CONFIDENTIAL

FISHERIES RESEARCH BOARD OF CANADA

ANNUAL REPORT

for

1951

of the

PACIFIC FISHERIES EXPERIMENTAL STATION

NEAL M. CARTER, Director

VANCOUVER, B.C.

December, 1951

FISHERIES RESEARCH BOARD OF CANADA

PACIFIC FISHERIES EXPERIMENTAL STATION
VANCOUVER, B.C.

REPORT FOR 1951

Neal M. Carter, Director

This Report covers the period from November 1, 1950, to October 31, 1951.

During the above period the Station completed a quarter century of what is confidently believed to have been useful service to parties interested in the fisheries industries, particularly those of Western Canada. Many important contributions to scientific knowledge also were made.

Collection of the nucleus of a staff began in the fall of 1925 and temporary quarters were established by March, 1926, in the basement of a boarding house at Seal Cove on the outskirts of Prince Rupert, while awaiting construction of a building on the Provincial Government dock in Prince Rupert. The official opening of the Station took place in November of that year, following occupancy of the leased two-thirds of the new building.

In 1931 a new three-storey building on a Dominion Government site, just above the older building, was sufficiently completed to allow partial occupancy. Although it was intended that this second building should eventually house the whole Station establishment, funds for completion of the interior of most of the main floor did not become available and for the following eleven years the Station operated from both buildings.

In 1942 the Navy requested the use of both buildings and financed the transfer of the Station to Vancouver. Wartime exigencies allowed no more than interior reconstruction of a building, part of which was at that time thirty years old. This building still housing the Station contains 17% less floor space than the combined occupied parts of the two Prince Rupert buildings, and further expansion is impracticable. A modern building, originally designed for research and having some adjacent ground area, is required if expansion of this Station's work is expected to keep pace with the growth of the Board's activities.

BUILDING AND EQUIPMENT

An Aero Automatic fire alarm system operating on the air expansion principle was installed and is connected with the central office of the B.C. District Telegraph Protection Service. This ensures immediate attention and action in case of fire when none of the Station staff is on duty. The agency's tri-nightly patrol service is also employed.

Additional fluorescent lighting was installed to the annual extent authorized, and several laboratories, offices and halls were repainted. This

painting, as well as practically all alterations and maintenance work in the building, was ably performed by Mr. F.C. Freeman, Maintenance Supervisor.

Acquistions of equipment during the period under review included:

(a) Two-cylinder diesel engine, compressor and heat exchanger to replace unsatisfactory equipment installed last year on the vessel "Tauranga" used for experiments on freezing fish at sea. (Turn-in exchange made).

(b) Wide-angle lens for Filmo camera, to enable comprehensive views to be taken in confined spaces such as ships holds.

(c) Speed-O-Copy attachment for Leica camera to facilitate making microfilm copies.

(d) Stainless steel rotary oven for heating materials such as fish meals being used in the fish-meal nutritive value programme.

(e) Electric motor, pump and shafting for circulation of brine in the mechanized herring salting experiment on a commercial scale.

(f) An additional potentiometer.

(g) A Selecta balance, which greatly facilitates weighing of quantities up to 200 grams by visual recording of the smaller fractions of a tenth gram.

(h) Incubator for bacteriological cultures.

(i) Large-capacity shaking machine for microbiological and antibiotic experiments.

(j) Laboratory mill for fine comminution of dried materials.

(k) "Magic Mix" stirrer.

(l) Fractionation column to replace the only piece of equipment irrevocably destroyed in the fire reported last year.

(m) Two additional CO_2 fire extinguishers.

STAFF

A list of staff employed or given working facilities by the Station during the period under review, as well as the organization of staff as of November 1, 1950, follows on pages 7 and 8.

The staff has not been substantially increased, due to lack of space for working facilities. Mr. O.C. Young continued to be seconded to the Headquarters Unit of the Board in Ottawa, and Mr. N.E. Cooke's leave of absence for service with the Armed Forces in Korea continued throughout the period under review. The only change in staff was the resignation of

Mr. B. E. Maxwell, Librarian, to accept a very attractive British Civil Service post concerning the freshwater fisheries work in Rhodesia. The position of Station Librarian has been filled by the appointment of Mr. Eric Holmgren. Staff on strength Oct. 31, 1951 - 22; (Oct. 31, 1950 - 23).

PUBLICATIONS

A complete list of staff publications that appeared during the period under review follows on pages 9-11.

The usual four annual issues of the Pacific Progress Reports (Nos. 85-88) were published under the editorship of Dr. Carter. Issue No. 89 is planned to appear before the end of 1951. The mailing list of these Progress Reports has rapidly increased from the 1674 reported last year; partly through addition of names of companies and individuals concerned with the fisheries industries of Western Canada, and partly through names recommended by the Board's Editor as a result of exchange arrangements in Canada and many other countries.

Various of the publications listed were reprinted in whole or in part by scientific or trade publications, also by abstracting services (e.g. Commercial Fisheries Abstracts, U.S. Fish and Wildlife Service; World Fisheries Abstracts, F.A.O., U.N.; Chemical Abstracts). Some results of this Station's work are thereby quickly drawn to the attention of many interested persons who do not receive the original publications.

In addition to unlisted forthcoming publications, it can now be reported that the revision of Board Bulletin No. 59 on the chemistry and technology of marine animal oils has been completed to the stage of indexing from the page proofs. The proofreading and indexing of 399 pages has occupied a great deal of the time of Drs. Bailey, Carter and Swain, with very material assistance from Misses Porter and Tweedale. The printing should be completed within the fiscal year 1951-52.

Two theses, one for a Ph.D. (Dr. M.M.R. Khan) and one for a M.A. (Mr. B.E. Maxwell), based on investigations carried out through official arrangements between the Board and the University of B.C., were submitted for publication in the Board's Journal after arrangement and preliminary editing by Dr. Carter.

TRAVEL

In addition to many visits to various fish processing plants on the lower B.C. coast by different members of the staff for investigational purposes and to accompany official visitors desiring to see something of the fishing industries, trips further afield included:

November, 1950: Mr. Lantz to Nanaimo Station, re refrigeration plant.
November: Drs. Bailey, Carter, Swain and Tarr to Seattle to attend the opening of the new Fisheries Building of the University of Washington.
January, 1951: Drs. Carter and Tarr attended the annual meetings of the Board at Ottawa.

February: Drs. Carter and Swain to the head of Bute Inlet, on HMCS "Cedarwood", in company with Dr. M.Y. Williams of the Dept. of Geology, U.B.C., and several members of the P.O.G., for the purpose of investigating the waxy material reported on page 28.

February: Mr. Roach to Masset, Q.C.I., to give assistance at the Queen Charlotte Canners plant.

May: Messrs. Carter, Kilpatrick, Lantz and Tarr to Nanaimo Station, for Sub-Executive meeting.

May: Mr. Maxwell to Vancouver Is., to attend Librarians' Convention, also visited Nanaimo Station.

June: Dr. Carter to Montreal, for Board Executive meeting.

June: Drs. Carter and Swain to Winnipeg, to attend Annual Conference of the Chemical Institute of Canada, the former as a member of the Board of Directors and a Councillor, the latter to present a paper and as a delegate to a meeting of Canadian Food Technologists.

June: Mr. Lantz to Prince Albert (side trip while on holiday), to observe progress made in various processes recommended earlier by this Station.

July: Mr. Lantz to Namu, B.C., in the course of a trip on the refrigerated vessel "Tauranga" to witness method of conducting the handling and refrigeration of the fish used in experiments (pages 15-18).

August: Dr. Tarr to Montreal, New York, Washington, and New London, New Hampshire, to attend the Gordon Research Conference on Food Technology (A.A.A.S.), and to visit several universities and companies in connection with his programmes.

August: Mr. Baker to Montreal and Ottawa, in connection with his participation in the railway refrigerator car experiment conducted by the National Research Council (see page 41).

September: Dr. Tarr to Prince Rupert, to visit most of the fishing industries and to address a meeting of representatives of such companies, arranged by Mr. Walker and Mr. Harding.

October: Dr. Carter to Ottawa, for Board Executive meeting.

October: Mr. Lantz to Prince Rupert, to visit the fishing industries and at request of the Fishermen's Co-Op.

SCIENTIFIC, INDUSTRIAL AND OTHER RELATIONS

The preceding outline of staff travel mentions various valuable relations formed or maintained. Additional activities included:

Dr. Carter completed his two successive terms as member of the Board of Directors and as Councillor for the Chemical Institute of Canada, and continued as Chairman of the Fish Sub-Section of the Canadian Committee on Food Preservation, with Dr. Tarr as Secretary. Dr. Swain completed his term of office as President of the B.C. Academy of Sciences.

In February fisheries technologists from Oregon, Washington, British Columbia and Alaska held their second very successful annual meeting, with the B.C. members acting as hosts for the two-day conference at the University of B.C. Dr. Carter as Chairman and Dr. Swain as Secretary were responsible, with the assistance of committees and the Department of Extension, U.B.C., for arranging the Conference and its programme.

Several important visitors from overseas were entertained and familiarized with the work of the Board and the Station, also taken to representative fish processing plants. Members of the staff of the U.S. Fish and Wildlife Fisheries Technological Laboratory at Seattle visited the Station, and Dr. W. Hastings of the University of Washington School of Fisheries brought a group of his students to the Station in October.

The scientific staff presented at the Station the balance of the 1950 fall term U.B.C. course in Zoology 405 (Fisheries Technology), and the 1951 spring term course in Zoology 411 (Advanced Fisheries Technology). Dr. Carter as Honorary Lecturer in the Zoology Department supervised the organization of these courses and the setting and marking of the examinations. The fall term course was not given this year.

Relations with the Fisheries Department, other Government Departments and with Industry have been maintained in a mutually satisfactory manner. Much assistance is being given to the Department of Fisheries local office in connection with specifications for the present pack of "dry salt" herring. The Winnipeg office of the Department is being supplied with much requested information concerning utilization of beluga and their by-products. The Vancouver office of the Technical Information Service of the National Research Council frequently appeals to the Station for assistance in supplying information not readily available in that office or from its headquarters at Ottawa. We are pleased to report that we are usually able to supply sufficient information immediately or on short notice, sometimes on subjects rather remotely connected with the Station's work.

The Station's own information service on problems connected with fisheries technology has operated for twenty-five years without an official designation except for participation in the term "trouble-shooting". A recent re-arrangement of Dr. Bailey's duties has given him most of the responsibility of preparing the replies to the many verbal and written enquiries received at the Station. Some such enquiries are answered by himself, some in collaboration with the Director and other members of the staff. In quite a few cases considerable time is spent in collecting the necessary data, statistics, trade information and the like; such replies are prepared on sheets separate from a covering letter, so that extra copies are available for future use. It is surprising how often these copies are useful in answering similar enquiries, allowing moderate variations to be handled in the covering letter. This practice has been used to some extent in the past, but suffered from lack of uniformity of treatment when handled by the scientific staff as a whole.

Complete acknowledgment of services, samples and other materials supplied gratuitously by Government Departments, firms and individuals would make a list too lengthy to be included here. However, special appreciation is expressed to the Headquarters Unit of the Board for its many prompt services; to the International (halibut) Fisheries Commission and the Department of Fisheries for permission to retain for experimental purposes halibut caught out of season; to the P.O.G. for transportation and assistance in observing oceanographic conditions in Bute Inlet in connection with the waxy material mentioned; to Dr. M.Y. Williams for efforts to determine its source;

to Dr. Shemilt of the Chemical Engineering Department of U.B.C. for services rendered in connection with the Station's equipment installed there (page 42); to the Francis Millerd Co. for permission to modify one of their herring salting tanks and for risking some 15 tons of herring in the experiment (page 22); to the B.C. Packers Ltd., Canadian Fishing Co., and Nelson Bros. Fisheries for donations and special treatment of large quantities of herring meal for the nutritive value programme (pages 28-33).

The above resumé is for purposes of record and is not intended for inclusion as such in the printed Annual Report. The subsequent report on Investigations is considerably more detailed than in previous years, and is intended for publication after any necessary revision. As stated, this fuller form of report covers much of the information that would otherwise be presented in Investigator's Summaries, which are consequently greatly decreased in number as compared with those in recent processed Annual Reports of this Station.

STAFF OF THE PACIFIC FISHERIES EXPERIMENTAL STATION

SCIENTIFIC STAFF

N. M. Carter, M.A.Sc., Ph.D., F.C.I.C., F.R.G.S., Director.
O. C. Young, M.B.E., B.Sc., M.E., Principal Scientist (seconded to Headquarters).
B. E. Bailey, M.A.Sc., Ph.D., Senior Scientist.
H. L. A. Tarr, M.S.A., Ph.D., Senior Scientist.
N. E. Cooke, M.A.Sc., F.C.S., M.S.C.I., M.C.I.C., Associate Scientist (on leave of absence for military service).
J. S. M. Harrison, B.A.Sc., Assistant Scientist (to March 31), Associate Scientist (from April 1).
A. W. Lantz, B.Sc., M.C.I.C., Associate Scientist.
S. W. Roach, B.A.Sc., Assistant Scientist (to March 31), Associate Scientist (from April 1).
L. A. Swain, M.A., Ph.D., M.C.I.C., Associate Scientist.
P. J. Schmidt, B.Sc., Assistant Scientist.
B. E. Maxwell, M.A., Assistant Technician, Grade 3 (to June 30), Junior Scientist (July 1 to October 16).
Miss B. A. Southcott, B.S.A., Junior Scientist.
Miss H. M. Bissett, B.S.A., Senior Research Assistant.
Miss S. Kristjanson, B.A., Senior Research Assistant.

TECHNICIANS

E. G. Baker, Assistant Technician, Grade 3 (to March 31), Technician Grade 1 (from April 1).
E. J. Holmgren, Technician, Grade 1 (Librarian) (from September 20).
Miss I. M. Porter, Assistant Technician, Grade 1.
Miss I. R. Smith, Assistant Technician, Grade 1.
Miss J. B. Walton, Assistant Technician, Grade 1.

OFFICE AND BUILDING STAFF

J. W. Kilpatrick, M.C., Administrative Officer, Grade 2.
Miss P. Tweedale, Clerk (Secretary), Grade 3.
Mrs. N. E. McBride, Stenographer, Grade 2B (to June 30). Grade 3 (from July 1).
Miss L. Ferguson, Clerk, Grade 2B (from December 1, 1950).
F. C. Freeman, Maintenance Supervisor, Grade 2 (to December 31, 1950), Grade 3 (from January 1).
P. E. Enright, Caretaker, Grade 2.

Temporary

Mrs. R. Gordon-Findlay, Typist, Grade 2B (November 7, 1950 to January 27).
W. I. Herkes, Caretaker, Grade 1 (January 1 to April 30).
B. A. Herring, B.A., Caretaker, Grade 1 (to December 31, 1950).

ORGANIZATION OF STAFF OF THE

PACIFIC FISHERIES EXPERIMENTAL STATION

(22 members as of Nov. 1, 1951)

Administrational

Director	Dr. N. M. Carter
Executive Assistant (Supervising Clerk)	Mr. J. W. Kilpatrick
Secretary and Clerk (Clerk Grade 3)	Miss P. Tweedale
Stenographer (Clerk Grade 3)	Mrs. N. E. McBride
Clerk (Grade 2B)	Miss L. Ferguson

Investigational Staff

(1) Bacteriology and Microbiology:

Senior Scientist	Dr. H. L. A. Tarr
Junior Scientist	Miss B. A. Southcott, B.S.A.
Senior Research Assistant	Miss H. M. Bissett, B.S.A.

(2) Biochemistry and Technical Information Service:

Senior Scientist	Dr. B. E. Bailey *
Asst. Technician (Grade 1)	Miss I. M. Porter

(3) Chemistry:

Associate Scientist	Dr. L.A. Swain
(Associate Scientist (On leave of absence for Military Service)	Mr. N. E. Cooke, M.A.Sc.)
Assistant Scientist	Mr. P. J. Schmidt, B.Sc.
Senior Research Assistant	Miss S. Kristjanson, B.A.
Assistant Technician (Grade 1)	Miss I. R. Smith
Assistant Technician (Grade 1)	Miss J. B. Walton

(4) Engineering:

(Principal Research Engineer (Seconded to Headquarters Unit)	Mr. O. C. Young, M.E.)
Associate Scientist	Mr. A. W. Lantz, B.Sc.
Associate Scientist	Mr. J. S. M. Harrison, B.A.Sc.
Associate Scientist	Mr. S. W. Roach, B.A.Sc.
Technician (Grade 1)	Mr. E. G. Baker

Library

Technician (Grade 1)	Mr. E. J. Holmgren

Maintenance

Maintenance Supervisor (Grade 3)	Mr. F. C. Freeman
Caretaker (Grade 2)	Mr. P. E. Enright

* Just as this sheet was going to press, it was learned that Dr. Bailey passed away on the evening of November 28.

PUBLICATIONS OF THE PACIFIC FISHERIES EXPERIMENTAL STATION

NOTE: For sake of continuity of these lists in the Station's Annual Reports, certain publications that appeared in print during December, 1950, too late to be listed in last year's Report, have been included here. Such publications were included in the list given in the 1950 printed Annual Report. Certain publications which are expected to appear in print during November or December, 1951 cannot yet be listed here, but will be included in the list prepared for the 1951 printed Annual Report.

1. Bailey, B.E. "Chalky" halibut. II. Prog. Rept. Pac., No.88, p.61. (See also No.18).

2. Bailey, B.E., A.W. Lantz and P.J. Schmidt. Utilization of freshwater fish, trimmings, and offal. Prog. Rept. Pac., No.88, pp.66-67.

Baker, E.G. (See No.17).

Bissett, H.M. (See Nos.12, 13, 14).

3. Carter, Neal M. Summary of packaging studies at the Pacific Fisheries Experimental Station, Vancouver, B.C. Canadian Packaging, Vol.4, No.8, pp.37,39. (See also No.9).

4. Harrison, J.S.M. Machine for "scorching" fish meal. Prog. Rept. Pac., No.85, pp.86-87. (1950).

5. Harrison, J.S.M. and S.W. Roach. Canned salmon-cakes. Prog. Rept. Pac., No.86, p.16.

6. Harrison, J.S.M. and P.J. Schmidt. Mechanical brining for salt herring. Prog. Rept. Pac., No.86, pp.3-5.

7. Kristjanson, Svava. The separation of cholesterol from halibut liver oil. Prog. Rept. Pac., No.88, pp.51-52.

8. Lantz, A.W. Crab processing. Prog. Rept. Pac., No.87, pp.34-36.

9. Lantz, A.W. and Neal M. Carter. Freezing British Columbia fish at sea. Prog. Rept. Pac., No.88, pp.57-60.

Roach, S.W. (See No.5).

Schmidt, P.J. (See Nos.2, 6).

Southcott, B.A. (See Nos.11, 12, 13).

10. Tarr, H.L.A. Microbiological formation of vitamin B_{12}. Canadian Journal of Technology, Vol.29, No.8, pp.391-400.

11. Microbiological formation of vitamin B_{12} in fishery waste materials. Federation Proceedings (of Fed. Amer. Soc. Exptl. Biol.), Vol.10, p.257.

12. Tarr, H.L.A., H.A. Southcott and H.M. Bissett. The nutritive value of fish meal and condensed fish solubles. Prog. Rept. Pac., No.85, pp.83-85. (1950).

13. Control of rancidity in stored fish. IV. Prog. Rept. Pac., No.88, pp.67-68.

14. Tarr, H.L.A., B.A. Southcott, H.M. Bissett, and Jacob Biely and B.E. March. Nutritive value of fish meal and condensed fish solubles. II. Effect of heat on herring meal. Prog. Rept. Pac., No.87, pp.42-46.

15. Young, O.C. Quality of fresh and frozen fish and facilities for freezing, storing and transporting fisheries products. Food Technology, Vol.4, No.11, pp.447-450. (1950).

16. Mechanical refrigeration for railway cars. Canadian Fisherman, Vol.38, No.9, pp.16-18, 20.
(See also Nos.22, 23, 24, 25).

17. Young, O.C. and E.G. Baker. Refrigerator car experiments X. Final report on the experimental mechanical car. Prog. Rept. Pac., No.86, pp.21-24.

INDUSTRIAL MEMORANDA, MANUSCRIPT REPORTS AND OTHER REPORTS

18. Bailey, B.E. The effects of different methods of preservation on the nutritive factors in fish. Pac. Fish. Exptl. Stn. Indus. Memo., No.15, 4 pp.

19. Khan, M.M.R. Studies on the "lipoxidase" in the flesh of British Columbia herring. (Submitted for publication in Journal of Fisheries Research Board of Canada).

20. Maxwell, B.E. The distribution of vitamin B_{12}-active substances in some marine invertebrates of British Columbia. (Submitted for publication in Journal of Fisheries Research Board of Canada).

21. Maxwell, B.E. (Compiler). List of serials in the library of the Pacific Fisheries Experimental Station. 18 pp.

22. Young, O.C. Transportation of fishery products. (In Marine Products of Commerce by Tressler and Lemon), Chap.15, pp.307-327, Reinhold Publishing Corporation, New York, N.Y.

23. Some means of retaining quality in fresh and frozen fish. (Proceedings of 8th International Congress of Refrigeration).

24. Some cold storage practices in Canada with particular reference to jacketed holding rooms. (Proceedings of the 8th International Congress of Refrigeration).

25. (Co-author with W.H. Cook and M.V. Thistle). Handling of perishable traffic on Canadian railways. (Proceedings of the 8th International Congress of Refrigeration).

INVESTIGATIONS

This summary does not attempt to cover all the varied investigations, technical services, etc. included in the year's work at the Station. Progress in some of the more important continued programmes is described, and the background and significance of some of the more important or novel of the newly undertaken investigations are given.

Preservation of Quality of Fresh Fish

The deterioration of quality of fresh unfrozen fish and fish products is due very largely to the growth of micro-organisms which invade the flesh after death. The control of these organisms and the spoilage they occasion has been one of the most important general problems of this Station since it was first established, and a number of direct and indirect methods of suppressing their growth have been investigated from time to time. These have included the application of germicidal substances either by incorporation in ice or in solutions in which fish fillets are immersed, the influence of temperature on the growth of spoilage organisms, washing fish to remove micro-organisms which would otherwise seriously contaminate the cut fillets, and disinfection of fish boats and fish handling premises. One useful observation made during these investigations was that nitrite salts (particularly sodium nitrite), which are normally either added or are naturally formed in meat curing processes, often retard bacterial spoilage of fish very markedly. This finding has been widely applied with considerable financial benefit, particularly in Eastern Canada, and, more recently, in certain Scandinavian countries. Though sodium nitrite is a useful bacteriostat for delaying bacterial spoilage and certain other undesirable changes in fresh fish, it seemed possible that more effective substances might be found. With this idea in mind a study of the effect of bacteriostatic compounds which are loosely termed "antibiotics" was commenced by Dr. Tarr in 1946. This investigation was temporarily dropped after the first year due to the lack of new antibiotics, for penicillin and streptomycin had not proven at all efficacious when used with fish stored at about 32°F. A large number of new antibiotics became available during the past few years and many of these have been studied in recent experiments. Grateful acknowledgment is made to Merck and Company, the Lederle Laboratories, Chas. Pfizer and Company, S.B. Penick and Company, The Upjohn Company and Parke and Davis and Company for liberal supplies of the various antibiotics studied.

During the course of this work one interesting fact has emerged, namely that few of the numerous antibiotics investigated would retard bacterial spoilage of fish at desirable cool storage temperatures (32° and 38°F.). Thus subtilin, polymixin B, neomycin, circulin, gramicidin, tyrothricin, metholyl gramicidin, streptomycin, penicillin and one unnamed antibiotic when incorporated in 10 and 50 parts per million (p.p.m.) concentration into fish flesh which was stored at these temperatures had little or no preservative action. On the other hand aureomycin, terramycin and chloromycetin proved very effective in this respect. The most spectacular results were obtained with aureomycin which markedly retarded growth of spoilage bacteria in fish flesh in 1 to 2 p.p.m. concentration, (about 1/30 to 1/15 of an ounce per ton of fish flesh). Thus in one experiment after 11 days at 38°F. untreated coho salmon flesh contained about 4500 million bacteria per gram and was putrid,

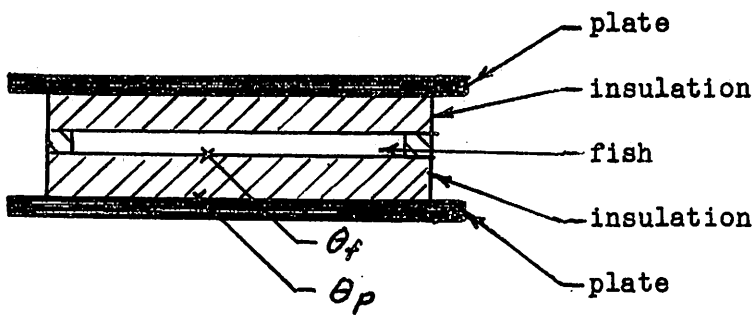
while identical fish in which only 2 p.p.m. of aureomycin (as hydrochloride) had been incorporated contained only about 50 thousand bacteria per gram and evidenced no unpleasant odour. Aureomycin can be incorporated readily into fish flesh by a brief immersion in solutions containing about 10 p.p.m. of the antibiotic. When lingcod steaks were thus treated they contained only about 100 thousand bacteria per gram after 9 days at 38°F., while untreated steaks contained 240 million bacteria per gram after 6 days and were very putrid after 9 days.

Miss Southcott is attempting to determine the mode of action of certain of these antibiotics at low temperatures, and has isolated from fish a number of organisms which will grow readily at 32°F. The effect of antibiotics on the enzyme systems of these organisms will be investigated at low temperatures.

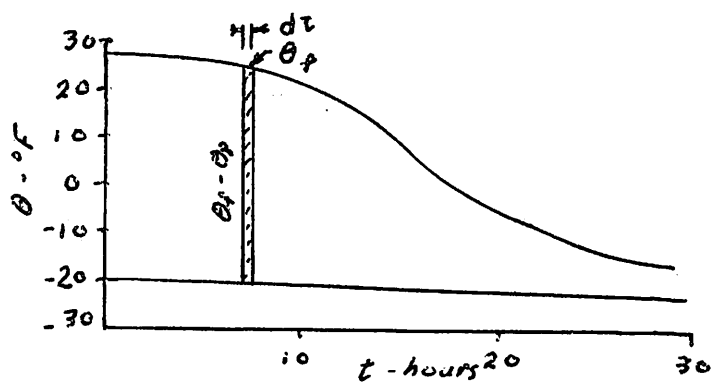
Fish Freezing

The relation between the percentage of water frozen from fish and temperature is an old problem of importance to our knowledge of fish freezing. At this Station two different methods have previously been used to determine the relation and a third method has now been worked out by Mr. Harrison employing heat transfer calculations.

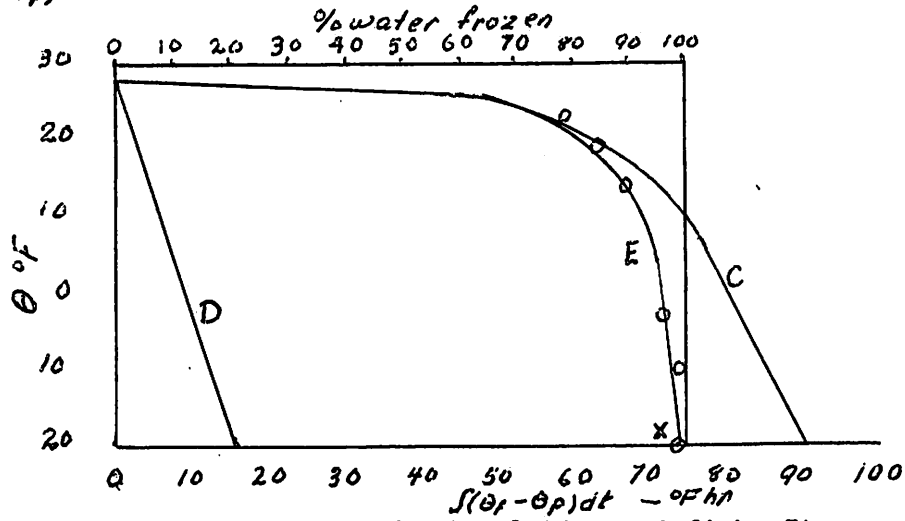
The method is to place a slab of fish muscle $\frac{1}{8}$ inch thick between two 1-inch slabs of insulation, which is in turn placed between refrigerated plates, as in the accompanying diagram. Temperatures are taken by



thermocouples at the interface of the fish and insulation (θ_f) and the interface of the insulation and plate (θ_p). Curves A and B are the plots of θ_f and θ_p versus time, the Y-axis representing the start of freezing the area $(\theta_f - \theta_p)dt$ is proportional to the quantity of heat transferred



through the insulation at the fish temperature θ_f . Curve C is $\int(\theta_f - \theta_p)\,dt$ plotted against temperature. Curve D represents the



sensible heat extracted from the insulation and fish. It was calculated from specific heats given in the literature and proportioned to the same scale as curve C by making the assumption (based on results from previous investigations by a different method at this Station) that at point X the water was 99% frozen. Curve E is curve C minus curve D, and is proportional to the heat extracted from the fish, and to the percentage water frozen.

As the curve is based on the assumption that 99% of the water is frozen at -20°F. the values obtained are not absolute; but it does appear to give good relative results in the range 0° to 20°F. which is one of interest in commercial cold storage practice. To substantiate the validity of the curve, the K factor of the insulation used (Rubatex), calculated from these results, is 0.205 B.t.u. in./°F. ft.^{2} hr. The factor is reported as about 0.20. The points circled on the third diagram are those determined by dilatometer experiments in an earlier investigation at the Station.

Control of Oxidative Rancidity in Frozen Fish

As a direct result of an investigation initiated at this Station in 1944 considerable commercial interest has been taken in the application of antioxidants as a means of delaying the development of rancid odours and flavours in frozen fish. Due to its relative effectiveness and harmlessness when ingested, l-ascorbic acid (synthetic vitamin C) has been the preferred antioxidant for this purpose and a large proportion of British Columbia salmon, sole and other fillets have been treated with this antioxidant for the past two years. Ascorbic acid has been applied commercially either by immersing fillets for a brief period in a 1% watery solution of the acid, or in an 0.3% solution which has been made slightly viscous by addition of 0.5% carrageen (a natural harmless thickening substance extracted from a sea plant).

There has not been a complete agreement regarding the effectiveness of ascorbic acid in retarding development of oxidative rancidity in cold stored fish, and results reported for such treatment have varied from marked improvement in keeping quality to no noticeable favourable effect.

It was thought that the post-mortem "age" of fish at the time of treatment might have a bearing on these rather conflicting reports, and experiments were therefore initiated by Dr. Tarr in order to examine this possibility. Since no data have been accumulated at this Station regarding the relative effectiveness of the two types of ascorbic acid treatment referred to above, the experiments were designed to compare the two techniques. Strictly fresh red spring salmon, high quality fish which are fatty and very liable to become rancid during frozen storage, were used.

Steaks were cut from fish stored for about one half day, 4 days and 6 days in ice following capture. Some steaks were left untreated as controls and others were dipped in a 1% solution of ascorbic acid or in a solution containing 0.3% of ascorbic acid thickened with 0.5% of high viscosity carrageen. All the steaks were wrapped tightly in glassine-laminated aluminum foil, and representative samples were frozen and stored in sealed containers at 14°, -4° and about -18°F. Development of rancidity in the stored samples is being followed by means of peroxide value determinations. A summary of the results was recently published in Pacific Progress Reports No.88 (October, 1951). So far no very important difference has been observed in the rate of fat oxidation in steaks cut from fish stored for different periods in ice. The ascorbic acid treatments proved quite effective in retarding the onset of rancidity, and both were about equally effective. As in previous work, deterioration was much more rapid in all samples at the higher storage temperatures.

Refrigerated Transportation

Present commercial procedures following catches on certain fishing grounds distant from British Columbia ports sometimes militate against a wide distribution of uniformly high quality fresh or frozen product to the consumer because of the time lapse between capture and landing, and between landing and consumption. For example, it is not unknown for the earliest-caught fish on some trips to be carried for up to 18 days merely packed in ice aboard the fishing vessel before it reaches port. Obviously such fish may have a very limited remaining period of acceptable quality if unfrozen, and even if frozen immediately upon being landed the quality will not compare favourably with that of fish frozen sooner after being caught.

The freezing of commercial fish at the scene of fishing is not by any means a recent development. At many northern inland fisheries the air is so cold that fish caught through the ice freeze very quickly; freezing of fish at sea by applied refrigeration aboard fishing boats, collector vessels or factory ships is commercially practised in several countries.

Since it is illegal to land at a British Columbia port fish frozen on board any vessel other than one from which the fish were actually caught, freezing fish at sea has not been favoured economically in this Province. Several previous Annual Reports have described the results of experiments conducted by this Station to ascertain the comparative taste appeal of certain British Columbia fishes (e.g. halibut, salmon, cod) that had been packed only in crushed ice for different periods up to 12 days after catch, of fish that had been frozen within a few hours after being caught and then stored frozen for various periods, and of fish that had been held for up to 8 days in ice before freezing and then stored. Various other holding and

freezing conditions commercially practised at the time were also investigated. The experiments with halibut were devised principally to determine effects of rapid versus slow freezing and of different cold storage temperatures, but advances in commercial freezing and cold storage techniques now make quite practical the maintenance of high quality in frozen fish providing that the quality of the fish was excellent when freezing took place. Some of the objects of the experiments mentioned have therefore been realized. However, it seemed desirable to ascertain, at least from an experimental standpoint, the consumer appeal of samples of local commercial species of fish frozen at sea as compared with samples of the same species caught at the same time but carried packed in ice in the usual commercial manner.

When those earlier investigations were conducted, there was no local vessel available with holds equipped for experimental freezing of fish representative of those caught on distant fishing grounds. Experiments were limited to nearby-caught fish that could be frozen at the Station immediately after being landed, for comparison with similar fish from the same catch held unfrozen in ice at the Station.

Last year's Report described how an opportunity arose for the Station to conduct the desired experiments through the owners of a recently built 57-foot fishing vessel offering their collaboration. Unlike most fishing vessels of similar size on the British Columbia coast, the Tauranga was built with a metal hull, thereby necessitating insulation of the fish-carrying holds. When the Station was consulted on types and methods of insulation, the owners agreed to joint experiments not only with insulation, but also with mechanical equipment for freezing and refrigerated storage. As stated in that Report, the Station installed in the vessel a diesel-driven Freon-type refrigerator compressor operating two evaporator units, and made necessary alterations in the holds to provide forced refrigerated air circulation and additional insulation for the refrigerated hold. Insulated holds for ordinary storage in crushed ice are also available in the aft section of the vessel. The jacketed-space principle demonstrated over twenty years ago by two of the Board's eastern Stations was employed for the refrigerated compartments. This principle had been further developed by this Station and satisfactorily used in its previously reported experiments with a refrigerated railway car for transportation of fish and other perishable commodities (see page 41), and is being adopted to an increasing extent in cold storage plants.

The section of the hull refrigerated is approximately 14 by 14 feet. The inner steel sides of this portion of the vessel were thoroughly cleansed and coated with two courses of asphalt emulsion applied as a vapour barrier. The propeller shaft was suitably boxed in. Glass fibre insulation was used on the ceiling deckhead, walls and wing bulkheads of the hold, and against the engine bulkhead. With the exception of that on the ceiling, this insulation had a density of $4\frac{1}{2}$ lb. per cu. ft. The ceiling insulation density was $2\frac{1}{2}$ lb. per cu. ft. The floor was insulated with Rubatex averaging approximately 4 in. in thickness, all properly protected against traffic and sloped for drainage. The hold was fitted with an all-welded aluminum alloy jacket. Air passages through which the cooled air is circulated are $1\frac{1}{2}$ in. in depth. Starboard and port sections of the jacket are independent units. Air passages of the jacket on each side of the hold are connected to their respective fan and evaporator by means of a transition or radial duct in the wing bulkhead. With the exception of the area at the wing bulkheads and at the door, cooled circulating

air surrounds the storage space.

Following the trial trips made during the latter part of 1950, certain alterations to the equipment were considered desirable, as mentioned in the Report for that year (page 107). These changes were effected early in 1951. The original auxiliary diesel engine for driving the refrigerator compressor, 5-kilowatt electric generator and the water pump for the refrigerator condenser was replaced by a more robust two-cylinder diesel. The Freon-12 compressor was replaced by one of a sturdier type, the position of the two evaporators was altered, and certain other changes were made. Later, a well-insulated cabinet with rack compartment for blast freezing small quantities of fish was installed in one of the pens in the refrigerated hold.

Recording instruments were placed aboard the Tauranga for several of the trips made. Consistently low temperatures have been maintained in the hold of the vessel while temperatures approximating 36°F. were held in the ice pens.

A photograph of the Tauranga was reproduced on page 47 of the June, 1951 issue of Pacific Progress Reports. The subsequent issue, No.88 (October, 1951), showed a cut-away view of the interior to illustrate the positioning of the refrigeration facilities, and described the results of some of the 1951 trips. The owners' primary commercial interest was in trawling for flatfishes (sole, flounder, brill, and the like), but through the courtesy of the International (Pacific Halibut) Fisheries Commission the Station was able to authorize the retention of limited quantities of halibut for experimental purposes during the closed season for halibut.

Freezing of commercial catches of flatfish was shown to present some special problems due to the continued exuding of slime from such fish for several hours after death. The usual practice of packing in melting ice laves the fish and to some extent removes the post-mortem slime; when frozen soon after catching, the fish presented on landing an appearance that was unfamiliar, and to some extent unacceptable, to the trade. Experiments are being continued to ascertain a suitable stowing procedure that will convince buyers that despite unfamiliar appearance of such fish, the quality of the flesh itself may be improved by early chilling on board the fishing vessel. On the two most recent trips of the Tauranga, refrigeration of flatfish to about 29°-30°F., involving no general freezing but possibly some localized incipient freezing, led to enthusiastic reception by buyers.

To assist in the assessment of the consumer appeal of halibut and flatfish frozen soon after catching, as compared with similar fish caught on the same trip and iced according to usual procedure, the assistance of the tasting panel organized in 1950 to consist of some 75 families with a total of some 135 tasters has continued. In 1951, six landings of halibut and one landing of flatfish were so tested, and the results on halibut were summarized in the Pacific Progress Reports No.88 mentioned.

Observations to date indicate that shelf life of fish stored in ice under refrigerated conditions may be extended to 18 days or longer before off-flavours were detected. Fish which was stored under these conditions for 18 days was very palatable when cooked. Very little if any difference could be detected in the flavour of the frozen and iced halibut, the

preferences being on the basis of moisture content. From the investigation thus far there are two interesting observations which require further analysis and laboratory correlation. It appears obvious that the method of thawing hard-frozen halibut affects the "drip" and consequently the moisture of the cooked product. It is very difficult to distinguish properly frozen halibut, carefully thawed, from iced halibut of high quality. There is also evidence that halibut chilled and in rigor prior to freezing has greater palatability than halibut frozen prior to state of rigor, though the method of thawing also influenced the quality of this fish appreciably.

The number of individuals who have contributed toward this investigation are too numerous to mention individually, consequently this opportunity is taken of acknowledging the assistance of the tasters on the panel, the crew of the Tauranga, and of Mr. P. J. Schmidt and Mr. E. G. Baker of the Station staff in preparing and packaging of the fish for the tasting panel.

The interior of the mechanically refrigerated railway refrigerator car, on which final road tests by this Station were completed late in 1950 (Pacific Progress Reports No.86, April, 1951), was dismantled early this year by the Station's staff. In the course of dismantling, an examination of materials and structural features incorporated in our remodeling of the car was made to find how they had stood up to operating conditions encountered in the numerous road tests. At the time of construction, infiltration of moisture, compacting of insulation, and failure of the built-up floor were feared. None of these occurred. There was evidence of moisture on the floor, indicating that the defrost drainage arrangements were inadequate, but the cellular rubber insulation used on the floor as protection against such a contingency was unaffected. Present reports from both Canadian transcontinental railways indicate they are proceeding with the further development of mechanically refrigerated cars, employing the findings of this Station's work in that field.

Fish Canning

The successful canning of many types of fish depends on the removal of a certain proportion of its water content by some means prior to thermal processing. In some types of packs, such as sardines, anchovy, and herring, partial moisture removal is desirable for purely physical reasons of appearance and firmness. In others, such as cod and tuna, moisture removal reduces off-flavours, also discoloration caused by chemical activity, possibly including the "browning reaction" mentioned on page 36 and described more fully in the 1948 Annual Report. Among the many methods used for removing moisture from fish are: steam precooking, air drying, oil frying, infra-red drying and the patented Borg centrifugal process. Our experiments with such methods have shown that the best product is obtained with the above-mentioned types of fish if there is a shrink of approximately 25% by weight during this pretreatment. At that level the flesh reaches a point where no further moisture is released during processing, nor are the undesirable colour and flavour changes associated with the browning reaction as evident. The universal practice in B.C. canneries is to steam such fish in retorts or exhaust boxes, which gives up to 15% shrinkage; thus additional means must be used to give a further 10% shrinkage or inferior packs may result.

A new method which greatly simplifies moisture removal has been developed at this Station and gives up to the full 25% required shrinkage in one operation. Our proposal is to follow precooking by evacuating the retort containing the fish which are either in unsealed cans or whole on trays. In this way excess moisture immediately evaporates, cooling the fish to the reduced boiling point corresponding to the absolute pressure. The moisture removal will be uniform at all times since it depends only on the initial and final temperatures of the fish, both of which can be exactly controlled. An experimental model was built to test the process. It consisted of a small retort and a condenser attached to a two-stage water ejector to produce the desired vacuum. The equipment produced a vacuum of slightly better than 29.25 inches of mercury, corresponding to a temperature within the fish of 65°F.

Due to frequent requests for technical assistance on tuna canning the first application of the new process was on albacore tuna. The most serious problem has been a surface discoloration of the product and observations led us to suspect improper precooking as the cause. The canning procedure for tuna is to dress the fish; to precook in steam for about four hours at two pounds pressure; let stand about 24 hours to drain and cool; remove skin, bone and dark meat; then pack into cans, add oil and process. The precook is of great importance, its purpose being to remove excess water, natural oils and soluble substances from the fish. The time and temperature of precook have been arrived at by experience in the industry and are strictly controlled, but the draining or cooling which is also important is subject to weather conditions of temperature and humidity. In our tests the fish was given the standard precook in the experimental retort then cooled by the vacuum process. Tuna prepared in this way was ready for packing immediately and the canned product was of the highest quality. Besides the advantages of speed and uniformity, the process is advantageous in that the hot fish is rapidly cooled without exposure to air, thereby virtually eliminating oxidation.

Tuna was also canned by another method on the basis of this equipment. The raw fish was cleaned and packed in cans; these were placed inverted in the retort and given a 30-minute precook at two pounds pressure; then quickly cooled by vacuum as above. At this stage in the process the product is the same as the standard one and is finished in the same way.

This process for tuna was experimented with because machines have been developed for the skinning, boning and cleaning of raw tuna. Fish so prepared could be filled automatically by salmon filling machines, then precooked as described. In this way, tuna could be machine packed with a tremendous reduction of labour.

The canning of herring and similar fish such as pilchards and anchovies also lends itself to the use of vacuum processing. The present practice is to steam the filled cans inverted in retorts or exhaust boxes, then add tomato sauce. However, particularly in the latter case, the moisture removed is insufficient and the tomato sauce is greatly diluted by liquids exuded from the flesh. As a result, the appearance of the product is impaired, the flesh is darkened and the fish are soft and apt to break if the cans are handled roughly. Texture, flavour and appearance were much improved in samples which were retorted and then vacuum cooled. The flesh of herring canned

this way was firm and white and there was no dilution of the tomato sauce.

Specialty products from halibut and chum salmon were also prepared in this manner with favorable results. Whole fish were precooked, skinned and boned after vacuum cooling, then packed, solid in oil or flaked in jelly.

The application of this process in industry appears quite desirable and practical. Retorts now in use are built to withstand more severe stress from pressure than would result from evacuation, and the doors of many of them are so arranged that evacuation would assist the sealing mechanism. Steam, being available in all canneries, could be used to operate steam-jet ejectors to provide vacuum, or water ejectors could be used where suitable water supplies permit.

The processes described above were investigated by Messrs. Harrison and Roach of the Station's engineering staff, in consultation with the industries interested.

A canned seafood cocktail was developed in response to a commercial request. Scarcity of crabs at certain localities or seasons indicated the desirability of extending the utilization of some of the available crab meat further than is possible when it is canned alone. The ingredients chosen were crab, shrimp and flakes of gray cod, plus a cocktail sauce made up from one of various standard recipes. Preparation of the shellfish for canning followed usual practice, but the cod required special treatment. Whole cod were steamed for one hour at 2 lb. steam pressure (about 219°F.), then quickly cooled by evacuating the retort as described in a preceding paragraph; the flesh was then separated into flakes resembling crab body meat in colour and texture. The flesh ingredients were mixed in the proportion of 50% crab, 45% cod flakes and 5% shrimp, and faced with crab leg meat at the top and bottom when packed in No.1 "picnic" cans (211 x 400) for a 60-min. processing at 240°F. The sauce was filled hot (200°F.) into 3-ounce paste cans which were processed for 15 min. in boiling water and cooled rapidly. A can of the sauce nests into the lid of a can of the seafood ingredients and is fastened there, through labelling or other means, to give a neat-appearing finished package. This method yielded a complete seafood cocktail without incurring the unattractive appearance that sometimes results when sea foods are processed in contact with a sauce. A few experiments were also made on the preparation of a crab cocktail that could be held and sold in the frozen state. Great care is necessary in preparing the sauce, since freezing intensifies the flavour of some spices. A mild sauce added to fresh crabmeat and frozen, then slowly thawed later, made a very palatable cocktail. Commercial development of these products has been hindered by a scarcity of crabs.

Other canning investigations carried out by Messrs. Harrison, Lantz and Roach have included following up of work described in previous Reports. An article in Progress Reports No.87 (June, 1951) described assistance given to a firm that had been producing fresh crab meat and desired to engage in crab canning. Details of the procedures recommended were given in that article, and periodic checks on the satisfactoriness of the product have been made since November, 1950. Random sample cans from the commercial pack incubated at 98°F. showed no deterioration of the contents and the

entire production has been favourably received on the market. The use of ultra-violet light to assist in separating bits of shell and skeletal material from the crab flesh before packing was not entirely satisfactory during December, 1950, when the meat fluoresced almost as much as the shell. Since the middle of February, 1951, the difference in fluorescence has been satisfactory, but results are again being checked closely to ascertain whether the method will again become less effective during November and December of this year, possibly due to a seasonal change in the nature of the flesh.

The number of oysters considered undersized for the fresh trade has at times been sufficiently great to cause concern. Though the usual practice is to return these oysters to the grounds, the possibility of survival was doubtful and the practice in itself expensive. A company wishing to can some of the smaller oysters as a smoked product was given assistance in adapting methods published in 1934 and 1939 by this Board. A small tray-equipped experimental smoking tunnel was loaned by this Station to investigate the possibilities of operation. The oysters are hand shucked, washed in 10° salinometer brine and then steamed for 15 min. to reduce the moisture in the flesh. The smoking time was decreased to 2 hours and kiln temperature increased from 120°F. to 160°F. The oysters are packed in ½-lb. cans, 1 fluid ounce of cottonseed oil is added, and cans closed under vacuum. Processing is for 60 min. at 240°F. The product has been very satisfactory.

Considerable advice on both the layout of the plant and various aspects of the process was given to a small salmon cannery which started operating during the past summer, and a northern B.C. cannery received assistance in developing a minced salmon product using edible trimmings and tips. The product is marketed in cans. A canned, fried fish-cake product developed by a local company in collaboration with this Station as described in last year's Report and more fully in Progress Reports No.86 (April, 1951) sold so well during this year that the company plans to produce a much increased pack for 1952.

Fish Curing

Renewed interest and activity in the production of salt herring has resulted in a major investigation into means of its mechanization. In its years of importance as a fisheries product in B.C., salt herring was made profitable by cheap labour. If it is to be revived on a large scale, mechanization and increased efficiency must offset higher labour costs.

In reviewing work on the purely scientific aspects of herring salting by this Station and others in the period 1932-4, it was noted that herring cured entirely in nearly saturated brine should differ little from those cured by the present method of starting the curing in dry salt. It was proposed to apply these experimental findings to the problem by mechanically inducing circulation of brine through the herring and reconcentrating it externally. This would eliminate the heavy labour expenditure in "rousing" the fish to maintain the high brine strength required. It would also make it feasible to hold all fish submerged below the brine level. The floating of the herring is a problem now encountered. Furthermore, a more efficient utilization of salt may be possible as large surpluses are now used to ensure adequate distribution through the tank.

A laboratory model capable of producing about 200 lb. per batch was constructed and tested at the Station by Messrs. Harrison and Roach, and a summary of results obtained was published during the year in Pacific Progress Reports No.86 (April, 1951). The product of this equipment met with what few analytical standards are known and was judged satisfactory by men familiar with herring salting. The tests also showed that a uniform cure had been obtained throughout the tank.

Because of the success of these experiments, it was decided to conduct a test on a larger scale, to determine the feasibility of industrial application. A company engaged in herring salting let us equip one of their salting tanks (15-20 ton capacity) and agreed to provide fish at the earliest opportunity.

The laboratory model had been scaled to provide as much information as possible for eventual expansion to an industrial scale. The height of the model tank had been made the same as industrial tanks so that any adverse effects of pressure in compacting the fish, thereby impeding brine flow, would be known. As the test results had shown no such effect an industrial model should be equally successful provided the flow of brine is proportionally increased, kept at saturation, and distributed uniformly over and through the herring.

The design of the large scale equipment was based on a production of 15 tons per batch. From the laboratory tests the maximum rates of water loss and salt absorption had been determined, from which could be calculated the maximum salt solution rate required (approximately 1.5 lb. per min.). The salinity differential through the brine cycle was more or less arbitrarily set at 1^{0} salinometer (0.25% salt approx.). From this and the salt solution rate the brine flow required was calculated at 50 gal. per min. At the low head against which the pump must operate, a 2-inch, 1/6-h.p. circulating pump met with the requirements. For consideration of space and equipment cost, a fine salt trap as used in the model was omitted in the new equipment. In its place, the salt-separating cone in the reconcentrator was increased in size to give the same velocity at the top of the cone as the velocity in the trap, thereby giving the same salt particle depositing effect. In the trap the flow was about 1.25 gal. per min. and the cross-section area 80 sq. in. The new flow being 50 gal. per min., the cone diameter must be about 5 ft. to provide the same velocity.

In the model the salt solution rate had been about 2 lb. per hr. The new rate was 1.5 lb. per min. or 90 lb. per hr., giving a scale ratio of 45:1. A generally accepted index for scaling agitator systems is volume, maintaining equal power per unit volume. Therefore the reconcentrator agitation chamber must have a volume 45 times the 0.8 cu.ft. volume of the model agitator tank, or 360 cu.ft. A tank of diameter 4 ft. 6 in. and a depth of 4 ft. was provided by the company co-operating in the experiments. This was considered close enough to the calculated 5 ft. diameter required, and would provide a volume of 360 cu. ft. in the agitation chamber as calculated.

Twin 8-inch, four-blade turbine agitators, geometrically similar to the model agitator, were chosen as the most practical agitation arrangement,

as a simple belt drive from ¼-h.p. motors available to us could be used to rotate them at 450 r.p.m. This satisfied the power requirements according to the following reasoning. The model agitator was 6 inches in diameter and driven at 250 r.p.m. Applying the relation $P \propto n^3 d^5$

$$\frac{P_2}{P_1} = \frac{n_2^3 d_2^3}{n_1^3 d_1^3} = \left(\frac{8}{6}\right)^3 \left(\frac{45{\cdot}0}{2{\cdot}5{\cdot}0}\right)^5 = 24.8$$

The power of the pair of agitators is 49.6 times that of the model, being slightly greater than the scale ratio of 45:1. The calculated power per agitator is 0.1 h.p.

Distribution of brine over the surface of the tank is provided through a distributing trough from which weirs lead the brine between beams of a grill over the tank. The space between the beams in turn provides distribution of the brine over the openings in the grill.

The equipment was built and installed by this Station staff and the first large-scale test of the process has been made. The final product compared favourably with conventionally dry-salt-cured herring in appearance and analysis. The equipment met or exceeded design specifications. Within 4 hours of loading all brine in the system was at saturation, and was maintained at saturation for the legally-required 6-day duration of the curing period. No solid salt left the agitator at any time. Inconclusive but conservative estimates of salt usage in the process show a 20% saving over the conventional process. This full-scale trial was conducted so recently that comparative examination and analyses of the experimental product and of similar fish cured in the conventional manner are not yet completed. A typical analysis is:

	% Water	% Salt
Conventional process	49.7	9.7
Experimental process	48.3	11.4

Further tests will be carried out if the experimental pack meets with the approval of buyers in the Orient.

A sample of commercial dry-salted herring was submitted for analysis by a Vancouver firm in connection with the increasing negotiations with the Orient for B.C. dry-salt herring. Owing to a change in consumer demands, more critical consideration of the salt content is necessitated. The fish were segregated by sex and both groups were found to contain 49.4% water. The females contained 11.8% salt, the males 12.3%. The females averaged 0.20 lb. each, the males 0.19 lb.

Nutritive Value of Fish Tissues

Niacin (nicotinic acid) is an important member of the vitamin B-complex, apparently essential for the operation of many enzyme systems. Humans, dogs and pigs require dietary sources of niacin, its lack leading to pellagra.

In expansion of work commenced last year with whale liver tissue, the chemical method for the measurement of the B-vitamin niacin was adapted by Mr. Schmidt to the measure of its content in fish meals and other

fishery products. Factors involved in the reaction of cyanogen bromide (CNBr) with the vitamin were examined. Portions of suitable mixtures were maintained at three temperatures, sampled at various periods of time, and the colour then developed in each with metol (p-methylamino-phenol sulphate). Increasing temperature of reaction with CNBr caused a greater final colour development, and maximum intensity was reached in shorter time. Incubation at 40°C. for 20 minutes with CNBr was found to be the most desirable condition of those studied. The pH of the reacting mixture was found to be very important; it must be adjusted to 5 before addition of CNBr. Maintenance of this was accomplished by addition of a phosphate-citric acid buffer. The required concentration of CNBr was determined; 3 ml. of a 0.5M solution in a total volume of 25 ml. gave the maximum density of colour which remained constant on further addition of CNBr.

The amine used for colour development is important. Primary amines caused an immediate colour which was very unstable. Secondary amines caused a colour which was slower in developing but was more stable. Procaine hydrochloride was shown undesirable for the analysis of niacin in fish meal and fish solubles. Metol was satisfactory for this use; it required 60 minutes for maximum colour development, which colour was then stable a further 45 minutes.

Before application of this method of analysis, the niacin must be extracted from the material to be tested. Digestion with 5N sodium hydroxide produced a dark-coloured extract (except in the case of whale liver). Digestion with calcium hydroxide gave a lighter-coloured product containing fewer amine-reactive substances, as did digestion with 2N sulphuric acid. Digestion with a mixture of the enzymes papain and takadiastase, followed by further digestion with calcium hydroxide, gave a still lighter-coloured extract, with the additional advantage that the same extract could be used for the determination of other B-vitamins.

Dark pigments in these extracts interfere with the colorimetric test. Charcoal was found to be ineffective in decreasing sufficiently the colour (except with whale liver) and also caused a loss of niacin. Ammonium sulphate was unsatisfactory for decolorizing; but zinc hydroxide, precipitated *in situ*, gave good results.

The method adopted gave 99.5% recovery of a known amount of niacin added to herring meal. When this method was applied to the materials under investigation, condensed solubles from California sardines showed much the highest content of niacin:

Material	Niacin content (mg. per lb.)
Sardine solubles	119.3
Commercial B.C. herring meal	25.5
Sperm whale liver	13.7
Fresh whole herring	13.1
Herring press cake	8.7

Investigation of what is known to the trade as "chalky" halibut was resumed from last year, and results appeared in Pacific Progress Reports No.88 (October, 1951). In this further study by Dr. Bailey it was demonstrated that protein does substantially make up the balance of the composition of the halibut flesh after allowing for oil, water and mineral constituents. The results are summarized in the accompanying table.

Type of flesh	Protein %	Oil plus water %
Non-chalky	11.9 - 18.1	77.9 - 86.1
Moderately chalky	19.8 - 20.0	76.9 - 79.9
Very chalky	16.9 - 21.6	75.9 - 80.2

The content of mineral matter varied only between 1.14 and 1.48%. Hence these results suggest that chalkiness is due in some way to the observed variations in composition and possibly the effects of these on the transparency of the flesh. There is no evidence of lack of wholesomeness in the flesh of chalky halibut; actually the food value in terms of calories per pound is greater in the chalky than in the non-chalky flesh.

Analyses were made to provide additional information for the chart of "Nutritive Values of B.C. Fishery Products", which appeared in Pacific Progress Reports No.53 (1942). Among other results, glycogen was shown to be absent in the flesh of fresh halibut, herring, smelts, and skate. Two skate wings were found to contain 80.6 and 81.9% water, 19.44 and 18.0% protein, and 0.32 and 0.29% oil.

Other analyses of fish tissues are given in appropriate sections of this Report.

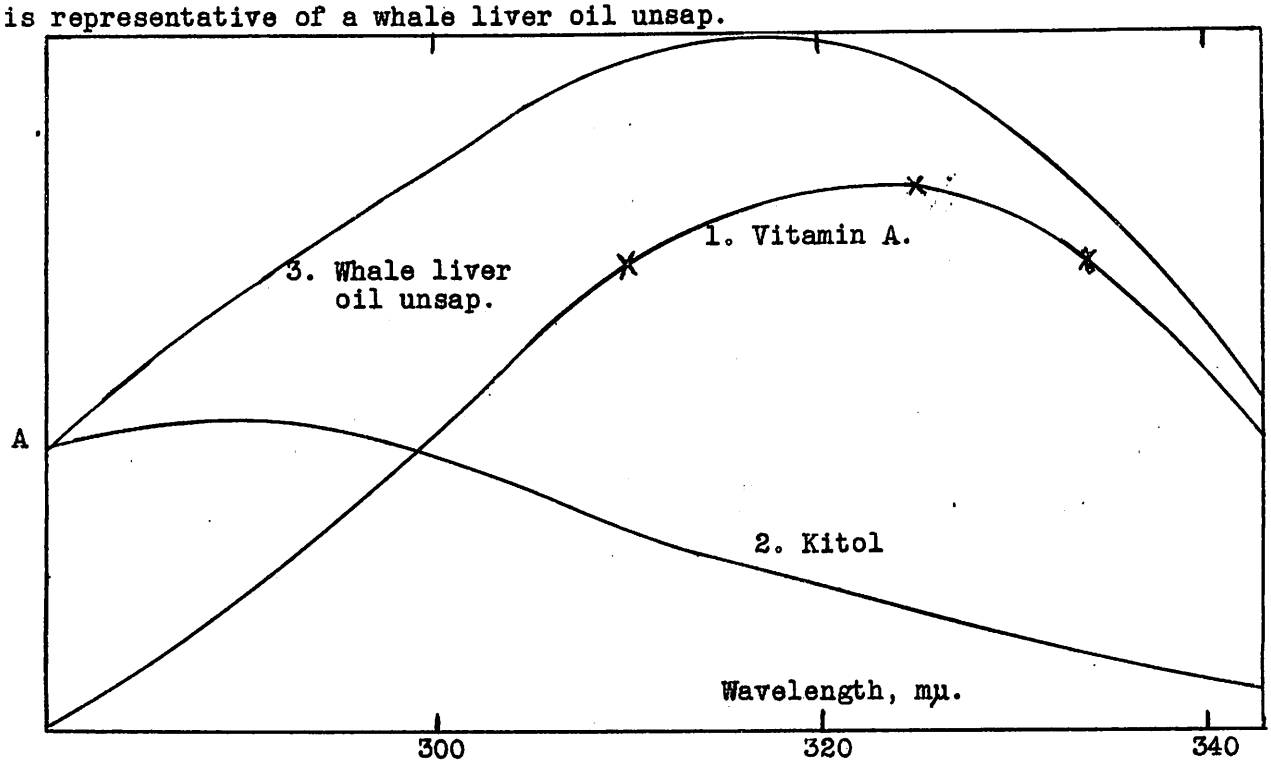
Through request of the Vancouver office of the National Research Council's Technical Information Service, a sample of salmon fish paste manufactured by a Vancouver Island firm was analyzed and found to contain 37.1% oil, 38.1% moisture and 3.8% sodium chloride. The firm was also interested in the use of sodium nitrite as a preservative to be added during the brining process. Suggestions for suitable practical experiments were given to assist the firm to determine in its plant a suitable combination of nitrite concentration in the brine and duration of brining, without incurring risk of exceeding the legal limit of 200 p.p.m. of sodium nitrite allowed as preservative in a finished product. These experiments were controlled through analyses made on sides of the brined salmon supplied for testing. A nitrite content of about 15 p.p.m. was found, well below the legal limit, and the firm was advised accordingly.

Fish and Whale Oils (including Vitamin A)

Whale liver oil has become an important source of vitamin A on this coast but, unfortunately, this oil may contain varying amounts of kitol. Kitol is a substance recently identified, the structure of which is essentially that of two molecules of vitamin A combined together. It can be partially converted to vitamin A by heat, but apparently not in the

metabolism of animals studied. It interferes seriously with the assay for vitamin A by the ultraviolet absorption method, necessitating a very large correction factor in the equation given in the U.S.P.XIV for calculating vitamin A potency.

In the accompanying idealized graph are shown the absorption curves (1) due to vitamin A, (2) due to kitol, and (3) that would result from a mixture of these, each at the same concentration as above. Curve 3, then, is representative of a whale liver oil unsap.



It is apparent that the absorption at 325 mμ of the unsap of an oil is only partially due to vitamin A, and this fraction is the correction factor that must be applied to a measurement of the vitamin A potency of the oil by the ultraviolet absorption method. This correction may be calculated by measuring the ultraviolet absorption of the unsap of the oil at three wavelengths, namely 310, 325 and 334 mμ, and substituting these values into an equation. The resulting vitamin A potency of the whale oil may be only a small portion of the value calculated directly from a measurement at 325 mμ (the older method). In addition to this misfortune to the whale liver oil industry, there seems to be an antipathy of buyers to an oil which has such a big correction factor.

Molecular distillation carried out last year by Dr. Swain resulted, as has been shown by others, in a concentration of a purer vitamin A and in an increased quantity of vitamin A due to its production by decomposition of kitol through heating. This year further work was done by Dr. Swain on the separation of kitol and vitamin A by solvent partition experiments and by chromatographic techniques, with some degree of success.

Extraction of whale liver oil with liquid Rock Gas (butane) at -25°C. did not separate kitol and vitamin A, as measured by the ultraviolet absorption curves of the soluble and extracted fractions. Extraction of oil

with six different concentrations of aqueous ethanol, and similar extractions of the unsap of this oil, were not successful in achieving a separation.

Some of the same sample of oil was refluxed with methanol at 70°C. in the presence of potassium hydroxide as catalyst. The product, consisting of methyl esters of the fatty acids in the oil and of the free (alcoholic) form of vitamin A (and presumably of most of the remaining unsap), was extracted with 50% aqueous methanol. Ultraviolet absorption curves indicated some degree of separation, but vitamin A was present in both phases. Chromatographic adsorption of the oil on alumina, the adsorptive strength of which had been decreased by shaking with 10% its weight of water, resulted in removal of some kitol from the vitamin A, as evidenced by the peak at 290 mμ of the alcohol eluate. However, the absorption curve of the vitamin A fraction (eluted by light petroleum) was still somewhat displaced, indicating kitol was still present in that fraction. A similar partial separation was achieved with alumina activated by heating.

The effectiveness of a column of activated alumina in separating vitamin A ester from vitamin A alcohol in whale liver oil, by adsorption from light petroleum and elution with ethyl ether, was shown to be satisfactory, especially when the vitamin A alcohol determinations were corrected for the presence of kitol by application of the U.S.P. formula for vitamin A determination.

The present importance of cholesterol in the manufacture of synthetic vitamin D, its possible importance as a point of departure in the synthesis of cortisone, and the waning importance of halibut liver oil as a source of natural vitamin A (due to availability of synthetic vitamin A), all make this oil worthy of renewed consideration as a source of cholesterol. The possibility of securing it by alcoholysis of the oil followed by chromatographic separation of the product was investigated, and a preliminary report of its successful recovery appears in Progress Reports No.88 (October, 1951). Although little factual information is available regarding the potential quantity of cholesterol from this source, it may be estimated that some 3500 pounds are contained in the liver oil of an annual landing of Pacific halibut in British Columbia. At the present time this would have a value of some $30,000.

Optimal conditions of the alcoholysis reaction for splitting cholesterol esters, and of the colorimetric Lielbermann-Burchard reaction for determination of cholesterol, were determined. In the ethyl ether eluate from a column of activated alumina to which treated halibut liver oil had been added, 90% of the cholesterol originally in the oil was recovered. This was accompanied by about half its weight of other materials, including vitamin A. Crystallization of this product from a suitable solvent will yield a fairly pure cholesterol and a concentrate of the vitamin A originally present in the oil.

Two samples of oil from Hudson Bay beluga, one from the head and one from the blubber and skin, were examined at the request of the Chief Supervisor of Fisheries in Winnipeg. Chemical analyses were made, and viscosities were measured at several temperatures in comparison with those of a BA lubricating oil 5-W, kindly provided by the local office of the British-American Oil Company. The head oil was very similar in viscosity to this

lubricating oil, the blubber oil slightly more viscous.

A local firm was experiencing difficulty in producing a clear ratfish liver oil. It was demonstrated that this could readily be accomplished by cooking the livers in boiling water and draining the product through double cheesecloth.

The fat-like material found periodically in Bute Inlet in cold winter months, and which was examined last year (1950 Annual Report, pp.115-116; Pacific Progress Reports No.86, April, 1951), appeared again during the winter of 1950-51. Although this material has not been identified as having any connection with fish or whale origin, the further work done this year by Dr. Swain in determining its composition is conveniently reported in this section on oils. A large new sample was received through the kindness of the Pacific Oceanographic Group. Its analysis has confirmed the conclusions arrived at last year. It may be considered to be docosenyl palmitate (C_{22} mono-unsaturated alcohol combined with C_{16} saturated fatty acid), containing also esters of several fatty acids both smaller and larger than palmitic acid, and with some degree of unsaturation. Only 0.49% glycerol can be determined in its saponification products, indicating almost complete lack of glycerides (true fats) in the wax. There is present a saturated hydrocarbon to the extent of 3% of the wax. Docosanol (C_{22} saturated alcohol) has been demonstrated in the unsap of the hydrogenated wax. The similarity in properties of the seed wax of the plant Simmondsia (described elsewhere by other workers) to those of this wax led to examination of the acetone extract prepared from seeds of Simmondsia chinensis kindly provided by Mr. P. A. Munz, Rancho Santa Ana Botanic Garden, California. The similarity was, in general, confirmed. However, the fatty acids of the Bute Inlet wax were shorter in C-chain length and more saturated. Examination of a sample of the wax for its radioactive C_{14} content, through the courtesy of Dr. H. R. Crane at the University of Michigan, indicated the wax to be of contemporary origin. Continued observations by Mr. L. Parker, one of the few residents of Bute Inlet and who has supplied much information of interest, have led him to doubt his earlier impressions that the wax arose from the bottom of the inlet. The origin of the wax remains a mystery. One possibility lies in the facts (1) that forest surveys have shown the greatest concentration of lodge-pole pine on the Canadian west coast exists around Bute Inlet; (2) that large quantities of pollen identified as from the lodge-pole pine have been observed in Bute Inlet, and (3) that a sample of one such deposit has yielded a small amount of oily material with properties somewhat similar to those described above. It is, however, difficult to entertain the possibility of such an origin in view of the reports that "tons" of the wax have been observed at one time in the inlet.

Poultry Feeding Value of B.C. Herring Meal and Condensed Fish Solubles

This investigation commenced several years ago at first consisted of a few random determinations of essential amino acids and, later, of vitamin B_{12} in fish meals and fish solubles. During the past year it has grown to one of major importance, partly as a result of the interest of the fishing industry prompted by the economic considerations outlined in last year's Annual Report (pp.111-113).

From its inception this investigation was planned with a view to establishing the conditions necessary for the production in general of fish meals and solubles of the highest possible nutritive value for livestock. It was realized that, although considerable information was already available concerning these conditions, there were many points which required new or at least more detailed investigation. The need for a more scientific standardization of these products in keeping with modern trends in our knowledge of the exact nutritional requirements of livestock has become increasingly evident.

Since the latter part of 1950, the programme has been concerned primarily with British Columbia herring meal, which is a product of major economic importance. The relation of the conditions used in production of these meals and the influence of seasonal variations in the raw material to their nutritive value is being determined (Pacific Progress Reports No.85, December, 1950). In view of the more modern concept of what constitutes nutritive value, the following analyses are being carried out by Dr. Tarr and his associates: (1) a determination of their comparative growth-promoting property for young chicks when the meals constitute a major portion (up to 21%) of the protein intake; (2) a study of the value of these meals as suppliers of as yet uncharacterized factors of the "Animal Protein Factor" (A.P.F.) complex; (3) the influence of fat extraction on the nutritive value for chicks of meals subjected to moderate or intense heating; (4) determination of the available essential amino acid content of the meals, and (5) microbiological determination of vitamin B_{12}.

In November, 1950 and in February, 1951 "ideal" herring meals were prepared from industrial herring press cake by air-flow drying at 100° to 110°F. At the same time typical high quality (light coloured) industrial meals were secured, though it was not possible at the time to ensure that these came from identical raw material. Portions of these ideal meals were subjected in different instances to heating for ½-, 1-, 2- or 3-hour periods at 300°F. using a heated rotating stainless steel drum. It was realized that this apparatus did not duplicate conditions in commercial flame driers, but no other equipment was then available.

Arrangements were made between the Fisheries Research Board and the Poultry Nutrition Laboratory of the University of British Columbia whereby all biological assays of these meals, using chicks, are being carried out under direction of Professor J. Biely and B. March. In the early stages of the work a positive "protein control" ration was formulated using corn, casein and gelatin supplemented with dl-methionine and dl-tryptophane as protein source. Initial assays were then carried out using an industrial February, 1950 meal which was then the only material available. These tests showed that better chick growth resulted in all instances when rations were formulated using mixtures of soybean meal and the herring meal in different proportions than when either was used alone as the sole supplementary protein. The reason for this has not been determined.

When the low temperature meals became available it was found that they usually, but not invariably, supported chick growth better when fed at a 20% protein level, than did commercial meals selected at the same season. However, strict comparison could not be made due to the fact that

the raw materials used in the preparation of these meals were not identical. In further biological tests it was found that heating the ideal meals for half an hour or for one hour did not impair their nutritive value. On the contrary there was in most experiments an apparent enhancement in nutritive value. This effect will require a more thorough examination to determine its significance. It has been suggested that heating the low temperature meals may inactivate chick growth inhibiting factors such as the vitamin B_1-destroying enzyme thiaminase, thus occasioning an apparent increase in nutritive value. This point will be investigated. Meals heated for 3 hours at 300°F. had their nutritive value very seriously impaired by this treatment. It was evident from these results that, with the method of heating employed, impairment in nutritive value of the fish protein commenced after the 1-hour heating period. The addition of the essential amino acid lysine to the 3-hour heated meals did not improve their growth-promoting properties.

A further experiment was carried out in which samples of the November, 1950 ideal meal were heated without extracting the 7.6% fat present, and after it had been extracted with hexane to about 0.2% fat content. The results obtained when these meals were fed to chicks indicated that the 1-hour heating had no important effect on the nutritive value of either meal. There was a noticeable depression in the growth of chicks fed the oil-containing meal that had been heated for 2 hours, but this differential disappeared after 3 hours' heating, when extremely poor growth was obtained with both meals. Since there was in both instances a very sharp decline in nutritive value between the 1- and 3-hour heating periods, it is possible that slight unavoidable differences in heating conditions were responsible. Further experiments will be required to check this point. Three-hour heating undoubtedly rendered the proteins of both meals relatively unavailable as will appear from following data regarding available essential amino acids.

Attempts are being made to ascertain how the nutritive value of commercial meals may be enhanced. Experiments have shown that a mixed vitamin supplement which included thiamine, pyridoxine, inositol, menadione, para-amino benzoic acid, alpha-tocopherol and folic acid improved the nutritional quality of a commercial fish meal so that it supported chick growth as well as did the ideal meals. Further tests indicated that at least part of the difference in growth response normally found between ideal and commercial meals might be due to a folic acid deficiency. Inclusion of an antibiotic (aureomycin) in the commercial fish meal ration had the same effect as the mixed vitamin supplement. When rations containing fish meal and soybean meal in a ratio of 1:2 on a protein basis were fed, it was found that ideal and commercial meals caused an almost identical growth response. This test indicated that with the amount of fish meal fed in normal chick starter rations, the rather exaggerated differences which may appear between ideal and commercial meals when fed at about 20% protein level may no longer be apparent.

A comprehensive analysis for eleven amino acids, most of which are considered indispensable for the chick, has been conducted by Miss Bissett on all the commercial and specially prepared herring meals used in these experiments. In an attempt to correlate the amino acid data with the results obtained in the chick biological assays, two techniques have been used; one involved chemical hydrolysis to give the total amino acid content, the other employed enzyme hydrolysis which is conceded to show the amino

acid content actually available to the chick. It was first found that the distribution of the essential amino acids lysine, arginine and methionine in whole herring and press cake was very similar to that in the ideal meal prepared from similar material. With the commercial meals, the ideal meals, and the latter after heating for ½ or 1 hour, the available amino acid content was usually about two-thirds or more of the total amino acid content. On the other hand, with the ideal meals heated for 3 hours only about one-fifth to one-tenth of the total amino acids was still available. The following figures, found in the case of the November, 1950 ideal meal, are typical. The figures are in grams per 16 grams of nitrogen, which is roughly equivalent to percent of the total protein of the meal.

Amino acid	Ideal meal unheated		Ideal meal heated 3 hours at 300°F.	
	Total	Available	Total	Available
Arginine	11.3	8.3	6.5	2.3
Histidine	2.8	1.8	2.2	0.2
Isoleucine	4.9	4.1	4.4	0.9
Leucine	7.6	8.0	7.0	0.8
Lysine	11.8	7.7	10.5	1.1
Methionine	3.1	2.6	2.6	0.9
Phenylalanine	3.7	3.6	3.9	0.35
Threonine	4.1	2.4	6.8	0.26
Tyrosine	2.8	3.1	2.6	0.4
Tryptophane	1.5	2.0	0.6	0.18
Valine	5.3	3.5	5.5	0.4

These results indicate that a fairly prolonged and severe heating is necessary in order to seriously affect the amino acid availability of fish meal. They also explain in part why lysine supplementation alone did not improve the nutritive value of the 3-hour heated ideal meal. Amino acid analyses of the unheated and heated solvent extracted meals are now in progress, and in these, as in further assays which are planned, it is intended merely to use the available lysine and possibly tryptophane or methionine content as an index of heat damage.

The microbiological determination of vitamin B_{12} in the various fish meals has been carried out by Miss Southcott and by Dr. Tarr. It was realized at the outset that the problem was not entirely straightforward since no standard method was available. Moreover, quite different methods of extraction from the raw material and of treatment of the extracts for assay had been used by various investigators. The problem was therefore conducted as much with the intention of evolving a standard, rapid and reproducible technique, as with the idea of solely determining the vitamin.

The tube turbidimetric microbiological assay procedure which has been adopted by this Station was used throughout. Whole herring, press cake, press liquor (stickwater), ideal herring meal unheated and heated for ½, 1 and 3 hours, and a commercial meal, were analyzed exhaustively. Three methods of extraction of the vitamin were used, (1) autoclaving for 30

minutes at 120°C., (2) digestion with Mylase P (a mould enzyme) and (3) digestion with papain activated with cysteine. The filtered extracts were suitably diluted and assayed, and the whole procedure was repeated so that at least two, and in many instances three, assay results were obtained for each sample. Since chromatography of these extracts had shown that they usually contain quite a large proportion of vitamin B_{12a} (or similar form chromatographically), and evidence has been obtained indicating that this form is liable to serious destruction during assay by the turbidimetric procedure used, two modified forms of assay were employed. In one the extracts wereadded to the medium prior to sterilization, and in the other they were sterilized separately and added to the previously sterilized assay medium.

The results of this experiment were very disappointing. There was in general a fair agreement in the results obtained with the whole herring, press cake and stickwater, and in these the two assay modifications yielded somewhat similar results. On the other hand, with the fish meals there was by no means a consistent agreement, and results often varied very markedly. In extreme instances assay results varied by about 100% to 400%. With all samples of fish meals the assay results were almost invariably higher when the aseptic addition technique was followed, and usually enzyme hydrolysis gave higher apparent recoveries of the vitamin.

There seemed little doubt from these results that under certain conditions either more vitamin B_{12} was being liberated, or, what seemed more probable, substances which possessed vitamin B_{12} activity in the assay procedure, but which were not really the vitamin itself, were being formed during extraction. This point is now being exhaustively investigated, and is involving recovery experiments in which known amounts of crystalline vitamin B_{12} or B_{12a} are added to the fish meals, followed by cyanide treatment of the extracts to convert the vitamin to the more stable cyano form, and assay of the extracts both directly and after chromatographic separation of the vitamin. In this work cyanide treatment is being used because during paper chromatography cyano cobalamine moves more rapidly from the point of application than do the other forms of vitamin B_{12} and can thus be readily located, eluted and assayed. Also, the results can be expressed directly as vitamin B_{12}. The outcome of this work is by no means complete, but it has been definitely established that there is not always good agreement between the direct assay result and that obtained after chromatographic separation, and this is more especially true of extracts obtained by enzyme hydrolysis. In general, chromatographic results indicated that both the unheated ideal and commercial herring meals contained from 300 to 400 mμg. of vitamin B_{12} per gram (1.35 to 1.7 mg. per pound). In one instance a papain hydrolysate of a sample of an ideal meal had an apparent vitamin B_{12} content of 930 mμg. per gram, but chromatographic separation and elution gave a recovery of only 310 mμg. per gram. It is interesting to note that these vitamin B_{12}-active substances are largely alkali labile, and are therefore apparently not deoxyribonucleic acid, or the nucleotides or nucleosides which are formed during its hydrolysis. It has been found that during papain hydrolysis of fish meals the apparent vitamin B_{12} content as determined by direct assay increases very markedly.

By both direct assay, and to some extent by chromatography, elution and re-assay, it was established that the vitamin B_{12} content of the ideal meals decreased progressively during heating, and in the 3-hour heated meals

only about 25% of the original amount remained. This held true for both the original and the fat-extracted meals.

In work expected to commence shortly, it is intended to prepare ideal meals from the same lot of herring press cake which is also to be used in making a normal flame-dried meal and flame-dried meals overheated to variable degrees under industrial conditions. By conducting chick and microbiological assays of these meals according to the plan followed in the above work, it is hoped that the critical heating conditions which may lead to impairment in nutritive value of meals made under some commercial conditions may be determined. An outline of the proposed programme has been prepared and submitted to a committee consisting of Dr. C.R. Elsey and Mr. N.L. Armstrong (B.C. Packers, Ltd.), Mr. G.F. Boothby (Canadian Fishing Co.), Dr. N.M. Carter and Dr. H.L.A. Tarr.

The work on herring meals has been made possible through the full collaboration of the fishing companies who have not only prepared the required meals but have carried out detailed analyses of these meals for protein, fat, calcium, moisture and ash.

Microbiological Formation of Vitamin B_{12} in Fish Waste Products

Vitamin B_{12} has been recognized as an important factor in the A.P.F. complex since its isolation as a crystalline entity in 1948. Work which was commenced that same year at this Station established that this vitamin was widely distributed, and often in significant amounts, in many fish tissues, more especially in the viscera. Subsequently it has been shown that many marine invertebrates are a good source of the vitamin (page 40). At the present time the important protein by-products of the fishing industry, namely fish meals and condensed fish solubles, are undoubtedly valued to some extent on their vitamin B_{12} content. The distribution of this vitamin in these products is inclined to vary, and for this reason a study of the conditions necessary for increasing the amount present by simple microbiological fermentation was undertaken by Dr. Tarr.

A number of bacteria which are known to form vitamin B_{12} are available, but these are generally types which generate very unpleasant odours when cultured in fish wastes. However, many of the mould-like Streptomyces organisms which are used to produce antibiotics were found to grow readily in fishery materials including fish solubles (stickwater) formed during fish meal manufacture. Moreover, the odours formed in such cultures were not unpleasant.

In preliminary studies Streptomyces aureofaciens and five strains of S. griseus were grown in aerated herring stickwater, which was preferably diluted somewhat with water to facilitate vitamin B_{12} formation. In different experiments aeration was achieved either by use of a standard shaking machine or by aeration with sterile air. The investigation was complicated in the early stages by difficulties encountered in microbiological assays for vitamin B_{12}; the results obtained by two very different assay procedures rarely agreed. Moreover, as previously mentioned, it was found by chromatographic procedure that most of the vitamin occurred as B_{12a} which is subjected to serious destruction in the tube turbidimetric assay procedure employed. Highest apparent vitamin B_{12} recovery was obtained by

chromatographic separation of the vitamin, elution and microbiological assay of the eluates by aseptic addition to previously sterilized assay medium in order to avoid destruction of vitamin B_{12a}. It was found that a 4- to 5-day fermentation of herring stickwater containing 2 p.p.m. of added cobalt caused a 20- to 50-fold increase in the initial natural vitamin B_{12} content. The yield of vitamin B_{12} was usually about 10 mg. per pound, calculated on the basis of a 50% moisture content as is usually found in condensed fish solubles. Normally good quality condensed fish solubles assayed at this Station have had not more than 0.2 to 0.25 mg. of vitamin B_{12} per pound, and frequently considerably less than this.

Some of the more fundamental aspects of the problem of vitamin B_{12} formation are being investigated with a view to eventually improving yields of the vitamin. One important known degradation product of the vitamin B_{12} molecule, namely 5,6-dimethylbenziminazole, has been synthesized, as has the closely related 1,2-dimethyl-4,5-diaminobenzene. So far the addition of these compounds (1 to 10 µg. per ml.) to a simple medium containing inorganic salts (including cobalt), asparagine and pentose sugar in small amounts has neither enhanced nor depressed the yield of vitamin B_{12}. Complex protein fish substrates such as muscle, meal, peptone and kidney all support vitamin B_{12} formation, but there has been no apparent relation between the initial natural concentration of the vitamin in these substrates and the amount formed on fermentation.

In completion of work for a Master's thesis at the University of B.C., Mr. Maxwell made vitamin B_{12} determinations on the tissues of eight more species of B.C. marine invertebrates, to supplement the determinations made and reported last year on seventeen species. The additional assays were principally on mollusca, and showed that in general the B_{12} content (averaging about 1500 millimicrograms per gram of dry tissue) is higher in this phylum than in the representative species of other phyla investigated.

Some more detailed data (not necessarily intended for publication) on vitamin B_{12} fishery by-products are given in appended Investigators' Summaries.

Use of Other Fishery Products for Feeds or Fertilizer

In Pacific Progress Reports No.78 (October, 1948) it was suggested that the trimmings and offal from the processing of freshwater fish in the central regions of Canada should be utilized as fish meal, and various methods of meal manufacture were outlined. Considerable interest was evidenced in this information, and assistance was given later in designing simple inexpensive equipment suited to the circumstances under which much of freshwater fishery takes place. This year Messrs. Bailey, Lantz and Schmidt followed up the interest in small-scale batch processing by conducting experiments on pressing and drying procedures (Pacific Progress Reports No.88, October, 1951). The process consisted of cooking the fish or fish waste in an open barrel with steam, pressing with a hydraulic press, and drying the press cakes by simply placing them on open racks, without any artificial means of drying. A pilot-plant-scale hydraulic press was constructed, using a 12-ton jack as the pressure unit.

In preliminary experiments which were carried out using this press, it was found that press cakes prepared by pressing cooked whole fish (fine-scale suckers) on this press, would dry in a few days to a hard consistency when placed on open racks in a room at 60° to 70°F. No spoilage took place during drying. The time of drying was inversely proportional to the thickness of the press cake but was not greatly affected by the time of pressing, as long as the pressing was continued until liquid had stopped dripping freely from the pan of the press. Burlap sacking proved to be a more satisfactory press-cloth material than canvas.

In the above experiments, fish from a northern B.C. lake were used for convenience. For purposes of relating feed values of the meal to the composition of the raw materials, the following proximate analyses were made:

Species	Protein,%	Moisture,%	Fat %	Ash %
Fine-scaled sucker, Catostomus catostomus	16.8	75.8	4.90	3.98
Coarse-scaled sucker, C. macrocheilus	16.1	76.7	3.87	4.46
Peamouth chub, Mylocheilus caurinus	16.4	76.9	3.51	4.45
Squawfish, Ptychocheilus oregonensis	19.1	73.3	3.82	3.94

In the feeding of fur-bearing animals it is very important to know the protein and oil contents, and the calorific values, of the feeding materials. To assist the industry in marketing fish wastes as fur-farm feeds, the determination of water, protein and oil contents, and the calculation therefrom of calorific values, of a large number of fish-waste materials was undertaken. Separate determinations are being made on the milt, roe, livers, kidneys and digestive tracts of different species of salmon, and on the filleting wastes from a number of different fishes. The moisture, protein and oil determinations have been completed to date on forty individual samples.

The proximate analysis of a sample of tuna waste, consisting largely of brown meat with no viscera, was made for a local firm. The sample contained 30.8% protein, 56.6% moisture and 8.2% fat.

Analysis of a commercial fish hatchery feed ("Fish Flake") was made at the request of the B.C. Game Commission. It contained 5.56% moisture, 35.2% protein, 5.01% fat and 47.2% carbohydrate, yielded a residue of 7.04% on ashing, and was calculated to contain 1726 calories per pound.

An investigation of the nutritional value of lyophilized (freeze-dried) whale liver was reported last year. This year proximate analyses were made of twenty whale livers, and their niacin contents determined. A summary of the results is shown as follows:

Species	No. of livers assayed	Average protein %	Average moisture %	Average fat %	Average ash %	Average niacin mg.per 100gm.
Finback	8	19.5	74.2	5.24	1.14	7.0
Humpback	5	19.0	74.3	5.55	1.14	7.7
Sperm	7	22.7	73.4	2.41	0.95	4.4

At the suggestion of this Station, a local company handling miscellaneous fish products undertook the bottling and distribution of condensed fish solubles for use as a liquid fertilizer. Considerable advice and assistance were given about various problems in connection with the project. Tests were made on its fertilizing effect compared with that of a commercial liquid "Fish fertilizer" and compared with a negative control, using lettuce, radishes and spinach. All were grown from seed, in boxes of earth on the roof of the Station. Both the commercial liquid fertilizer and the condensed fish solubles were used in a 1:320 dilution with water. This approximated the dilution recommended for the commercial fertilizer (1 tablespoonful to 1 gallon of water). Growth of all the plants in each of the fertilized boxes was markedly better than that of the plants in the negative control box. There was no noticeable difference between the growth of the plants fertilized with the commercial preparation and with the condensed fish solubles. A test was made to see if the condensed solubles had a corrosive effect on tinplate. No corrosion was noticed after one month.

A local company drying and grinding salmon roes for use as fish-hatchery food experienced considerable difficulty in grinding roes which had been dried directly in a drying tunnel. At their request methods of producing a dried product which would grind more readily were investigated. Experiments showed that the dried roe could be ground with less difficulty when it had been precooked, by either steaming or direct cooking over gas before drying at 105°C. in a hot air oven. Precooking followed by partial drying at 105°C. and completion of the drying at 70°C. still further improved the grinding properties. Mincing together five parts of the salmon roe with three parts of salmon milt and three parts of salmon liver before drying yielded a dried product which ground better than the dried roes alone.

Miscellaneous

The Maillard Reaction in Canning of Fish. Some two years ago an investigation was undertaken with the object of determining the cause of the brown discolorations and acrid flavours which frequently occur when white fleshed and certain other fish are heat processed as in canning. It was found that reactions of the type occasioning the so-called "non-enzymic browning" or "Maillard" reaction in foods were responsible, and a scientific paper dealing with the experimental details of the investigation was published. Due to pressure of other work the investigation was temporarily suspended, but during the past year Dr. Tarr had the opportunity to carry out some additional observations. During a holiday visit to Terminal Island, California, some samples of skipjack tuna were collected at different stages in a projected modified process for canning tuna. These were promptly frozen and kept in this

condition until analyzed. It was found that when small samples of the raw or precooked flesh were heated for one hour at 248°F. a very pronounced brown discoloration occurred, accompanied by simultaneous development of a rather "caramelized" flavour. Chemical examination of the cooked flesh and of the "cooker juice" which was extracted during the cooking of the loins indicated that they contained a significant concentration of pentose sugar. On a dry weight basis the cooker juice contained 37%, and the cooked flesh over 0.7% of pentose sugar. Since pentoses have been found to occasion pronounced browning when added to dialyzed fish muscle which is subsequently heated, it is suggested that the natural pentose content of fish muscle may be largely responsible for non-enzymic browning. This suggestion will be tested in further experiments.

Shrimp Sorting Machine. The shrimp sorting machine described in Pacific Progress Reports No.79 (July, 1949) was again loaned for tests under commercial operating conditions. It proved satisfactory for washing and eliminating undersized shrimp and in doing so, both increased the amount of shrimp peeled per worker and decreased the amount of commercially usable shrimp discarded. On returning the sorter, the company requested a design for a similar machine adaptable to its plant. A two-cylinder sorter to grade the shrimp in two usable sizes and reject the undersized ones was designed and is now being built commercially. Many enquiries about the equipment are received; the latest being from a Fishermen's Co-operative Association in Texas.

Utilization of Fish Scales. Experiments on the use of herring-scale carbon for decolorizing were described in 1947 and 1949 Reports. During this year it was shown that herring-scale carbon prepared from herring scales soaked in a saturated calcium chloride solution was a very active adsorbent for ammonia. Since ammonia has an intense odour, and is related chemically to the amines which are a cause of putrid odours, it follows that the adsorbent so prepared should be effective for removing foul odours. In view of the known ability of calcium chloride to combine with ammonia, further tests are necessary to determine to what extent the activity of the carbon may augment the action of the calcium chloride present.

"Ambergris" Identification. As usual, a number of samples of material were submitted to the Station in hopes that they were ambergris and, as usual, they were found to be not ambergris. This year samples were received from Hawaii, California, Washington State, Newfoundland and several British Columbia coastal points as far north as the Queen Charlotte Islands. The actual nature of the materials submitted is not always determinable but a wide and curious variety of substances are received. One recently submitted sample proved to be merely a jellyfish of the species Cyanea capillata.

Analysis of Water for Poison. The death of a larger than usual number of salmon in the Kitsault River, northern B.C., raised the suspicion that cyanide from a closely adjacent smelter was the cause. No indication of cyanide could be found in the analysis performed either at this Station or in the laboratory of the City Analyst.

SUMMARY NO. 1

VITAMIN B_{12}-ACTIVE SUBSTANCES IN CHUM SALMON KIDNEY AS INDICATED BY DIFFERENT EXTRACTION METHODS

Miss B.A. Southcott

Amounts of vitamin B_{12}-active substances in chum salmon kidney as found by different treatments prior to microbiological assay by autoclaving in L. leichmannii assay medium are given in the following table. The kidneys were from a sample of 50 salmon from the November 1950 catch and were thoroughly blended with an equal volume of water before treatment.

Treatment		Vitamin B_{12}-active substances, mμgm. per gm. (wet wt.)
1. Cold water extract		2000
2. Hot water extract		1500
3. " " " at pH 4.5		936
4. " " " at pH 5.0		936
5. " " " at pH 4.5 followed by digestion with:	A	592
	B	700
6. Digestion with:	A	2300
	B	1900
7. Alkali treatment for 30 min. at 100°C. with 0.2N NaOH		128
8. Digestion followed by alkali treatment:	A	380
	B	600

A = Cysteine activated papain (1% by weight); B = mylase-P (1% by weight).

SUMMARY NO. 2

ESSENTIAL AMINO ACIDS IN WHALE MEAL

Miss H.M. Bissett

A supposedly typical sample of B.C. whale meal (lab. No. 115) was analyzed for the essential amino acids noted in the following table. The content in these compounds was as high as in a good fish meal as indicated by chemical hydrolysis, but they are relatively unavailable to animals as judged by assay after enzyme hydrolyses. The method of preparation of whale meal in which the meat is exposed for 4 hours to steam at about 45 lb. pressure may be responsible.

Amino acid	Grams amino acid per 16 gm. of nitrogen	
	Acid digestion	Enzyme digestion
Arginine	8.1	2.2
Lysine	9.1	2.0
Valine	4.9	1.0
Leucine	8.5	1.8

SUMMARY NO. 1A

CONTENT OF VITAMIN B_{12}-ACTIVE SUBSTANCES IN INDUSTRIAL FISHERY PRODUCTS

Miss B.A. Southcott

From time to time there has been occasion to perform for our own information some analyses of commercial fishery products or by-products. The results may be made available to the manufacturer, with possible restriction on their use (e.g. for advertising). Because of the origin of the materials, like that of most of the materials listed in the table of Summary No. 3, it is not always desirable that the results be published.

In addition to other materials reported, the following materials of this type were also assayed for their vitamin B_{12} content:

(I) Frozen material consisting of a mixture including cod or flatfish frames (i.e., residue after filleting) plus fish viscera with or without livers, intended as a feed for mink.

Five samples were obtained, the differences in composition being unknown. The samples were extracted with hot water at their original pH (between 6.8 and 7.0 in every case).

Sample	Vitamin B_{12}-active substances mμgm. per gm. (wet wt.)
1	45
2	54
3	58
4	34
5	28

(II) B.C. whale meal (lab. no. 10908/6).
(a) Hot-water-extracted - 22 mμgm. B_{12}-active substance per gm.
(b) Papain-digested - 7 mμgm. B_{12}-active substance per gm.

(III) Newfoundland whitefish meal.
(a) Hot-water-extracted - 14 mμgm. B_{12}-active substance per gm.
(b) Papain-digested - 39 mμgm. B_{12}-active substance per gm.

SUMMARY NO. 3

VITAMIN B_{12} CONTENT OF VARIOUS MATERIALS SUBMITTED BY INDUSTRY FOR ANALYSES

H.L.A. Tarr

Most of these materials were analyzed by making a 1 in 10 aqueous suspension, autoclaving this 5 minutes at 120°C., and pH 6.5 - 7.0 diluting the supernatant or filtrate as necessary and adding the solution aseptically to previously and separately sterilized Lactobacillus leichmannii assay medium (Skeggs).

Material	Mμg. of vitamin B_{12}-active substances per gram of material as received (not on dry weight basis)		
Salmon liver meal			900
" egg "			420
Condensed herring solubles (Alaska)			220
" " " (Brit. Columbia)			140
" menhaden " (Brunswick oil)			550
" " " (Charlotte & Reedville)			560
" sardine " (Van Camp) California			670
" " " (Seeley) "			530
Sample of air dried whole fish sold as a tropical fish food			340
Salmon liver (wet)			880
" " meal			2400
Condensed herring solubles (Brit. Columbia)			560
" " " " "			555
Whole herring meal, dry fat extracted material			340
Whale meat meal (dry)			30
Condensed salmon solubles (Brit. Columbia)			470
" herring (?) solubles			290
			Average
Frozen spring salmon livers (March 1951)	177,	162	170
Mixed salmon livers (1951 season)	179,	142	161
Lyophilized whale liver powder	1290,	1440	1365
Pink (humpback) salmon liver, vacuum drum dried	764,	741	753
Clam nectar (concentrated about 10 times)	2960,	2970	2965
Av. sample condensed herring solubles (Brit. Columbia)	413,	433	423
" " " sardine " (Calif. 1950-51)	621,	569	595
Dried Australian liver meal (sells at $0.30 per lb.)	327,	309	318
Av. drum dried condensed herring solubles (B.C.)	600,	510	555
" " " " whale solubles (B.C.)	373,	361	367
High quality vacuum drum dried liver meal (sells at $1.70 per lb.)	1342,	1130	1236
Fresh beef liver	1750,	2033	1891

(No. 3 Cont'd)

Material	Mug. of vitamin B_{12}-active substances per gram of material as received (not on dry weight basis)	
Sperm whale meat and blood meal	(A)* 234	(M)** 398
Finback whale meal containing added whale solubles	(A) 114	(M) 192
Drum dried whale solubles	(A) 173	(M) 272
Finback whale gut meal and residues	(A) 209	(M) 394
Whale liver effluent residues	(A) < 10	(M) < 10

* A = Ascorbic acid used as reducing agent in the medium.
** M = Mercaptosuccinic acid used as reducing agent in the medium.

It appears that the mercaptosuccinic derivative of vitamin B_{12} gives high results in assays and it is doubtful if it should be used.

A large amount of data has been accumulated relative to the optimum conditions for cyanide treatment of natural materials to change the B_{12a} and other forms of the vitamin to B_{12} (cyanocobalamine) and assay for the vitamin after chromatographic separation. Since it is intended to publish the results fully they will not be recorded here.

SUMMARY NO. 4

THE DISTRIBUTION OF VITAMIN B_{12}-ACTIVE SUBSTANCES IN SOME B.C. MARINE INVERTEBRATES

B.E. Maxwell

Within the past few years vitamin B_{12} values in a number of biological materials, mainly those apropos of mammalian and other vertebrate tissues, have received considerable attention. Practically no systematic comparative study of the content of vitamin B_{12}-active substances in marine invertebrates have appeared. Quantitative estimation of the amounts of vitamin B_{12}-active substance in eight additional different marine invertebrates common to the south-east coast of British Columbia was made using the same microbiological assay as used in the work last year. In general, species from phylum Mollusca were found to be richer in content of these substances than were species from phyla Echinodermata and Annelida and class Crustacea. No definite relationship was found to exist between the content of vitamin B_{12}-active substances in an animal and its phylogeny.

The values found are given in the following table, which supplements that given in Investigator's Summary No. 37 of the 1950 processed Annual Report of this Station. These values all fall between the highest (2860 mμg. per gram of dry tissue from the sea snail Thais lima) and lowest (84 mμg. per gram of dry tissue from the sea cucumber Cucumaria) values reported last year.

(No. 4 Cont'd)

The complete results of this investigation were prepared and submitted for publication in the Board's Journal.

TABLE I. Content of vitamin B_{12}-active substances in marine invertebrates.

Class and species	B_{12}-active substances mμg. per gram	
	Wet basis	Dry basis
Arthropoda - Crustacea		
Pagurus hirsutiusculus (Dana)	96	285
Hemigrapsus oregonensis (Dana)	49	138
Mollusca - Gastropoda		
Acmaea scutum patina	187	989
Mollusca - Pelecypoda		
Schizothaerus nuttallii (Conrad)	249	1,750
Paphia staminea Conrad	314	1,900
Mytilus edulis Linnaeus	121	932
Ostrea gigas Thunberg (diff. locality)	129	740
Echinodermata - Ophiuroidea		
Ophiura sarsii (Lutken)	145	275

SUMMARY NO. 5

ASSISTANCE IN RAILWAY REFRIGERATOR CAR EXPERIMENT BY THE NATIONAL RESEARCH COUNCIL — E.G. Baker

In the latter part of August and the first week of September the writer accompanied an experimental shipment of frozen fish from Vancouver to Montreal. The test shipment was carried out by the National Research Council and the Canadian Pacific and Canadian National Railways with assistance from the Fisheries Research Board. The Station was requested to line up the three commercial carloads of frozen fish desired for shipment from the Pacific coast in this test, and the writer was requested to participate because of his experience with the procedures, gained in several earlier road tests with the Station's experimental refrigerator car. The purpose of the trip was to test finned bunkers in overhead refrigerator cars. While in Montreal the Engineering Department of the Canadian Pacific Railway Company was visited to see what progress had been made in the construction of their mechanical refrigerator car and also how the present overhead cars were built. Two days were also spent in Ottawa visiting the head offices of the Fisheries Research Board and the Division of Applied Biology of the National Research Council.

SUMMARY NO. 6

REFRIGERATION SERVICES

E.G. Baker

In May of this year a local company experimenting with dry-ice refrigeration in trucks asked for assistance in taking temperature readings. They received the loan of an eight-point recorder and the writer assisted in the setting up of the instrument.

Assistance was also given to a local fish company when they wanted pH and specific gravity tests on their calcium chloride brine used in their ice-making tanks.

SUMMARY NO. 7

PHOTOGRAPHY

E.G. Baker

The amount of photography done this year compares favourably with other years. Nearly all new equipment built or purchased by the Station was photographed, as well as new installations built by commercial firms embodying ideas developed by this Station.

New photographic equipment purchased included a Speed-O-Copy which can be used for copying a small article or micro-filming a complete book. It has been used for both of these purposes and has proved to be very quick and easy to operate. A wide-angle lens for the 35-mm. Leica camera has proved very useful for photography in confined spaces such as holds of a boat.

SUMMARY NO. 8

UTILIZATION OF EQUIPMENT LOANED TO UNIVERSITY OF BRITISH COLUMBIA

N.M. Carter,
L.W. Shemilt
(Assoc. Prof. Chem. Eng., Univer. of B.C.)

Investigator's Summaries Nos. 53 and 55 in this Station's processed Annual Report for 1949 described the designing of a pilot-plant spray drier and heat-pump evaporator by Mr. Cooke of the Station staff. Summaries Nos. 52 and 53 of the 1950 Report illustrated these pieces of equipment and described arrangements made to have their installation at the Chemical Engineering Laboratory of the University of B.C. completed, and to allow Dr. Shemilt to have the use of the equipment for experimentation and demonstration. These arrangements were occasioned through there being no space at the Station to accommodate or test the equipment, and to the circumstance that Mr. Cooke was given leave of absence for military service. The following reports by Dr. Shemilt describe the use made of each apparatus. Most of the alterations and additions were performed at the expense of the University in return for the loan of the equipment. An article by Dr. Shemilt on pages 150-154 of the August, 1951 issue of Chemistry in Canada illustrates the apparatus and mentions the collaborative arrangement with this Station.

Pilot Plant Spray Dryer. In the academic year 1950-1951 this was used for research work by fourth year students in Chemical Engineering leading to their B.A.Sc. degree. In addition it was used for general Chemical Engineering

(No. 8 Cont'd)

demonstration as a special application of the unit operation of drying.

From the operational standpoint, difficulties were experienced in the spray wheel bearing and mounting. In addition no feed mechanism had been initially installed. A motor-operated displacement device designed by N.E. Cooke was installed, and the following work has been carried out in the period 1950-1951:

1. Further adjustments of the spray wheel bearing were made and a new mounting for the feed line to the spray wheel was devised and installed.

2. Calibration of the voltage regulator of the spray wheel was carried out using a Strobatac. Difficulties in reproducibility of the speed for the same voltage setting has been traced to poor bearing design and further changes may have to be made.

3. The leather gasket in the positive displacement pressure feed system was replaced by a heavier and more suitable one.

4. Installation was completed for measurements on steam condensate, outlet air temperature and humidity, and air velocity to the drying chamber.

5. Preliminary trials with water were carried out satisfactorily.

The following work is planned:

1. Completion of equipment and installation for measurement of all variables.

2. Final adjustment of automatic controller and indicators.

3. A trial run to determine the characteristics of the dryer and to indicate any necessary design changes. These runs will be carried out using milk and probably egg-whites.

4. Experimental investigation of drying of tannin extract, waste sulfite liquor, and waste stickwater will then be carried out.

Pilot Plant Heat-pump Concentrator. This was used for B.A.Sc. research programs and general Chemical Engineering demonstration in the year 1950-1951.

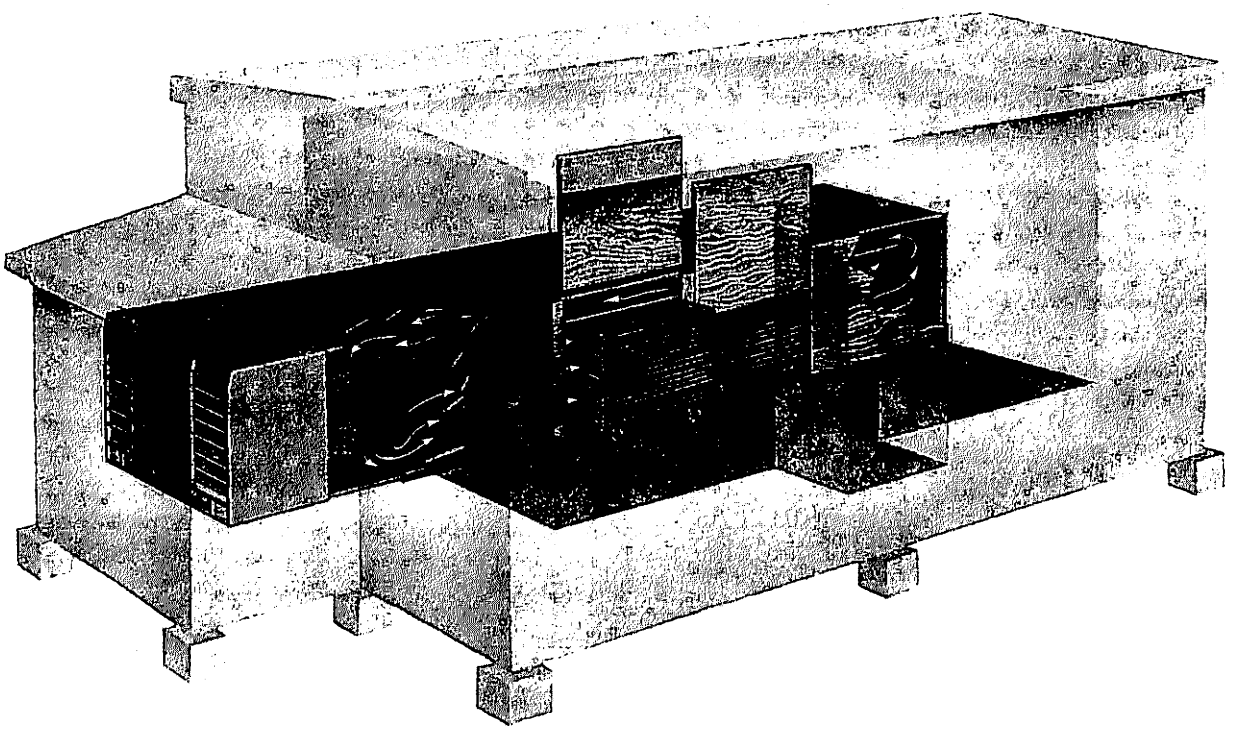
Several changes in design and installation were made including vertical placement of the condensate receiver, new controls on the feed line, rearrangement of the thermocouple set-up, and improvement of the vacuum system. The new controls on the feed line are not as yet working too satisfactorily, and in addition there has been difficulty in obtaining the necessary recording instruments for connection to the thermocouples. Plans for further work include improvement in the feed line controls and basic determination of heat transfer coefficients for the evaporator. In addition various types of solutions including stickwater will be concentrated.

SUMMARY NO. 9

PORTABLE FREEZER UNIT FOR LAKE FISHERIES

A.W. Lantz

A brief visit was made to Prince Albert, Sask., to discuss portable freezer equipment for use at the lakes in those northern areas inaccessible by road. It was proposed to fillet the fish, sharp freeze and store them at the lake's shore until such time as they can be transported out by air. Several manufacturers suggested equipment including collapsible storage huts. To determine the effectiveness of such a programme it was suggested that our U.S. Thermo King refrigerating unit from the refrigerated railway car experiment be made available on experimental basis. A portable storage hut was recommended and plans were drawn up (see accompanying drawing of suggested hut with unit in place). We were later advised that the Prince Albert firm had located a suitable compact refrigerating unit manufactured in Canada and that the loan of our unit would not be required. The rest of the plans are proceeding.



INDEX OF MARINE ANIMALS USED IN INVESTIGATIONS, EXPERIMENTS, ETC.

INDEX OF OBJECTS OF INVESTIGATIONS, ETC.

(Numerals refer to page numbers in Report)