winter of 1966/67 and, between 1st September 1966 and 16th February 1967, 427 fish were caught, of which 402 were tagged. Of the total caught, 214 were fish about to spawn, 211 were spring fish and 2 were kelts. To date all but one of the recaptures of these tagged fish have occurred in the North Esk District, mostly relatively soon after tagging, but two fish, tagged during September 1966, were not recaptured until the summer of 1967, one during July and the other during September, when they were returning to spawn for a second time. The single recapture outwith the North Esk District was that of a fish caught in November 1966 in the River South Esk, approximately one month after tagging. Although ripe when tagged, this fish had not yet spawned when recaptured.

74. On May 25th 1967 a salmon tagged as a grilse during the 1965/66 close season was caught several miles from the sea in the River Helmsdale. Another fish bearing a close season tag was reported as having been caught and impounded for stripping on the River Spey but precise details are not yet available.

75. Analysis of the material collected during the 1966/67 season confirmed the results obtained during the previous four seasons. The two well-defined groups which make up the runs during the close season exhibit differences in their earlier river life, in that there is a marked tendency for the spawning fish to have originated from larger and younger smolts. In the present material, for example, the calculated smolt length for the spawning fish was approximately 2 cm greater than that for the spring fish and the proportion of fish which had migrated as two-year old smolts was 77 per cent for the former group and 30 per cent for the latter.

76. Close season trapping began again on 2nd September and up to 31st October a total of 464 fish had been examined, of which 452 were caught in September and only 12 in October. Because of the presence of disease among salmon in the River North Esk, only about 30 per cent of these fish were tagged.

77. *Commercial catches.* The commercial catches within the North Esk Fishery District were again sampled. During the spring, salmon catches were of the same order as in 1966 but the salmon catch for the whole season was higher. The grilse catch was also higher than in 1966 and the run of grilse began earlier than usual, as there were reasonable catches in June. Although this suggests that the stock of fish entering the river may have been greater than in 1966, the absence of any reliable information on the spawning escapement and its relationship to the commercial catch makes any firm conclusion impossible.

78. Scales, lengths, weights and sexes were again taken at regular intervals from samples of the commercial catch and, in connection with fecundity studies, samples of ovaries were also preserved. The latter material was augmented by counts made on the eggs produced by salmon stripped by the staff of the district fishery board.

79. The material collected from the commercial fishery during 1966 was analysed and gave results which were remarkably similar, in most respects, to those obtained from the material collected during 1965. For example, the average weights of one-, two- and three-sea winter fish were 5·8, 9·3 and 15·2 lb in 1965 and 5·7, 9·4 and 15·9 lb in 1966. In general the pattern of entry of the various age groups into the fishery was as expected but the grilse fishery was later in attaining its peak in 1966 than in 1965. Similarly, more catchable salmon were available during August 1966 than during the corresponding month in 1965. The proportion of previous spawners was smaller in the 1966 catch than in that for 1965, the values being 2·4 per cent and 3·3 per cent respectively.

80. A comparison of the contributions made by various brood years to the stocks in 1965 and 1966 is given in the following table.

	Percentage of Total Catch	
Brood Year	1965	1966
1964	0·0	0·3
1963	0·2	20·5
1962	19·1	36·8
1961	53·3	36·9
1960	24·7	5·0
1959	2·0	0·5
1958	0·6	0·0
1957	0·1	0·0

81. Thus, in both years, the commercial catch was largely drawn from the survivors of three brood years. The occurrence, in 1965, of a high proportion of grilse which had migrated as three-year-old smolts in 1964 was a reflection of the strength of the 1961 brood and, as expected, this was followed in 1966 by a high proportion of fish of the same smolt age in the salmon catch.

Greenland Salmon Investigations

82. As mentioned in the report for 1966, the investigation of the salmon fishery on the west coast of Greenland was resumed during the autumn of that year and Mr. K. H. Balmain and Mr. Shearer again formed the team from the Pitlochry laboratory. Tagging operations lasted from 19th September to 13th November and two teams, each consisting of a member from Denmark, England and Wales and Scotland, took part. In addition, teams investigating the parasites and the blood characteristics of the Greenland salmon stock were in Greenland over the period mentioned.

83. As in 1965, shore-set gill nets were used, but the Norwegian 'kilenot',

fished in 1965, was not used in 1966. A yellow plastic, double plate tag was again used. During the whole period of 79 days fishing, 2,137 salmon were caught, of which 801 (37 per cent) were alive and of these 728 were tagged. During this period six tagged fish were caught (five carrying Canadian tags and one a fish which had been tagged in the River Axe (Devon)). Unfortunately all these tagged fish were dead when caught.

84. A total of 27 recaptures were recorded locally, of which three-quarters were made within four days of release and, with two exceptions, all were taken in the Godthab district, where the tagging took place. The two exceptions were fish caught in the Fiskenaesset area, almost 50 miles south of the tagging site.

85. Four recaptures in home waters have been recorded from this experiment. Three of these were taken in Scotland (two in the River Tweed, one in March and one in July, and one in a tributary of the Spey in October) and one in the estuary of the Miramichi (Canada) in June.

86. The general characteristics of the salmon caught on the west coast of Greenland in 1966 were very similar to those of the fish caught the previous year. The overall length was similar, the average weight was much the same and there was again a preponderance of female fish in the catch. Again virtually all the fish caught (98 per cent) had spent one winter in the sea and most had migrated to sea after two or three years in fresh water. The relative importance of the two-year and three-year old smolts was, however, reversed in 1966 as compared with 1965.

87. One of the disappointing features of the tagging operations on the Greenland coast, both in 1965 and in 1966, was the small proportion of the total catch which was fit for tagging. In 1965 only about 30 per cent of the catch could be tagged and in 1966, though this proportion was slightly higher (about 34 per cent), the improvement was scarcely significant. The main reason for the low proportion of taggable fish seemed likely to be that gill nets were used and it was therefore decided that some form of trap net should be used instead. After considerable discussion, it was decided that the Northumbrian T-net possessed most advantages and arrangements were therefore made to fish nets of this type in Greenland in 1967.

88. The general arrangements for the Greenland programme in 1967 were similar to those for 1966. Two tagging teams participated, again composed of members from Denmark, England and Wales and Scotland. Mr. Munro was the Scottish representative in the first team and Mr. Struthers in the second. The first team arrived in Godthab on 14th September and the second left on 6th November. Members of the staff of the Marine Laboratory, Aberdeen carried out parasite and blood studies within this period.

89. Five T-nets were fished, at five different sites south of Godthab, at depths ranging from 6 fathoms to 20 fathoms. Gill nets were also fished and the Danish workers fished some gill nets before the party from the United Kingdom arrived. They caught their first salmon on 22nd August and had caught 55 salmon by the end of the month.

90. Including the fish caught by the Danes, 1,546 salmon were caught up to 6th November and of these 347 (22·4 per cent) were tagged. This latter total is less than half that for 1966 but the particularly disappointing aspect of the tagging operations this year was the poor performance of the T-nets as, of the total caught, only 28 were taken in the T-nets and of these 15 were tagged. The proportion of taggable fish from the T-nets (about 55 per cent) was higher

than the corresponding figure for the gill nets (nearly 22 per cent) but the number caught was very small.

91. There were reasons, however, why this poor result from the T-nets may not be a fair estimate of the value of these nets and it seems prudent to test them further on the Greenland coast. It is clear, however, that some method of capture is needed which will produce good catches with a high proportion of taggable fish because, until this is available, vital questions about the west Greenland fishery must remain unanswered. This is one of the problems which are receiving attention from the ICES/ICNAF Joint Working Party, which continues to be responsible for much of the co-ordination of the research work on the Greenland salmon fisheries.

Damage by Seals to Salmon Nets and their Catches

92. Mr. Shearer reported that during the 1967 commercial netting season thirteen sets of records were received from salmon netting stations on the east coast from Goswick and Cheswick in the south to West Delnies (Moray Firth) in the north. An analysis of these records shows a decrease in the amount of damage to the nets and the percentage of seal damaged salmon in the catch over the season as a whole, compared with the previous year. These changes may not reflect a real decrease in the amount of seal activity because the decrease in the amount of net damage may be due to the increasing use of synthetic twine in net construction and the decrease in the number of damaged salmon in the catch may have arisen because catches were low during the spring when seal-damage occurs most frequently.

93. As in previous years the commercial catch for the River North Esk on two days each week was examined in order to ascertain the number of seal-damaged fish present. The results of these examinations are shown in the table below, together with the corresponding figures for 1966 and 1965.

Month	*Percentage of Seal-damaged Salmon*		
	1967	1966	1965
February	6·0	8·6	3·9
March	4·8	7·4	7·0
April	5·4	7·9	7·1
May	4·6	7·5	6·5
June	4·0	7·9	5·4
July	1·3	2·7	1·8
August	4·4	3·3	1·0
Overall	4·3	5·6	4·2

Salmon and Sea Trout Statistics

94. Mr. Balmain continued to be responsible for the analysis of the statistics of salmon and sea trout catches, received under the Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951, and he has brought these analyses up to date. A further report on Scottish salmon catch statistics was submitted to the ICES/ICNAF Joint Working Party on Atlantic salmon which brought the earlier report up to date and also included statistics of catch-per-unit-effort.

Kelt Tagging

95. As in 1965, a number of kelts were tagged after they had been stripped at impoundments in the Awe, Conon, Ness and Shin river systems. Mr. Shackley was in charge of this work and further details are given in the table on next page.

Site	*No. Tagged*	*No. Recaptured*	
		Before 31.5.67	*After* 31.5.67
Loch Awe	100	0	0
Loch na Croic	375	2	3
Orrin	227	3	0
Poulary	100	1	0
Shin	100	0	2

96. Further recaptures were recorded of kelts tagged at Loch na Croic in 1965, bringing the total records of recaptures to 12, or 1·1 per cent of the kelts tagged. One of these fish was taken on the west Greenland coast and another off Erris Head, Co. Mayo.

Rehabilitation of the Trout Fishery of the Lake of Menteith

97. Dr. T. A. Stuart reports that this project continues to produce most encouraging results. He and Mr. B. R. Morrison are responsible for this investigation.

98. The result of the first phase of the operation, aimed at control of the predatory pike population, has been very satisfactory and there is clear evidence of an increase in the numbers of the native brown trout population and of the survival and good rate of growth in the introduced rainbow trout.

99. Gill-netting of pike was begun as an exploratory exercise during the late summer and autumn of 1965. Guided by the results of this *ad hoc* operation a large scale effort was made during the spring and summer months of 1966 using about 30 gill nets of varied mesh sizes which were set singly and in groups to intercept fish travelling to spawning areas. The nets were moved regularly to cover, eventually, most strategic points in the lake. This work continued in the spring of the current year but was stopped in early June when only a few very small pike were being captured while an increasing number of brown and rainbow trout were being killed in the nets.

100. The gross and average weights of the pike taken during the three seasons are as follows:

Year	*No.*	*Weight (cwt)*	*Average (lb)*
1965	311	26	9
1966	991	26	3
1967	371	3	1

101. It will be seen that there was a severe reduction in the number and average weight of individual pike taken by the nets this year. Whereas pike weighing 20 to 29 lb were being caught regularly during 1965 and 1966 the largest fish taken in 1967 was only 4 lb. During the earlier netting operations about 40 brown trout weighing from one to four lb (also one fish of six lb) were captured, all in excellent condition. During the current year the number of trout killed in the nets increased, due chiefly to the appearance of a larger proportion of younger fish of around three-quarters to one lb. This is considered to be due to enhanced survival of the native nursery stock from the streams which, as reported last year, carried a good stock of 0+ and 1+ trout.

102. Owing to the concentrated effort to reduce the numbers of the chief predator (pike), and to uncertainty regarding their ecological status in relation to a trout population (which is at present an important aspect of this study) no special work was done on perch and roach. However, over 16,000 perch, measuring roughly from 7 to 15 cm, were taken by seine net and a much smaller number, measuring up to 31 cm, was taken by seine and gill net. From visual

observations of shoals in the lake, this number represents only a very small proportion of the total population. Comparable shoals of roach were also observed and many were taken in the nets. It is hoped that perch and roach fry may produce useful forage for the experimental stock of rainbow trout as well as the native brown trout, and this aspect will be examined next year when the increase in the trout population will permit more extensive sampling for stomach content analysis.

103. In addition to the experimental gill-netting (which was concerned chiefly with mesh size, location and orientation) a purse-seine, designed by Messrs. Foster and Strange of the Marine Laboratory, Aberdeen, was introduced during the spring. After initial difficulties, related chiefly to the weight and the capacity of the available boat, this net showed great promise when operated in conjunction with an echo-sounder. When further modified in the light of this year's experience it should prove to be a valuable tool in fresh water.

104. Confirmation of an increase in the native population of trout was also obtained from sampling the spawning runs. In the autumn of 1966 the spawning streams were searched very thoroughly but only 36 mature trout were captured, chiefly towards the end of November and in December, and the majority were males. In the year to 31st October 1967, this number was exceeded in one stream with females forming a majority of two to one. Selected specimens were stripped and the fertilised ova removed to the hatchery.

105. During 1967 details of 34 brown trout caught by gill-net and angling were recorded. The fish ranged from 25·0 cm (6 oz) to 55·0 cm (3 lb 12 oz) and most of them were caught by gill-nets set for pike in the early summer. 32 sets of scales were available for examination and details of the average calculated lengths at the end of each year are given below.

Year	*Length (cm)*	*No. of fish*
1	6·0	32
2	14·8	32
3	28·1	27
4	35·5	8
5	42·5	2

106. In the early months of the year a further 1,609 immature brown trout, 1+ years and older, were caught by electrical fishing in two spawning streams and were measured, fin-clipped and released. These do not represent the total population of the streams but are intended eventually to provide some data for growth rate measurements, distribution in the lake and local movements in general.

107. At the end of April 1967, 11,217 rainbow trout reared in the hatchery were introduced into the lake as yearlings. A measured sample of 250 showed an average length of 17·0 cm, range 13·0–21·5 cm. The first fish to be recaptured was taken on 4th June, the scales of which showed that an increase of 4·0 cm had been made in length since introduction, and on 22nd June a further two fish were recaptured showing an increase since introduction of 7·5 and 9·5 cm respectively. By early August samples were more readily available and 24 fish caught between 1st and 14th showed increases ranging from 9·5 to 15·5 cm with a mean of 12·6 cm. The average calculated length at the end of the first year (i.e. at time of introduction), was 15·7 cm. Further samples were taken up to 25th September, when an angling catch of 12 fish, which had an average length

at introduction of 15·4 cm, showed an average increase in length of 13·9 cm. This shows very clearly that growth continued much more slowly after mid-August. This slowing of growth rate was not obvious in the majority of scales although some did show a check about mid-August. This contrasts strongly with the few brown trout caught at the same time, the scales of which showed a definite decrease in growth rate.

108. Following the introduction, the young rainbow trout were seen to be well distributed over the 650 acres of the lake; some entered the streams and were found several hundred yards upstream. During the next few weeks almost every small pike taken in the gill nets had a young rainbow trout in the stomach but by June the incidence had decreased greatly, small perch replacing the trout. These rainbow trout and later occasional captures, as noted above, showed a satisfactory growth rate. In order to obtain further information before introducing additional stock the fishery, which was scheduled to open to the public in 1968, was opened during August and September to a restricted number of anglers whose catch was restricted to six fish with a minimum size limit of 10 in. (25 cm). This proved highly successful and many anglers obtained their quota. Altogether, 211 rainbow trout were caught with weights ranging from 12 to 16 oz, all in first class condition and it was of special interest to note the regular occurrence of one or two brown trout of comparable size in the catch.

109. A marked feature of the spawning runs was the presence in the streams of ripe rainbow males which were running with the brown trout. A total of 22,600 1+ and 0+ rainbows has now been placed in the lake and about 10,000 0+ are held in reserve in the hatchery ponds.

110. A large amount of time was spent on a general ecological survey of the lake and its effluent streams. The bottom fauna of the streams and the plankton of the lake were examined, the latter chiefly in connection with a study of the food organisms taken by roach and perch which form a large part of the fish population. Of special interest is the information to be obtained on the status of perch and roach fry as convertors of planktonic and other particulate material into food of a size and nature acceptable to trout. To this end studies on the food, behaviour and distribution of the fry were made in the field and collections made for examination of stomach contents, etc. Concurrently, information on rates of growth of the current year's fry were obtained from sampling throughout the year. Owing to the necessity to conserve stocks of trout only a very few were killed for examination but an adequate number for this purpose would be available next year.

111. The bottom fauna of the nursery streams was systematically examined throughout the year and the results of this survey will be related to the food requirements and competition of the immature trout populations, both native brown and introduced rainbow, and their local migrations. The effects on the fauna and flora in the streams following spawning ground improvements would also be studied.

The Loch Leven Fishery

112. Work on the fish populations of Loch Leven continued throughout the period under review, at first by Dr. D. M. Witcomb and later by Dr. D. A. Cadwalladr and, once again, most attention was given to the trout population and less detailed studies were made on the pike and perch.

113. Regular sweep net sampling at selected sites along the shore, which

began in June 1966, was continued each month up to and including August 1967, except for January when weather conditions prevented netting. During September and October the intensity of sweep net sampling was reduced to enable work to be started on the life history of the young trout in the spawning streams and the patterns of their recruitment to the loch.

114. The recapture of tagged trout by anglers and by sweep-netting during 1966 confirmed that tagged fish tended to remain in the areas in which they had first been caught and tagged, while there was also evidence, from the monthly sweep net samples, that there was a general movement of the larger trout away from the shore during the latter half of the year and an influx of younger fish into this area of the loch during September. In an attempt to follow the movements of the various size groups of fish in the loch more closely and to improve the distribution of tagged fish throughout the loch, trials were made with a small trawl towed by the Nature Conservancy's catamaran *Anodonta*. This trawl, which was borrowed from the Marine Laboratory, Aberdeen, was 24 ft long with a mouth 26 ft wide and 5 ft deep and with mesh sizes varying from $1\frac{1}{2}$ in knot-to-knot at the mouth to $\frac{1}{2}$ in knot-to-knot in the cod end. The initial trials with this net were so successful that trawling was immediately added to the monthly sampling programme and has continued on a routine basis since March. During the period under review a total of 2,323 trout were caught, 1,710 by sweep net and 615 by trawling.

115. Plans to tag and release a large sample of trout before the start of the angling season were frustrated by high winds which prevented netting on most days during March and April. Nevertheless, approximately 1,300 trout were tagged during the year, 57 per cent of which were caught by sweep-netting and the remainder by trawling. To date, 8·5 per cent of the sweep-net caught fish and 5·5 per cent of the trawl caught fish have been recaptured by anglers. A further 54 fish tagged during 1966 were also recovered bringing the proportion recaptured from the 1966 tagging up to almost 20 per cent.

116. Examination of the stomach contents of trout collected during March and during June to September 1966 has shown that, during these months, chironomid larvae and pupae were the most important food organisms during each month, accounting for from 39–78 per cent of the wet weight of the stomach contents. Chironomid larvae predominated in March, August and September while pupae dominated the samples in June and July. Gastropods and zooplankton were also seasonally important, the former forming over 15 per cent of the stomach contents in June and 7 per cent in September, while the latter accounted for 13 per cent and over 30 per cent of the stomach contents in July and August respectively. Only in June and September did adult insects feature in the food, when they accounted for about 5 per cent of the stomach contents.

117. Since September samples of juvenile fish have been taken by electric fishing at three stations in the South Queich, one of the main spawning streams. The age/length ratio for these fish has been determined and compared with that calculated from the scales of older fish caught in the loch. Although this work is only beginning, the results so far obtained suggest that most trout spend between one and two years in the river before entering the loch and that many do so at a length of about 12·0 cm.

118. All the perch (over 3,000) taken by sweep-net and by trawl were measured and weighed and ten fish from each sample were retained for more detailed examination of age and stomach contents, while the remainder were marked

by clipping the second dorsal fin before release in an attempt to estimate population size. Since there is no angling for perch on the loch, recoveries are at present only likely to be made during subsequent routine samplings and it is not therefore surprising that only a small number of these marked fish have been recovered to date.

119. During April and early May an outbreak of disease occurred among the perch and several were found in a moribund condition in shallow water. The disease was characterised by patches of softened and discoloured skin, often breaking out into open sores which subsequently became covered with a secondary infection of fungus. Specimens were submitted for bacteriological examination but the causative agent was not isolated.

120. The collection of information on the length, weight, age, sex and stomach contents of pike caught during routine sweep-net and trawl sampling and in gill-nets operated by the Loch Leven Fisheries during the winter months, was continued. Analysis of the data from 131 stomachs taken from pike caught in gill nets during March and April 1966 showed that only trout and perch are of real importance in the diet of the larger pike and that, on the basis of wet weight of stomach contents, trout are three to seven times as important as perch.

121. Mr. A. D. Campbell started work on the status of fish parasites in relation to the ecology of the fish populations. A detailed study is being made on the degree of infestation and on the types of parasite present in ten trout from each routine sample and on a smaller sample of ten perch per month. Specimens of pike are also being preserved for subsequent examination. So far sixteen species of parasite, in various stages of development, have been recorded from the trout.

122. Although this work is only beginning there is already evidence of a seasonal pattern both in the types of parasite and in the degree of infestation. Results to date suggest that, in trout, the parasite fauna is at its lowest in June and early July and that adult trout returning to the loch after spawning, or new recruits from the rivers, may have a parasite fauna different to that commonly found in trout resident in the loch. Similarly, in perch, there appears to be a seasonal variation in the abundance of the trematode *Bunodera lucioperca*, which is abundant in April and May but decreases in abundance during June and then appears to be replaced by the nematode *Raphidascaris acus*, which, however, is not so abundant.

123. For comparison with the streams at the Lake of Menteith, bottom fauna samples and samples of trout were collected from the Westbank and Golland burns at Loch Leven during May. The range of organism types present was similar to that found at the Lake of Menteith, but relative numbers of each were slightly greater, particularly in Westbank burn where the single most significant difference was in numbers of *Gammarus*. In the Westbank burn, 2,250 specimens were taken in one sample compared with 270 taken in a similar habitat in the Lake stream three days later.

124. Chironomids were the dominant food organisms in a sample of trout from Westbank burn with *Gammarus* present in four out of ten specimens. In the sample of fish from the Golland burn the stomach contents showed a wider range of food material with chironomids the chief organisms in only one fish. Both terrestrial and aquatic insects were taken by the others in the sample with no particular group dominant. Only one specimen had eaten *Gammarus*.

125. In all, 2,575 juvenile trout were captured, marked and returned in the

Golland and Westbank burns and the estimated trout population of the Golland burn, using the mark and recapture technique, was 2,850.

Furunculosis and Other Diseases

126. Dr. A. L. S. Munro and Mr. K. G. R. Elson of the Marine Laboratory, Aberdeen, report that, largely as a result of outbreaks of salmon disease in some of the major salmon rivers, there was a sharp increase in the number of fish submitted for examination. During the twelve months ended 30th September, 402 specimens were submitted; full details of the diagnoses made on these fish are given in the table which appears as an appendix to this report.

127. In the report for 1966, reference was made to an extension of the provisions of the Diseases of Fish Act 1937 which made columnaris disease notifiable. This step was taken because it was then thought that a new disease, which was affecting salmon in some Scottish rivers, was columnaris disease. Investigations in Scotland and elsewhere have made it clear that it is not columnaris disease as recognised in the United States, and pending the identification of the disease, it has been termed *Ulcerative Dermal Necrosis* (*UDN*). This term does not imply any specific causative organism but it has been adopted as a descriptive term for the symptoms which seem to characterise the disease.

128. After the first outbreak of UDN in southern Ireland in 1964, the disease did not appear in Scotland until the late summer or early autumn of 1966, when fish showing symptoms characteristic of the disease were found in rivers in the Solway area. The next outbreak of UDN in Scotland occurred, in March and subsequently, in the Tweed. As a result of this latter outbreak, those salmon district fishery boards which had submitted fish with symptoms of UDN were asked to prepare weekly returns of diseased fish removed from rivers in their district.

129. The returns which are summarised in the report of the Inspector of Salmon Fisheries (page 44) indicate that rivers in the south-west (notably the Nith) and many of the east coast rivers (particularly the Tweed, the North Esk, the Aberdeenshire Dee, the Deveron and the Spey) have been seriously affected. It should be emphasised, however, that the returns cover all diseased fish and not only those thought to be suffering from UDN. The proportion of the latter is unknown and, because of this, district boards were asked in August to send a small proportion of the diseased fish removed to the Marine Laboratory for examination.

130. Though nearly 50,000 salmon and sea trout were removed from the rivers affected it should be emphasised that this represents only a very small fraction of the salmon and sea trout stocks of these rivers and an even smaller fraction of the total Scottish salmon and sea trout stocks. It is difficult to give a precise estimate of the proportion which may have been involved but it seems likely that the total removed represents not more than 3 per cent of the stocks of the rivers affected and not more than 1 per cent of the total Scottish stocks.

131. The highest mortalities were among adult salmon but sea trout also were affected in some numbers on the Spey and Tweed. During the outbreaks on the rivers of the Solway area and on the Tweed, brown trout and grayling also contracted the disease in moderate numbers. The incidence in parr was very low but some showed convincing symptoms of UDN.

132. The diagnosis of UDN is difficult because it has to be made, at present, only on the external appearance of the affected fish. Areas of necrosis and, usually, shallow ulceration are common, especially on the head but the first,

and often the only, symptom is an area devoid of pigment on the crown of the head, usually associated with a distinct depression. These white patches may occur on other parts of the head, including the snout and operculum, and they may also occur on other parts of the body. Fish from the upper reaches of some of the rivers affected have fungal infections as well, but this condition was not found in all the rivers affected. The flesh and internal organs of infected fish are usually in excellent condition.

133. The findings from 94 fish considered to be suffering from UDN are summarised in the table below. These findings indicate the association of several well-known bacterial pathogens with UDN but the lesions typical of UDN have never previously been noted in connection with the diseases produced by these pathogenic bacteria. It therefore seems probable that the occurrence of one or more bacterial pathogens in cases of UDN is secondary to a primary cause. The occurrence of fungal infections externally (though seldom internally) suggests a loss of the protective properties of the skin.

	Salmon	*Sea Trout*	*Brown Trout*	*Parr*	*Other Species*
Total	76	12	3	1	2
Taken alive	68	11	3	1	2
Taken dead	8	1			
With pathogenic bacteria	63	11	2		1
Without pathogenic bacteria	13	1	1	1	1
With fungus	22	7	2		1
Pathogens isolated:					
Bacterium salmonicida (furunculosis)	11	2	1		
Vibrio anguillarum (vibriosis)	6	3			1
Corynebacterium (kidney disease)	5				
Aeromonas spp.	14	2			
Pseudomonas spp.	7	1			
Haemolytic Micrococcus	2	1			
Chromobacterium spp.	1				
Mixed infections	17	2	1		

Pathogenic bacteria were always isolated when fungus was present.

134. Histological examination of the white areas showed complete absence of the epidermis and the pigment cells at the epidermis-dermis interface as well as severe damage to the collagen fibres of the dermis. Histological examination of the internal organs of salmon revealed a wide variation in appearance of normal tissue. At present no pathological features have been recognised after histological examination of the internal organs of fish suffering from UDN.

135. The results of systematic bacteriological and histological examinations of fish from many sources suggest that the cause of UDN is unlikely to be bacterial, fungal or protozoan. It is therefore possible that the primary cause of this disease is a virus and considerable efforts are now being made to investigate this possibility. In connection with this investigation valuable assistance was received from Professor A. Macdonald of the Bacteriology Department, Aberdeen University.

136. Viruses are best demonstrated by growth in cultures of host tissue and two cultures of fish tissues were obtained from the United States. The results using these two cell lines were negative, although final tests, made with the kind assistance of the Virology Department, Edinburgh University, using an electron microscope, have still to be evaluated. It should be emphasised that the testing of two tissue cultures is only the beginning of this investigation and work is now starting on the preparation of tissue lines from *Salmo salar*.

137. Plans were prepared for the installation of tank facilities at Johnshaven. These are urgently needed for work on the pathogenesis of UDN and as a source of supply of diseased material for laboratory investigations.

138. Mr. Elson attended a course in fish diseases in the United States during February and visited a number of freshwater fisheries laboratories in the United States and Canada. A Land Rover Caravette which was fitted out as a mobile laboratory has proved very useful in enabling investigations to be made in the field. The latter are important in this study because of the value of examining fresh specimens of diseased fish.

139. Fish found to be infected with *furunculosis* (54 salmon, 11 sea trout, 2 finnock and 2 brown trout) were present in most of the river systems from which diseased specimens were submitted for examination, although in some specimens furunculosis was in combination with one or more other diseases. Adult salmon held for spawning purposes on the Ness and Conon river systems were again treated with injections of intramycetin in order to prevent or retard infection with furunculosis. As far as can be ascertained this treatment was as successful as in 1965 and 1966.

140. The incidence of *kidney disease* was similar to that of last year, and evidence of this disease was found in 56 per cent of the river systems submitting specimens for bacteriological examination. Of the 65 fish infected, 59 were salmon, 4 sea trout and 2 brown trout. It was interesting to note that two of the infected salmon were taken in bagnets several miles from any river.

141. A total of 89 cases of *vibriosis* (the disease caused by *Vibrio anguillarum*) was confirmed. As might be expected, since the causative organism is a common marine bacterium this disease occurred in almost all of the rivers from which fish were submitted for examination.

142. The incidence of disease caused by *Aeromonas* spp. was 26 per cent, which is rather a higher proportion than the value recorded (21 per cent) for the preceding twelve-month period. In many instances, however, the pathogen occurred in mixed infections. Isolates of *Pseudomonas* spp., which are common water bacteria and opportunist pathogens, were obtained from 14 per cent of the fish examined. *Myxobacteria* were isolated from 15 fish and were found to be responsible for two outbreaks of peduncle disease in rainbow trout. A number of salmon parr and rainbow trout fingerlings submitted for examination proved to be infested with *Costia* spp., a parasitic protozoan. Advice was given to the hatcheries concerned, treatment was carried out and the infestation removed.

143. Requests for advice on practical problems arising out of the recurrence of fish diseases continue to be received and, because of the occurrence of UDN, these have been particularly numerous this year. When necessary, visits were paid to deal with particular problems. Two leaflets on diseases were produced and it is hoped to continue the series during the next year; these leaflets are available on demand from the Marine Laboratory, Aberdeen, or from the Freshwater Fisheries Laboratory, Pitlochry.

Scale Reading

144. Although scale reading has been one of the standard procedures of the fisheries biologist for many years, it still presents many problems and much still depends on the skill and experience of the scale reader. Mr. I. J. R. Hynd has been studying one of the problems of the scale reader, that of erosion, and his comments on this problem are given in the paragraphs which follow.

145. One of the major difficulties in the accurate determination of age and

in the calculation of growth rates from the examination of the scales of migrating salmonids is the amount of erosion or absorption of the scale edge that takes place during their stay in freshwater during the spawning migration. In many cases this erosion is so severe that all of the scale margin disappears and in some cases, especially in male spring salmon, much of the remaining surface ridge formation disappears as well. Scale erosion normally starts on the shoulder of the scale where the circuli merge into the clear exposed part. The accepted way of measuring this erosion is to divide the scale edge into six equal divisions for each side between the shoulder and the apex.

146. While reading scales from very old sea trout (up to 19 years) that had spawned several times and thus had been subject to considerable scale erosion, great difficulty was found in differentiating between years from scales taken from the usual location, i.e. immediately below the dorsal fin. Scales were therefore taken from other areas of the body to see if any showed better definition and it was found that scales taken from below the adipose fin were consistently more easily read than those from below the dorsal fin.

147. In order to check this finding scales were taken from eleven selected sites (Fig. (a)) on the bodies of eight salmon kelts. Eight scales were taken from each site and erosion estimates made for each side of each scale. The results are shown in the table below. These estimates suggest that erosion appears to be greatest on the shoulders of the fish (areas B, D) and much less near the tail (areas G, Z).

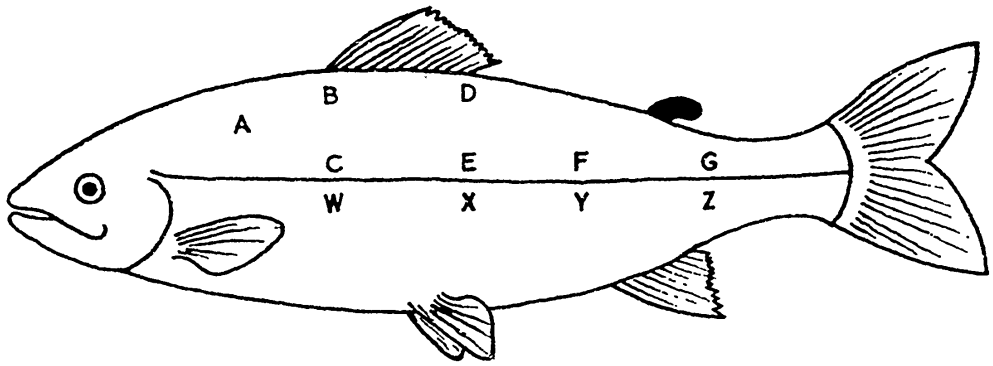


Fig. (a) Sites of Scale Samples

C, E, F & G	1st & 2nd rows above lateral line
W, X, Y & Z	1st & 2nd rows below lateral line
A	4th & 5th rows above lateral line
B & D	6th & 7th rows above lateral line

Percentage Scale Erosion at Sites

Fish No.	A	B	C	D	E	F	G	W	X	Y	Z
1	96	99	98	99	98	93	84	97	98	99	98
2	0	34	18	41	16	0	0	49	53	10	4
3	6	37	18	65	11	4	2	21	30	16	4
4	48	89	66	85	67	31	11	47	58	49	24
5	9	29	10	46	5	1	2	6	18	5	2
6	2	0	1	3	0	—	0	5	9	0	0
7	0	22	8	18	—	1	0	0	8	0	0
8	0	0	0	0	0	0	0	0	0	0	0

Other Projects

148. The census of ascending and descending migrants below the Meig and Luichart dams on the Conon River system was continued. Mr. Shackley

supervised these operations until he left Contin at the end of May; since then the trap watchers have been responsible for the maintenance of the records. The heavy floods experienced in December 1966 did some damage to the Meig trap, which was quickly repaired, but the Luichart trap was so seriously damaged that it was decided not to replace it. To maintain the census of upstream migrants, however, a temporary trap was constructed in the channel leading to the Borland lift at Luichart dam and this served its purpose very satisfactorily.

149. The smolt run through the Meig trap numbered 5,561 fish and, though this was less than the run in 1966, it was well above the recorded average (about 3,800 smolts) for the past five years. Of the smolts passing through the Meig trap, 4,179 were tagged. During the season 90 of the smolts tagged at the Meig trap in 1966 were recaptured as grilse. This is about 1·8 per cent of the total tagged and is a much better return than any recorded previously. Most of these recaptures (92 per cent) were made at the Meig trap.

150. The upstream runs of adult fish at both traps were much higher than those of 1966 and were similar to those recorded in 1965. Up to the end of October, 834 fish had passed upstream through the Meig trap and 545 fish had entered the Luichart trap. The run at the Meig trap was just higher than that recorded in 1965 (829 fish) which was the largest run recorded at this site since the census began.

151. Requests for advice on fishery problems and fisheries management continued to be received steadily and, during the twelve months covered by this report, some 230 new requests were received. Mr. Balmain continued to be responsible for this side of the laboratory's work and, in this connection, he paid a number of visits, ranging over most of the country, to discuss problems and investigate conditions in the field.

152. It is of interest to record the capture of two more pink salmon (*Oncorhynchus gorbuscha*) in Scottish waters. One of these was caught at Bonar Bridge, Ross-shire, in July and the other (a particularly fine specimen) was caught in Stromness Voe, Shetland, at the end of August. Another capture of particular interest is that of an Atlantic salmon, taken by the weather ship, *Weather Surveyor* when on Station 'India' (59° 00'N, 19° 00'W), in June. This is the first record of an Atlantic salmon being caught so far out in the Atlantic.

Bottom Fauna Studies

Studies on the Bottom Fauna of Nursery Streams

153. Work on the factors affecting the distribution and the numbers and weight of benthic invertebrates in streams in which young salmon and trout live has continued. A paper on the distribution of invertebrates on the substrates of these streams was completed.

154. Previous reports and publications have described the importance of decomposing plant material as a source of food for the bottom fauna of streams. In order to investigate the breakdown of plant material experimentally, work was carried out by Dr. H. J. Egglishaw and Miss A. G. Young to discover suitable plant materials that would be convenient to handle in the laboratory and readily available for the greater part of the year. Naturally-occurring plant material from streams was found to be too heterogeneous in kind and particle size to give easily interpretable results. Some preliminary experiments with rice grains, dried leaves and other materials have emphasised the complexity of the

process involved and the techniques that it may be necessary to use. Present studies are intended to determine those aspects of plant breakdown most appropriate to investigations of bottom fauna and fish productivity.

155. From the amounts of bottom fauna and plant detritus occurring in streams with different calcium concentrations it seemed likely that the detritus was breaking down and accumulating at a quicker rate as the calcium concentration increased. To investigate this possibility, a study was made of the rate of breakdown of introduced plant material. Ten nylon mesh bags, each containing 10 g of rice grains, were boiled for five minutes and then placed in each of six streams, each with a different calcium concentration. Each week one bag was removed from each of the streams and the weight of rice grains still present determined. Results showed that the breakdown of rice proceeded quicker as the calcium concentration of the streams increased. After six weeks the dry weight of the rice had fallen from an initial weight of 8·45 g to 6·91 g in the stream with the lowest calcium concentration but to 1·15 g in the stream with the highest calcium concentration. The results of laboratory experiments in which the rice grains decomposed in tanks of aerated and frequently changed water from the streams, so avoiding possible differences due to current speeds, supported these findings although the rates of breakdown of the rice grains were slower.

156. It thus seems likely that the standing stock of a large proportion of the bottom fauna of streams is related to the rate of breakdown and accumulation (i.e. the rate of turnover) of the plant detritus. The mean standing stock of plant detritus in the Shelligan Burn is about twice that in the headwaters of the River Almond. Field experiments suggest that the plant detritus breaks down about 1·5 times faster in the Shelligan Burn than it does in the River Almond so that, for the same period of time, about three times more detritus is involved per unit area in the former stream. This probably accounts for the mean standing stock of the bottom fauna in the Shelligan Burn being about three times that of the River Almond.

157. A paper on seasonal changes in the bottom fauna of three streams has been published (2) and one on the quantitative relationship between bottom fauna and plant detritus in streams of different calcium concentrations has been prepared.

Feeding Biology and Production of Salmon and Trout in Streams

158. Dr. Egglishaw and Mr. Shackley continued their work on the relationships between the feeding and the numbers, growth and production of salmon and trout in Highland streams. During the year a paper was published (1) on the feeding biology of salmon and trout in the Shelligan Burn and the headwaters of the River Almond.

159. Since March 1966 the size of the salmon and trout populations in each of three stretches of the Shelligan Burn were estimated, at approximately four-weekly intervals, from the numbers of fish caught in four successive periods of capture using electric fishing apparatus. The lengths of all fish caught were measured and samples of fish have been weighed.

160. The mean standing stocks of the 1966 year class of salmon and trout per 100 m^2 of the three stretches of the Shelligan Burn are given in Fig. (b). Although recently-emerged fish were seen in May, estimates of the size of their populations were first made in July. In early summer there are several times more 0+ salmon than 0+ trout present but during the following months there is

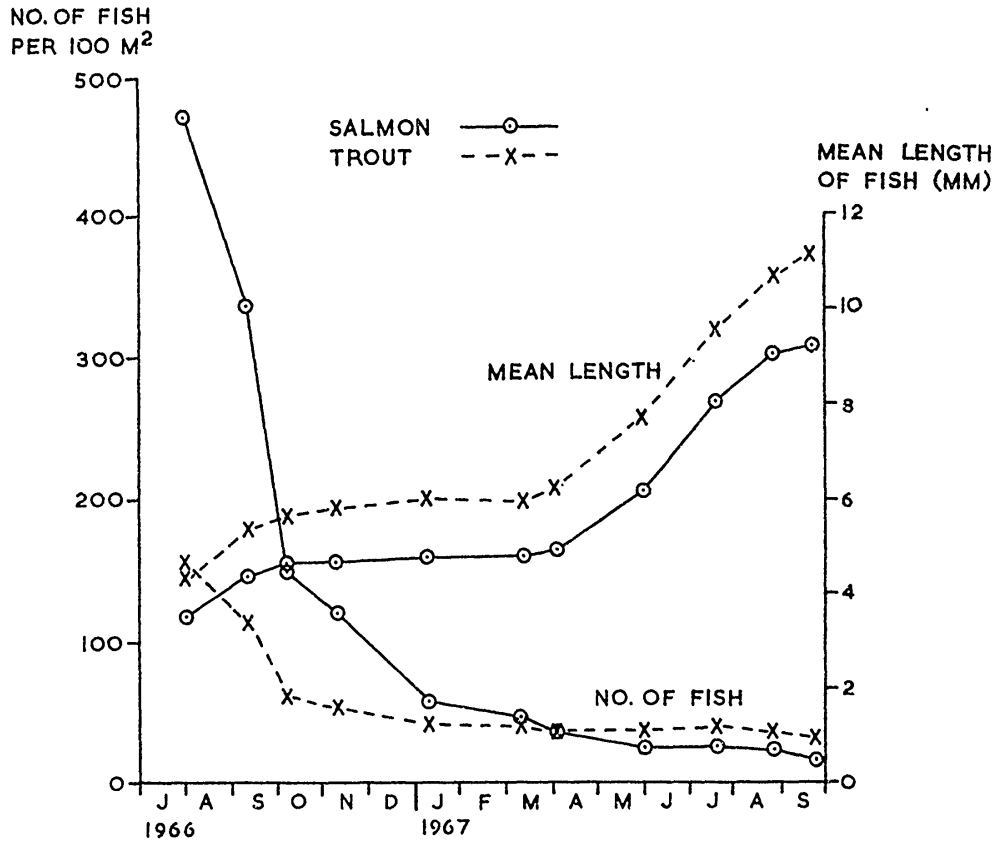


Fig. (b) Standing Stocks and Mean Lengths of the 1966 Year Class of Salmon and Trout in the Shelligan Burn.

a much sharper decline in the numbers of salmon than there is of trout, so that by January the population densities of the two species are similar. The increase in length of the salmon and trout in each year class throughout the year was determined and the results for the 1966 year class of fish are included in Fig. (b)

161. Production curves for each year class of salmon and trout have been constructed (Fig. (c)). The mean weights of the fish were determined from graphs relating known weights and lengths of fish at different times of the year. The production between date points on the curve is represented by the area under the curve. The net production, in g per 100 m² of each year class of salmon and trout during 1966 and 1967, is given in the table below. The figures for 1967 are complete only to October but the final values are not expected to be much greater than those given. In 1966 the net production of salmon was 701 g per 100 m² and of trout 865 g per 100 m²; in 1967 corresponding values were 1,095 g and 1,358 g.

	Salmon *Year class*					*Trout* *Year class*				
	1963	1964	1965	1966	1967	1963	1964	1965	1966	1967
During 1966	10	99	112	480	—	26	160	361	318	—
During 1967	0	8	44	251	792	0	51	157	550	600

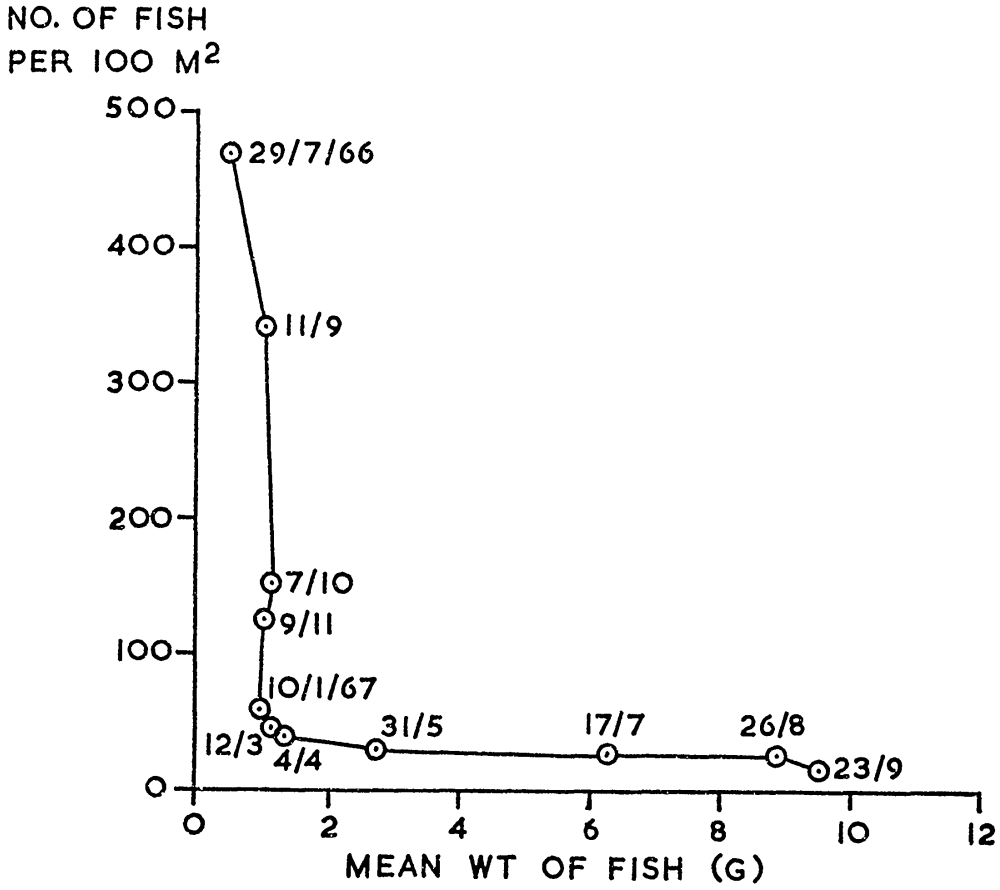


Fig. (c) Production Curve for the 1966 Year Class of Salmon in the Shelligan Burn.

162. These estimates of the net production of salmon and trout in the Shelligan Burn are subject to possible errors and are therefore provisonal. Errors in the population density estimates are slight and can be determined: errors in growth calculations based on the length of fish are more difficult to determine. The chief error in growth calculations is caused if fish larger or smaller than the average of their year class move into or out of the stretches of stream being studied. There is also the possibility that some environmental factors (e.g., predation, disease, flood conditions) will cause higher mortalities among fish of a certain size within the size range of a year class. The present studies are forming a basis on which the productivity and net production of salmon and trout in these streams can begin to be estimated and, after further work, it is hoped that it will be possible to determine the size of the errors involved.

Chemical Investigations

Pesticides in the Aquatic Environment

163. Investigations into the extent of contamination of the aquatic environment by organochlorine pesticides were continued and other chlorinated substances and samples from many sources, both freshwater and marine, were examined. In addition, preliminary examinations of techniques for residues of organo-phosphorus insecticides, and of certain herbicides, were made. These

investigations involved all the members of the chemistry section (Mr. A. V. Holden, Mr. L. A. Caines and Mr. K. Marsden) for much of their time during the year.

164. *Methods.* In addition to the two standard types of column used for gas chromatographic analyses (employing a DC-200 or combined DC-200/QF-1 stationary phase), a third column using a cyanosilicone (XE-60) stationary phase was employed to check on the presence of polychlorinated biphenyls. These compounds (PCBs) were first identified in wildlife in Sweden in 1966 and are probably identical with most of the unknown substances known to occur in samples from several types of wildlife, including seals and estuarine sea trout in the aquatic environment, as mentioned in the Annual Report for 1966. The PCBs are known to be toxic and their identification in wildlife, in the presence of pesticide residues, raises the question of the possible influence of both groups of chemicals on living organisms.

165. The polychlorinated biphenyls are widely used in industry and are virtually indestructible by normal processes. Their presence among chlorinated insecticides complicates the problem of identification, as two of the PCBs interfere, on many GLC columns, with the p.p'-TDE and p.p'-DDT peaks. Consequently, quantitative measurements of these pesticide peaks in the past may have been subject to error. Research into this problem during the year included an assessment of the quantitative separation and recovery of residues by thin-layer chromatography, and quantitative hydrolysis of the TDE and DDT residues to determine the amount of PCB interference. In general PCB interference in the aquatic species so far examined is small, and is mainly evident in seal blubber. Many species, including salmon from the sea, sand eels and marine zooplankton, show no significant PCB contamination.

166. During 1967 several other pesticides were responsible for fish mortalities, among them two organo-phosphorus sheep dips (carbophenothion and pyrimithate). Both were detectable by gas chromatography, and carbophenothion was isolated from dead fish. One herbicide, DNBP (dinoseb), was responsible for four mortalities, and a technique using gas chromatography is being developed for the detection of this chemical in fish.

167. *Loch Leven.* Analyses of trout, perch and pike for dieldrin and other pesticide residues continued. The industrial dieldrin discharge ceased in 1964, and there has been a significant decrease in the levels of dieldrin residues during 1965 and 1966. The mean values of dieldrin concentrations in p.p.m. in muscle tissue and fat in the three species over the period 1964–1966 are as follows:

		Pike	*Perch*	*Trout*
Muscle	1964	0·44	0·78	0·30
	1965	0·07	0·25	0·08
	1966	0·10	0·08	— [1]
Fat	1964	8·1	24·9	2·8
	1965	3·5	5·7	0·27
	1966	2·6	2·3	— [1]

[1]Not yet analysed

168. Other organs and tissues showed a similar decline, but the 1966 levels are still high by comparison with uncontaminated environments.

169. *Other Freshwater Fish.* During the year, samples of salmon parr and smolts supplied by the Fisheries Research Board of Canada were analysed for DDT residues. The fish were taken from areas where forests had been regularly sprayed with DDT and the residue levels, mainly of DDE, were much

higher than those encountered in Scotland. Fish which had died following spraying, or had been found alive in areas where others had died, had higher levels of DDT, and in general the concentrations were consistent with the data previously obtained in toxicity tests with trout.

170. Samples of salmon from the Greenland area are being examined to assess whether there is any possibility that fish from different countries may contain residues in different proportions according to pesticide usage in the country of origin. Low residue levels have been found in the fish so far analysed. Negative peaks have been obtained in gas chromatograms from some of these fish (see para. 175).

171. *Toxicity Tests.* The collaborative studies with the Salmon and Freshwater Fisheries Laboratory of the Ministry of Agriculture, Fisheries and Food in London were continued. Trout subjected to various concentrations of dieldrin under controlled conditions were analysed for dieldrin residues at Pitlochry. The residue levels in muscle tissue and in the viscera were determined both in terms of unit weight of tissue and of unit weight of the lipid content of the tissue. Fish which died, those surviving, and fish which were subsequently transferred to clean water, in test periods lasting up to three months, were examined.

172. There was generally a similarity between the dieldrin concentrations in the lipid fractions of muscle and viscera, although concentrations expressed in terms of tissue weights differed widely. Even when fish had survived in potentially lethal solutions for several weeks, a steady increase in the dieldrin concentration in both muscle tissue and lipids was found, suggesting that death might well have resulted on longer exposure. When fish surviving exposure were transferred to clean water, the dieldrin levels in the muscle tissue and lipid fractions fell rapidly within a few days, but were never completely eliminated. Loss of condition after prolonged experiments, as evidenced by a decrease in fat content, in some instances resulted in a consequent increase in the dieldrin content of the remaining lipid fraction. Death usually resulted when the dieldrin level in lipids exceed 100 p.p.m.

173. *Marine Environment.* Apart from the samples of mussels (*Mytilus edulis*) analysed in the O.E.C.D. study (see paras. 178–182), zooplankton from several areas, sand eels, seals and porpoises were examined.

174. Zooplankton samples, which were usually dominated by one of three species, were all found to contain measurable, but low, levels of pesticides. Samples dominated by *Calanus* spp. were exceptional in that negative peaks on gas chromatograms (using electron-capture detectors) were also found. Residues of dieldrin, p.p'-DDE, p.p'-DDT were detected in all plankton samples examined but, with few exceptions, the levels of individual substances were less than 0·01 p.p.m.

175. Sand eels (*Ammodytes* spp.) also were analysed, total residues of dieldrin and the DDT group being in the range 0·024–0·11 p.p.m., most being found as p.p'-TDE. This latter feature may have been the result of preservation in formalin, although no evidence for such a conversion in formalin was observed in other samples. The sand eels also produced negative peaks. These samples, together with samples from salmon from the Greenland coast and the samples of *Calanus* spp. referred to above, are the only ones of several thousand analysed which have so far exhibited such peaks.

176. Further samples of seal blubber, from Scottish and Canadian seals, were examined. Some interference by PCB-type substances was found, but in

general this was small. Although there is no clear distinction between the levels of contamination in specimens from different areas of the Scottish coast, the highest contamination occurs on the east coast south of Aberdeen and the lowest in the seals from Harris, off the west coast. Seals examined from Canada were generally less contaminated than Scottish seals, although one adult male contained a total of 35 p.p.m. (dieldrin+DDT group) in the blubber, half being p.p'-DDT. Dieldrin levels in Canadian seals were much lower than in Scottish seals.

177. Two porpoises were examined, one from Aberdeen having 7 p.p.m. of dieldrin and 45 p.p.m. of the DDT group (including 24 p.p.m. p.p'-DDT) in the blubber. The other porpoise, from Orkney, contained less than one-tenth of these values. Two other porpoises from the north-east coast were also found to have high pesticide contents, as reported last year.

178. *O.E.C.D. Co-operative Study.* At a conference in Paris in 1966, sponsored by the Organisation for Economic Co-operation and Development, a preliminary study of organochlorine residues occurring in four species of wildlife was planned, and was co-ordinated by Mr. Holden. This study, which involved the sampling and analysis of earthworms, mussels, pike and starlings, in areas not known to have been contaminated by pesticides, involved twelve countries of Europe and North America. Following the completion of the analyses a conference, sponsored by O.E.C.D. and the Natural Environment Research Council, and organised by the laboratory, was held at Taymouth Castle, Perthshire, in order to discuss the results and plan future co-operative studies.

179. The analyses of the samples of pike and mussels obtained in Scotland indicated that, even in areas where no known local usage of pesticides existed, pesticide residues, primarily of dieldrin and the DDT group, could be found. Pike from an Ayrshire loch contained dieldrin in muscle tissue in the range $< 0{\cdot}001$–$0{\cdot}005$ p.p.m. and total DDT in the range $0{\cdot}011$–$0{\cdot}096$ p.p.m. Loch Skiach, near Pitlochry, produced corresponding values in muscle tissue of $0{\cdot}001$–$0{\cdot}044$ p.p.m. dieldrin and $0{\cdot}09$–$1{\cdot}09$ p.p.m. total DDT, although there is no evidence that DDT has been used at any time in the catchment area of this loch during the past ten years.

180. The mussel samples were taken from nine stations on the east and west coasts of Scotland and all contained residues of dieldrin, the DDT group and the BHC group, as well as some PCB compounds. The highest levels were found in polluted estuaries, a sample from the Clyde Estuary containing $0{\cdot}10$ p.p.m. dieldrin and $0{\cdot}20$ p.p.m. of the DDT group. The cleanest sample, from the River Ythan, contained $0{\cdot}011$ p.p.m. dieldrin and $0{\cdot}050$ p.p.m. of the DDT group (all the pesticides were in the soft tissue of the mussels).

181. At the invitation of the Swedish Royal Commission on Natural Resources, following the successful initiation of the O.E.C.D. study in 1966, Mr. Holden visited Sweden and Norway in November 1966 to discuss the work being done there on pesticide problems affecting wildlife. A joint meeting of representatives from Sweden, Norway, Finland and Denmark was held in Oslo to plan the co-ordinated study of residues in Scandinavian wildlife, in conjunction with the O.E.C.D. programme.

182. Following discussions with Swedish workers concerned with the contamination of rivers by mercury compounds used as fungicides, a series of samples of Scottish pike were sent to Stockholm for analysis by neutron activation. The results from a few of the samples have so far indicated a much

lower mercury content in pike in Scotland than in Sweden, where the use of mercurials in pulp-mills is largely responsible for the contamination.

Loch Leven Investigations

183. Regular sampling of the surface water of Loch Leven, its inflowing and outflowing streams, and the three major sewage discharges to the loch system was continued by Mr. Holden and Mr. Caines, and an assessment was made of the present nutrient balance. The weekly phosphorus input to the loch from all sources during the period March 1966–March 1967 was 197 lb, giving a mean inflow concentration of 0·050 p.p.m., as compared with the mean loch (and outflow) concentration of 0·076 p.p.m. Such a situation cannot be permanent and investigations are proceeding to determine the source of the extra phosphorus at present being lost from the system. Of the phosphorus entering the loch, about 50 per cent was carried in by the streams, some 20 per cent introduced by sewage and 30 per cent by industrial discharges. In the period March–October 1967 the average weekly discharge of phosphorus due to sewage increased significantly and the overall mean inflow concentration was 0·058 p.p.m. The mean outflow concentration during the same period was 0·086 p.p.m.

184. The mean nitrogen concentration in the loch outflow (1·2 p.p.m.) was much lower than the calculated mean inflow concentration from all sources (2·1 p.p.m.), but the mean nitrate levels in two of the three major inflowing streams during 1967 were higher than in the corresponding period of 1966, as is shown below. Nitrogenous fertiliser usage in the area is understood to have increased in 1967.

Mean Nitrate-N Concentrations in Streams (p.p.m.)

	1966	1967
North Queich Burn	1·21	1·08
South Queich Burn	1·45	1·89
Gairney Water	1·66	2·07

The total nitrogen discharge from the streams is calculated to be about 96 per cent of the nitrogen entering the loch from all sources.

185. During the winter of 1966/67 there were signs of renewed algal activity, and high chlorophyll levels were reached in April 1967, due to an intense bloom of *Oscillatoria* spp. This collapsed in May, with a temporary release of nitrate and phosphate, followed by a second, less intense, algal bloom in June and July. By August this, too, had disappeared and the chlorophyll level fell to the lowest value since February 1966. Although algal activity was not as pronounced as it had been in 1963–65 it was greater than in 1966, and recurrent blooms must be expected in the future in view of the very high nutrient levels existing in the loch. Such blooms are likely to be detrimental to the trout fishery.

Detection of Cyanide in Fish Tissues

186. Mr. Marsden reports that during the year 20 incidents of fish mortality were reported to the laboratory in circumstances where the use of Cymag was suspected. In 13 of these evidence for the use of cyanide was proved or strongly suspected. A total of 82 fish were analysed for cyanide content.

Other Fish Mortalities

187. In addition to the 20 incidents referred to above a further 17 cases of fish mortality were reported to the laboratory. Of these, one was caused by the

wash-out of slurry from a building site, two from farm effluents (including a lime-wash in one case), two from organo-phosphorous sheep dips (the first recorded instances in Scotland), eight from herbicide sprays (the highest number so far reported in one year, four being due to one chemical, dinoseb), and four due to unknown causes. Several of the mortalities caused by herbicides were due to carelessness on the part of the spray operators. The River Purification Boards, with whom the laboratory works in close collaboration, are taking a serious view of such incidents and legal action may follow in future cases.

Loch Harray

188. A severe fish mortality occurred in Loch Harray, Orkney, in the summer of 1964, resulting in the death of thousands of brown trout, sea trout, flounders, sticklebacks and eels. In the late summer of 1966 trout were found to be suffering from a 'sickness' which caused them to float at the surface and to be taken easily by anglers, although few died. An investigation did not reveal the actual cause, although the circumstances suggested a relation between the incidents and the combined effect of inflowing sea water and fertiliser nutrients from the surrounding land.

189. In the summer of 1967 a further serious mortality occurred, several hundred trout crowding into the only inflowing burn with sufficient water to support them, but succumbing to the effects of the toxin present in the loch. Following a suggestion from Dr. J. W. G. Lund, of the Freshwater Biological Association's laboratory, Windermere, plankton samples were taken and the presence of the phytoflagellate *Prymnesium parvum* Carter was confirmed. This alga, a brackish water species, produces a substance extremely toxic to fish and it is encouraged by the presence of high levels of nitrate. Mortalities due to this species have been recorded in Holland, Denmark, Israel and in England, but that in Loch Harray, over an area of four square miles, appears to be the most extensive on record. The salinity level in the loch (approximately 1–2 per cent sea water) is at the lower end of the tolerance range of the species of alga and action is being taken to exclude the entry of sea water into the loch as far as possible.

PUBLICATIONS

1. EGGLISHAW, H. J. 1967. 'The food, growth and population structure of salmon and trout in two streams in the Scottish Highlands.' *Freshwat. Salm. Fish. Res.*, 38, 32 pp.
2. EGGLISHAW, H. J. and MACKAY, D. W. 1967. 'A survey of the bottom fauna of streams in the Scottish Highlands. Part III. Seasonal changes in the fauna of three streams.' *Hydrobiologia*, **30**, 305–34.
3. HOLDEN, A. V. and BALMAIN, K. H. 1966. 'The management of trout lochs.' *Scott. Fish. Bull.*, 26, 10–12.
4. HOLDEN, A. V. and MARSDEN, K. 1967. 'Organochlorine pesticides in seals and porpoises.' *Nature, Lond.*, **216**, 1274–76.
5. HOLDEN, A. V. and WHEATLEY, G. A. 1967. 'Cleaning of tritium foil electron capture detectors.' *Journal of Gas Chromotography*, **5**, 373–76.
6. MARR, D. H. A. (with SWINGLE, H. S. and EL-ZARKA, S. E. D.). 1967. 'The standardisation of research techniques' *Proceedings of the World Symposium on Warm-Water Pond Fish Culture*, 1, (F.A.O. Fisheries Reports, No. 44).
7. PYEFINCH, K. A. and ELSON, K. G. R. 1966. 'Salmon disease in Irish rivers.' *Scott. Fish. Bull.*, 26, 21–23.
8. SHEARER, W. M. and BALMAIN, K. H. 1967. 'Greenland salmon.' *The Salmon Net*, 3, 19–24.
9. SHEARER, W. M. and BALMAIN, K. H. 1967. 'Greenland salmon.' *Salm. Trout Mag.*, **181**, 239–44.

The following relevant publication has also been issued by the Department:

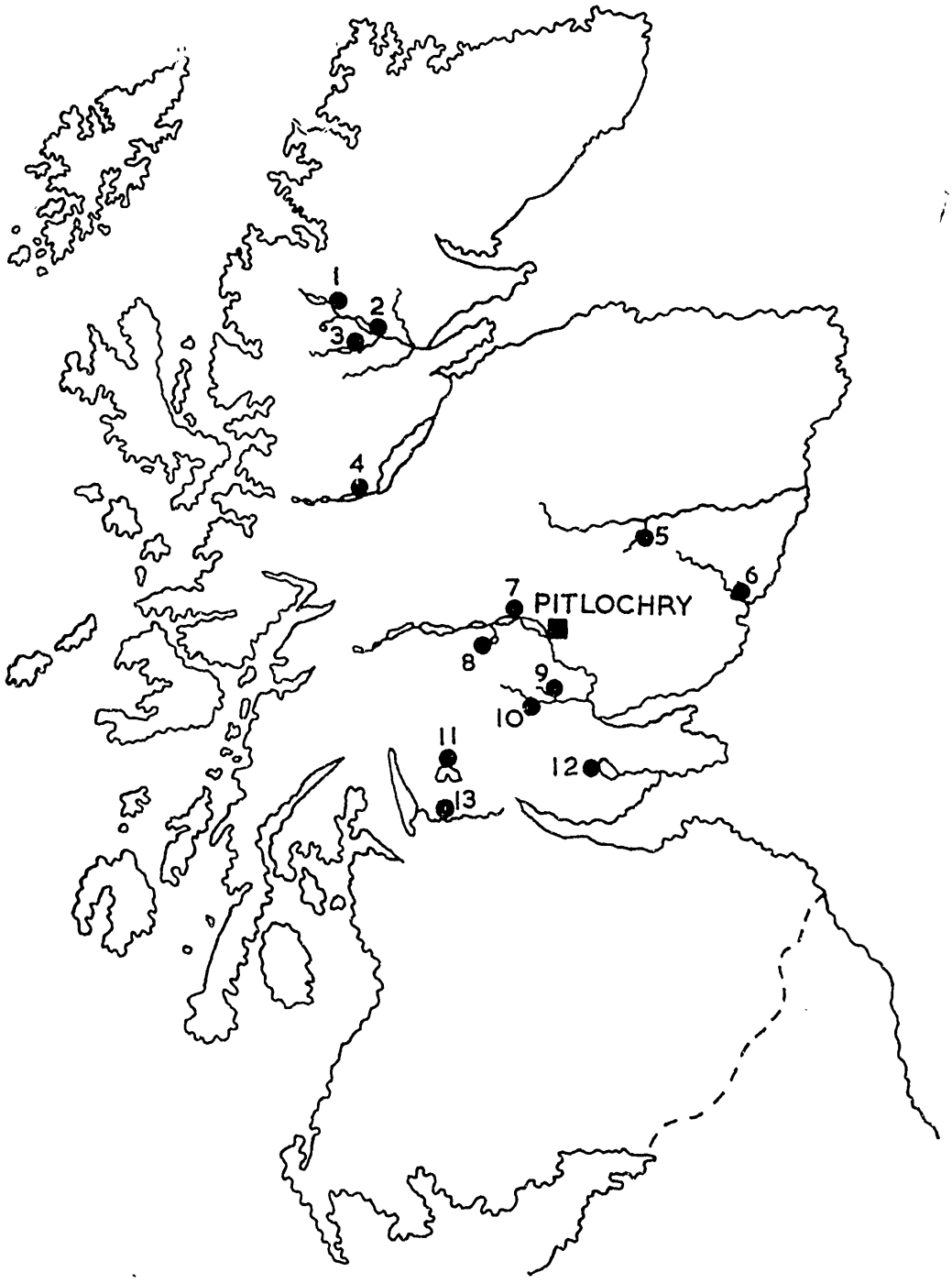
10. Department of Agriculture and Fisheries for Scotland. 1967. 'Fisheries of Scotland. Report for 1966.' Cmnd. 3460, 148 pp., Edinburgh, H.M.S.O.

The following contributions by members of the freshwater staff were presented at the meeting of the ICES/ICNAF Joint Working Party on North Atlantic Salmon at Boston in June 1967:

11. BALMAIN, K. H. 'Notes on salmon caught in Greenland 1966.' *ICNAF Res. Doc.* 67/58, 3 pp.
12. 'Scottish salmon catch statistics.' *ICNAF Res. Doc.* 67/60, 9 pp.

The following contribution by a member of the freshwater staff was presented at the meeting of ICES in Hamburg in October 1967:

13. MARR, D. H. A. 'Experiments on the artificial rearing of young Atlantic salmon (*Salmo salar* L.).' ICES/CM. 1967, M.25, 6 pp.



● PLACES WHERE WORK IN PROGRESS

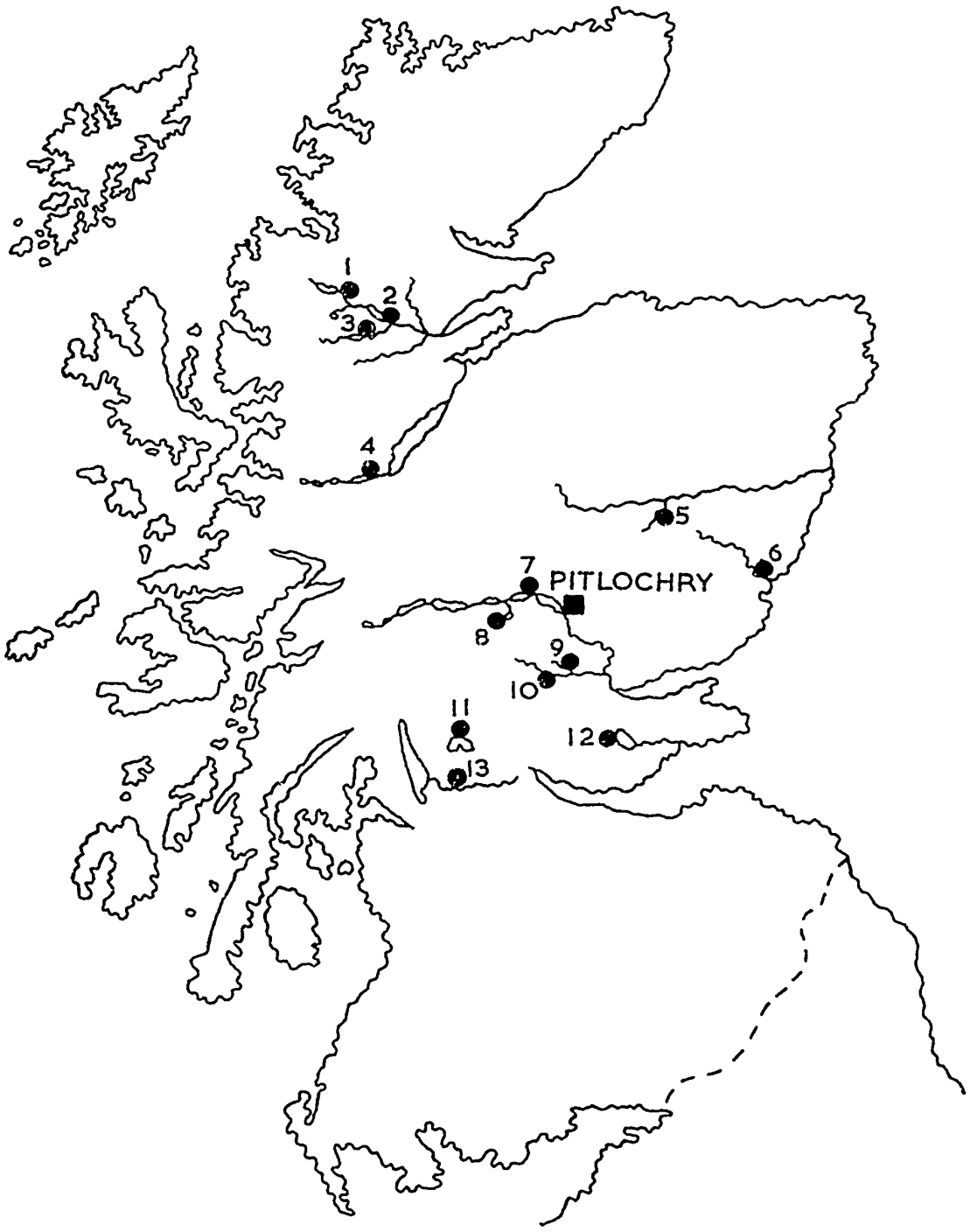
1. River Bran
2. Luichart Dam
3. Meig Dam
4. Invergarry Hatchery
5. Girnock Burn
6. River North Esk
7. Clunie Dam
8. Loch Kinardochy
9. Shelligan Burn
10. River Almond
11. Lake of Menteith
12. Loch Leven
13. River Endrick

Table incidence of disease in specimens

Appendix

Incidence of disease in specimens submitted for examination
(October 1966–September 1967)

Specimen	*Diagnosis*	Tweed	Forth	Tay	South Esk	North Esk	Carron & Cowie	Dee	Don	Ythan	Deveron	Spey	Findhorn	Nairn	Ness, Garry, Moriston	Beauly	Conon	Kyle of Sutherland	Shetlands	Hebrides	W. Coast and Islands	Ayr R.P. B'd.	Solway R.P. B'd.	Sea	Source Unknown	Lancashire	*Totals*
Brown Trout	Furunculosis	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2
	Aeromonas spp.	–	1	4	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	9
	Kidney disease	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Vibriosis	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	2	–	–	–	–	–	4
	U.D.N.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	4
	Chromobacterium spp.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2
	Negative	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Sea Trout	Furunculosis	–	–	–	–	–	–	2	1	–	2	2	–	–	–	–	–	1	–	1	–	–	3	–	–	–	12
	Aeromonas spp.	–	–	–	–	–	–	–	2	–	1	3	–	–	–	–	–	–	–	1	–	–	4	–	–	–	11
	Kidney disease	–	–	–	–	2	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
	Vibriosis	–	–	–	–	–	–	–	–	1	4	4	–	–	–	–	–	1	–	–	–	–	2	1	–	–	13
	Pseudomonas spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	2
	Coliform bacteria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
	Haemolytic Micrococcus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	4
	Myxobacteria	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2
	U.D.N.	1	–	–	–	1	–	–	–	–	2	5	–	–	–	–	–	–	–	2	–	–	–	1	–	–	12
	U/S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
	Negative	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1



● PLACES WHERE WORK IN PROGRESS

1. River Bran
2. Luichart Dam
3. Meig Dam
4. Invergarry Hatchery
5. Girnock Burn
6. River North Esk
7. Clunie Dam
8. Loch Kinardochy
9. Shelligan Burn
10. River Almond
11. Lake of Menteith
12. Loch Leven
13. River Endrick

Table incidence of disease in specimens

Appendix

Incidence of disease in specimens submitted for examination
(*October* 1966–*September* 1967)

Specimen	*Diagnosis*	Tweed	Forth	Tay	South Esk	North Esk	Carron & Cowie	Dee	Don	Ythan	Deveron	Spey	Findhorn	Nairn	Ness, Garry, Moriston	Beauly	Conon	Kyle of Sutherland	Shetlands	Hebrides	W. Coast and Islands	Ayr R.P. B'd.	Solway R.P. B'd.	Sea	Source Unknown	Lancashire	*Totals*
Brown Trout	Furunculosis	–	–	1	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2
	Aeromonas spp.	–	1	4	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	9
	Kidney disease	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Vibriosis	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	2	–	–	–	–	–	4
	U.D.N.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	4
	Chromobacterium spp.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2
	Negative	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Sea Trout	Furunculosis	–	–	–	–	–	–	2	1	–	2	2	–	–	–	–	–	1	–	1	–	–	3	–	–	–	12
	Aeromonas spp.	–	–	–	–	–	–	–	2	–	1	3	–	–	–	–	–	–	–	1	–	–	4	–	–	–	11
	Kidney disease	–	–	–	–	2	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
	Vibriosis	–	–	–	–	–	–	–	–	1	4	4	–	–	–	–	–	1	–	–	–	–	2	1	–	–	13
	Pseudomonas spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	2
	Coliform bacteria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
	Haemolytic Micrococcus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	4
	Myxobacteria	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2
	U.D.N.	1	–	–	–	1	–	–	–	–	2	5	–	–	–	–	–	–	–	2	–	–	–	1	–	–	12
	U/S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
	Negative	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1

Specimen	*Diagnosis*	Tweed	Forth	Tay	South Esk	North Esk	Carron & Cowie	Dee	Don	Ythan	Deveron	Spey	Findhorn	Nairn	Ness, Garry, Moriston	Beauly	Conon	Kyle of Sutherland	Shetlands	Hebrides	W. Coast and Islands	Ayr R.P. B'd.	Solway R.P. B'd.	Sea	Source Unknown	Lancashire	*Totals*
Salmon	Furunculosis	–	–	3	4	12	1	7	1	1	2	4	–	–	1	1	–	4	–	–	2	3	4	2	–	2	54
	Aeromonas spp.	1	–	–	–	9	2	7	1	2	1	4	1	–	–	1	–	10	1	–	9	6	14	1	1	7	78
	Kidney disease	2	–	–	–	7	–	20	–	1	2	6	–	–	–	1	–	9	–	–	3	3	3	2	–	–	59
	Vibriosis	6	–	2	–	5	1	6	3	5	2	2	–	1	1	1	1	4	–	–	5	2	13	5	–	–	65
	Pseudomonas spp.	6	–	4	–	2	–	11	1	1	–	2	–	–	–	–	1	4	–	–	2	2	4	–	–	9	49
	Chromobacteria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	3
	Coliform bacteria	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	3
	Haemolytic Micrococcus	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	4	–	–	–	9
	Myxobacteria	–	–	–	–	2	–	4	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	9
	Piscine tuberculosis	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	U.D.N.	8	–	–	1	20	–	1	–	–	1	2	1	1	–	–	–	7	–	1	9	11	6	7	–	–	76
	Negative	–	–	1	–	1	–	6	–	–	2	–	–	1	–	–	–	2	–	–	8	–	2	4	–	–	27
	U/S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	3	2	1	1	–	3	12
Parr	Aeromonas spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	2
	Pseudomonas spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
	Haemolytic Micrococcus	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
	U.D.N.	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Negative	–	–	–	–	–	–	–	–	–	1	–	–	–	8	–	–	–	–	–	–	–	–	–	–	–	9
	Costia spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	5
Rainbow Trout	Aeromonas spp.	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Vibriosis	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
	Pseudomonas spp.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Peduncle disease	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	4
	Coliform bacteria	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Costia spp.	–	–	22	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	22
Others	Aeromonas spp.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	3
	Kidney disease	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
	Vibriosis	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	2	–	–	–	5
	Pseudomonas spp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
	U.D.N.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
	Totals	30	1	47	5	62	4	67	12	11	24	38	2	3	19	4	2	47	2	7	52	30	79	24	1	21	594

APPENDIX IV

ORGANISATION OF THE FISHERIES ADMINISTRATION, CHIEF ADMINISTRATIVE, EXECUTIVE AND PROFESSIONAL OFFICERS.

Secretary of the Department	Sir MATTHEW CAMPBELL, K.B.E., C.B., F.R.S.E.
Fisheries Secretary	A. J. AGLEN, C.B., F.R.S.E.

DIVISION J
(Fisheries I)

A. T. BROOKE, Assistant Secretary

Branch 1 Herring Industry and Overseas Trade	J. R. GORDON, *Principal*
Branch 2 White Fish Industry and International Questions	J. GLENDINNING, M.B.E., *Principal*
Branch 3 Grants and Loans for Fishing Vessels	R. M. BELL, *Senior Executive Officer.*

DIVISION K
(Fisheries II)

W. BAIRD, Assistant Secretary

Branch 1 Research and Freshwater Fisheries	B. GORDON, *Principal.*
Branch 2 Regulation of Fisheries	T. M. BROWN, *Principal.*
Branch 3 Harbours	Miss E. A. BUGLASS, *Senior Executive Officer.*

Inspectorate

Chief Inspector of Sea Fisheries	C. SIM
Deputy Chief Inspector of Sea Fisheries	J. STEVEN
Inspector of Salmon Fisheries	S. D. SEDGWICK

Marine Staff

Marine Superintendent	Capt. D. T. MACCALLUM, O.B.E. D.S.C.
Engineer Superintendent	S. G. BLYTH, A.M.I.MAR.E.
Assistant Marine Superintendent	Capt. F. C. CHISHOLM

Fishery Harbours Engineering Staff

P. MARTIN, A.M.I.C.E.
W. S. MACONACHIE, B.SC. (C.Eng.), A.M.I.C.E., A.M.I.W.E.

Scientific Staff

Director of Fisheries Research	C. E. LUCAS, C.M.G., D.SC., F.R.S.E., F.I.BIOL., F.R.S.
Officer in Charge, Freshwater Fisheries Lab.	K. A. PYEFINCH, M.A., F.R.S.E., F.I.BIOL.

Fisheries Organisation

Fishery Office	*District*
Eyemouth	Scottish Border to St. Abb's Head.
Leith	St. Abb's Head to Buckhaven (exclusive).
Anstruther	Buckhaven to south side of Tay.
Arbroath	North side of Tay to Bervie.
Aberdeen	Bervie (exclusive) to Aberdeen.
Peterhead	Aberdeen (exclusive) to Rattray Head.
Fraserburgh	Rattray Head to Troup Head.
Macduff	Troup Head to Cullen (exclusive).
Buckie	Cullen to River Spey
Lossiemouth	River Spey to Ardgay.
Wick	Bonar Bridge to Cape Wrath.
Lerwick	Orkney and Shetland Islands.

Fisheries Organisation—Contd.

Fishery Office	*District*
Stornoway	Lewis, Harris, and Outer Isles to Barra.
Ullapool	Cape Wrath to Diebeg (exclusive).
Kyle	Diebeg to Morar with Skye. South Rona, Raasay, Scalpay and Soay.
Oban	Morar to Crinan (both exclusive) with adjacent islands.
Campbeltown	Crinan to Rosneath Point with Colonsay Islay, Jura, Gigha, Bute and Arran.
Ayr	Rosneath Point to Scottish Border.

Scientific Laboratories

Marine Laboratory	Victoria Road, Torry, Aberdeen.
Freshwater Fisheries Laboratory	Faskally, Pitlochry.

Printed in Scotland for Her Majesty's Stationery Office, Edinburgh
by Messrs. Neill & Co. Ltd. Dd 230140 K12