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FOREIGN AND COMMONWEALTH OFFICE,

OVERSEAS DEVELOPMENT ADMINISTRATION

REPORT ON A VISIT BY A FISHERIES TEAM TO

THE FALKLAND ISLANDS,

NOVEMBER 1978

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REPORT ON A VISIT BY A FISHERIES TEAM TO THE FALKLAND ISLANDS, NOVEMBER 1978

Summary

a. The team consisted of Dr D N F Hall, ODA, Mr R C Cole, TPI and Dr J E Thorpe, DAFS Freshwater Fisheries Laboratory, Pitlochry. The purpose of the visit was to examine the possibilities of establishing a near-shore fishery and to consider the practicability of establishing a salmon ranching programme (para 1).

b. General considerations: The economy of the Falkland Islands is based on the export of wool. The population has declined from 2,500 in the 1950's to 1,850 today resulting in a high level of employment and a shortage of labour. The population is divided between Port Stanley (1,000) and many small, widely scattered (coastal) settlements between which there are essentially no roads, only tracks. Two vessels (FORREST, MONSUNEN) provide transport between the settlements by sea, and there is also a flexible internal air service. Recurrent expenditure is rising and new revenue is sought, but the Falkland Islands are a long way from the world's major markets. The weather is extremely variable but the mean wind speed is high (16 knots compared with 6 knots in UK). The sea is frequently rough but there are many sheltered anchorages. Major maintenance of the vessels is undertaken at Punta Arenas, Chile (para 2).

c. While salmon ranching might be undertaken mostly within existing labour limitations, sea fishing would require new immigrants, and the aim must be the exploitation of species of high value, low bulk (paras 3, 4).

d. The water surrounding the Falkland Islands is biologically productive and, as a result of surveys, substantial quantities of fin fish are known to be present but their commercial exploitation would probably be uneconomic. There are indications of various shell fish of high value but the precise nature of these resources, their size, location and seasonality, and the way in which they would be caught, processed and marketed are all essentially unknown (paras 5-14).

e. Survey: A survey of high value, low bulk fisheries resources is recommended. The survey would need a four-man team (fisheries biologist, processing/ marketing expert, skipper, engineer/mate) based on Port Stanley and a well equipped 60ft vessel. The survey would take about three years and is estimated to cost about £0.51 million (paras 15-20).

f. Detailed planning is impracticable but priority would be given to locations close to existing settlements starting with Port Stanley. Close supervision by ODA would be essential (paras 21, 22).

g. Processing trials should concentrate on developing frozen products for sophisticated markets although air drying and salting and drying are possible alternatives. Smoking trials should also be run. Fish meal is an unlikely product but ensilage is a possibility. Specific potential products from lobster krill, king crab, squid, octopus, crawfish (rock lobster), scallops, other shellfish and fin fish are noted (para 23-48), and a list of post-harvest equipment requirements is given (paras 49-56).

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h. Commercial feasibility: Trials lasting at least one year would be needed, once the survey had shown the existence of a substantial resource(s), the sole purpose of which must be to prove to immigrant families that they could sustain a profitable and satisfying livelihood from fishing. These trials would need the importation of a small commercial vessel(s) built specifically for the fishing to be undertaken otherwise no additional equipment would be needed beyond that provided for the survey (paras 57–60).

i. The commercial exploitation of highly valued resources would depend on attracting immigrant families who would be best located at Port Stanley (assuming an adequate exploitable resource). Ownership of boats, which it is recommended should be of steel, we foresee being in private hands but a fishing co-operative might have merit in the supply of fishing gear, for the ownership of processing plant and boat yard, and for marketing the catch. Much of the processing would be labour intensive, suitable for girl workers in particular. A professional fisheries officer would be needed from an early date, and his recruitment is included in the chart indicating the minimum time required to the commencement of commercial fishing to be $5\frac{1}{2}$ years from project approval (paras 61-63).

j. Requirements for ranching salmon: As a result of introductions of eggs between 1947 and 1962 the brown trout is now established in the Falkland Islands. In their fresh water phase their growth is slower than in UK but those individuals returning from a migration to sea (sea trout) have shown growth equally as good as in UK and have proved the marine environment well suited to their needs. The sea around the Falkland Islands is fertile and recent recoveries of ranched salmon from Chilean trials appears to confirm the general suitability of these latitudes to salmonids (paras 64–66).

k. The installations and the basic requirements needed for salmon ranching, the questions that have to be answered before any recommendation regarding commercial operations can be made, the criteria for selecting the species to be ranched and the suitability of the different species against these criteria are discussed. Atlantic salmon, chinook, coho, chum and pink salmom all have some desirable attributes (paras 64–79).

l. Based on past experience in other locations values of 0.3–3.0% returns have been assumed for chum salmon, and 0.5–5.0% initially rising to 1%–10% for Atlantic salmon. These assumptions need testing through a pilot scheme. A unit designed to produce 25,000 Atlantic salmon smolts and 1–2 million chum salmon fry annually would need 29–43 million litres of water per day. Emphasis should be placed on establishing a locally orientated, disease-free, brood stock (paras 80–85).

m. Ranching sites: Characteristics desirable in a ranching site are listed (para 86) and comment is made on a large number of potentially suitable sites of which seven were considered to be of greatest consequence (Table 6) and probably capable of producing some 665 tonnes of salmon valued at £707,400 annually. The cost of feed would be kept to a low level if use could be made of sheep carcasses and locally caught mullet. Tests on this are underway at the Institute of Marine Biochemistry, Aberdeen (paras 86–144).

n. Marketing: Although salmon may be marketed in several ways it is recommended that freezing of dressed fish should be the way to deal with most of the salmon produced in the Falkland Islands, and European markets are expected to be of

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first consequence. However, some limited smoking trials are recommended (paras 145-150).

o. The growth of the post-harvest activities during the pilot project is seen in three distinct stages and the equipment needed for each is discussed. The further development, of private commercial projects, is also considered and the need to bear in mind the freezing plant at Ajax Bay noted. Existing refrigerated cargo ship capacity supplemented by deck containers is expected to be able to cope with pilot scale production (paras 151-156).

p. Commercial salmon ranching: Although highest labour requirements, at the time of harvesting the returning adults in the late summer and early autumn (January-March), would take place after the highest demand on the farms nevertheless one full-time, trained individual would be needed by each unit. Training could be provided through the pilot scheme (paras 157-160).

q. Pilot scheme: A three-phased programme to test the biological and economic feasibility is recommended, which might last ten years but in which commercial ventures might be encouraged within six years. Following an engineering consultancy, two full-time experts (biologist, husbandryman) will be required with a third (post-harvest) expert undertaking, probably, one tour. The cost of setting up and running a pilot unit located on the Ceritos Arroyo/Camilla Creek, Darwin, is estimated, roughly, at £0.73 million over six years. Set against this there might be a revenue from the sale of returning adult salmon beginning in the second year from the commencement of rearing operations, which could build up to 150 tonnes valued at over £140,000 annually (paras 161-166).

r. Promotion and encouragement of private commercial ventures during the pilot scheme should include training individuals from settlements and involving school children and students in ancillary studies (paras 167, 168).

PURPOSE OF VISIT

1. The visit was undertaken by Dr D N F Hall, Principal Fisheries Adviser, Overseas Development Administration, Mr R C Cole, Tropical Products Institute, who had special responsibility for post-harvest matters, and Dr J E Thorpe, DAFS Freshwater Fisheries Laboratory, Pitlochry, who had special responsibility for the salmon ranching aspects of the visit, in order to examine the possibilities of establishing a near-shore fishery and, separately, to consider the practicability of establishing a salmon ranching programme.

GENERAL CONSIDERATIONS

2. No elaborate analysis of the problems of the Falkland Islands is necessary since in general terms they are already very well known but the points bearing directly on the fishery matters under examination are, briefly:

a. The Falkland Islands economy is based on the export of a single commodity, wool, which is taken from a combined flock of some 650,000 sheep which, apart from shearing time, are widely scattered over the countryside. The sheep have decreased in numbers over the years although the total wool yield has remained more or less even.

b. The population of the Falkland Islands has declined in recent years from 2,500 in the 1950's to 1,850 today. There seem to be many reasons for this decline including the increasing unattractiveness of life on the sheep stations and the lack of other job opportunities in particular the virtual impossibility of ever becoming an independent farmer.

c. The population has reached a level where some farms are short of labour. One authoritative estimate of the effect of further losses from the workforce suggested that the time when sheep farming would become very seriously effected was uncomfortably close.

d. There is virtually full employment within the remaining small population and wages were said to be high.

e. Apart from Port Stanley (Population 1,000) all other centres of population are small and widely scattered. However they are almost all located on the coast. In general these settlements do not have independent medical facilities nor schooling.

f. Away from Port Stanley there are virtually no roads. To the short term visitor the terrain seems to be either mountainous, rough moorland, or peat bog, and Landrovers with drivers choosing their own route are the only practicable form of wheeled vehicle in which to move from settlement to settlement. The settlements are served also by two transport vessels, MV FORREST (74' LOA) operated by the Government and MV MONSUNEN, slightly larger than FORREST, operated by the Falkland Islands Company (FIC). An inter-settlement air service, which operates a very flexible schedule, is provided by Beaver float planes. Twin engined Islander aircraft are to be introduced inthe near future and settlements are being urged to prepare

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landing strips. An all weather road is currently under construction between Stanley and the next largest settlement in the islands at Darwin/Goosegreen 60 miles away but it will be a long time (years rather than months) before it is usable.

g. Capital expenditures such as these on the road, new aircraft, and the international airport are increasing the recurrent expenditure of the Colony and unless new revenue is found it is foreseeable that the expenditure will exceed the income.

h. The Falkland Islands are a very long way from the world's major markets. Argentina, the nearest market, is largely meat eating and no reliance can be placed on substantial sales there of fish products.

i. The weather is characterised by extreme variability. The islands are surrounded by the cold but fertile Falkland (sea) Current which sweeps northeasterly from Cape Horn. Frontal systems moving generally from west to east cross the islands frequently and rapidly, but one fairly constant feature is the wind. Westerly winds predominate and although extreme gales such as occur periodically off the British coast are rare nevertheless the mean wind speed is high (16 knots compared with 6 knots in UK). The sea is frequently rough but the indented coastline provides for many sheltered anchorages. Conditions for drying fish products do occur but probably not for any lengthy period at one time.

j. Routine maintenance of the FORREST and MONSUNEN can be carried out at Port Stanley but slipping and substantial maintenance is undertaken at Punta Arenas in Chile.

3. The team was convinced that a prosperous future for the Falkland Islands can lie only in a diversified economy and an increased population. Although it seems possible that salmon ranching, if shown to be technically practicable, could be undertaken, at least to some extent, mostly within the existing labour limitations, since greatest demands for labour for the salmon ranching would not coincide with the greatest demands by the sheep farms, a commercial sea fishing industry could in no way depend upon the existing manpower situation but would require the immigration of families specifically for the purpose. However, although the Falkland Islands present the very rare situation these days of an essentially totally unexploited fisheries resource, at the present time, despite the various studies that have been made, there is no basis on which to recommend the establishment of a commercial fishery.

4. The size and scattered nature of the Falkland Islands population make it totally impossible to base a fishery on that market. On the other hand the distance of the Falkland Islands from the major world markets makes it imperative that exports should be of high value and low bulk. Economic viability would seem to preclude reliance on the immediate exploitation of either near shore or deep sea fin fish: on the other hand there is a total lack of commercially relevant information with regard to any other species but on biological grounds there is no reason to assume that such resources do not exist.

NATURALLY OCCURING FISHERIES RESOURCES

5. The Falkland Current, which bathes the Falkland Islands, has been described as amongst the most productive areas of the world oceans (Gulland (Ed) 1972, page 146)

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and substantial stocks of demersal fin fish have been shown to be present. Summarising the information, it has been estimated that the potential yields of demersal fish from the shelf area subjected to the Falkland Current are higher than those from the North Sea, 2.6 tonnes/sq km compared with 1.7 tonnes/sq km (Gulland (Ed) 1972 page 151). However as long ago as 1946 while writing the account of the Discovery Investigations and considering the prospects of a commercial fishery in the Falkland Islands, Hart wrote (page 391) 'It must be plainly stated that the results are not encouraging; but this is due to economic and geographical factors, rather than to lack of suitable fish".

6. Indications of possibly commercially significant resources in the Falkland Islands can be obtained by comparing the situation in similar latitudes in Latin America. There is a cannery for mussels, scallops and king crab (Centolla) in Punta Arenas and a small fishery for scallops and king crab in Southern Argentina. Surveys have shown the presence of deep water prawns and other Crustacea of commercial interest at depths of around 50 fathoms and although these indications are slight and preliminary Gulland (Ibid page 235) noted that they do suggest that the occurrence of extensive resources off the southern part of Argentina is at least a possibility.

7. Since the trawling surveys of the RRS WILLIAM SCORESBY during the period 1927-1932, reported by Dr Hart in 1946, there have been reported at least three specific fisheries surveys around the Falkland Islands. The first was carried out by the Taiyo Fishing Company in collaboration with British United Trawlers during 1974 and 1975 when a survey was made of the demersal fish stocks but the findings of the survey were not encouraging enough to suggest that a viable fishery could be based on the islands. The second survey, aimed at the crab resources, was again sponsored by the Taiyo Fishing Company. Three voyages were made on the chartered ketch PENELOPE during the period October to December 1976. One species of crab, the red king crab (Lithodes antarcticus) was considered to have commercial significance. Although the numbers taken were small nevertheless the individuals were of a good size and the recovery of meat was easy.

8. The third survey, recently completed, is a collaborative programme between Argentina and the Federal Republic of Germany involving the research vessel WALTER HERWIG. Although previous studies had tended to discount the Burdwood Bank, 100 miles to the south of the Falkland Islands, noting a surprisingly low abundance of demersal fish of commercial size in spite of the high abundance of benthos, this third survey has reported exceptionally good trawl catches of fin fish (in which blue whiting, Micromesistius australis, have featured prominently) from that area and from west of the Falkland Islands.

9. Further specific information on resources of high potential value and low bulk was difficult to obtain locally in the Falkland Islands but from talking to a large number of people who were either interested in or associated with the sea the following reasonably authoritative list was compiled:

a. Crabs (Centolla) - New Island, Fox Bay, Falkland Sound, Lively Island. Catches from 15 miles west of New Island were reported to contain individuals which were 3 ft from claw to claw.

b. Scallops - Speedwell Island, Campa Menta Bay (north coast, East Falkland). Small shells (1½ in) have been found on beaches in West Falkland.

c. Octopus - Stanley Harbour.

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d. Squid - very many observations from around the islands. From seal stomach evidence they must be plentiful, at least seasonally.

e. Lobster krill - Fox Bay, between Carcass Is and West Point Is.

f. Sea urchins - New Island.

10. It might be noted that the lobster krill have been recorded very widely in the south western Atlantic Ocean where enormous shoals of the juvenile, so-called Grimothea stage, may colour the sea bright red over large areas. The adult of one species (Munida gregaria) may also be found in swarms at the surface although the adults of lobster krill are usually to be found on the sea bed. RRS DISCOVERY trawled Munida species from the sea bed off Eddystone Rock in the East Falklands in 1926 in 50-60 fathoms and Harrison Matthews, who recorded the survey, noted that they were 'much appreciated in the Ward Room and on the mess deck'.

11. One eye witness to whom we spoke referred back to the landings of RRS WILLIAM SCORESBY and gave a description of what appears to have been a large prawn or more likely a rock lobster (crawfish). There was one further account of lobster-like crustaceans that were attracted to bright lights at night in Sparrow Cove (East Falkland) during a Vancouver Zoo expedition in about 1947/48. If crawfish occur in numbers and can be caught economically they could provide the basis for a near shore fishery entirely on their own merits.

12. Our attention was drawn repeatedly to the abundant mussels around the Falkland Is which, it is reported, grow quickly. Mussels are not, however, highly valued. On the other hand it may be that some selected fin-fish species and individuals, which in general terms we have discounted above, might justify further consideration on account of either their quality (for example a report of shoals of large tuna-like fish, seen seasonally - March - between Bleaker and Triste Is (East Falkland)) or quantity (for example densely shoaling species that might be caught very cheaply for fish meal production).

13. Thus in summary, while there are many indications that the near shore waters of the Falkland Islands contain potentially high value resources, possibly in abundance, the precise nature of these resources, their size, location, seasonality, and the way in which they would be caught, processed and marketed are all essentially unknown. Whether one species could provide the basis of a fishing industry or whether boats would have to exploit several resources each at the peak of their season, and the extent to which selected fish species might be incorporated into exports are all matters that can only be determined by trial. In view of the uncertain future of the Falkland Islands without a diversified economy and an increased population, and in a broader context, the need for more information on the resources of the southwest Atlantic which might be of ultimate benefit to many developing countries, the team recommend that a survey should be undertaken.

14. The team was impressed not only with the potentialities of the Falkland Islands with regard to the natually occurring marine productivity and fisheries resources but also by the way in which the brown trout, introduced 25 years ago, have generally thrived during their migrations to sea and by their high marine growth rate. This is discussed further in the detailed account of salmon ranching matters (paragraphs 64 et seq) from which the team further recommends that a pilot salmon ranching scheme be undertaken.

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15. The remainder of this report is devoted to the proposed survey of natually occurring highly valued fisheries resources and the necessary follow-up action, the prospects for salmon ranching, and post-harvest matters bearing on both these projects.

SURVEY OF FISHERIES RESOURCES

General considerations

16. Because there is insufficient information to justify any immediate investment in fishing, though there would appear to be a potential, we recommend a survey aimed at an assessment of the resources of high potential value and low bulk to determine what can be taken and how much, and the how, when, and where of commercial exploitation. The survey should also study the post-harvest handling, preservation, processing, packaging and transport to meet specific market demands. The total cost of the survey is estimated at £510,000 over three years (Table 2).

17. The main tool of the survey would be a vessel which, in view of the sea conditions, could not be less than 60 ft in length. A relatively new (say not more than two years old) stern trawler is recommended which is likely to require some modification. It would need comprehensive electronic equipment including conventional echo location gear, together with sonar and recorder for a mid-water trawl transducer. The vessel would need to be equipped for bottom trawling, mid-water trawling (for which a separate winch for the headline transducer would be needed) and the operation of dredges particularly for shellfish such as scallops. Other fishing gear which should be operated include pots for rock lobster (crawfish) and Centolla (king crabs), bottom set tangle nets and trammel nets for crawfish and crabs, which would require a power block, long lines which, together with the pots, would require a line hauler, hand lines and beach seines.

18. For the retention of the catch the vessel would need an insulated hold for ice together with live tanks on the deck supplied with clean, fresh sea water by pump. A detailed list of all minor items should be drawn up by the project leader in consultation with the ODA Advisers.

19. The survey would require four expert staff from the United Kingdom:

a.	Fisheries Biologist	) Either would be suitable as
b.	Processing/Marketing Expert	) the team leader.
c.	Fishing Skipper	
d.	Engineer/Mate	

It is foreseen that these experts might be supplemented by a natural resources student since the project would provide excellent training for such a student. The operation of the survey vessel would require also four local crew members. If one of these could be a Chilean with practical experience of shellfish fishing it would be exceedingly helpful.

20. The prime base for the survey, it is foreseen, would be Port Stanley where the public jetty would seem to be well suited to the needs of a 60 ft vessel (see also paragraph 33). However, the vessel could not return to Port Stanley even at weekends if it were operating in West Falkland and it is foreseen that

/MV FORREST

MV FOREEST would be required to give logistic support particularly for fuel, water and ice. If necessary personnel could travel between the survey vessel and Port Stanley also by air.

21. Since immigrant families would be best located at existing centres of populatio it is foreseen that first priority would be given to the identification and assessment of exploitable resources within the proximity of existing settlements. It would be the intention to complete the survey as quickly as possible. In view of the large area to be covered and the wide variety of gears that would need to be used it is foreseen that a minimum duration of the field work would be three years but it is possible that after two years there would be enough information to justify approving a commercial feasibility project which almost certainly would require its own vessel equipped specifically for the exploitation of the identified resource(s).

22. Detailed planning of the survey is impracticable at the present time and should be, in any case, a responsibility of the project leader. In this planning it would be desirable for him and the fishing skipper to visit the shellfish fishermen of southern Chile to gain experience of, for example, Centolla fishing and to acquire a feel for the preferred localities of these crabs [contact Sr Guido Celedon, Director, Instituto Fomento Pesqueras (IFOP), Punta Arenas]. Clearly, however, flexibility within the project and the ability to react quickly to a changing basis of information will be an important consideration. This means that close supervision of the project by ODA would be an essential requirement. To facilitate progression to commercial feasibility trials supervisory visits, including both pre- and post-harvest advice, should be considered at the end of nine months and at the end of 18/21 months.

<u>Fish handling, processing and marketing during the resource survey</u>

23. It was noted in para 4 that the local market for fish for human consumption will always be very small indeed and that the main thrust of the inshore fisheries project should be to attempt to develop high value low bulk products for export to sophisticated markets. This suggests that the post-harvest expert's programme should be directed in the first place to the development of products from the shellfish resources, which are thought to include at least one or more species of lobster krill (<u>Munida sp</u>), the king crab or Centolla (<u>Lithodes antarcticus</u>), an unidentified scallop, squid and octopus. It is possible that a crawfish (rock lobster) or prawn resource might be found but there is at present only the flimsiest evidence that either exists.

24. Many of these shellfish could in theory be exported either as frozen or as canned products. The advantage of canning would be that the product would be stable for a very long time at ambient temperatures. There would thus be no difficulty in storing or transporting the final product. Canning would, however, involve the use of complicated machinery, the operations are labour-intensive and it would be necessary to import cans at regular intervals since the operation could not be big enough to justify the use of can-forming equipment. While it may be that a cannery would prove to be the best long-term solution to the problem of exporting shellfish from the Falklands it seems likely that the advantages would be heavily outweighted by the disadvantages. Initial experiments should be concentrated therefore on freezing any shellfish which may be found in exploitable quantities. The advantage of freezing lies in the relatively simple nature of the operation and, in spite of the difficulty that the products, once frozen, must be stored at low temperatures, it is thought that freezing would be more profitable than canning. For long-term storage fish products should be held at minus 30°C: for relatively short-term storage it would be possible to make use of the butchery cold store which at present operates at minus 18°C.

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25. While squid do not fetch such high prices as many other shellfish, they are likely to be more valuable thanthe fin fish. These could also be canned or frozen. The arguments against canning apply here also and freezing would be the preferred method of processing.

26. Large mussels, so far unidentified, appear to exist in substantial quantities. At present the European market is saturated and it is understood that other markets are small. These are, in any case, a cheap food and, while the possibility of marketing small quantities on the American mainland cannot be entirely discounted if an export market for other products could be developed, it is not thought likely that export of mussels would be profitable. Any small-scale operation using mussels would be labour-intensive.

27. Fin fish, with the exception of the salmonids and few other species, are much less valuable than shellfish. There could be no question of canning any of the species likely to be taken by an inshore fishery. None of these species are known in Western markets and while a market for some species might be developed on the European continent, especially in the Mediterranean area, it is likely that most species could not bear the cost of freight. Much depends, of course, on the cost of catching the fish. Possible alternatives to freezing are air drying or salting and drying. Properly prepared and carefully stored, such products should be stable at ambient temperatures and humidities in the Falklands for much of the year. It might prove necessary, however, to finish drying unsalted products mechanically and fuel costs would be high unless a method of using peat could be developed. Present methods of peat cutting are labour-intensive but mechanised cutting and stacking might be possible. Dried products are relatively bulky and of relatively low value; possible markets exist in developing countries, such as in NE Brazil, Jamaica and Nigeria. Tariff barriers and occasional prohibitions against the import of dried fish products render these markets problematical.

28. Some of the fin fish might be converted into smoked products. If the fish were to be smoked locally this would require either that sawdust be imported or that drying/smoking methods using peat be developed. Smoking operations are labour-intensive except when on a scale large enough to permit mechanisation. The best smoked products are made by smoking close to the point of sale. All this suggests that, in spite of the added value which could accrue by smoking locally, if smoked products were to be required, other than for the very tiny local market, the fish should be frozen fresh and cold stored for export in that state (cf smoked salmon para 149).

29. The possibility of manufacturing fish meal was mentioned on a number of occasions during our discussions. The point was made that imported fertilizers are at present expensive. Fish meal is an excellent fertiliser and was formerly used extensively for this purpose; it is now generally regarded as too valuable for use as a fertiliser and almost the whole of the fish meal now produced is used as an essential component in compounded animal feeds. These feeds are used largely in intensive pig and poultry rearing units. Although fish meal is an essential feed component, the Falkland Islands do not produce the energy-providing components which are also needed in a compounded feed. There thus seems little prospect of developing intensive animal rearing units. If fish meal were to be produced it must either be used as a fertiliser or exported. These possibilities depend on the cost of catching the fish which would provide the raw material.

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30. The production of formic acid fish silage is an alternative to fish meal manufacture. This can be a small-scale operation and the process is a simple one. The product is liquid and must therefore be used as near as possible to the point of production since the bulk precludes long distance transport. Like other chemical processes fish silage manufacture is temperature-dependent; higher temperatures, within the range of enzyme activity, produce more rapid breakdown than lower ones. In the Falkland Islands this breakdown would be relatively slow, but complete breakdown is not essential. Once the acid is mixed with minced fish, a product which will not putrify is achieved.

31. So far as is known, no one has attempted to feed such a product to sheep and the indications are that free-ranging Falklands sheep will not take compounded feeds nor use mineral licks. However, it would be a simple matter to test the manufacture of silage on a small-scale and attempt to feed this to sheep. This is outside the general concept of the main project and details of the manufacturing process have been sent separately to the Grasslands Trials Unit.

Suggested post-harvest programme

32. The difficulties inherent in attempting to draft a programme to deal with both the technological and marketing aspects for a project which may produce a wide variety of quite different raw material are obvious. An attempt must be made but it is impossible to set priorities at this stage beyond stating the obvious fact that the project should concentrate its activities in the first place on those potential products which command a high price in relation to their bulk and weight.

33. The expert's first task should be to supervise the installation of the equipment provided and to test it. The preferred site for the project's activities would be the building vacated by Alginates Industries Ltd (AIL). The building has a 3-phase electrical supply and town water supply, and a crude dry laboratory already exists. The remaining rooms, if cleared of the equipment left by AIL, could provide a wet laboratory to be shared by the biologist and post-harvest expert and could house most of the processing equipment. The icemaking machine and silo would best be sited on the public jetty since the fishing vessel would be the major ice user. Other heavy equipment could be placed in a room near the wet laboratory. Subject to agreement air drying might be undertaken at the project site or prepared fish could be taken to the butchery site.

34. The following notes, not in any order of priority, are on the most likely potential products.

35. Lobster Krill (Munida spp): These are relatively small animals and the tail, which is the only edible part, is small while the cephalothorax is large. It would seem that the best approach would be to remove the tails at sea (unless the quantities taken preclude this), to ice the tails in plastic fish boxes and freeze the tails on landing. The frozen tails should be glazed, packed in cartons and cold stored. It is expected that the product would be similar to small scampi.

36. Nothing is known about the length of time for which tails could be held in ice before freezing but this would be very short. It may be necessary to investigate the possibility of cooking the tails on board and freezing the cooked tails after they had been landed on ice. It may be essential to freeze at sea. Tailing commercial quantities would almost certainly be an expensive labour-intensive

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operation; so far as is known no machinery at present exists for this. Since we do not know at this stage what quantities of lobster krill would be landed by the project no freezing equipment for use at sea is provided: if freezing at sea proves to be essential an American brine freezing unit should be supplied during the course of the project.

37. The various possible ways in which Munida might be processed and stored should be examined by taste panelling before test marketing although samples could be shipped for trade evaluation at an earlier stage.

38. King crab (Centolla (Lithodes antarcticus)): The team did not see this animal, which is harvested in Chile between October and December. There, a substantial part of the catch is reportedly canned, the remainder being sold fresh or frozen. Only the possibility of making a frozen product is of interest to the Falkland Islands. If a resource is found, commercial exploitation would require that the crabs be landed alive. Dead animals spoil rapidly. The legs are removed and boiled. Once cooked the leg meat must be separated from the shell and frozen as quickly as possible.

39. It seems likely that the project would be able to make only small-scale trials because it would be difficult to hold substantial quantities of crabs alive on board the project vessel. Meat separation is a hand operation if a top quality product is to be made: only the crushing stage could be mechanised. While it is possible to use mechanical meat separators the product obtained would be of relatively low value.

40. At present frozen Alaskan king crab meat is in short supply. It is so expensive, at US$8.00/lb, that none is imported into the United Kingdom. The profitability of selling to the United States of America and to other American markets should be investigated if an exploitable resource is found. This would require preliminary storage trials and organoleptic assessment as well as yield assessment If, as seems likely, this proved to be a fishery with a relatively short season it might be unprofitable to exploit the resource unless other resources which were available in a different season could also be found.

41. Squid: Samples should be frozen for test marketing in Southern Europe: while there is a market in Japan it seems likely that it would be more difficult to ship frozen material there than to European or American markets. Small animals should be gutted and frozen whole. With larger animals (ie those more than about 8in body length) only the skinned body meat is likely to be saleable at a price which would cover catching, processing, packaging and freight costs. Freezing whole fish is obviously a better prospect if small fish can be found since labour requirements would be low. Octopus should be dealt with in a similar manner to squid.

42. Crawfish (rock lobster): Nothing is known of this possible resource but the possibility of marketing frozen tails or of shipping live fish by air to the Argentine Republic could be investigated. A good quality frozen product would result only if the animals were landed alive. Live crawfish are flown to luxury markets over distances of thousands of miles, for example from Madagascar to Paris and it would, theoretically, be possible to fly live crawfish profitably from the Falkland Islands to Buenos Aires.

43. Scallops: These should be stored on board the survey vessel "dry" (ie periodically drenched but not kept under water) alive in sacks until the shucked

/meats

meats can be frozen individually (within a few days of catching). The frozen meats should be glazed and stored for test marketing in Europe or Japan.

44. Fin fish: These fall into three groups. First there are the large food fishes including "mullet" (Eleginops maclovinus), hake (Merluccius hubbsi), the Antarctic "cod" (Notothenia spp) and possibly other species which could, technically, be frozen for sale in Europe or America. As noted earlier, however, the profitability of such operations is doubtful. Hake are soft fleshed fish which require care in handling and processing: on the other hand, although little information is available in the literature on the other species it is thought that there would be few technical problems in dealing with them. The economics of selling selected frozen dressed fish should be investigated by trade assessment followed by test marketing if the trade assessment is promising. A lower bulk, higher value product would be made if the fish were filleted and the fillets skinned before freezing; it seems likely that this would have to be a labour-intensive hand operation although it might be possible to modify existing machinery to deal with one or more of the species under discussion.

45. Should the reports of "tuna-like" fish (para 12) be substantiated and the species be identified as true tunas a separate and quite specific evaluation of the data will be required, and because of the relatively high value of those species some revision of the work programme of the survey might be needed.

46. The third group includes blue whiting, Micromesistius australis, known to be heavily parasitised, and Falkland herring, Clupea fuegensis. At present it seems likely that such fish could be marketed only if reduced to fish meal and oil. There is little point in attempting pilot-scale fish meal manufacture: the parameters about which information is required could be obtained by analysis. The possibility of fish meal and oil manufacture should be investigated by a desk study if substantial quantities of schooling fish are found by the survey. The inputs required from the project would be an assessment of the size and seasonality of the resource together with the seasonal variation in oil content and projected landed value. Profitability would hinge on the cost of catching the fish: fish for meal and oil must be caught very cheaply if any profit is to be made.

47. Other shellfish: Although clam shells litter some beaches, no other major molluscan resource is known to exist apart from the mussels. It seems unlikely that a viable industry could be based solely on the known or anticipated resources of mussels but if it proves possible to market some other fish or shell fish then trade assessment could be made of frozen, cooked mussel meat, salt pickled raw mussel meat and frozen raw clam. The removal of meat from the shell would almost certainly have to be a hand operation which suggests little prospect of profit since the product value would be low. However, potential markets are thought to exist for small quantities in the nearby countries of South America. Gonads of sea urchins could conceivably represent a resource. The major world market for these, raw frozen, is Japan, but as with many other products noted above the extraction of the gonads and their preparation is labour intensive.

48. Products suitable for transport by air to Buenos Aires: Stanley is at present linked to Argentina by a twice weekly passenger flight to Comodoro Rivadavia. From Comodoro Rivadavia to Buenos Aires there is a regular and frequent service. In theory, therefore, it should be possible to carry high value, low bulk products to Buenos Aires in less than 24 hours. This could be considered as a possible means of selling live crawfish. Other possibilities which might be considered are the marketing of frozen crab meat and chilled

/or

or frozen lobster krill tails. Since these are only hypothetical possibilities no attempt has been made to investigate the economics of such operations The possibility of test marketing during the project should be kept in mind.

Post-harvest equipment requirements

49. The equipment needed is basically that required to investigate, at pilot-scale, profitability of exporting frozen products. Some of the projected fish catches would be boxed and iced at sea, but crabs and crawfish would be landed alive.

50. Ice machine and silo: Ice would be required both at sea and ashore. A 60 ft vessel operating commercially might well carry more than 5 tonnes of ice but for the project's operations a silo holding 5 tonnes of ice sited below a flake ice machine making one tonne of ice in 24 hours would be adequate. The vessel would be the major user so the machine should be sited on the jetty if this is feasible and arranged so that ice can be shot from the silo direct into the fish room. This would minimise ice loss through melting. The relatively small quantities of ice needed ashore would be boxed and taken to the project site in a Landrover and trailer.

51. Live storage: The project should have a small live storage well. This could be a wooden or GRP box (on deck if stability requirements permit) with pumped sea water supply. Exact requirements would be specified when a vessel has been selected. A cage should be constructed locally of weldmesh, chicken wire or sheep fence wire and should be set in the harbour if pre-processing storage is needed.

52. Freezer: Since it may be necessary to freeze a variety of products a blast freezer is preferred to other types because it is the most versatile. For most of the work which is to be undertaken, a blast freezer capable of taking a 100lb load and freezing the material within 2 hours would be adequate. If, however, it became necessary to freeze large quantities of salmon from the salmon ranching project, a 100lb per load freezer would be much too small. Since doubling the freezer size almost doubles the cost, it is suggested that a freezer for either the near-shore fisheries project or the salmon project capable of freezing 100lb at a charge should be supplied in the first instance and that a second and larger freezer should be supplied later if it became apparent that this was needed.

53. Cold store: For pilot-scale work a cold store operating at minus 30° Celsius would be required. Although only about 5 tonnes of storage space is likely to be required, unless it becomes necessary to store salmon, it may prove difficult and would be unwise to buy a store to hold less than 20 tonnes of fish. A walk-in modular design would be preferred.

54. Smoking/drying kiln: A Torry minikiln should be supplied. This would enable the post-harvest expert to decide which fish, if any, might be used to make smoked products. The kiln could also be used for drying trials.

55. Shrimp/crab boiler: Although this might be locally made it would be preferable to include a small commercial boiler. The possibility of using an oil fired boiler which could be used at sea if necessary should be investigated.

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56. Minor items: A final list of these items should be prepared in consultation with the post-harvest technical co-operation officer when appointed. Items which would obviously be required include: 100 50kg plastic fish boxes; a rubber tyred platform trolley; a porter's barrow; plastic storage tubs; 2 tonnes of fishery salt; splitting, gutting and filleting knives; filleting boards; a tool kit; packaging materials; freezer trays; a platform scale reading by ½kg to 100kg; a 9 station probe thermometer reading -50°C to 150°C together with probes; 2 Dependatherm probe thermometers with rechargeable batteries, fish and shrimp probes and one set of spare probes; a recording hygrometer; a Whirling hygrometer with 2 sets of spare thermometers; a Ventimeter; 2 brass hydrometers (salinometers); a top pan balance; an analytical balance; 6 Soxhlet apparatus with a 4 heater bank; moisture dishes; a laboratory oven; 2 deep freeze chests; a domestic refrigerator; a supply of laboratory glassware and consumables including chemicals.

Commercial feasibility trials

57. Immigrant families will not be attracted to the Falkland Islands without very positive evidence of being able to sustain a profitable and satisfying livelihood from fishing and the sole purpose of these trials must be to collect enough information to persuade fishing families to emigrate to the Falkland Islands. If this is not achieved then everything else will have been in vain. Proven viability based on low levels of production must be an essential results of the trials since it must be foreseen that the fishery will be very small to begin with, say four to six boats; but only on such a financially sound basis can long term development plans be made.

58. A commercial vessel has to be designed and built with a specific fishery in mind if it is to operate with maximum efficiency. It is extremely unlikely that the survey vessel would be suitable to undertake any of the commercial feasibility trials and one (or more) commercial vessels would be required, depending on the resources to be tested. These vessels should be as small as possible consistent with the fishing to be undertaken and the weather conditions to be expected, and they should have the smallest possible crew complement who should be dependent on their performance for a proportion of their total remuneration.

59. Marketing the catch should follow commercial practice as nearly as possible although the co-operative suggested (paragraph 61) for the full commercial exploitation of course would not be possible. So far as trial shipments of products from the Falkland Islands are concerned there is adequate transport on the FIC charter supply vessel ANNETTE DANIELSON, which operates out of Gravesend. The ANNETTE DANIELSON has a 16 ton deep freeze and could, in addition, take two 15 ton cold store units as deck cargo. This vessel makes four visits annually to Port Stanley: when the annual production of fisheries products approaches 180 tons/year an additional means of moving the cargoes will need to be sought.

60. The duration of the feasibility trails cannot be expected to be less than one year.

Commercial exploitation of highly valued resources

61. Comment can be made only on some very broad considerations at this stage and the first of these is that immigrant families have to be able to integrate into the Falkland Islands community. Families already familiar with life on an island or in remote locations would have an advantage over others. The logical base for the first immigrant families, given an adequate fisheries resource, is Port Stanley with its medical and educational facilities and the availability of household supplies: the degree of self reliance of the camp settlements is a matter which few if any families within the United Kingdom have

/experienced.

experienced. Housing and finance for mortgages and for the provision of fishing boats and equipment would be needed. It is foreseen that fishing boats in the first instance would be imported from UK. In the complete absence of indigenous wood we recommend that steel be considered as the only practicable building material. The boats, we foresee, would be individually or family owned but a fishing co-operative would seem to have merit for the supply of fishing gear, for the ownership of processing plant and the essential cold store and for marketing the catch.

62. Opportunities for new local employment will be present from an early stage of the fishery. It is foreseen that much of the processing will be labour intensive with requirements particularly for girl workers. The wive and daughters of the fishermen would be particularly helpful in forming the skilled nuclei of such working groups. A co-operative boat yard will be required as the fleet develops, initially for boat maintenance but possibly, in due course, being able to undertake construction sufficient to build up the fleet and replace the vessels as they became old and uneconomic. From an early date there will be a need for a professional Fisheries Officer. The maintenance of fisheries statistics is not immediately productive but it is vital in fisheries management and at some stage all boats will need to be licensed and ultimately the total fishing effort may need to be controlled. A local (Pt Stanley) fish shop is also foreseen.

Time scale

63. The time scale is extremely problematic because of the many imponderable factors involved but some indication of the minimum time required to the commencement of commercial fishing is given in Table 1.

TABLE 1. Minimum time needed to the commencement of commercial fishing

	ITEM	YEARS 1	2	3	4	5	6	COMMENT
1.	Identifying survey vessel and affecting modifications. Obtaining equipment, recruiting staff and transporting all to the Falkland Islands	—						
2.	Resource survey		—	—	—	- - -	- - -	Survey vessel might have a continuing role in fisheries management and development
3.	Publicity campaign		····	····	···· - - -	- - - —		
4.	Obtaining vessel(s) for commercial feasibility trials			- - -	—			
5.	Feasibility trials				—	— - - -	- - -	These vessel(s) could have a continuing role in the commercial fleet
6.	Planning and setting up finance, housing, boats, gear, workshop, processing/storage requirements and marketing outlets				—	—	—	
7.	Recruitment of professional Fisheries Officer					—		
8.	Identifying and moving families to the Falkland Islands					—	—	
9.	Commencement of commercial fishing						●	

TABLE 2. ROUGH COSTS FOR THREE-YEAR FISHERIES SURVEY

(Commercial Feasibility Trials Not costed at this stage)

Capital Costs	Year 1	Year 2	Year 3
Vessel (60' 2 year old stern trawler) 1. Basic cost £120,000 2. Alterations a) Electronic £15,000 b) Other £15,000	150,000	–	–
Fishing gear	10,000	5,000	5,000
Long wheel base Landrover and trailer	8,000	–	–
Scientific equipment	5,000	1,000	1,000
Cold store, 20 tonnes (minus 30°C)	8,000	–	–
Blast freezer, 100lb charge	8,000	–	–
1 tonne/24 hours flake ice machine mounted over refrigerated (minus 10°C) insulated silo to hold 5 tonnes	20,000	–	–
Torry mini smoke kiln	1,000	–	–
Shrimp/crab boiler, oil or gas fired	1,000	–	–
Minor items	1,500	–	–
	£212,500	6,000	6,000

Running Costs	Year 1	Year 2	Year 3
a) Staff: Fisheries biologist Processing/marketing expert Skipper Engineer/Mate	64,000	64,000	64,000
b) Vessel passage to Falklands	5,000	–	–
c) Vessel fuel, oil etc (200 x 12 Hrs/day)	20,000	20,000	20,000
d) Vessel and vehicle spares and maintenance	10,000	5,000	5,000
e) Laboratory expendibles	5,000	1,000	1,000
	£104,000	90,000	90,000
Total	£316,500	96,000	96,000

(Say £0.51 million)

NOT considered

Sea time allowances
Travel to Chile
Vessel major servicing/slipping
Housing
Local crew members (4)
Electricity

SALMON RANCHING

Introduction

64. Between 1947 and 1962, 107,000 eggs of the Brown Trout, *Salmo trutta* L. were imported into the Falkland Islands from the United Kingdom. Fry from these eggs were planted in some 18 stream systems in East and West Falkland, and the species has succeeded in establishing breeding populations in these and several other neighbouring streams during the past 30 years. Samples of these fish in 1972 (Stewart 1973) indicated that their growth in freshwater was rather slower than that of the species in the UK, but that some individuals had migrated to sea and showed growth performance comparable with sea-trout from UK waters, some reaching weights of 8kg. The flesh of these sea-run fish was pink to deep red, implying a crustacean diet. The important implication of these findings is that whereas the trout can just adapt to freshwater conditions in the islands, the marine environment there is well suited to their needs.

65. Over the past century it is likely that the natural predator pressure on planktonic crustaceans of the South Atlantic and the Southern Ocean has been reduced, due to heavy exploitation of marine mammals and penguins by man. The Falkland Islands once supported whaling and sealing stations, and penguins were taken by tens of thousands for reduction to oil (Cawkell et al 1960, Strange 1972). Whereas the latter species may now approach their former abundance the seals have not returned to the areas from which they were formally cropped (C Bertrand, pers comm) and the great whales are now seemingly virtually extinct in the area. The crustaceans consist largely of euphausiids (krill, *Euphausia superba*) and related species. The predator pressure on these creatures could be increased to the levels once exerted by the whales and seals. Direct harvesting of krill and its congeners by man is possible, and is under active investigation in the Southern Ocean by the Russians and Japanese among others, but to employ ships and men in such a commercial enterprise would be costly in energy terms let alone the risk to life and limb, and once harvested the krill require considerable processing before they are useable as human or animal food. Much of this cost could be circumvented if anadromous fish species such as salmon were used to prey on the crustaceans and were themselves harvested on returning to spawn at their points of release into the ocean, a method of exploitation used widely in the North Atlantic and North Pacific and recommended for consideration in the Falkland Islands by the Shackleton committee (1976).

66. In this consideration it is important to note that salmon ranching in the Falkland Islands would not need to rely on the salmon finding their way south beyond the oceanic discontinuity known as the Antarctic Convergence to feed on the krill stocks of the Southern Ocean and subsequently finding their way back to the Falkland Islands, again crossing the Antarctic Convergence. As indicated in paras 5, 64 and 65, the seas surrounding the Falkland Islands are themselves very fertile and are believed to be well capable of supporting considerable numbers of salmon. It is relevant to note that in May 1979 the Subsecretario de Pesca for Chile announced (*Mercurio* of Santiago) that the first returns of Pacific salmon, planted as fry off the island of Chiloe (a latitude north of the Falkland Islands) in Spring 1976 (November), were recorded in April 1979 at weights up to 4kg. Although the species of salmon is not stated, it is likely that these fish were coho, returning after 18 months at sea. This is good evidence of the ability of this species to thrive in the southern hemisphere, and to return successfully to its release point.

/67.

67. The costs involved in this form of exploitation would be limited to installation, maintenance, and operation of:

a) Rearing facilities for freshwater stages;
b) Holding facilities for pre-migrant fish and broodstock;
c) Capture facilities for returning adults;
d) Handling and storage facilities for the harvested product.

68. The Falkland Islands have no native species of fish which are suitable for use in this role. Since brown trout have demonstrated their ability to flourish in the area, it is at least possible that they and other salmonid species could be ranched from the islands. All Atlantic and Pacific species of sea-running salmonine fishes (genera Salmo, Salvelinus, and Oncorhynchus) should be considered as candidates for introduction to this South Atlantic area, for use from controlled rearing and harvesting sites. As their specific biological requirements are not identical (eg their ability to range widely, their food particle-size preferences, their age and size at entry to and return from the sea) it would be desirable to consider a mixture of these species.

69. The unknowns in such an enterprise for the Falkland Islands are broadly:

a. Are the physical conditions (eg water quantity, chemical quality, temperature) appropriate for rearing sufficient quantities of juvenile salmonids in freshwater?

b. Are the physical and biological conditions appropriate for release of juvenile migrants to sea?

c. Once released, will the migrants grow to a marketable size and return in commercially acceptable quantities to their release point?

d. Are the physical and biological conditions appropriate for harvesting the adults, and holding broodstock?

e. What are the particular logistic problems associated with handling, storage, and shipping the products?

f. Do the islands possess the necessary manpower?

g. Would the undertaking be economic?

Basic requirements for ranching salmon

70. Salmon species spawn naturally in the gravel of stream beds in the autumn and winter months, their alevins hatching in these "redds" and developing for the first 4-6 weeks on their yolk supply before emergence into the open to grow up on external food sources. Simple incubation systems for these stages have been developed over the past century and are used in cultivation throughout the native range of all salmon species. In principle the eggs are held in the dark on perforated trays through which a gentle current of water flows to permit necessary gaseous exchange, and at hatching the alevins remain on the trays or drop through perforations on to an uneven surface, on which they continue to develop until ready to feed. At this stage they are transferred to tanks or troughs in the light, and offered a small particulate diet virtually continuously during daylight hours throughout the rest of their freshwater life (Fig 10). As a very rough guide their water requirement is about 10 litres/min/kg of fish, but

/this

this will vary with the design of the holding facility.

71. When ready to migrate seaward they are released into the wild preferably at the site from which they will ultimately be harvested, as their homing behaviour will ensure that the majority return to the point of release. The return of the migrants does not take place uniformly throughout the year but is confined to specific months. In the Falkland Islands it is believed that the returns would take place during the general period January-March: this is towards the end and after the major demand on labour by the farms, for shearing, which is mostly completed early in the year.

72. Since the larvest site will be not necessarily by the rearing site, it is desirable to detain the migrants briefly (1-7 days) at the relase site to imprint its characteristics on them and so ensure a reasonable accuracy of return to the site as adults. These retention devices will depend on the site and may be tanks or troughs, cages or enclosures, but they should be sited so that the smolts can be released from them simply by opening the devices, and the adults can re-enter them on return. These then serve also as harvesting traps and at that stage it is also necessary to provide ponds or enclosures for holding potential broodstock.

73. Since salmon species are in prime condition for the market just prior to entry to full freshwater the release and harvest facilities should be sited in brackish or salt water with a tidal or freshwater flow through them to aid the fish's orientation. Also, the broodstock can be maintained in better physical condition in salt rather than fully freshwater. It is to be noted that, although the habits of salmon have been compared with trout, above, salmon ranching does not require the entry of salmon into the existing river systems; in fact the whole point of salmon ranching is that the returning migrants should all be caught and used either for brood stock or for processing for sale, and never enter the rivers. It is always possible that some returning adults might avoid capture and so swim into the rivers, but they would represent a loss to the scheme and every effort would be made to prevent it happening.

Candidate species for ranching

74. While in the long term it is desirable to consider a range of salmon species to crop marine resources of a wide variety, in the short term the economic practicality of the operation will restrict the choice of those species. In this context, the salmon can be considered as four separate life-history groups (Table 3):

A: Species having a short freshwater residence;

B: Long freshwater residence species, with short sea absence;

C: " " " " " " , with moderate sea absence;

D: " " " " " " , with long sea absence.

75. In group A there are two species, pink (*Oncorhynchus gorbuscha*) and chum salmon, (*O. keta*), whose juveniles migrate to sea as fry, soon after hatching and thus, as ranchable animals, they are attractive because they require minimal freshwater facilities.

/76.

TABLE 3 Characteristics of salmon species

Group	Species	Freshwater Egg (mo)	Freshwater Fry–Migrant (yr)	Sea absence (yr)	Weight at return (kg)
A.	Pink salmon (*Oncoryhncus gorbuscha*)	6–8	0.1–0.2	1.25	1.5– 3.0
	Chum salmon (*O. keta*)	6–8	0.1–0.2	2.25–4.25	2.0– 9.0
B.	Arctic char (*Salvelinus alpinus*)	6–8	1–7	0.25–0.5	1.0–10.0
	Brook trout (*S. fontinalis*)	6–8	1–4	0.25–0.5	0.5– 3.0
	Sea trout (*Salmo trutta*)	6–8	1–4	0.25–4	0.3– 8.0
C.	Atlantic salmon (*S. salar*)	5–7	1–4	1.25–3	1.5–10.0
	Steelhead trout (*S. gairdneri*)	1–4	1–4	1–4	1.5–10.0
	Chinook salmon (*Oncorhynchus tschawytscha*)	6–8	0.25–2.25	1–5	6.0–18.0
	Coho salmon (*O. kisutch*)	5–7	1–2	1–2	2.5– 5.5
	Masu salmon (*O. masou*)	5–7	1–2	1–2	1.0– 2.0
D.	Sockeye salmon (*O. nerka*)	6–8	1–3	1–4	2–3.5

Data derived from: Hart (1973); McNeil and Bailey (1975); Scott and Crossman (1973).

76. Group B contains those species which require at least one growing season as fry in freshwater, and then migrate as smolts, but tend to return to freshwater repeatedly over subsequent years, at first at a relatively small size. This habit is prevalent among the chars (Salvelinus alpinus and S. fontinalis) and sea trout (Salmo trutta). Thus, although ultimately these fish may reach adequate marketable size (over 2 kg), they may take longer to do so than fishes of group C.

77. Group C contains fish which require at least one growing season in freshwater, but under the low temperature conditions of Falkland Islands waters might require up to three seasons in freshwater. Once they have migrated to sea as smolts these species will spend one or more winters there, returning as marketable sized adults 1.5 or more years later. These are the Atlantic salmon (Salmo salar), steelhead trout (S. gairdneri), chinook (Oncorhynchus tschawytscha), coho (O. kisutch) and masu salmon (O. masou).

78. The sockeye salmon (O. nerka) is allocated to a separate group D since it requires up to 4 years rearing in freshwater in lacustrine conditions, before emigration at the smolt stage, and then it may remain at sea for 1.5 years or more, before returning at a marketable size.

79. In view of these life history variations, choice of ranchable species should be restricted within groups A and C, in the short term. Of these species masu salmon is a Japanese species, unfamiliar on the European market, and thus not one to be considered immediately. Atlantic salmon commands the highest market price but would probably also be the most expensive to produce owing to its long freshwater growth period. In descending order of market value below Atlantic salmon come chinook, coho, chum and pink salmon, an order which also reflects their production costs.

80. The economic yield from a ranching operation will depend substantially on the growth and return success of the released fish, and both these characteristics are quite unknown for the Falkland area. The introduced trout appear to grow well at sea, but where they feed, and at what density of fish is not known. In any event fluctuations in the marine environment will be reflected in variations of growth and survival up to the time of their return at maturity, and so annual percentage returns from release may vary by a factor of 10. In the section on economics (paras 137-144) values of 0.3 - 3.0% return have been assumed for chum salmon, and mean values of 3% (ie 0.5 - 5.0%) initially, and 5% (1 - 10%) subsequently, have been assumed for the Atlantic salmon. None of these assumptions can be verified without testing in a pilot-scale salmon ranching project, which is necessary to demonstrate the viability of the industry in the Falkland Islands before the location, scale and nature of production units could be recommended.

81. Such a pilot unit should be designed to produce up to 25,000 Atlantic (or coho or chinook) smolts per year, together with 1-2 million chum (or pink) fry, thus allowing information to be accumulated simultaneously on the suitability of particular species and the best combinations of species to produce together. Calculating on a basis of 10 litres/min/kg fish, such a pilot unit would require a maximum water supply of 29-43 million litres/day, this maximum occurring just prior to release of the fish in late spring. Thus suitable locations for the unit would be limited by the minimum annual flow of potential supply streams and in visiting sites on the ground this requirement was borne in mind, as well as the more general one of the suitability of each site for the commercial production of single species of salmon.

82. Accumulated experience with transplants of salmon stocks outside their native range indicates that initial levels of success are liable to be low until stocks are developed which are adapted to the characteristics of the new environment. Therefore a pilot scheme should itself be seen as a long-term proving procedure, and might be expected to run for at least 10 years. At the first return of adults there should be emphasis on building up local Falkland stocks of salmon by using these individuals, which have demonstrated their ability to thrive and return in the new environment, as broodstock. This must take priority over the achievement of a high initial yield of fish for the market.

83. To aid rapid achievement of a good yield of fish surplus to broodstock needs, and to assist in the rapid establishment of local stocks, imports of additional eggs should be made each year for the first 5 years. These eggs should be obtained from reliable sources, should come from stocks certified disease free by the exporting countries, and the progeny should be tested regularly to guard against accidental transfer of salmonid diseases into the new environment. In these contexts it would be advantageous to maintain close contact with the similar projects being developed in Chile, especially with that proposed for the new Centro de Ecologia Magellanica, at Estancia Las Coles, Punta Arenas, under the auspices of the Universidad de Chile, Santiago.

84. The pilot project should serve the purpose also of building up a local source of supply of eggs for use in future in commercial production units in the Falkland Islands.

85. The initial stocks should be chosen from areas with comparable gross physical characteristics, if possible from latitudes between 50-60°N to ensure adaptation to comparable light conditions in the Falkland Islands, and from areas subject to similar fresh and seawater temperature regimes. Since insufficient is known of the mechanisms determining migration at sea, precise guidelines for choice of stocks to ensure reasonable success in homing are not available. Hence, it would be prudent to use material from a wide range of sources to increase the range of genetic adaptability, and improve the chances of early success. Techniques that have been shown to improve return rates, such as the retention of pink and chum fry for several weeks of feeding prior to release and delayed release of smolts of other species, should also be used during the pilot project.

Location of possible ranching sites

86. In considering sites for salmon hatcheries the following criteria of suitability were used:

a. The site should be near to a settlement for the provision of manpower and for ease of management
b. pH of the water should be over 5.8, but preferably nearer neutrality (7.0) to allow maintenance of fish stocks at moderately high densities
c. The minimal seasonal flow should be more than 100 million litres/day (say 20 million gallons/day), to allow production of at least 30,000 Atlantic salmon (Salmo salar) smolts (or their equivalent among other species) per annum
d. The gradient of the water course should be at least 1:100, to allow acquisition of water by gravity flow with a pressure head of at least 6 metres, without excessive capital costs
e. There should be few potential predators in the immediate vicinity

/f.

f. The probability of floods should be low
g. There should be access to sheltered estuarial water with a depth of at least 1 metre at lowest low water spring tides (for release, recovery, and broodstock holding facilities).

87. In the month available for the initial survey it seemed prudent to concentrate on those areas near settlements on the northern halves of East and West Falkland as the map suggested that the criteria of water quantity and gradient of water courses would be met best in those more mountainous areas (Fig 1). Therefore an itinerary was arranged to cover the settlements of Bluff Cove, Fitzroy, Darwin, San Carlos, Port San Carlos, Douglas and Teal Inlet on East Falkland; and on West Falkland the route covered Port Howard, Hill Cove, Chartres, and Fox Bay. At every potential site the water temperature and the pH value were recorded. Widths and depths were measured on the smaller streams with a steel tape, and on the larger ones were estimated crudely by eye, or widths measured if gauged at a bridge. Surface velocities were estimated over a 10m distance by timing the passage of an aluminium 35mm film-cassette holder, half filled with water. The places reported on below are ordered by settlements, in the time sequence of visits made to them (see Itinerary, Annex A(ii)).

88. <u>A: DARWIN - GOOSE GREEN: Ceritos and Camilla Creek Arroyos (Figs 2, 11, 12)</u>:

There are no large rivers in the immediate vicinity of Darwin but two streams discharging into Camilla Creek, 4 km to the north of the settlement, are of considerable interest. The larger of these, Ceritos Arroyo, gave a reading of pH 6.7, at 10°C at noon, when the flow was estimated as 89 million litres/day, immediately above the wooden bridge close to the head of the tide. Upstream of this bridge, and on the left bank of the stream, there is a level area of several hectares suitable for a salmon rearing facility. To obtain a sufficient pressure head on the water supply here might require 1-1½ km of piping. The flow was considered to be close to its annual minimum, but the water supply at this site could be augmented relatively easily, if necessary by piping or pumping across from the smaller Camilla Creek Arroyo 500-1,000m to the west, which has an estimated 30 million litres/day of water at pH 7.0. These streams discharge into the tidal inlet of Camilla Creek which drains over a hard shale substrate.

89. About 1 km downstream from the mouth of the Camilla Creek Arroyo a rocky ridge crosses the bed of the inlet, and at low tide the creek forms a deep brackish pool some 5-10m wide at this point. If a low causeway were constructed on this rock ridge, with a bridge across the pool, the upper part of the creek could be converted into a large shallow tidal pool as a holding area for potential broodstock, while the bridged area could house a trap for the release of juvenile migrants and recapture of returning adults, serviceable through the bridge decking. Such a causeway and bridge already exist across the bay at Darwin (Figs 11, 12). Repair and modification of this latter bridge as a release/recovery facility would allow the products of a freshwater unit at Ceritos Arroyo to be released at two sites, northwestwards through Camilla Creek into Brenton Loch and thence into Falkland Sound or southeastwards at Darwin into Choiseul Sound and thence to the open ocean. The Ceritos Arroyo site would therefore serve particularly well as pilot project location, to produce say 25,000 Atlantic salmon smolts and 2 million pink or chum salmon fry annually, with spare capacity for other species also. Ultimately, if the pilot scheme were successful, this site could be enlarged as a production unit.

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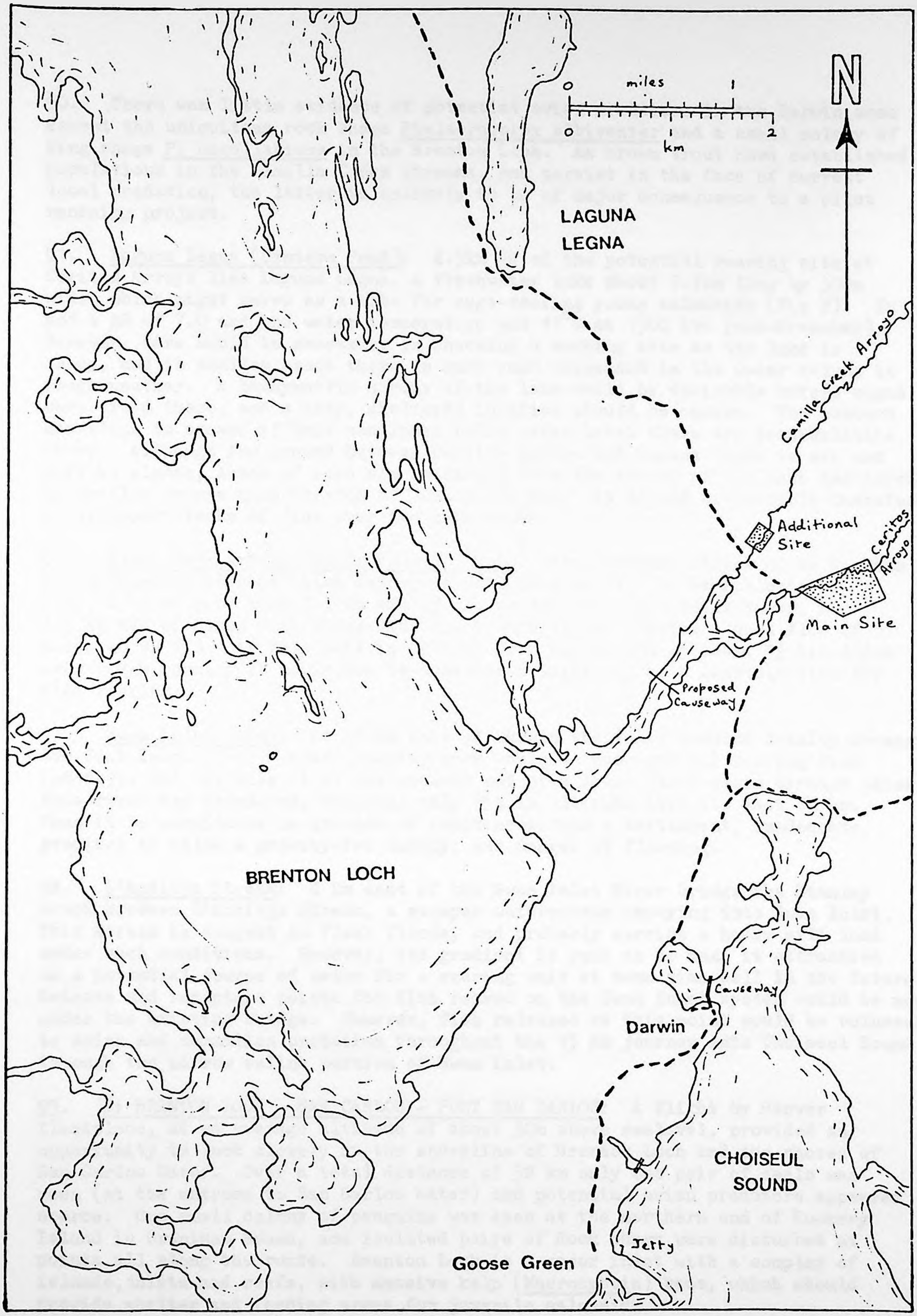

Fig 2. The Darwin area showing the proposed main site for the pilot scheme on Ceritos Arroyo and the additional site on Camilla Creek Arroyo, with release/recapture sites at the causeways.

90. There was little evidence of potential avian predators in the Darwin area except the ubiquitous rock shags Phalacrocorax albiventer and a small colony of king shags P. magellanicus in the Brenton Loch. As brown trout have established populations in the Camilla Creek streams, and persist in the face of current local predation, the latter is unlikely to be of major consequence to a pilot ranching project.

91. Laguna Legna (Cantera Pond): 4.5km NW of the potential rearing site at Ceritos Arroyo lies Laguna Legna, a freshwater lake about 2.7km long by 300m wide, which might serve as a site for cage-rearing young salmonids (Fig 2). It had a pH of 7.0 and the water temperature was 11°C at 1500 hrs (mid-November). However, care would be necessary in choosing a mooring site as the lake is sandy, and in shallow areas there is much sand suspended in the water column in rough weather. A bathymetric survey of the lake would be desirable before cages were sited there, and a deep, sheltered location should be chosen. The western shoreline is steep: if this continues below water level there are possibilities there. Although the ground between Ceritos Arroyo and Laguna Legna is wet and soft in places, loads of sand are extracted from the shores of the lake and carried by trailer across this stretch of land to Darwin. It should be possible therefore to transport tanks of fish over the same route.

92. Black Rock Arroyo, at Dr Fowley's Hole: The southern slopes of Mt Wickham are drained by streams which discharge into Swan Inlet. At Dr Fowley's Hole, a trout pool some 7.5 km WNW of the bridge over Swan Inlet River, and 1.3 km NNE of Black Rock House, the Black Rock Arroyo carries a good flow of water at pH 6.4. As this site is 22.5 km from Darwin and at least 1½ hrs drive over rough country it would not be considered initially as a suitable site for fish rearing.

93. Swan Inlet River: At 29 km east of Darwin the track towards Stanley crosses the Swan Inlet River. Water quality here would be adequate for rearing fish (pH 6.9), but the site is at the seaward end of a level flood plain through which this river has meandered, dropping only 15m in altitude over its last 15 km. Thus it is unsuitable on grounds of remoteness from a settlement, inadequate gradient to allow a gravity-fed supply, and danger of flooding.

94. L'Antioja Stream: 4 km east of the Swan Inlet River bridge the Stanley track crosses L'Antioja Stream, a steeper watercourse emptying into Swan Inlet. This stream is subject to flash floods, and probably carries a heavy silt load under such conditions. However, its gradient is such as to make it attractive as a potential source of water for a rearing unit at some time well in the future. Release and recapture points for fish reared on the Swan Inlet system could be arranged under the existing bridge. However, fish released at this point would be vulnerable to avian and mammalian predation throughout the 15 km journey into Choiseul Sound through the narrow saline portion of Swan Inlet.

95. B: BRENTON LOCH - SAN CARLOS - PORT SAN CARLOS: A flight by Beaver floatplace, at an average altitude of about 30m above sealevel, provided an opportunity to look closely at the shoreline of Brenton Loch and the shores of San Carlos Water. Over a total distance of 52 km only one pair of seals was seen (at the entrace to San Carlos Water) and potential avian predators appeared scarce. One small colony of penguins was seen at the northern end of Rookery Island in Grantham Sound, and isolated pairs of Rock Shags were disturbed at points all along the route. Brenton Loch is a major inlet with a complex of islands, inlets and reefs, with massive kelp (Macrocystis) beds, which should provide shelter and feeding areas for juvenile salmonids.

/96.

96. C: TEAL INLET: Malo River (Figs 3, 13): The Malo River drains a substantial area of land on the NE side of the Wickham heights. Its flow at the bridge just upstream of tide limits was estimated as 410 million litres/day, and this is probably very close to its minimum. With a pH of 5.8 its water quality is borderline, but more importantly the site is remote from a settlement, the nearest being at Teal Inlet 14 km to the north over rough open countryside without a road. Flooding would be a severe problem since the river level has been known to rise to the bridge deck some 3.5 m above its level at the time of the visit. Under these circumstances a rearing unit would have to be sited on the hillside, and the water conveyed from a point 5-6 km upstream. The narrows 500 m downstream of the bridge (Fig 13) suggest a possible site for a 15 m-high dam to retain freshwater and provide the necessary pressure head for a rearing unit on the shore of the estuary about 1 km further downstream. However, even if this were socially acceptable (the Angling Club in Stanley maintains a fishing hut close to these narrows, and regard this as one of their prime trout rivers) it would not be fully successful without building a subsidiary barrier across the valley to the east of lower Malo House where the watershed itself is at an altitude of less than 15 m. Also, it would create a complex freshwater lake extending 6 km up the present Malo valley, and 5 km southwards up the Pasa Maneas brook, flooding the houses at Lower Malo House, and the bridge over the river Malo. Such a solution seems unreasonable at present.

97. Streams to the East of the Teal Inlet settlement: Several small streams were crossed on the way from the Malo bridge to Teal Inlet, but all had a rather slight gradient, and a low flow. David Barton, Teal Inlet, also pointed out that they flood. These therefore seem poor sites.

98. Kettle Paddock Creek: The streams to the northwest of Teal Inlet are generally too acid for immediate interest as water supplies. Kettle Paddock Creek, at pH 5.7, is below standard, and although it has a moderately good dry weather flow it is subject to flooding.

99. Turners Stream: Slightly larger than Kettle Paddock Creek, but at pH 5.5, this stream is less suitable. Also it is subject to flooding, making the siting of a hatchery difficult, and increasing the cost of piping in the water supply.

100. Pedro River: This large river meanders extensively through a flat valley, the whole area flooding from time to time. Again, the water quality is rather too acid, at pH 5.7, and a rearing unit would have to be sited well up-river, over 10 km from Teal Inlet, and that over very rough terrain. For all three of these water courses on Teal Inlet Farm, the release of migrant juveniles and the recovery of adults would be a problem as the inlets from Port Salvador are shallow, and any causeway like that at Darwin would have to be built well out into a bay, making it a costly and relatively inaccessible device.

101. Port Salvador generally: The tidal currents entering Port Salvador through the narrows between Salvador and Rincon Grande flow in at 7 knots, and once inside the protected bay turn southward at 4 knots (J. Sollis, pers comm). This strong flood-tide flow may account for the apparent aggregation of animals in the southern part of this bay, as David Barton has noted that both mullet (Eleginops maclovinus) and trout are larger around the entrace to the Malo estuary than they are nearer to Teal Inlet. Also, krill are stranded more often and in greater

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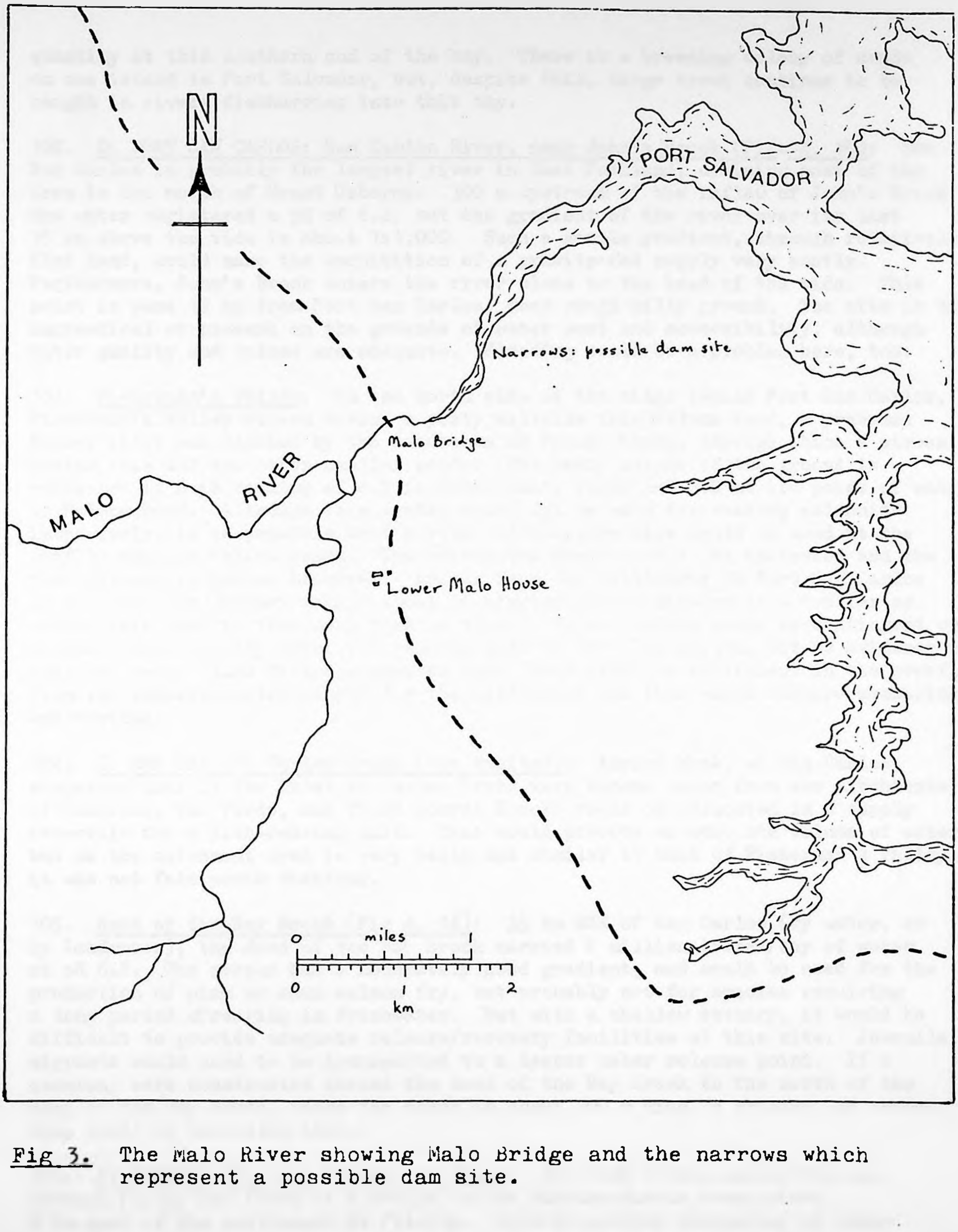

Fig 3. The Malo River showing Malo Bridge and the narrows which represent a possible dam site.

quantity at this southern end of the bay. There is a breeding colony of seals on one island in Port Salvador, but, despite this, large trout continue to be caught in rivers discharging into this bay.

102. D: PORT SAN CARLOS: San Carlos River, near John's Brook (Figs 4, 18): The San Carlos is probably the largest river in East Falkland, draining most of the area to the north of Mount Usborne. 300 m upstream of the inflow of John's Brook the water registered a pH of 6.2, but the gradient of the river over its last 15 km above the tide is about 1:1,000. Such a gentle gradient, through relatively flat land, would make the acquisition of a gravity-fed supply very costly. Furthermore, John's Brook enters the river close to the head of the tide. This point is some 12 km from Port San Carlos, over rough hilly ground. The site is thus impractical at present on the grounds of water cost and accessibility, although water quality and volume are adequate. Flooding could be a problem here, too.

103. Fisherman's Valley: On the north side of the ridge behind Port San Carlos, Fisherman's Valley stream drains a peaty hillside into Paloma Pond, a presumed former inlet now blocked by the sandbanks of Paloma Beach, through which a stream drains this and two other smaller ponds. The peaty nature of the ground is reflected in a pH reading of 4.7 in Fisherman's Creek and 5.0 at its point of entry to Paloma Pond. Although this system could not be used for rearing salmonids intensively, it is possible that a release/recapture site could be used at the outflow through Paloma Beach. The stream bed would need to be excavated and the pool allowed to become brackish. Access from the settlement at Port San Carlos is not bad, the journey taking about 30 minutes, or 40 minutes if a trailer or sledge were used to transport fish in tanks. Such a scheme would be contingent on adequate good quality water for rearing fish at Port San Carlos, but no evidence of this was seen. Alan Miller suggested that there might be sufficient in the overflow from the domestic water supply for the settlement but this would require measuring and testing.

104. E: SAN CARLOS: Curlew Creek (not visited): Adrian Monk, at San Carlos, suggested that if the inlet at Curlew Creek were dammed water from the catchments of Camerons, The Verde, and Third Corral Brooks could be collected in a supply reservoir for a fish-rearing unit. This would provide an adequate volume of water, but as the catchment area is very peaty and similar to that of Fisherman's Valley, it was not felt worth visiting.

105. Head of the Bay Brook (Fig 4, 14): 3½ km SSE of San Carlos (by water, or by Landrover), the Head of the Bay Brook carried 8 million litres/day of water at pH 6.2. The stream has a moderately good gradient, and could be used for the production of pink or chum salmon fry, but probably not for species requiring a long period of rearing in freshwater. But with a shallow estuary, it would be difficult to provide adequate release/recovery facilities at this site. Juvenile migrants would need to be transported to a deeper water release point. If a causeway were constructed across the Head of the Bay Creek to the north of the Head of the Bay House, where the creek is about 200 m wide, a release and recovery trap could be installed there.

106. F: FITZROY (Fig 5): Frying Pan Creek: The Peak Stream enters the sea through Frying Pan Creek at a bridge on the Stanley-Darwin track about 8 km west of the settlement at Fitzroy. With 30 million litres/day of water at pH 7 this is an interesting site, but it would be difficult to obtain an adequate head of water to run rearing tanks without building a dam about 10 m high. This would inundate a narrow fertile valley creating an elongated reservoir about 3 km long by about 100 m wide. Fish reared here could either be released from cages set between the piers of the bridge, or transported to Fitzroy, and released from similar cages set under the jetty there. The latter site has the

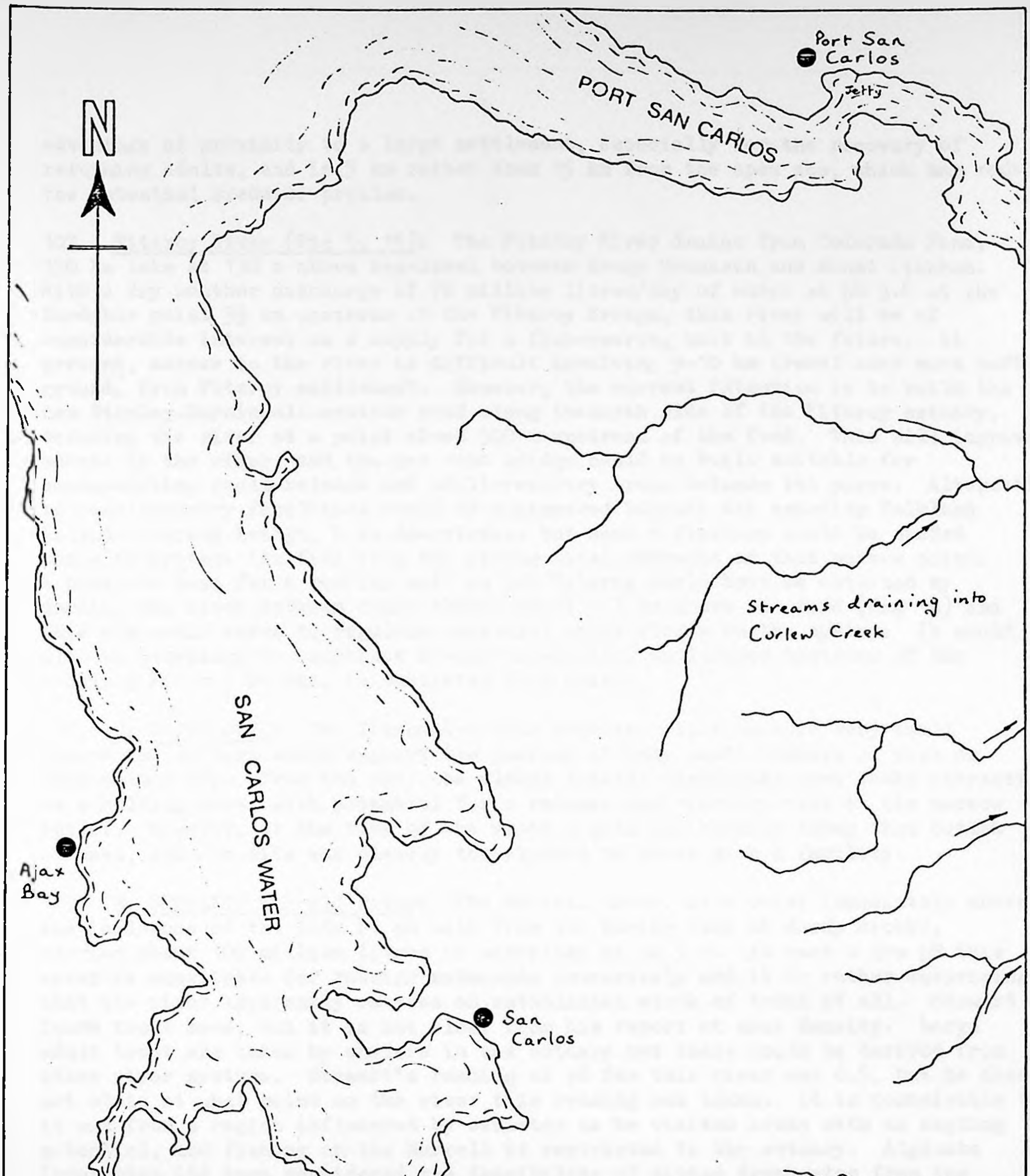

Fig 4. Port San Carlos and San Carlos Water showing Head of the Bay Brook and possible site of causeway. Ajax Bay is on the western side of San Carlos Water.

advantage of proximity to a large settlement, especially for the recovery of returning adults, and is 5 km rather than 15 km from the open sea, which may reduce the potential predator problem.

107. Fitzroy River (Fig 5, 15): The Fitzroy River drains from Colorado Pond, a 150 ha lake at 130 m above sea-level between Rocky Mountain and Mount Wickham. With a dry weather discharge of 70 million litres/day of water at pH 5.8 at the fordable point 5½ km upstream of the Fitzroy Bridge, this river will be of considerable interest as a supply for a fish-rearing unit in the future. At present, access to the river is difficult involving 9-10 km travel over much soft ground, from Fitzroy settlement. However, the current intention is to build the new Stanley-Darwin all-weather road along the north side of the Fitzroy estuary, crossing the river at a point about 500 m upstream of the ford. This will improve access to the river, and the new road bridge could be built suitable for accommodating smolt-release and adult-recovery traps between its piers. Alternatively release/recovery facilities could be engineered beneath the existing Falkland Islands Company bridge, 6 km downstream, but some deflectors would be needed there to protect the fish from the strong tidal currents at that narrow point. A pressure head for a rearing unit on the Fitzroy could best be obtained by damming the river between rocky bluffs about 1.3 km above the ford (Fig 15) and this dam would serve to regulate potential minor floods on the system. It would also be necessary to construct broodstock-holding enclosures upstream of the existing Fitzroy Bridge, in sheltered deep water.

108. G: BLUFF COVE: The freshwater flow entering Bluff Cove is very small indeed and at best would support the rearing of only small numbers of pink or chum salmon fry. From the map, the almost totally landlocked cove looks attractive as a holding area, with potential for a release and recovery site at its narrow outlet. However, at the time of the visit a gale was blowing along that outlet channel, and the site was clearly too exposed to house such a facility.

109. H: STANLEY: Murrell River: The Murrell River, at a point immediately above the influence of the tide (7 km walk from the Marine Camp at Moody Brook), carried about 100 million litres of water/day at pH 5.0. At such a low pH this water is unsuitable for rearing salmonids intensively and it is rather surprising that the river apparently carries an established stock of trout at all. Stewart (1973) found trout here, but it is not clear from his report at what density. Large adult trout are taken by anglers in the estuary but these could be derived from other river systems. Stewart's reading of pH for this river was 6.5, but he does not state at what point on the river this reading was taken. It is conceivable that it was from a region influenced by seawater as he visited areas with an angling potential, and fishing on the Murrell is restricted to the estuary. Alginate Industries Ltd have considered the feasibility of piping freshwater from the Murrell to the north shore of Stanley harbour for kelp processing purposes. In preliminary discussion with a representative of the company it had seemed likely that some of this water could also be used, at Stanley, for rearing fish but its high acidity would preclude this.

110. Moody Brook, Stanley: Stanley's public water supply is derived from Moody Brook, a short stream flowing from the north side of Tumbledown Mountain into the head of Stanley Harbour 4 km west of the town. The shell of the hatchery in which the original imported trout eggs were incubated stands on the banks of Moody Brook, but it would be inadvisable to reinstate this hatchery as the water quality is unsuitable. Regular acidity measurements are made at the town's filtration plant and these were reported to go down to pH 4.5.

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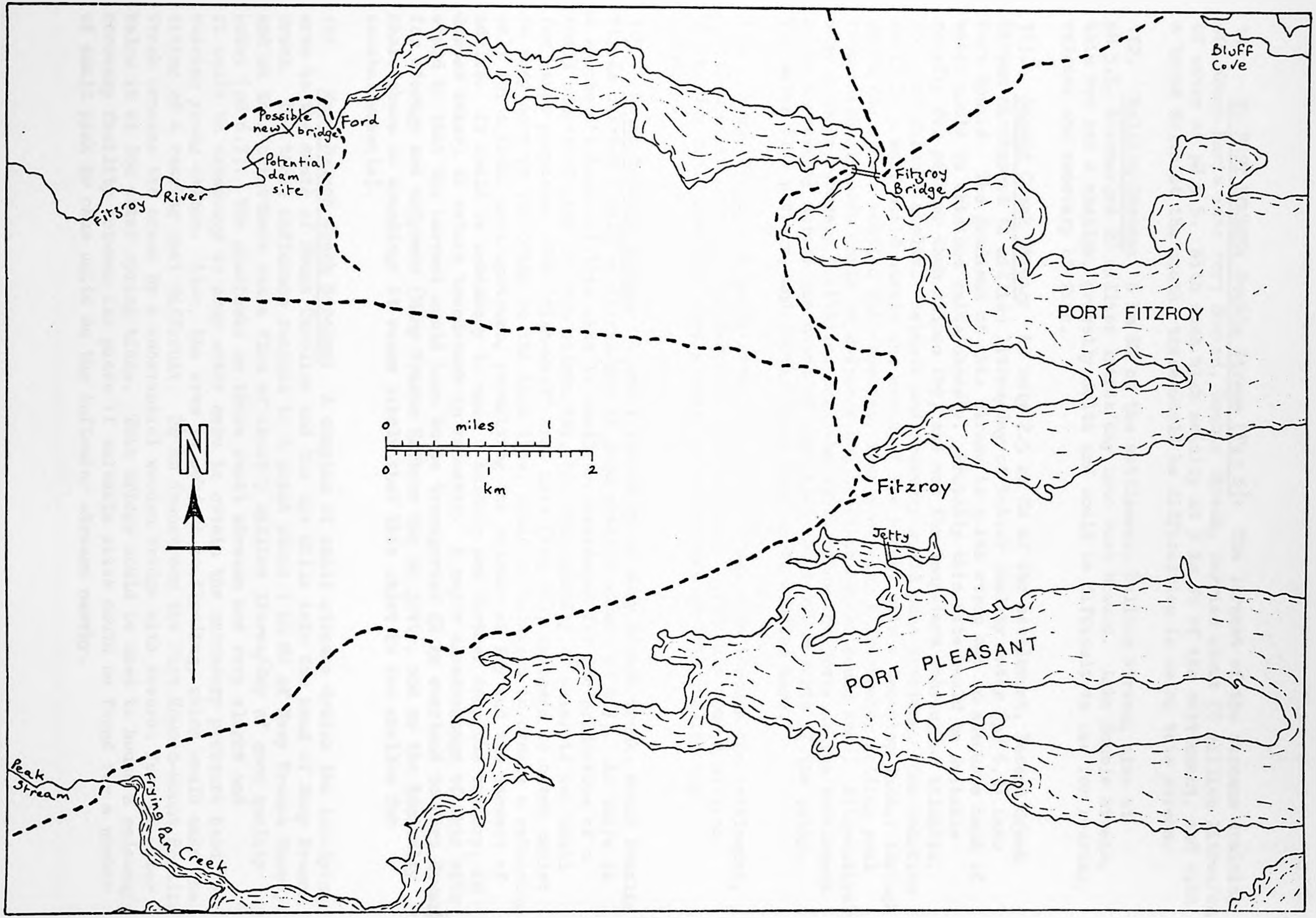

Fig 5. Fitzroy Settlement area.

111. I: PORT HOWARD: Double Stream (Fig 6): The largest of the streams draining off Mount Maria into Port Howard, Double Stream, carried about 88 million litres/day of water at pH 5.5. With such high acidity at 9 km SW of the settlement, and with a broad delta at the mouth, there would be difficulties in using this stream.

112. Ballion Stream: 6 km SW of the settlement, Ballion Stream, also at pH 5.5, discharged 22 million litres/day into Port Howard. Like Double Stream, this too has a shallow, gravelly delta and would be difficult to use for rearing, release and recovery of fish.

113. Second Creek Stream: At only 2.5 km SW of the settlement, Second Creek Stream discharged 14 million litres/day of better quality water (pH 6.3) into Port Howard. The gradient of this stream is quite steep and an adequate head of water could be obtained quite cheaply. Probably this site would be suitable chiefly for pink or chum salmon fry, and not for long-term rearing of Atlantic, coho, or chinook smolts. Release and recovery would pose problems. One solution would be a wall built across the mouth of the creek, with a two-step ladder through which the stream emptied into the sea, thus providing a freshwater holding pool from which migrants could be released and to which adults could home. Alternatively, cage release/recovery facilities could be built below the jetty at the settlement or in a causeway across the mouth of the inlet about 100 m north of the jetty. The water flow pattern, and depth, would need to be studied here.

114. House Stream: A small stream of pH 5.9 flows down through the settlement, and is used in part for the domestic water supply. With only some 2 million litres/day available this supply would be borderline in both quality and quantity.

115. Mount Rosalie Stream: A small tributary of Many Branch Creek, Mount Rosalie Stream carried 3 million litres/day of good quality water (pH 6.7). As there is a shepherd's house at this site it could be considered for the production of a small number of pink or chum salmon fry, but the quantity of water is too small for other purposes. The "fish-wall" trap here (Fig 16), designed to catch mullet as they move up the creek on the high tide, could be enlarged to create a retaining wall for a tidal pool upstream, permitting the release of fry and the harvest of adults. It would be necessary to moor a holding pen further down the estuary, in deeper water, to retain broodstock in seawater. A major disadvantage of this site would be that the harvest would have to be transported 22 km overland to Port Howard for storage and shipment (Many Branch Harbour has no jetty, and as the Admiralty chart shows no soundings it seems likely that this inlet is too shallow for coastal vessels).

116. Many Branch Creek Streams: A complex of small streams drains the low-lying area to the south of Mount Caroline and the Six Hills into the head of Many Branch Creek. The tidal influence reaches to a point about 1 km NW of Many Branch House, and at this point there was a flow of about 5 million litres/day of good quality water (pH 6.7). The gradients on these small streams are very slight and it would be necessary to pump water here to obtain the necessary pressure head for rearing young salmon. Also, the area is subject to flooding, which would make the siting of a rearing unit difficult. 2½ km downstream the Port Howard-Mount Rosalie track crosses the creek by a substantial wooden bridge with several feet of water below it at low water spring tides. This bridge could be used to house a release/recovery facility between its piers if suitable sites could be found for a number of small pink or chum units on the inflowing streams nearby.

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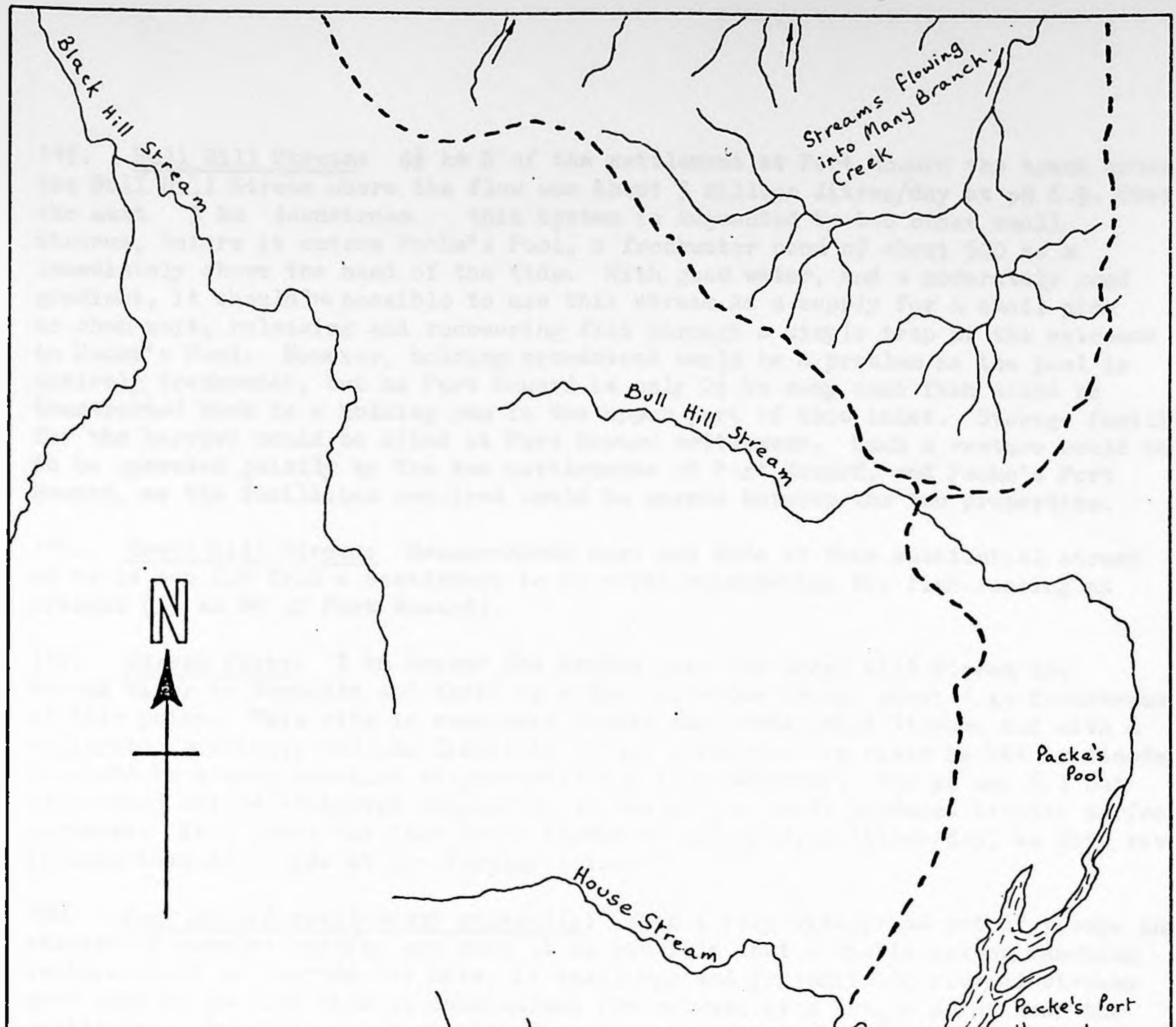

Fig 6. Port Howard Settlement area.

117. Bull Hill Stream: 4½ km N of the settlement at Port Howard the track crosses the Bull Hill Stream where the flow was about 3 million litres/day at pH 6.9. Over the next 3 km downstream this system is augmented by two other small streams, before it enters Packe's Pool, a freshwater pond of about 500 sq m immediately above the head of the tide. With good water, and a moderately good gradient, it should be possible to use this stream as a supply for a small pink or chum unit, releasing and recovering fish through a simple trap at the entrance to Packe's Pool. However, holding broodstock could be a problem as the pool is entirely freshwater, but as Port Howard is only 2½ km away such fish could be transported back to a holding pen in the upper part of this inlet. Storage facilities for the harvest could be sited at Port Howard settlement. Such a venture would need to be operated jointly by the two settlements of Port Howard, and Packe's Port Howard, as the facilities required would be spread between the two properties.

118. Green Hill Stream: Measurements were not made at this substantial stream as it is too far from a settlement to be worth considering for fish-rearing at present (15 km NW of Port Howard).

119. Warrah River: 7 km beyond the bridge over the Green Hill Stream the Warrah River is fordable and there is a new Landrover bridge about 1 km downstream of this point. This site is even more remote than Green Hill Stream, and with a negligible gradient, and the liability of 3-5 m increase in river height in floods, it would be a poor location at present for a fish hatchery. The pH was 6.3 but flow could not be estimated reasonably as the strong winds produced erratic surface currents. At a guess the flow is in excess of 400 million litres/day, as this river is more than 40 m wide at the fording point.

120. Port Howard settlements generally: With a very widespread set of rivers and streams of varying quality and size it is possible that a viable salmon ranching venture could be carried out here, if small egg and fry units on several streams were used to produce pink or chum salmon for release at a single point near the settlement. Probably the best site for release and recovery would be from a cage unit set in a causeway across the inlet at the settlement, about 100 m N of the deepwater jetty.

121. J: HILL COVE: Doree Stream (Fig 7): A series of swift streams drain northwards from the Mount Edgeworth-Mount Robinson-Mount Adam group of hills. The Doree Stream, just at its junction with Blackburn River, carried about 70 million litres/day of pH 6.3 water. About 1 km upstream from this point there is a fishing hut at Sound House, and the gradient of the stream immediately upstream of this section is about 3%. At such a place it would be feasible to operate a salmon rearing unit for both short and long-term freshwater residents but the products of such a unit might have to be transported elsewhere for release. The estuary of the Blackburn system widens rapidly into broad mud flats and there is no deep sea-water close inshore. If a causeway were built across at Head of the Sound Pass, and the estuary immediately upstream were dredged, a brackish pool could be created for maintenance of broodstock there. Release of migrants and harvest of adults could be made through the causeway entrance.

122. The Blackburn River: Surprisingly, the main Blackburn River carried less water than its tributary, the Doree Stream, having about 50 million litres of pH 6.5 water flowing through it each day just above the confluence of the two streams. The gradient of the Blackburn is much poorer, at 0.25%, and it would thus be costly to obtain water from this source. However, if additional water were required for a rearing unit based on the Doree Stream, a second large tributary of the Blackburn,

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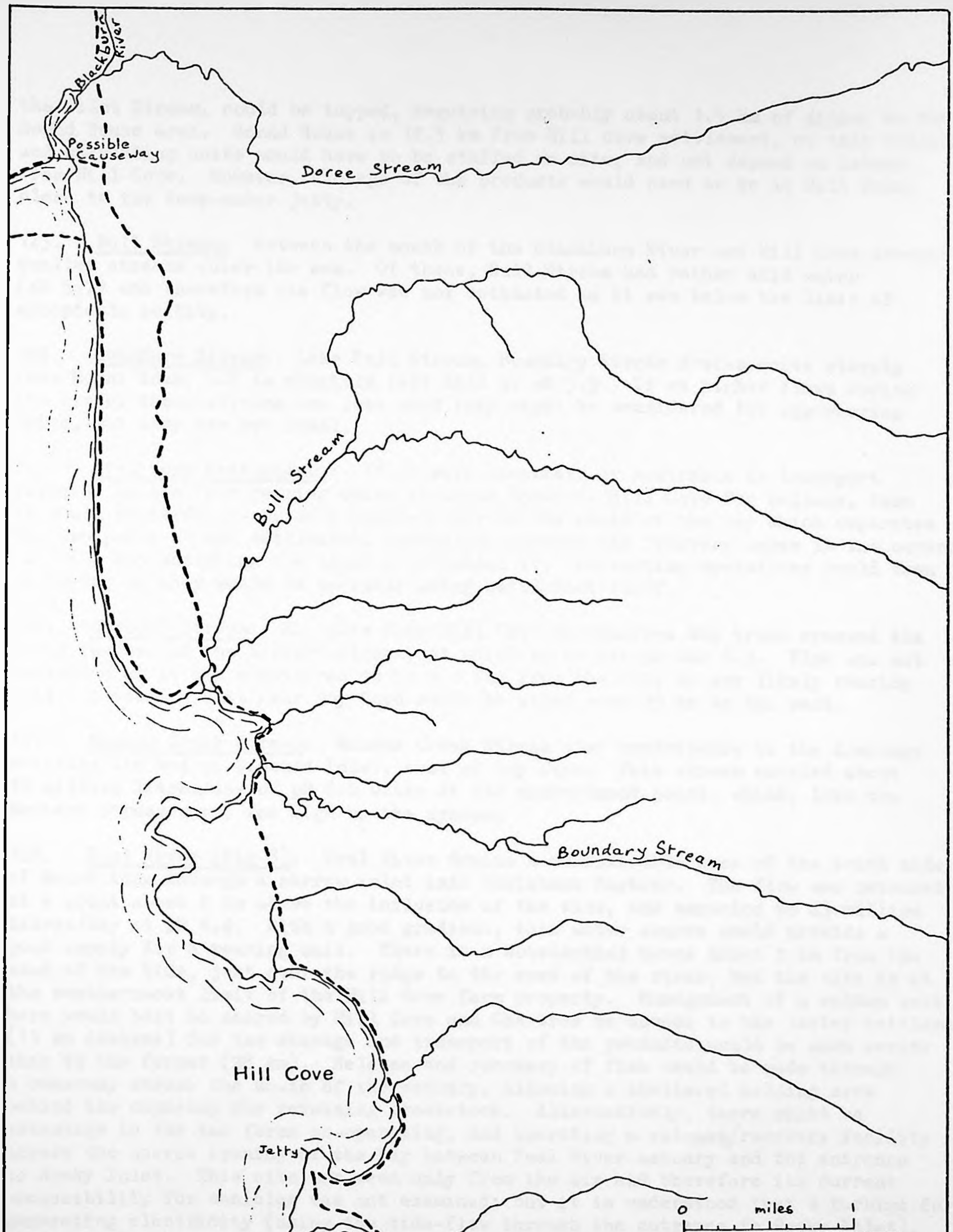

Fig 7. Hill Cove Settlement area.

the Pilot Stream, could be tapped, requiring probably about 1.5 km of piping to the Sound House area. Sound House is 12.5 km from Hill Cove settlement, so that rearing and harvesting units would have to be staffed on site, and not depend on labour from Hill Cove. However, storage of the products would need to be at Hill Cove, close to the deep-water jetty.

123. Bull Stream: Between the mouth of the Blackburn River and Hill Cove several smaller streams enter the sea. Of these, Bull Stream had rather acid water (pH 5.7) and therefore its flow was not estimated as it was below the limit of acceptable acidity.

124. Boundary Stream: Like Bull Stream, Boundary Stream drains quite steeply from Mount Adam, but is slightly less acid at pH 5.9. If at higher flows during the winter these streams are less acid they might be considered for egg-rearing units, but they are not ideal.

125. Hill Cove Settlements: If it were necessary or desirable to transport juvenile salmon from rearing units at Sound House to Hill Cove for release, then it would be useful to build a causeway across the mouth of the bay which separates the two parts of the settlement, installing release and recovery cages in the centre of this, and enclosing the large pool behind it. Harvesting operations would then be easier as they would be operable using settlement staff.

126. Herbert Stream: En route from Hill Cove to Chartres the track crossed the upper reaches of the Herbert Stream, at which point its pH was 6.3. Flow was not estimated as it was considered to be too far from the site of any likely rearing unit. A rearing unit near Roy Cove would be sited some 15 km to the west.

127. Manada Creek Stream: Manada Creek Stream also contributes to the drainage entering the sea at Crooked Inlet, east of Roy Cove. This stream carried about 12 million litres/day of pH 6.0 water at the measurement point, which, like the Herbert Stream site, was high up the system.

128. Teal River (Fig 8): Teal River drains a considerable area of the south side of Mount Adam through a narrow inlet into Christmas Harbour. The flow was measured at a point about 2 km above the influence of the tide, and amounted to 43 million litres/day at pH 6.4. With a good gradient, this water course would provide a good supply for a rearing unit. There is a substantial house about 1 km from the head of the tide, just over the ridge to the east of the river, but the site is at the southernmost limit of the Hill Cove farm property. Management of a salmon unit here would best be shared by Hill Cove and Chartres as access to the latter settlement (11 km distant) for the storage and transport of the products would be much easier than to the former (28 km). Release and recovery of fish could be made through a causeway across the mouth of the estuary, allowing a sheltered holding area behind the causeway for retaining broodstock. Alternatively, there might be advantage in the two farms co-operating, and operating a release/recovery facility across the narrow opening of the bay between Teal River estuary and the entrance to Rocky Inlet. This site was seen only from the air and therefore its current accessibility for vehicles was not examined; but it is understood that a turbine for generating electricity (using the tide-flow through the entrance to Rocky Inlet), which would require improved access, is under consideration. Such a new track would need to be extended an extra kilometre. There might be a need for predator control in this region as during the visit to Teal River a sealion was seen actively fishing at the head of the estuary.

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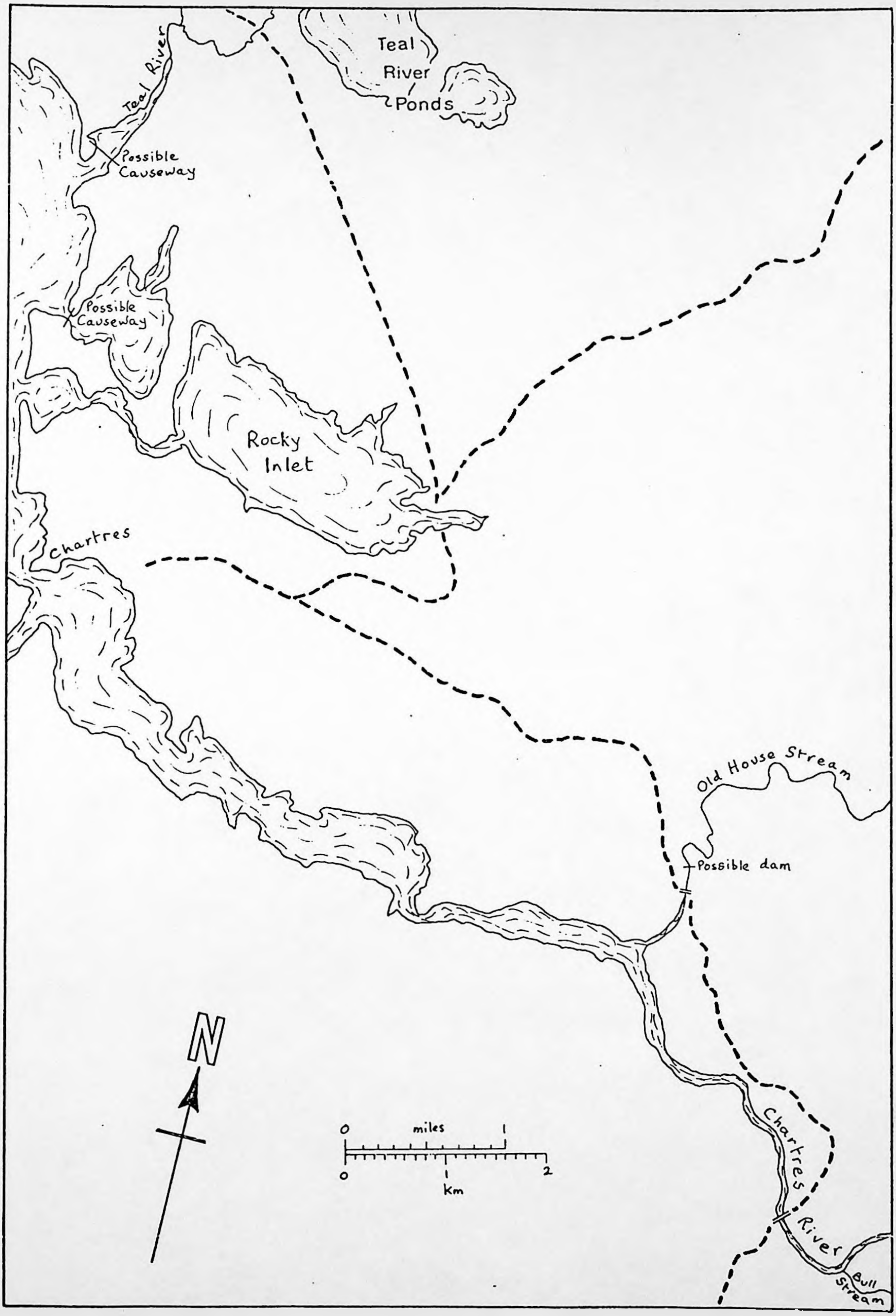

Fig 8. Teal River and Chartres Settlement area.

129. K: CHARTRES: Old House Stream (Figs 8, 17): The Old House Stream enters the Chartres River, close to the site of the old settlement at Chartres. With a flow of 45 million litres/day of water at pH 7.2, this supply is one of the best found on the islands. Unfortunately, the gradient is only modest, but with this volume of water available it would probably pay to build a dam across the stream at the rocky bluffs 300 metres upstream of the bridge carrying the track from Chartres to Fox Bay to obtain an adequate pressure head to supply rearing tanks situated downstream of the bridge on the west bank of the stream. As there is good access by Landrover from here to Chartres it would be preferable to transport juvenile migrant salmon for release at the suggested site (para 128) 2½ km to the north of the settlement (across the narrow opening of the bay between Teal River and Rocky Inlet). This would be a distance of 9 km from the rearing site. Such a release would be preferable to one nearer the rearing unit as it would ensure the return of adults to a harvest point in seawater, close to the major settlement, but the bridges over Old House Stream, and at Little Chartres over the Chartres River, could be used also as sites for installing cages.

130. Chartres River: The Chartres River, at its junction with the Bull Stream 1 km upstream of Little Chartres, has a pH of 6.3. It is wide and shallow, has negligible gradient (dropping 15 m in 18 km) and is influenced by the tide for several kilometres above the bridge. As a water supply it would require pumping, which seems unnecessarily costly, when a gravity-fed supply could be obtained from the Old House Stream.

131. L: FOX BAY EAST: Doctor's Ditch (Fig 9): About 3 km NE of the settlement at Fox Bay East the track crosses the head of Doctor's Creek. The stream at this point, Doctor's Ditch (or Stud Paddock Stream), carried 3 million litres/day of water at pH 6.3. Although this is rather small, it would still serve as a supply for a small egg and fry unit for pink or chum salmon and combined with other small units on similar streams nearby, such as that draining into Cheeks' Creek, and Dip Valley, it would be the nucleus of a viable production system. Release and recovery facilities could be engineered in a causeway built across the mouth of Cheeks' Creek, where the domestic water supply pipe crosses the inlet at present. Such a causeway would create a sheltered pool upstream for the retention of broodstock.

132. M: FOX BAY WEST: Leicester Creek Stream (Fig 9): The track to Fish Creek crosses a small bridge over Leicester Creek Stream 15 km west of Fox Bay West. Here the stream carried about 3 million litres/day of water at pH 6.3. The sampling point was 4-5 km from the sea: as 10 small tributaries enter this stream en route the volume of the flow nearer the sea should be considerably greater. There is a good enough gradient for the provision of a gravity-fed supply to tanks from at least the upper part of this 5 km stretch. It is possible that release and recovery facilities could be constructed in Lake Hammond across the narrows of Leicester Creek at Scrag Paddock Point but this site was only seen from a distance, and from the air. The disadvantage of siting a rearing unit in this lower middle point of West Falkland is its general remoteness from a settlement. Were communications better the Leicester Creek site could be a useful one, as fish reared here could be released to enter Falkland Sound via Lake Hammond and Port Edgar and also to enter Queen Charlotte Bay via Port Richards.

133. There was not time to look at the terrain between Leicester Creek and the mouth of Port Edgar, but it is clear from the map that fish released from Leicester Creek would have to travel through a narrow sea channel for more than 10 km before reaching the open sea. During such a journey they would probably be very vulnerable to avian and mammalian predation and on the return journey the adults would be similarly at risk. Release from Port Richards could be achieved by

/building

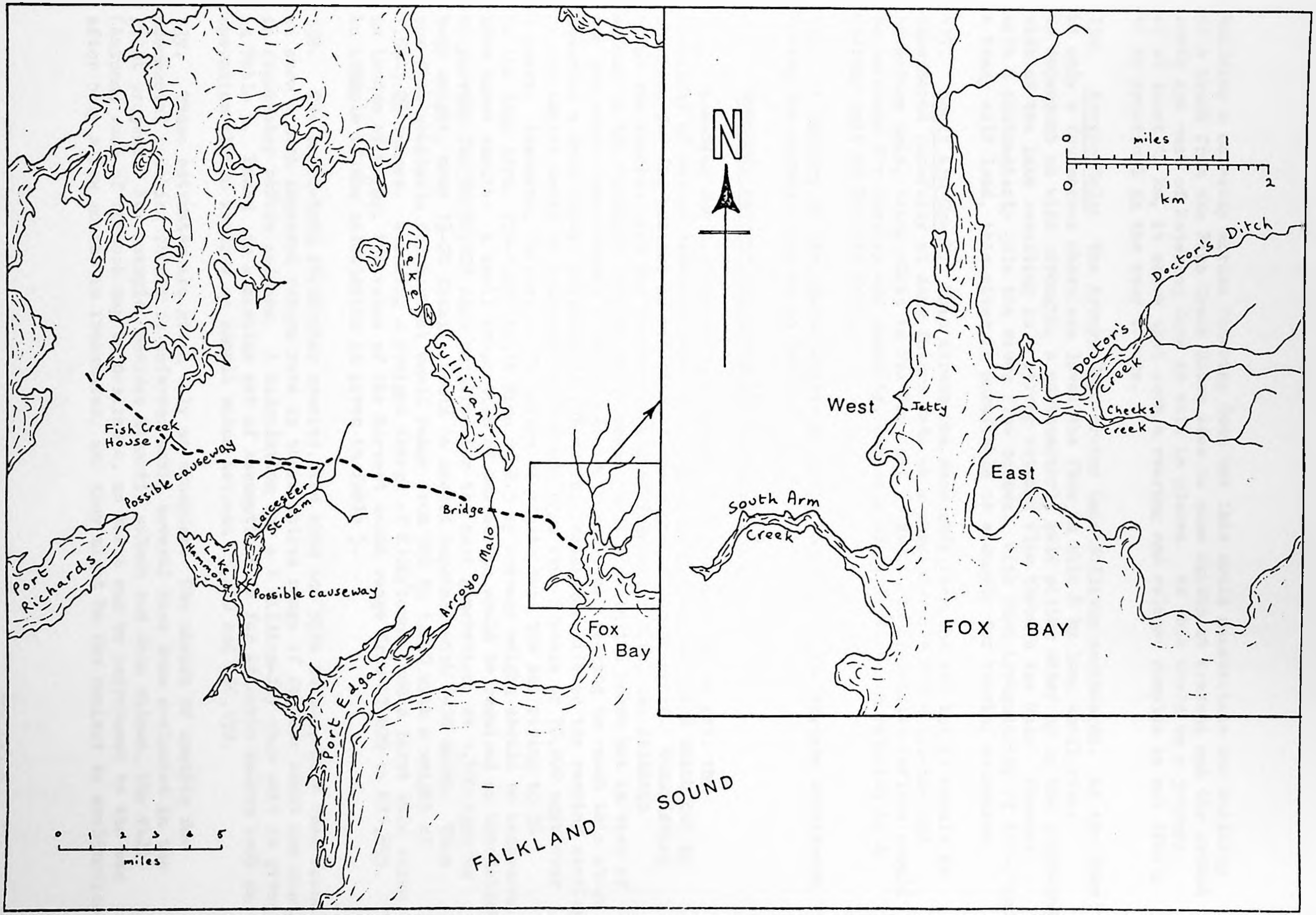

Fig 9. Fox Bay Settlements

building a causeway across Watering Cove but this would necessitate the building of a track from the Fish Creek House area as none exists at present and the ground north and east of Watering Cove is soft in places. As this would be a journey of at least 12 km, it seems that such a rearing and release complex is not likely to be practical in the near future.

134. Arroyo Malo: The Arroyo Malo drains Lake Sullivan southwards. As the lake is only a few metres above sea level the flow in this 8 km long small river is dependent on wind strength, a northwesterly gale piling water up on the southeast side of the lake resulting in a strong outward flow through the Malo. However, with a southesterly gale the river flow ceases. With such irregularity of flow, and a heavy silt load, this river is unsuitable as a supply for rearing salmonids.

135. South Arm Creek: This stream was seen only from the air but it should be considered carefully at some future date as a possible site for a release and recapture unit, being close to Fox Bay West (1 km). Its freshwater inflows should be assessed for quality and quantity, and ease of collection, in relation to a rearing unit at Fox Bay West.

136. A summary of the characteristics of the Falkland Island streams considered during the survey is given in Table 4.

Economic returns and operational considerations

137. Assuming the biological and logistic requirements can be met, the viability of salmon ranching will depend ultimately upon the price which can be obtained for the product in relation to the costs of producing it. Considering first the species with the longest period of freshwater life, the Atlantic salmon in the Falkland Islands might reach smolt size in two years but in view of the low water temperatures it might require three years rearing to reach this stage. Assuming a mean annual survival of 70% during freshwater life in the rearing station, 25,000 smolts could be produced from 50,000 eggs over 2 years or 70,000 eggs over 3 years. Assuming, further, a 3% return of adults from the sea rising to 5% in the long term, 750–1,250 adult fish of 2.5 kg average weight should be recovered from these smolts. A small proportion of the adults would be required as broodstock, to provide the 50–70,000 eggs required for the next generation: at 1,500 eggs/kg body weight, some 15–20 females would be needed together with 8–10 males. Thus the fish available for harvest would range from 720 to 1,220 with a weight of 1.80–3.05 tonnes. Assuming a freight charge of £100/tonne, and a first sale value in London of £4/kg, the value of the harvest would range from £7,020 to £11,895. An example of the calculation is given in Table 5.

138. The short-term freshwater species, the chum and pink salmon, have been found to show a much improved return rate in their native range if fed for about one month in freshwater before release. A calculation for a 1 million-fry chum unit is given in Table 5. Based on a similar set of assumptions as for Atlantic salmon such an operation should realise an annual value between £5,400 and £66,150.

139. These estimates are given only as examples. The choice of species for commercial ranching should be deferred until several have been evaluated in the pilot project. For example, besides Atlantic salmon and chum salmon, the fall (Autumn) race of chinook may be desirable, as these can be introduced to the sea after only a few months in freshwater, and they might be the easiest to acclimatise.

/Similarly,

Table 4. Summary of characteristics of Falkland Island Streams.

Name of streams:	Date visited	Time	Water Temperature °C	pH	Volume flow (million litres/ day)	Gradient A: Good B: Moderate C: Poor	Liability of Floods	Distance from a Settlement km	Predato A: Fe B: Moderat C: Many
Ceritos Arroyo, Darwin	15.11.78	1200	10.0	6.7	92	B	–	4	A
Camille Creek Arroyo, Darwin	"	1215	9.5	7.0	c.30	B	–	4	A
Black Rock Arroyo	16.1178	1030	8.5	6.4	–	B	–	22.5	A
Swan Inlet River	"	1230	10.0	6.9	> 200	C	Yes	29	B
Malo River	20.11.78	1615	14.5	5.8	> 400	B	Yes	14	B
Kettle Paddock Creek, Teal Inlet	21.11.78	0930	11.0	5.7	15	B	Yes	2	B
Turners Stream, Teal Inlet	"	1000	11.0	5.5	27	C	Yes	9	B
Pedro River, Teal Inlet	"	1030	12.5	5.7	> 150	C	Yes	10	B
San Carlos River	"	1320	16.5	6.2	> 200	C	Yes	12	A
Fisherman's Valley Stream, Port San Carlos	"	1500	15.0	4.7	–	A	–	10	B
Head of the Bay Brook, San Carlos	22.11.78	1030	13.5	6.2	8	A	?	3.5	A
Peak Stream, Frying Pan Creek	23.11.78	1630	13.5	7.0	32	B	–	8	B
Fitzroy River	24.11.78	1010	10.5	5.8	71	B	–	10	B
Murrell River	26.11.78	1415	13.0	5.0	104	C	?	11.5	A
Murrell River tributary	"	1040	11.0	4.8	–	C	?	7	A
Double Stream, Port Howard	29.11.78	1520	14.0	5.5	88	A	Yes	6	B
Ballion Stream, Port Howard	"	1500	14.0	5.5	22	A	Yes	6	B
Second Creek Stream, Port Howard	"	1615	14.5	6.2	14	A	?	2.5	B
House Stream, Port Howard	"	1750	12.5	5.9	2	A	?	0	B
Mount Rosalie Stream	30.11.78	1130	11.5	6.7	3	B	?	22	A
Many Branch Creek Stream	"	1430	12.5	6.7	5	C	Yes	11	A

Table 4 cont/d

Bull Hill Stream, Port Howard	30.11.78	1530	[illegible]	[illegible]	3	A	?	4.5	A
Warrah River	1.12.78	1030	12.0	6.3	> 400	C	Yes	[illegible]	?
Doree Stream Hill Cove	"	1400	12.0	6.3	69	A	Yes	12.5	A
Blackburn River, Hill Cove	"	1415	[illegible]	6.5	48	B	Yes	[illegible]	A
Bull Stream, Hill Cove	"	1510	12.0	5.7	–	A	Yes	6	A
Boundary Stream, Hill Cove	"	1540	12.0	5.9	–	A	Yes	5	A
Herbert Stream, Hill Cove	2.12.78	1030	10.5	6.2	–	C	?	7	?
Ensenada Creek Stream Hill Cove	"	1100	10.5	6.0	12	C	?	15	?
Teal River, Hill Cove	"	1200	12.5	6.4	43	A	Yes	28 (11)	B
Old House Stream, Chartres	"	1330	[illegible]	7.2	45	B	?	8	B
Chartres River	"	1500	13.0	6.2	–	C	Yes	13	B
Doctor's Ditch, Fox Bay East	2.12.78	1630	[illegible]	6.3	3	A	–	[illegible]	B
Leicester Creek Stream, Fox Bay	4.12.78	1500	14.5	6.3	3	A	–	15	B/C

Table 5. Examples of potential production from rearing units

Example 1: Atlantic salmon: 25,000 smolt unit

Maximum weight of fish in rearing unit, just prior to smolt release.

Scheme A				Scheme B			
Age-group	Number	Average weight	Total weight	Age-group	Number	Average weight	Total Weight
0	70,000	0.2g	14kg	0	50,000	0.2g	10kg
1	50,000	2.0	100	1	35,000	5.0	175
2	35,000	7.0	245	2	25,000	25.0	625
3	25,000	25.0	625				
			984kg				810kg
Maximum water requirement at 10 1/min/kg:			14 million litres/day (3 million gal/day)				12 million litres/day (2.6 million gal/day)

% survival from smolt release to adult harvest:

3%: 750 fish at 2.5kg av. weight.

5%: 1,250 fish at 2.5kg av. weight.

Average egg-production/female: 1,500 eggs/kg.

∴ Broodstock requirement for: Scheme A: 20 females + 10 males

Scheme B: 15 females + 8 males.

Table 5 continued

∴ <u>Nett harvest of saleable fish:</u>

	Scheme A		Scheme B	
Return	Number	Weight (tonnes)	Number	Weight (tonnes)
3%	720	1.8	727	1.8175
5%	1,220	3.05	1,227	3.0675

At £4/kg first sale value in London, and £100/tonne freight,

<u>Nett value of harvest:</u>

Return	Scheme A	Scheme B
3%	£7,020	£7,090
5%	£11,895	£11,965

Table 5 continued

Example 2: Chum salmon: 1,000,000 fry unit

Maximum weight of fish in rearing unit, one month after first feeding, and just prior to release:

1,000,000 fry at 1.0g weight = 1,000kg.

Maximum water requirement, at 10 l/min/kg: 14.4 million litres/day (3.1 million gal/day

% survival from release to adult harvest:

0.3%: 3,000 fish at 2.5kg average weight

3.0%: 30,000 fish at 2.5kg average weight

Average egg-production/female: 1,000 eggs/kg

∴ Broodstock requirement: 400 females + 200 males

Nett harvest of saleable fish:

Return	Number	Weight (tonnes)
0.3%	2,400	6
3.0%	29,400	73.5

At £1 per kg first sale value in London, and £100 per tonne freight:

Nett value of harvest

Return	Value
0.3%	£5,400
3.0%	£66,150

Similarly, coho, with a tendency to feed coastally in their native range, might utilize coastal resources effectively. On the other hand, pink salmon, although presenting the least problems from a freshwater management viewpoint, might be a poor choice since their homing behaviour is less precise (Bakshtansky, in press).

140. On the basis of the preliminary survey of potential sites for ranching in the islands, and the assumptions on growth, return rate, egg-production, and price made above, it is possible to make a tentative prediction of a potential total annual production of 665 tonnes of salmon valued at £707,400 from seven ranching units (Table 6). This estimate excludes any possible production at Stanley, Teal Inlet and Port San Carlos on the grounds of high acidity of the water supplies there. If the industry proved to be highly profitable, increasing the pH of water supplies by treatment might be worth considering at these sites in future, at least for small pink or chum salmon units. The estimate also excludes production at Teal Inlet, Port San Carlos and Fox Bay West on the grounds of inaccessibility to sites of adequate water volume and the cost of its acquisition. Such problems would also be worth reviewing, if the industry proved highly profitable.

141. At present no figures are available for the capital cost of rearing facilities or the operating costs in the islands. These depend on design details, costs of construction, labour and power costs, and can be determined only after a full engineering survey and design proposal have been obtained.

142. Feed costs for the fish could be kept to a very low level if a means could be found of using the sheep carcasses, which at present are largely wasted. With the co-operation of the Falkland Islands Company a whole frozen carcass has been shipped back to the UK for biochemical analysis and preparation of experimental salmon feeds. Mr C B Cowey, of the Institute of Marine Biochemistry, Aberdeen will carry out this work, and experimental diets can be tested on salmon in Scotland. As it is unlikely that all essential constituents of a salmon diet can be obtained from sheep some 10-12 frozen mullet have also been shipped for similar biochemical analysis, with a view to obtaining the necessary additives from this source. It is estimated that a total of 400 tonnes of scrap sheep carcasses are available in the islands annually. The availability of mullet is unknown but they are present in almost every inlet of the islands during the summer months, and can be caught easily by seining at low tide.

143. For simplicity of handling, and economy of preparation, it would be desirable to develop a method of feeding the salmon a freshly ground wet product from sheep and mullet than to prepare a dried meal which would involve heating costs.

144. Until feed trials have been carried out it will not be possible to estimate conversion efficiences, and therefore requirements by weight of sheep and mullet. However, the conversion is unlikely to be poorer than 10:1, and therefore for the production of 25,000 Atlantic salmon smolts the total annual need would be less than 10 tonnes of sheep and mullet combined. A similar quantity would be required for the production of 1 million chum or pink fry. Thus for a rearing unit producing 25,000 Atlantic salmon plus 2 million chum or pink fry, there would be a maximal annual requirement of 30 tonnes of raw feed consisting of sheep and mullet. The raw feed requirements to achieve the predicted total annual production of 665 tonnes of salmon would be a little over 300 tonnes of scrap sheep and mullet combined, which should be well within the current resources of the Islands.

/Fish

Table 6. Potential salmon harvest from Falkland Island ranching units

(Average values, as units producing Atlantic and Chum salmon)

Settlement	Atlantic salmon		Chum salmon	
	Weight (tonnes)	Estimated value (£'000)	Weight (tonnes)	Estimated valu[e] (£'000)
Darwin	7.3	28.5	238.5	214.5
Fitzroy	14.6	57	87.45	78.65
San Carlos	–	–	19.875	17.875
Port Howard*	2.4	9.5	29.8125	26.8125
Hill Cove	4.9	19	119.25	107.25
Chartres**	7.3	28.5	119.25	107.25
Fox Bay East	–	–	13.9125	12.5125
Total	36.5	142.5	628.05	564.85

* Jointly with Packe's Port Howard
** Jointly with Hill Cove

ie Total weight: 665 tonnes/annum
Total value: £707,400/annum

Note No estimates made for units at Stanley, Teal Inlet, Port San Carlos or Fox Bay West, on the grounds of unsuitable or borderline water quality, or current difficulty of access.

Fish handling, processing and marketing requirements in the salmon ranching project

145. Salmon may be marketed in a number of different ways. These include fresh, frozen, canned, salted and smoked.

146. As with most other valuable fin fish, salmon are sold fresh, chilled in ice, whenever this is possible. Processing costs are then minimal and the fish is disposed of rapidly and commands the highest possible price. Given a nearby market there should be no losses due to spoilage, but in the Falkland Islands there is no nearby market. The nearest possible market is in Buenos Aires which can be reached by air twice a week. The journey time with one change of aeroplane occupies some 6-7 hours. Allowing time for transport within the Falkland Islands and to a market in Buenos Aires it should be possible theoretically to see fresh chilled salmon in prime condition less than 24 hours out of the water. This possibility should be investigated but it is unlikely that the market would absorb more than relatively small quantities of fresh salmon. It is understood that Rainbow trout are produced in some quantity in Argentina and salmon would to some extent have to compete with these.

147. At one time almost all the Pacific salmon caught in North America was canned. This is no longer the case; freshing or freezing are more profitable outlets. Canning in the Falkland Islands would have the advantage of providing a product which would be stable at local ambient temperatures but a cannery needs a high labour input, large quantities of potable water and skilled supervision and management. The cans would have to be imported; the plant would be idle for most of the year, there being no alternative product; and the marketing of relatively small quantities of canned material would be problematical. These difficulties all suggest that it is unlikely that canning would be the most profitable way to dispose of the salmon harvest.

148. Salting has not been as profitable as other processing methods for many years. It was always something of a last resort when other processing was impossible and it can be discounted in the Falkland Islands situation.

149. Smoked salmon, especially that made from Atlantic salmon, is a highly prized delicacy for which there is an increasing demand. Chilled storage life of smoked salmon is short, a matter of a few days, and quality is lost in frozen storage. While it is possible that salmon produced in the Falkland Islands might finally be marketed in the smoked form, salmon smoking is unlikely to become a local (Falkland Island) industry of any importance. The smoking of frozen fish near the point of sale offers prospects of better quality and profitability. Small quantities might be smoked in the Falkland Islands for sale in Buenos Aires, freighting by air; a good product could sell well in a somewhat limited market. Peat smoke generally produces an acrid somewhat unpleasant flavour so it is fairly certain that sawdust would have to be imported for this smoking process. Some simple experiments could be made locally using the Torry minikiln which would be supplied for the inshore fishing project if this is approved (cf other smoked fin fish para 28).

150. Freezing of dressed fish is thus suggested as the best way to process ranched salmon produced in the Falkland Islands. The fish should be killed on removal from the water, dressed and washed in fresh water and promptly frozen. Care should be taken to see that the fish are not distorted during freezing. Following freezing, the fish should be heavily glazed, placed individually in plastic

/bags,

bags, cartoned and cold stored. It is important that the temperature should not be subject to fluctuation during cold storage and transportation. Since sea transport is at present available on a regular basis only to the United Kingdom, it is assumed that the main market would be in Europe. If more than one species were available for processing at one time, the various species must of course be packed separately both to comply with labelling regulations and because the fish command different prices. Larger fish take substantially longer to freeze to the thermal centre than smaller ones. Freezer trolleys should, therefore, be loaded with fish of similar size, actual freezing times for fish of different sizes being determined by experiments with a probe thermometer.

151. Several stages of development must be considered. Firstly, although many of the fish returning from the earliest releases may be needed for brood stock, as soon as the numbers of returning fish permit some fish should be frozen for test marketing. The blast freezer and cold store supplied to the inshore fisheries project would be adequate for this. Fish should be killed, dressed and carried to the inshore fisheries project site in ice. If this equipment is not available, it would be possible to freeze a very small quantity of fish, say 50lb at a time, in the air blast of the freezer at the butchery but this should be considered only as a last resort because the fish would freeze only slowly thus yielding an inferior product on thawing which could give an entirely false (poor) impression of the quality of Falkland Island salmon. If the salmon ranching project goes ahead but the inshore fishing project does not, the possibility of supplying the smallest possible air blast freezer for initial trials must be considered.

152. The second stage, if all has gone well with the pilot project, would be that at which, when brood stock requirements had been met, a substantial quantity of salmon would be available for processing over a period of some three months every year (para 71). The small air blast freezer (100 lb charge) recommended for the survey of fishery resources could freeze up to one tonne of fish every three days working at full capacity. It could thus handle up to 30 tonnes in three months. As suggested in para 52 a second, larger freezer could be needed in this second stage. It is difficult at present to suggest how large this should be or when it might be needed. It might, indeed, be possible to avoid this purchase altogether and move straight to the stage suggested in para 154. It seems likely, however, that a freezer capable of freezing one tonne of fish in 24 hours might be needed. The 20 tonne cold store suggested for the survey of fishery resources would be used as a temporary store pending removal of the frozen salmon to the Port Stanley butchery cold store. The butchery cold store at present operates at minus 18°C: frozen salmon, should be held at minus 20°C if storage for more than a few weeks is needed but in the intermediate stage there may be no alternative to using the butchery cold store. This should be run at as low temperature as possible and the storage time kept to a minimum. Whenever possible frozen material should, of course, be shipped direct from the project cold store.

153. If the inshore fisheries project processing equipment is available it should be used at the proposed inshore project's site, bringing the salmon to it in ice. It would not be advisable to transfer the inshore project freezer and cold store to the salmon ranching site as this would require that <u>frozen</u> fish be moved to Stanley. For this, refrigerated transport would be needed and even on the road now being built a refrigerated vehicle would have a very short life indeed. This assumes, of course, that the pilot project site would be near to Darwin, as recommended in para 161.

154. At the third stage, if the pilot-scale project produces the projected 150 tonnes of fish a year (para 163), it should have its own freezer and cold store. Subject to later review, a freezer capable of handling five tonnes of fish in 24 hours and a 300 tonne cold store would seem to be indicated. We are necessarily dealing in averages and in some years 150 tonnes of fish might be exceeded. It also makes sense to be able to accept fish from other (private) projects which might have been started and be in the early stages of development. At this stage it would be necessary to fill refrigerated containers at the salmon project site for transport by sea to Europe. The engineering implications of this should be investigated by the engineering consultant who would be employed to investigate the planning and construction of the necessary project infrastructure.

155. In November 1978 the structure of the cold store at Ajax Bay appeared to be in perfect condition (Fig 4). The state of the refrigerating equipment could be assessed only by stripping it; the generators had been removed. Nonetheless, the possibility of using one or more of the cold rooms should be considered if the production of salmon seems to necessitate the building of a large freezer and cold store. No jetty was ever provided at Ajax Bay but one would be needed if fish were to be properly handled from cold store into a ship.

156. The present charter vessel has refrigerated cargo space for 16 tonnes and could, it is believed, carry on deck a further 2 x 15 tonnes in refrigerated containers. With four trips a year it appears that a maximum of 180 tonnes of frozen fish products (all salmon if there were no inshore fishing project) a year could be carried to the United Kingdom by the charter vessel. It is believed that British Antarctic Survey vessels also could carry refrigerated containers but the shole problem of transport to Europe requires more detailed investigation. Ad hoc arrangements could be used in the developmental stages and it is impossible to decide at present what arrangement might eventually be best. All that can be said is that ultimately cold storage facilities to hold a year's production should be provided together with blast freezing capacity adequate to deal with the greatest single day's production. The fish could be held live for short periods and it should not be necessary to provide ice-making capacity, which at least during the pilot project would be needed only occasionally if at all. If the capacity of the vessels calling regularly is exceeded it might be necessary to arrange for a reefer vessel to call on inducement. Use might also be made of freezer trawlers fishing the Southern Ocean or their carrier vessels.

Commercial salmon ranching ventures

157. To begin with, commercial salmon ranching has to be accommodated within the constraints set by the shortage of manpower in the Falkland Islands, which was the reason for according high priority in the criteria of suitability for ranching sites to proximity to a settlement (para 86a). There is no lack of enthusiasm, resourcefulness, and adaptability among the islanders, but any diversion of manpower into salmon ranching would be at the expense of staff on the farms. With care in the choice of species ranched, and selective rearing for appropriate season of return, the time of highest labour requirement, namely at the harvest of the returning salmon adults in the late summer and early autumn, could be arranged to coincide with a relatively quiet time in the sheep-farming calendar, so that disruption of the traditional industry could be minimised. Nevertheless, the maintenance of

/individual

individual hatcheries (Table 6) will require one full-time adequately trained member of staff at each unit. Basic training for such staff could be provided by the staff of the pilot unit (para 164).

158. It is foreseen that the pilot project would need its own blast freezing and cold storage facilities by the time the harvest built up to the predicted maximum. If private commercial ventures get underway it might be feasible to expand the capacity of the project processing and storage facilities to accept inputs from these ventures, and, as noted in para 155, the use to which the Ajax Bay equipment might be put needs to be considered. However, it is possible that individual settlements might need to install their own freezing and minimum storage facilities. Adequate storage might be provided through refrigerated containers. As each settlement has a deepwater jetty (eg Fig 18) at which the supply ship MV MONSUNEN can berth such containers could be transported by this vessel to Stanley to await onward shipment in bulk to Europe or elsewhere.

159. Again, it is foreseen that training in these and associated post-harvest matters could be provided through the pilot project.

160. Should the salmon industry have potential to increase in size beyond the manpower available, then immigration would be necessary to meet this manpower demand, but this would permit the industry to grow away from absolute dependence on the sheep farms and allow it to be integrated as an independent Falkland Island co-operative activity, ultimately staffed, funded and controlled wholly within the islands, and retaining its income there. This goal will be aided if an interest in fish and fisheries can be engendered in the schools, so that a new generation can grow into a new tradition.

Recommendations on salmon ranching

161. It is recommended that the feasibility of commercial salmon ranching in the Falkland Islands be tested in a pilot scheme at the sites identified at Darwin, on the Ceritos and Camilla Creek Arroyos (paras 88, 89). This scheme should be undertaken in the three phases identified below, but it should be noted that the third phase will begin during, and might be completed before, phase II.

Phase I: Detailed design and construction of rearing, release and harvest facilities.

Phase II: Testing of rearing procedures, releasing of juvenile migrants, and recovering of adequate quantities of suitably large returning adults.

Phase III: Handling and marketing of the salmon harvest.

162. Phase I should be undertaken by a qualified civil engineer, experienced in construction for aquaculture. He should visit Darwin, make a detailed engineering survey on the site and draw up and cost a preliminary design for:

a. A complete rearing unit with capacity to produce 25,000 Atlantic salmon smolts per annum at Ceritos Arroyo.

b. A complete rearing unit with capacity to produce 2,000,000 chum salmon fry per annum at Ceritos Arroyo.

/c.

c. Release and recovery facilities in the causeway at Darwin.

d. A causeway across Camilla Creek to contain release and recovery facilities there.

e. A broodstock holding area at Darwin.

f. Housing, laboratory, power and storage facilities at Ceritos Arroyo.

g. Freezing and cold storage facilities at Goose Green.

It is foreseen that, once the designs have been approved, the same engineer should supervise the contracting and have oversight of the construction of the units. Draft items of reference are at Annex B.

163. Accepting that the purpose of a pilot scheme is to test the hypothesis that salmon ranching from the Falkland Islands is biologically and economically feasible, it is noted that the anticipated harvest from a scheme involving the release of 25,000 Atlantic salmon smolts and 2,000,000 chum salmon fry annually would begin, at the earliest, in the second year from the commencement of rearing operations and over the next seven years could build up to 3 tonnes of Atlantic salmon annually, valued at nearly £12,000, and 147 tonnes of chum salmon annually valued at over £132,000. Although reference is made above only to Atlantic and chum salmon, this is for ease of presentation, and as noted in para 81, the same facilities could be, and are expected to be, used to test other species too, and the time table at Table 8 incorporates those species.

164. Phase II requires the appointment of a salmon biologist (preferably at PhD level). It is foreseen that some 9-10 years of work will be required; six years (including any initial training in salmon culture methods that might be required, to be undertaken at the Freshwater Fisheries Laboratory, Pitlochry, and at a suitable institute in America) to cover one complete generation of Atlantic salmon followed by a further three to four years to ensure continuity of operation of the facility. In America, training would be undertaken best at the University of Washington College of Fisheries, Oregon State University, Sheldon Jackson College University of Alaska, or with a commercial organisation such as Oregon Aquafoods Inc, at Springfield, Oregon. In order to run the rearing unit at Darwin the biologist would need the help of a trained salmon husbandryman who should be recruited either from the salmon aquaculture industry or from a training school such as that run by the Highlands and Islands Development Board, Inverness. Supervision of the programme of work and development of the unit at Darwin by the Pitlochry laboratory should be mainly by correspondence but occasional visits would be needed. However, the salmon biologist should be of a sufficient calibre to run the scheme largely unaided.

165. Phase III, involving all the post-harvest considerations covered in paras 145-156 together with training in those fields, should be supervisied by the Tropical Products Institute (TPI), London, who will need to post one expert to the Falkland Islands at just the right time (at the beginning of the fourth year from the commencement of rearing operations) for, probably, just one tour. As noted earlier, the main thrust of this phase might be completed before phase II although it is foreseen that specific consultancies might be required in the development of the commercial ventures.

/166.

Table 7. Rough costs for pilot salmon ranching scheme

Capital costs	£
Water supply	50,000
Hatchery complex	140,000
Housing	30,000
Vehicles and boats	30,000
Release and recovery facilities	20,000
Generators and storage	60,000
Initial supply of eggs	30,000
Contingencies	40,000
	£400,000

Annual running costs	
Fish culturist	16,000
Assistant fish culturist	16,000
Post-harvest expert (years 4, 5 only)	16,000
Fuel and expendibles	18,000
	£50,000 (£66,000 in years 4, 5)

Total over 6 years: £732,000
" " 10 years: £932,000

Item	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1. Engineering survey, design & costing of rearing, release + recovery facilities etc.												
2. Construction of facilities												
3. Recruitment of biologist												
4. Training of biologist												
5. Recruitment of husbandryman												
6. Staff on site at Darwin			*		*		*					
7. Import of salmon eggs												
8. Releases of fry: pink salmon												
chum salmon												
9. Releases of smolts												
10. Recoveries of adults					+	+	+					
pink salmon												
chum salmon												
Atlantic/coho/steelhead												
Chinook												
11. Releases of "native" juveniles												
pink salmon												
chum salmon												
Atlantic/coho/steelhead												
Chinook												
12. Recoveries of "native" adults												
pink salmon												
chum salmon												
Atlantic/coho/steelhead												
Chinook												
13. Private commercial Ranching schemes												
14. Plankton surveys												
15. Indigenous fish studies												

* Visits of consultant salmon biologist: 1, initiation of programme; 2, first smolt releases; 3, first complex recoveries

+ Visits of consultant processing/marketing expert: 1, first harvest of pink salmon
2, first harvest of chum salmon
3, first harvest of complex of species

Table 8. Time table for salmon ranching schemes in the Falkland Islands

166. An accurate estimate of the costs likely to be involved in the pilot scheme is not possible until the engineering survey and the design work have been completed but Table 7 gives a rough guide and indicates some £400,000 capital costs with about £50,000 annual running costs, in total about £730,000 over the first six years.

167. To promote and encourage the adoption of commercial ventures it is recommended that opportunities be taken during the running of the pilot scheme to interest individuals at Darwin, and on other settlements, in all aspects of salmon ranching. Such opportunities should be devised with the help and co-operation of the farm managers thus ensuring that, when the commercial feasibility of the venture is demonstrated, a nucleus of local people with experience and knowledge of salmon culture, management, processing and storage exists to take advantage of wider local opportunities. In this context the Education Department in the Islands should be given every encouragement to help in the pilot scheme. Currently the Director of Education is anxious to foster projects for A-level students which have relevance for the Islands' development, and there are several young members of his staff with basic training in marine biology who are keen to supervise such projects. For example, it will be important for the leader of the pilot scheme to know how the abundance and size frequency distribution of zooplankton animals (the potential food of young salmon) varies with the seasons in the inshore waters of Choiseul Sound and Brenton Loch so that he can better judge the timing of his first releases of fish. Such information could be collected for him, under his guidance, by the senior students at the Stanley school, and with the help of the Masters of the FORREST and MONSUNEN from whose vessels regular plankton tows could be carried out, the samples being analysed at the school. If the collection of such information could be started at once, in advance of the appointment of a salmon biologist, it would be of even more value. The cost of this small programme (purchase of 2 plankton samplers, and provision for travel and board costs for occasional visits to Darwin area by the school teachers and students involved) could possibly be regarded as part of the cost of the pilot scheme.

168. Another contribution that local biologists could make to the project concerns the conservation of the two native freshwater fishes, Aplochiton zebra and Galaxius maculatus. Reference was made in para 73 to preventing salmon from entering the river systems. Whereas the impact of a small controlled tonnage of salmon on the marine environment is likely to be minute, its effect on the freshwater environment, if the returning adults were allowed access to the rivers, could be substantial. The two native freshwater fishes, noted above, have reputedly been eliminated from many streams on the northern halves of East and West Falkland during the slow spread of the brown trout. It would seem prudent to initiate a study of the species in order to ensure that the enhancement of salmonid stocks in the area does not accelerate their decline. Measures to protect them from further disturbance by salmonids might then be taken and areas might be designated specifically as reserves for them.

ACKNOWLEDGEMENTS

169. It would have been impossible for us to have completed our assignment, and particularly for Dr Thorpe to have carried out his survey without the help of a very substantial proportion of the total population of the Falkland Islands.

/We

We should like to express our thanks to all those kind and generous people, but special thanks are due to Mr W Sloman and Miss L Barton who took charge of our arrangements and itinerary, to Jack Sollis and the crew of FORREST and to Mr and Mrs B Hardcastle, Darwin; Mr and Mrs D Barton, Teal Inlet; Mr and Mrs Alan Mille Port San Carlos; Mr and Mrs A Monk, San Carlos; Mr and Mrs R Binnie, Fitzroy; Mr and Mrs C Stewart, Bluff Cove; Mr and Mrs S Lee, and Mr and Mrs R Lee, Port Howard; Mr and Mrs T Blake, Hill Cove; Mr and Mrs R Cockwell, Fox Bay East; and Mr and Mrs D King, Stanley; for their excellent hospitality; and in addition to all those named above HE The Governor Mr James Parker, Mr and Mrs C Bertrand, Messrs J Massingham, H Bonner, S Booth, A Carey, W Felton, Mr and Mrs C Kerr, Messrs T Lamond, H Milne, J Peatfield, N Reid, T Spruce, I Strange, R Summers, M Clarke and S Whitley, for valuable discussion.

London
July 1979

Fig 10: [illegible] [illegible] [illegible] station, Iceland.

Fig 11: Bridge and causeway across the bay at Darwin (Fig 2).

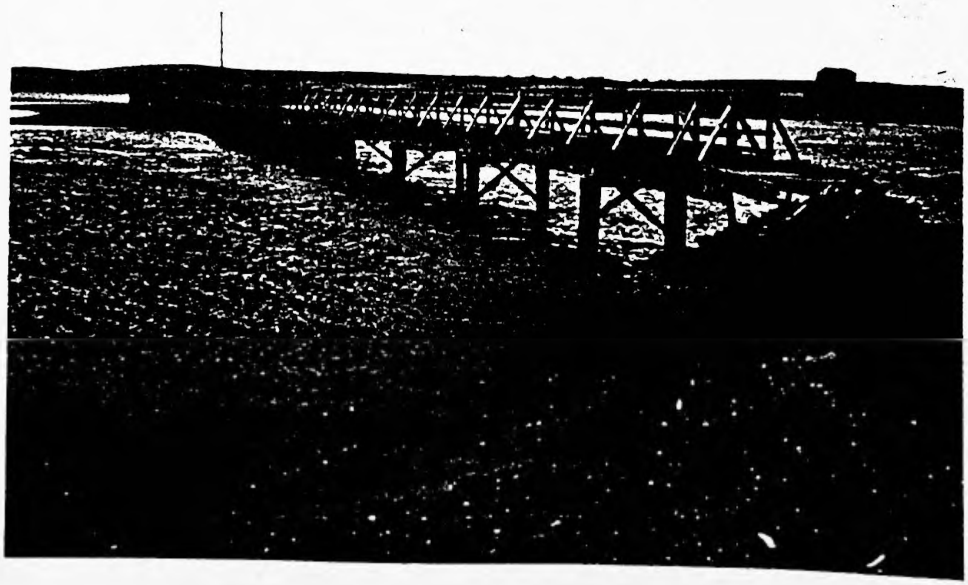

Fig 12: The bridge and causeway at Darwin (Fig 2).

Fig 13: [illegible] River [illegible] in the [illegible] at the head of [illegible] (Fig 3).

Fig 14: Head of the Dry Brook, San Carlos (Fig 4).

Fig 15: Fitzroy River; potential dam site between rock bluffs (Fig 5).

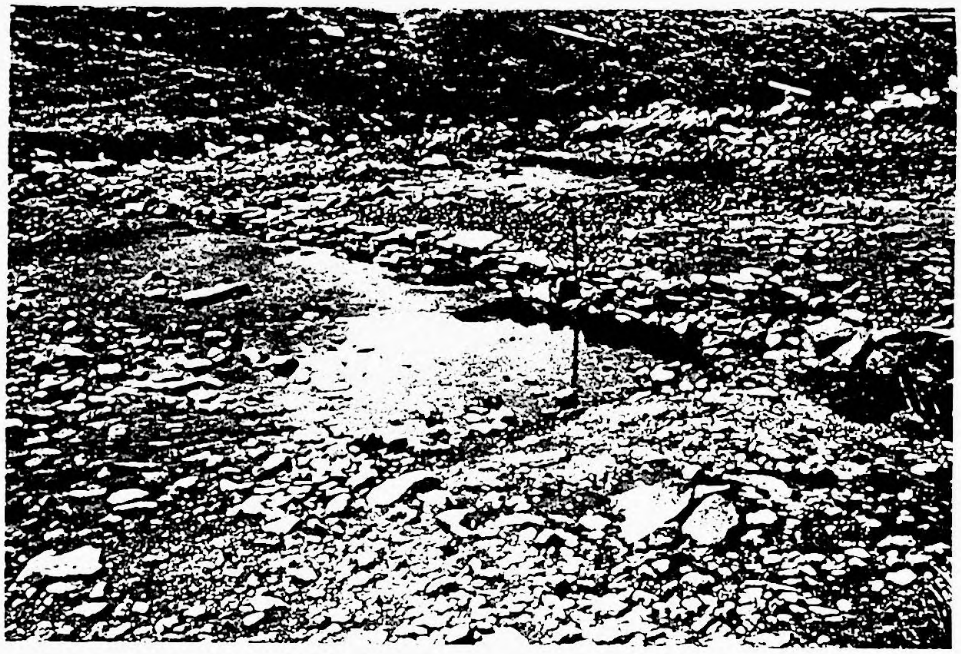

Fig. 16: Fish well, [illegible] Stream, low tide.

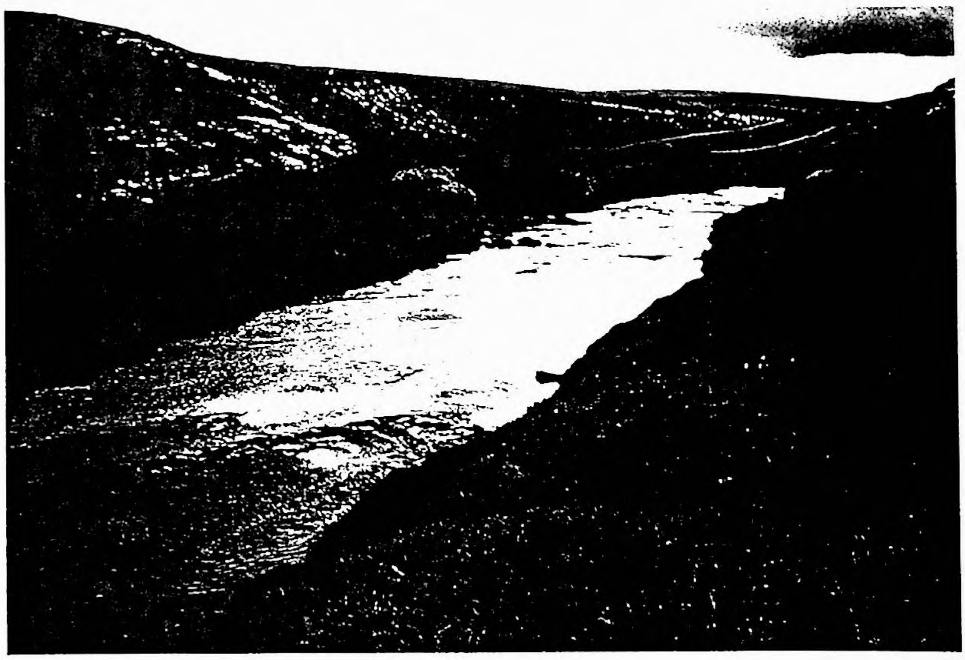

Fig. 17: Old House Stream; possible dam site (Fig. 8).

Fig. 18: MV "FOREST" at Port San Carlos (Fig. 4).

Itinerary - Dr Hall and Mr Cole

November 1978	
18	Arrived, one day late, from Comodoro Rivadavia 11.00 (LD 200). Met by Miss Lief Barton, Assistant Development Officer
	Participated in a seminar with Dr John Thorpe, Mr Tom Lamin Superintendent of Education, and several (expatriate) school teachers.
19 (Sunday)	Talks with Mr Neil Reid, Manager, Transocean Construction and Trading Ltd.
	Visited Alginate Industries Ltd laboratory and the adjacent boatyard.
20	Talks with Capt Jack Sollis, Master of the MV FORREST, with Mr William Sloman Development Officer, Mr John Massingham Chief Secretary and HE the Governor Mr James Parker.
	Visited the Royal Marines unit for talks with the OC Mj Ewan Southby-Tailyour.
	Visited the Grassland Trials Unit for talks with the Project Leader Mr Campbell Kerr and project staff.
	Talks with Mr W Goss Councillor for Port Stanley.
21	Sailed on the MV FORREST along the northern coast to Port San Carlc
	Talks with Mr Alan Miller the Port San Carlos Farm Manager.
22	Left Port San Carlos on FORREST to visit San Carlos Settlement for talks with Mr Adrian Monk, Member of Legco. Visited the Head c the Bay Brook, and the Ajax Bay meat processing plant.
	Left FORREST in Brenton Loch for talks with Mr Brook Hardcastle, F.I.C. Colonial Manager, and overnight visit at Darwin.
23	Visited locations around Darwin, in particular Ceritos Stream.
	Drove to Swan Inlet to meet Mr Ron Binnie, Fitzroy Farm Manager.
	Continued on with Mr Binnie to Fitzroy Settlement looking at Peak Stream on the way.
24	Drove to Bluff Cove with Mr Binnie for talks with Mr George Stewart and a view of the area, and then drove on to Port Stanley with Mr Micky Clarke.
25	Talks with Mr Clarke.
26 (Sunday)	(Free) Fishing in the Murrell River estuary.

November 1978 (cont)

27	Meeting with F.I.C. Manager and Accountant Mr Harry Milne and Mr Terry Spruce.
	Meeting with Mr Tony Carey, Government Supplies Officer.
	Viewed the public jetty and environs and visited the Pt Stanley cold store.
	Meeting with Mr Jimmy Stephenson, Meteorological forecaster.
28	Crossed the sound to view the Camber harbour and facilities and for talks with Mr Hector Anderson.
29.	Round-up meeting with Mr Massingham and Mr Sloman.
	Left Pt Stanley for Comodoro Rivadavia 1600 (LD 351).

Itinerary - Dr J E Thorpe

October 1978

26	London: visited Dr D N F Hall and Mrs M Rosser, ODM.
27	London - Reykjavik.
28	Reykjavik: visited Kollafjördur salmon ranching unit and a private station at Oxnalaekur with Arni Isaksson. Discussed the operation of these units with Thor Gudjonsson, Director of Salmonid Research, in Reykjavik.
29 (Sunday)	Reykjavik: discussion with Dr S St Helgason at Grindavik on rearing juvenile salmon in warm brackish water.
	pm. Reykjavik - Chicago - Seattle.
30	Seattle: visited College of Fisheries, University of Washington, to see salmon aquaculture facilities. Watched artificial spawning of Chinook salmon from College pool Discussed migration mechanisms of Pacific salmon with Profs. Ernest Brannon, Oneal Smitherman, and Lauren Donaldson.
31	Visited Cowlitz State Trout Hatchery and Federal Salmon Hatchery, and watched artificial fertilization of chinook salmon at the latter, performed <u>en masse</u> to obtain several million fertile eggs.

November

1	Seattle: met Dr Walter Dickhoff, for discussion on hormonal changes in Pacific salmon at smolting.
	Bellingham area: visited Lummi Indian Aquaculture Unit, to see 700 acre seawater pond system used for ranching Pacific salmon species.
	Seattle: discussion with Douglas Chapman, Dean of College of Fisheries, on salmon ranching in the southern oceans.
2	am. Seattle - Seabeck: visit with Professor Ernie Salo to Big Beef Creek experimental station, to see work on Chum salmon in a spawning channel.
	Seabeck - Clam Bay: visit to Anthony Novotny at Manchester Aquaculture station, to discuss delayed release experiments on coho salmon.

Clam Bay - Seattle: pm. discussion with Director of Fisheries Research Institute, University of Washington (Dr R L Burgner) on high seas migration of pacific salmon species

Seattle, evening: visit to College of Fisheries Trout hatchery on Lake Washington, with Prof. Ernie Brannon, and discussion with Dr L Donaldson.

3	Seattle - Eugene, Oregon: visited Springfield hatchery of the Oregon Aquafoods Corporation (Weyerhaeuser Corp.), with the manager Dr W J McNeil.
4	Eugene - Netarts Bay: visi ed the Keta Corporation chum salmon ranching unit en route to the Oregon State University experimental chum salmon ranching unit at Netarts Bay, with its originator, Dr W J McNeil.
	pm. Newport, Oregon: visited one of the release and recapture facilities of the Oregon Aquafoods Corporation, in the harbour at Newport.
5 (Sunday)	Eugene - San Francisco - Los Angeles.
6	Los Angeles - Mexico - Bogata - Lima - Buenos Aires.
7	Buenos Aires: documentation.
8	Buenos Aires - Comodoro Rivadavia - Port Stanley, arriving at 1400 hrs.
	pm. Discussed itinerary in Falkland Islands with Mr W Sloman Development Officer, and Lief Barton, ADO.
9-12 (Sunday)	Ill.
13	Visited Falkland Islands Company offices in Stanley, for discussions with Manager, Harry Milne, and accountant, Terry Spruce.
	pm. Discussed current patterns around the Falkland Islands, with Capt. Jack Sollis of the M V FORREST.
14	am: Discussed the present status of trout in the Falkland Islands with Mr Tony Carey. Met Campbell Kerr and some of his staff at the Grassland Trials Unit.
	pm: visited Moody Brook public water supply filtration plant, and the old trout hatchery nearby.
	Evening: visited Walter Felton and Tony Carey, to see freshly caught 8½ lb trout from Murrell River.

15 Flew to Goose Green, met by Brook Hardcastle, General Manager of the Falkland Islands Company. Visited Camilla Creek and Coritos Arroyos. Met Dr Ron Summers, Goose Project Scientist (TCO).

16 Drove to Black Rock Arroyo and Swan Inlet with Brook Hardcastle.

17 Revisited Camilla Creek, the north shore of Brenton Loch, Laguna Legna (Cantera Pond). Met a group of Goose Green Anglers at the Club.

18 Flew by Beaver over Brenton Loch, and Ajax Bay, to San Carlos and Port San Carlos. Returned to Stanley over same route to Darwin and then along coast of Choiseul Sound and shore of East Falkland.

pm: Seminar on salmon ranching potential in the Falkland Islands, with Bill Sloman, Lief Barton, Tom Lamond, Stuart Booth, Jim Bayliss, John Peatfield and Mrs Peatfield, Dennis Hall and Bob Cole, at the Secretariat.

19 (Sunday) Looked over Alginate Industries small laboratory building in Stanley. Visited Yorke Bay.

20 Discussion with Colonial Secretary, John Massingham. Flew to R. Malo estuary, walked upriver to bridge and thence travelled by landrover to Teal Inlet for discussions with Mr and Mrs David Barton.

21 Drove to Douglas Settlement, seeing Pedro River area, and on to Port San Carlos farm, seeing something of San Carlos River en route. Visited Fisherman's Brook, and Paloma Bay, on way to Port San Carlos settlement. Discussions in the evening with Alan Miller, Dennis Hall and Bob Cole.

22 By M V FORREST to San Carlos, for brief meeting with Adrian Monk; by inflatable dinghy to Head of the Bay Creek; and by M V FORREST to Ajax Bay, Falkland Sound, Brenton Loch. Met by Brook Hardcastle.

23 Revisited Camilla Creek with Brook Hardcastle, Dennis Hall and Bob Cole. Drove to Swan Inlet, Antioja Creek, and met up with Roy Binnie there. Visited Frying Pan Creek on the way to Fitzroy. Discussions with Roy and Linda Binnie.

24 Brief discussion with Harry Bonner, before visiting head of tide on Fitzroy River, and seeing some of its valley upstream. Returned to Fitzroy, and drove on to Bluff Cove for lunch with Mr and Mrs George Stewart. Discussed

original plantings of salmon and trout in the Islands. Travelled on by landrover with Mickey Clark and P.W.D foreman to Stanley.

25	Visited Yorke Bay again.
26 (Sunday)	Visited Murrell River.
27	Met Alan Mason, P.W.D Director and discussed line of the Darwin road near Fitzroy, and the construction of a bridge across the Fitzroy River. Discussed shipment of sheep carcass and frozen mullet, with Harry Milne and Terry Spruce Discussed the ideas of salmon ranching in the Falklands with the Governor.
28	Flight to Port Howard cancelled due to rough weather.
29	Flew to Port Howard and met Syd Lee. Visited streams along length of inlet at Port Howard. Discussions with Robin and Susan Lee, and Mr and Mrs Derek Evans.
30	Drove to Mount Rosalie to see Fish Wall and streams on the way.

December

1	Drove across the Warrah River, to meet Tim Blake at the Turkey Rocks. Drove to the north shore with Tim Blake, visiting the Blackburn River and a series of streams between there and Hill Cover. Discussions with Tim and Sally Blake.
2	Drove with the Blakes over the mountain to Chartres, visiting several streams and the Teal River on the way. Met Richard and Grizelda Cockwell at the Old House Stream, and drove on with them to Fox Bay East, visiting the Chartres River and one or two other streams en route.
3 (Sunday)	Visited several small creeks to the north of Fox Bay, and the coast ridge near Carcass Bay.
4	Flights cancelled due to high winds. Drove across West Falkland to Lake Hammond and Port Richards crossing the Malo River draining Lake Sullivan on the way. Discussions with the Cockwells.
5	Converation with Cecil Bertrand Carcass Island on the VHF Radio. Flew back to Stanley from Fox Bay West via New Island (met Ian Strange, briefly) West Point Island, Chartres (met Bill Luxton briefly), Hill Cove, San Carlos and Darwin.

6	Final discussions with Bill Sloman, Tom Lamond Lief Barton and Terry Spruce. Flew to Comodoro Rivadavia and Buenos Aires.
7	Flew from Buenos Aires to Santiago, Chile, to meet Dr Timothy Joyner.
	Discussions with Dr Joyner and Dr Guido Pincheira of the University of Chile, on their plans for ecological work in the Magallanic region of Chile, including work on ranching salmonid fishes from a site near Punta Arenas.
8	Natural History Museum, Santiago. Department of Hydrobiology University of Chile. Met Dr Irma Vila, for discussions on Chilean-Japanese salmon ventures.
9	Met Dr Wayland Cripe, Veterinary adviser at University of Chile. Discussions with Dr Joyner on general approach to salmon ranching in S. America.
10 (Sunday)	Flew from Santiago to London via Buenos Aires and Rio de Janeiro.

Terms of Reference - Civil Engineer: Salmon ranching project

Background

Consideration is being given by the Government of the Falkland Islands and the Overseas Development Administration of the Foreign and Commonwealth Office to testing the commercial feasibility of salmon ranching in the Falkland Islands. The best site for a pilot unit has been identified as the location on Ceritos Arroyo marked "Main Site" on Figure 2, attached.

2. The pilot unit will contain rearing facilities for Atlantic salmon smolts and chum salmon fry, housing for a biologist and a husbandryman, laboratory, power and general storage facilities.

3. Release and recovery facilities are to be provided on both the east and west side of the Darwin/Goose Green isthmus, at the locations marked "Causeway" at Darwin and "Proposed Causeway" on Camilla Creek (Fig 2), and a single brood stock holding area is to be provided at Darwin.

4. It is possible that the pilot project will not need any special equipment for preserving and storing the harvest for several years but ultimately it is foreseen that specific freezer and cold storage facilities will have to be provided in Goose Green and that frozen salmon will be shipped from there in refrigerated containers.

Duties

5. The engineer should consult and maintain close contact during the

assignment with Dr J E Thorpe, DAFS Freshwater Fisheries Laboratory, Pitlochry, on biological matters relating to points (a) to (f) inclusive, below, and with the Tropical Products Institute regarding point (g).

6. He should visit the Falkland Islands, make a detailed engineering survey of the sites and draw up and cost a design for:

a. A complete rearing unit with capacity to produce 25,000 Atlantic salmon smolts per annum.

b. A complete rearing unit with capacity to produce 2,000,000 chum salmon fry per annum.

c. Release and recovery facilities in the causeway at Darwin.

d. A causeway across Camilla Creek to contain release and recovery facilities.

e. A broodstock holding facility area at Darwin.

f. Staff housing, laboratory, power and storage facilities at the main site.

g. Blast freezing to handle 5 tonnes of fish in 24 hours and a 300 tonne cold store operating at minus 30°C, these facilities to be located at Goose Green in proximity to the jetty.

7. He should discuss his findings with HE The Governor of the Falkland Islands (or his representative), and within one month of his return to UK he should incorporate all his observations in a report submitted to the Overseas Development Administration.

<u>Duration</u>

8. The total duration of this assignment is expected to last two months.

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