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The Canning of Fish and Fish Products in Australia

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F O R E W O R D.

The object of this Circular is to present the available information on the subject of fish canning in such a way as to answer the majority of questions which prospective canners are likely to ask. It is not intended as a factory guide, for the fish canning industry in Australia has not progressed sufficiently for such a thing to be necessary. The reasons for publication are given in the introduction. It is considered desirable to call attention to the possibilities of successful fish canning as a war measure and also as a permanent feature of Australian industry. Australian fish can be profitably canned to give very palatable products, and, though there are often local prejudices against certain fish, it should be remembered that the canned product is frequently different in flavour and appearance from the fresh fish, and that in modern canned fish bacteria and other organisms are destroyed while the vitamin content is little impaired. The public should be encouraged to test Australian canned fish without prejudice, for our consumers of canned fish tend to be conservative, and are not, on the whole, anxious for new and distinctive flavours. Furthermore, they usually serve fish straight from the can, whereas Americans rarely do so, but prefer salads, sauces, chowders, etc. It may be necessary for Australian fish canners to popularize fish menus as is done in America. This would tend to increase the use of canned fish as well as to popularize local products. Publication of food values and vitamin content also has sales value.

The study of canning methods is still being pursued in the laboratory, and further results will, it is hoped, be published from time to time. At present, some of the less

abundant fish are being canned experimentally, so that the methods may be available to small canneries or to large canneries which could use such fish in the slack season.

The more highly technical aspects of fish canning will be undertaken when the industry demands. At present it is sufficient to base cannery methods on work done overseas with necessary modifications to suit local conditions.

H. THOMPSON,
Chief, Division of Fisheries.

Cronulla, New South Wales,
July, 1940.

The Canning of Fish and Fish Products in Australia

I. INTRODUCTION.

This paper is intended as a guide for those who wish to commence canning operations in Australia, and has been compiled owing to the increasing interest in fish canning, which is due to the successful commercial operation of one cannery; to the general interest in fisheries which has been stimulated by the publicity given to the work of the Fisheries Division of the Council for Scientific and Industrial Research; and to the increased need for the local production of canned fish brought about by the war. It was not originally intended to publish such a work until considerably more experimental work had been done, but it is felt that under the circumstances delay would be unjustified. Moreover, in commencing a new series of investigations it is well to prepare the way by a consideration of the information available, and it has been found that this information is of general interest.

The problems which will confront fish canneries in Australia are not yet clearly defined, except in a few cases, and these will have to be studied as they arise. Therefore, only general problems have been attacked, and these results are added to a discussion of canning practice overseas which is applicable to the industry here.

Each section of this work is followed by a list of papers which contain matters of interest to the trade in fuller detail than can be given here. The papers referred to in the text are indicated by giving the author's name and date e.g. Hess (1933). The title and Journal follow the authors' names which are listed alphabetically.

II. PREVIOUS CANNING VENTURES IN AUSTRALIA.

A number of small fish canneries have sprung up from time to time in various parts of Australia, but with variable success. It is difficult to begin an industry without adequate knowledge of the conditions involved, and, in the case of fisheries, these can only be determined by careful study. At the present time our information, though limited, is sufficient for an indication of the probable consequence of establishing a canning industry of a certain size in a given location. The following notes will be of value in that connexion.

Notes on existing and previous canning ventures.

1. Queensland.

(a) Turtle Soup. Turtle soup was canned at Heron Island in the Whitsunday Group, but the project failed owing to the difficulties associated with island enterprise (transport etc.), to the poor market in Australia, and to the failure of overseas agents to interest the public of London and New York. In other words, the location was wrong and the market not assured.

(b) Mullet. Mullet was canned at Wynnum with some degree of success, but the fishermen failed to keep up supplies even when fish were abundant, owing to the higher price of fish in the fresh fish market. There appear to have been some marketing difficulties also. The failure of fishermen to realize that a regular supply to a cannery at a constant price is frequently more profitable than an irregular supply to a market with its transport costs and fluctuating prices is not confined to Wynnum, but, as stated in Pamphlet 93 of the Council for Scientific and Industrial Research, has ruined several attempts at processing fish.

(c) Fish Paste. This is successfully manufactured by one Company in Brisbane.

2. New South Wales.

(a) Oysters. Oysters were canned at Port Stephens for some time, the product competing with American and Japanese canned oysters. The factory was burnt down and was not rebuilt.

(b) Mullet. Mullet, under the name "Butterfish", was also canned at Port Stephens, and the pack seems to have had at least a local popularity. The marketing problem does not seem to have been seriously attacked, and there was a difficulty over the name of the product. "Butterfish" was disallowed by the Health Department, and the name "mullet" was prejudicial to the sale. Another cannery was established at Maclean on the Clarence River, but this failed, it is stated, through lack of capital. Neither location could be called ideal, as it is considered risky to attempt a canning venture based on mullet alone.

(c) Fish Paste. Fish paste is manufactured by three companies in Sydney. Part at least of the fish used is imported as smoked or salted fish.

3. Victoria.

(a) Barracouta. Some 20 years ago, one canning firm undertook the canning of barracouta, but this failed through the fishermen not abiding by their agreements. The location of the cannery at Portland was not ideal for barracouta.

(b) Other Fish Products. Another firm, now successfully manufacturing fish pastes and other commodities, has made some attempts at fish canning but has not seen sufficient promise to warrant any commercial venture. This firm cans a large quantity of fish paste in which Australian fish are used as a base.

4. South Australia.

(a) Crayfish. Two companies for some years packed crayfish in glass, but the price of jars forced them to close. The product had a purely local market, but it is not known whether the firms could have carried on by using tin cans. It is obvious that the limited market was a factor in their failure; possibly also the seasonal occurrence of crayfish raised the cost of production too close to the economic limit.

(b) Tuna. A cannery at Port Lincoln is engaged in preliminary work in connexion with tuna canning.

5. Western Australia.

(a) Mullet, etc. Several fish canneries have, in the past (from 1879 to 1929), canned small quantities of mullet, and bony bream or Perth herring (Nematalosa richardsonii). The canning of mullet was discontinued owing to a marked decrease in size of available fish, i.e., local overfishing. Tommy ruffs were also canned, but apparently there were difficulties in obtaining supplies, while Nematalosa appears to have large and unpredictable seasonal variations in its occurrence. While it cans excellently as kippers, the fluctuations in supply make it unsuitable for large scale operations. These factory plants are still in existence, but the difficulties of obtaining supplies prevent large scale operations in this area.

(b) Crayfish. A cannery for some years canned crayfish at Geraldton. They had a certain amount of trouble with blue meat and blackening of cans (see Part VII, Sect. 10 of this report). Another company has revived the project, and it is likely that "blue meat" will be overcome.

(c) Turtle Soup. A turtle soup cannery is in operation at Perth, working on turtles brought from the north west coast.

6. Tasmania.

(a) Scallops. One firm at Hobart cans scallops to a limited extent, and produces a fine pack.

(b) Crayfish. The same firm also packs crayfish as a sideline. (Another firm on Flinders Island, see below, also carried out successful trials with a crayfish pack).

(c) Tuna. The Hobart firm is successfully packing tuna in the slack season and has a good local market.

(d) Salmon. A company based on Flinders Island has recently canned salmon, mutton birds, and some crayfish, tuna, and barracouta. The tuna and crayfish packs were very good, though blackening occurred with the latter owing to the use of unlacquered cans.

It will be seen that location, failure of supply, and failure to ensure a sound market for the canned product, are the three main causes of failure, where such has occurred.

III. THE FISH CANNERY.

1. Situation.

(a) With regard to supply.

It is customary in other countries to place the cannery close to the source of supply and to allow transport of the finished product to the market. This, of course, necessitates the transport to the cannery of cans or tinplate and cases of packages. For these reasons moderate ease of accessibility, preferably by water on account of cheap freights, is desirable though not essential. It is not economical to transport raw fish over longer distances than absolutely necessary, although the tuna industry of California gets its supplies from as far as the Galapagos Islands, and even from Japan.

Australia is fortunate in having its major supplies of fish suitable for canning within several hundred miles of the capital cities: salmon and tuna off the east coast of New South Wales; barracouta within range of Melbourne and Hobart; tuna in the Port Lincoln and Kangaroo Island areas; and salmon and probably tuna in the Esperance-Albany-Fremantle area. There are possibly good supplies of yellowfin tuna and Murray Island herring in our northern waters, but sufficient information concerning these fish is not available, so that their canning is only cursorily mentioned in this paper.

The writer wishes to stress the necessary preliminary of adequate biological investigation regarding seasonal distribution, centres of occurrence, and the possibility of depletion of supplies, before large canning operations are entertained. If this is not adhered to, canneries will be situated in the wrong positions and stand a good chance of failing. The first dictum is - In choosing a cannery site, study the fish supply, and build as near as possible to the centre of maximum occurrence.

(b) In regard to markets.

Where possible it is an advantage, if supply can be maintained, to site the cannery as close as possible to the market, or at least to a good harbour with port facilities. This, however, is secondary to supply. Islands are usually unsuitable for canneries however close to supply, because of difficulties of transporting requirements and the finished product, and of obtaining labour and supervision.

(c) Other essential factors.

The cannery should be situated at the water's edge, if possible on a sheltered harbour where fishing boats and freighters can anchor in any weather, and where wharfage is available. It is well for the cannery to have its own wharf or jetty. Seawater is cheaper than fresh, and can be used in the cannery for a number of purposes. If sufficiently pure it can be used to wash the fish, and also for "fluming" the fish to the wet end of the cannery.

A fresh water supply is essential for boilers and can washing, as well as other purposes. It is better practice to pipe the water to the shore than to locate the cannery away from the sea-front in order to be near the fresh water supply. The latter practice means that it will always be necessary to handle the raw fish twice. In addition to extra handling, time is lost and freshness impaired.

Accessibility to good arterial roads or rail is desirable, but not essential provided that sea transport is regular.

The labour market must also be considered. It is more difficult to get hands for a cannery distant from centres of population than for one close to some of the amenities of civilization.

A gently sloping piece of land is an advantage, as gravity can be made use of more freely. The fish can be elevated to the wet end at the highest point and gravity allowed to assist the subsequent conveyance, or gravity can be employed on the can line with the wet end and packing tables on the same level. The latter layout is better if fluming is to be used at the wet end.

Power is also a requirement, either coal or preferably coal plus electric power.

2. Essential Equipment.

(a) The Building.

The type of building depends on the capital of the company, probably the most economical is steel and wood framework and fibro-cement walls and roofing. Plenty of light should be admitted, not only for its psychological effect on the workers, but because it aids cleanliness and facilitates inspection. It is never possible to keep factory inspection so rigid if artificial light is used. The building should be roomy, as cramped space tends to produce slovenly work and to slow down production. Moreover, it may be found necessary to duplicate some part of the plant, and room should be left for this.

(b) The Mechanical Equipment, etc.

A fish cannery consists of four main parts :-

1. The wet end or butchering department;
2. The packing tables;
3. The processing department;
4. The labelling and packing department.

In addition there are, of course, the office, store rooms, and in large canneries the laboratory.

The wet end consists of some form of conveyor to bring the fish into the hopper or storage bin (in small canneries trucks are used for this purpose); a cold room for storage and holding (unnecessary for salmon, crayfish, or crabs); scaling tables or apparatus (where necessary); butchering tables, washing troughs, and a conveyor to the packing tables.

The packing tables may or may not be mechanically fed. They are metal covered, preferably with stainless steel or monel metal. The processing department consists of either an exhaust box and double seamer, or a vacuum seamer in which exhausting and seaming are carried out in one operation, and one or more retorts for processing the seamed cans. It is preferable to have two small retorts rather than one large one, so that one is being filled while the other is cooking, and the supply of cans to the labelling end is more constant.

The labelling department has usually a labelling machine, and in some canneries a packing machine to fill the cases or cartons.

In the simplest type of cannery, the fish are landed on the wharf by hand and carried on trucks to the storage bin, which is usually lined with galvanized iron and may have a hurdle to separate the bin into sections as and when required. The fish are hand fed to the scalers, which may be hand operated or electrically driven, and then to the butchers. These may clean and head or fillet the fish by hand, or some mechanical devices may be employed. A wash trough follows, and the fish then go to the packing tables. In most canneries, however large, packing is done by hand, usually by women. The cans are fed by gravity down a centre line, and full cans are either sent down by conveyor or on trays to the exhaust box. Other ingredients, spices, salt, brine, or oil, may be added before exhausting,or may be heated and added afterwards. From the exhaust box the fish goes without delay to the seamer, which in small canneries will be hand operated. The cans are washed in a soda lye or in a sodium metasilicate bath, and placed in racks for retorting.

3. Mechanization.

In larger canneries it is the practice to use conveyors and other mechanical devices where possible. The fish are carried from the ships by fluming for small fish such as pilchards, and by racked belts in the case of larger fish. Weighing devices will consist of self-tipping and self-recording machines which render the unloading process almost automatic. At the end of the first belt, the fish is diverted to the freezers or to the hopper as need be, and the supply from the hopper to the wet end is regulated in various ways. In the sardine industry rotary wire screens are used for scaling the fish, the scales being knocked off by rubbing against the wire and against other fish. A series of strong water jets assists in this process. The scalers are inclined, so the process is continuous. For other fish, e.g. salmon, scalers consist of bronze or steel cylinders with knurled faces or blunt blades, rotated by flexible drives from an electric motor. The operator runs the scaler over

the surface of the fish with much the same action as the shearer uses. The scaled fish are moved on by conveyors to the iron chink or heading machine, or to the filleting machines. If a heading machine is used, evisceration is carried out usually by automatic or semi-automatic devices - steel wire brushes or circular saws of decreasing radius. The fish are then washed, often on an inclined vibrating screen, and cut into lengths on an automatic or semi-automatic device. The pieces are put on conveyor belts, which run past an inspection area to the packing tables. Here, gravity brings down the cans, and another conveyor belt removes the packed cans which are inspected for weight, often by special machines, and are graded, rejects being returned to the patching tables. Machines are often used for this purpose. The full cans proceed via the salt machine, etc. to the exhaust box, from the other end of which they emerge to receive tomato sauce or other ingredient if this has not been added previously. In sauce packs the cans are mechanically inverted to drain off excess liquor between the exhaust box and the sauce machine. They then proceed to the seamer, where the lids are double seamed on, and fall in a lye bath for washing. They are then placed by hand on racks for retorting, at the same time being inspected for faulty seams. The retorts are fitted to receive steam, water under pressure, and compressed air, except where only glass packs are put up. Cooling is accomplished by admitting cold water, while keeping up the retorting pressure by air, thus ensuring the proper collapse of the cans and minimizing "flippers".

The cooled cans are wheeled on trucks to the labelling machine. In large canneries the cans are packed mechanically into cases for overseas, or cartons for local shipment, and carried by conveyors or trucks to the store. The store should be cool and well ventilated.

The actual details vary with canneries packing different commodities, and also in accordance with the ideas of the management. The above description is, therefore, a somewhat composite one. One of the finest examples of extreme mechanization is that of the Pioneer Clam Cannery as described in the "Pacific Fisherman" of June, 1939, page 23. The literature quoted through this paper gives descriptions of

much of the mechanical equipment used in fish canning, but it is impossible to give details here.

Much of the mechanical equipment used overseas will not be immediately suitable for Australian needs. It will, therefore, be necessary for each cannery controller to modify the design of such equipment in accordance with his particular needs, or to substitute his own designs. These are best worked out in conjunction with an engineer. Several firms making canning equipment in Australia are in a position to help in designing the most efficient apparatus. Practically all the necessary equipment can be made in Australia.

4. The Disposal of Cannery Waste.

This is always a problem. If the cannery is small, it may be possible to sell or give the waste, which amounts to 40 to 70 per cent. of the raw fish weight, to local farmers as fertilizer, but when this avenue has been exhausted it is necessary to resort to burning or disposal at sea. Both these methods lead to unpleasant consequences in the way of restraint by local authorities, and, if the cannery prospers, a fish meal and oil rendering plant are the natural outlet. There still remains a liquid waste which contains, besides water, some valuable substances including fish glue.

L. F. Smith (1931) describes a method for dialysing the waste liquors by means of viscose tubing. The waste, containing 9 per cent. protein, was run through 120 feet of 7/8 inch viscose tubing coiled round a wooden frame 2 feet in diameter and entirely immersed in fresh water in a 120 gallon tank - this water being constantly renewed. At a temperature of 189°F. and a rate of flow of 4 gallons per hour, 90 per cent. of the chlorine was removed, and the purified product was entirely suitable for glue.

Sanborn (1939) briefly describes methods for dealing with liquid cannery waste using rotary screen filters to remove the solids, and either dispersing the liquid in water, absorbing in soil, or using trickling rock filters. In other words the liquors can be treated as crude sewage, though the sewage organisms need to be added to cause the digestion of cannery waste. It may be said here that for efficient soil absorption a low rainfall and high evaporation rate are

necessary. It has been shown by Hart, Marshall, and Beall (1933) that water affected by pollution from pilchard reduction plants in British Columbia is restricted to an area less than 220 yards radius from the effluent outfall, and, except in an even more circumscribed area, effects are rapidly dissipated on cessation of plant activities. These authors conclude that reduction plants have no deleterious effects on, and may stimulate growth of, marine plants and animals.

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Hart, J. L., Marshall, A. B. and Beall, D. (1933), - The Extent of the Pollution Caused by Pilchard Reduction Plants in British Columbia. Biol. Bd. Can. Bull. 39.

Sanborn, N. H. (1939). - New Information on Cannery Waste Disposal. Canner 89, (12,II): 71.

Smith, L. F. (1931). - Fish Glue from Fish Waste: Final Report. Prog. Repts. Pacific Biol. Sta. 9: 1.

The following table, which is taken from Hess (1939), gives useful data for those proposing to can fish. The data are for "chicken haddies", and allow for a 40 per cent. yield. They can be applied to other fish by adjusting the yield, and referring the adjusted yield to the other columns except column 7, which is of use for the "chicken haddie" and for tuna style packs. In the latter case the yield may be regarded as 30 per cent. of the raw weight.

Number of cases packed per day	Amount of cooked meat required	Amount of fresh fish required	Number of batches per day	Number of cans per batch	Minimum no. of retorts required	Capacity of 3 steam boxes each
	lb.	lb.			480 can capacity	lb. fish
10	420	1,050	1-6	480- 80	1	25
20	840	2,100	2-6	480-160	1	50
30	1,260	3,150	3-6	480-240	1	75
40	1,680	4,200	4-6	480-320	1	100
50	2,100	5,250	5-6	480-400	1	125
60	2,520	6,300	6-12	480-240	1-2	150
70	2,940	7,350	7-12	480-280	2	175
80	3,360	8,400	8-12	480-320	2	200
90	3,780	9,450	9-12	480-360	2	225
100	4,200	10,500	10-12	480-400	2	250
110	4,620	11,550	11-12	480-440	2	275
120	5,040	12,600	12-18	480-320	2-3	300
130	5,460	13,650	13-18	480-347	3	325
140	5,880	14,700	14-18	480-374	3	350
150	6,300	15,750	15-18	480-400	3	375
160	6,720	16,800	16-18	480-427	3	400
170	7,140	17,850	17-18	480-454	3	425
180	7,560	18,900	18	480	3	450

IV. POSSIBILITIES OF THE INDUSTRY.

As stated above, the publication of this circular has been hastened by the advent of the war. Prior to this, the Fisheries Division had advocated a slow natural development following on the results of scientific investigation on the habits and movements of populations of fish, and on the technological aspects. Now, however, there is a tremendous impetus in that if an industry can establish a reputation for a good product during the war, its market will probably be secure after the war, and if Australia cannot import salmon, pilchards, etc., these must be replaced by local counterparts. It is, therefore, felt that the fullest information that is available should be given to the public at this juncture. To start a cannery now is admittedly a more precarious venture than it would be if all the necessary scientific data were available, but the possibilities of beginning a large scale industry in a short space of time are greater now than ever before, and so is the possibility of launching a successful venture if wisdom and foresight are used. The limiting factor at the moment is the inadequate fish supply. The number of fishermen and boats, and the amount of gear, are adequate only for a limited fresh fish industry, and totally inadequate for the needs of a country at war. With the increase in the fresh fish trade due to the restriction of imports, and the depletion of the trawler fleet by the war needs, even this market can barely be supplied by our fishing fleet. Deep sea boats and gear, and the men to man them, are urgently needed if Australia is to undertake fish canning seriously. It should also be remembered in considering the advisability of expanding the fishing industry, that the British fishing fleet has contributed much to the maritime greatness and defence of that country.

V. POSSIBLE AVENUES FOR FISH CANNING.

The fish which at the moment seem suitable for canning as regards quantity, period of occurrence, ease of catching, and price, as well as appearance and flavour, are salmon, barracouta, the tunas, the scombroids, pilchards, mullet,

crayfish and possibly crabs.

The salmon occurs in large quantities on the south-eastern coast, and it now appears on the south-western coast of Australia. It is easily caught by means of beach seine nets, can be kept in pens up to three months, and occurs throughout eight or ten months of the year. It is possible that this fish might be caught by purse seine or lampara nets if the need arose, though the cost would be greatly increased. The fish is easy to handle and is approximately equal to chum salmon, with the price of which it compares more than favourably. Improvements in the present packs may yet place the fish in the higher price grades. Perhaps the "chicken haddie" pack (see below) will find favour with the public.

An allied species, Arripis georgianus (tommy ruff), occurring in South Australian and Western Australian waters, cans and smokes very well.

Barracouta are numerous in Bass Strait and Tasmanian waters, the headquarters of the fishery being at Queenscliff and Hobart. It is found that as the distance from this area increases the fish become increasingly parasitized. There are two distinct types of parasitism - worm and milkiness. The former is due to cestodes, of which there are several species which infest the muscle but cause little or no deterioration of the flesh. If these fish were canned, the high temperatures used would kill all the parasites, so there should be no valid objection to its use. The uninfected fish gives a very good canned product after smoking. The possible size of a barracouta canning industry cannot at present be estimated but should be great.

The tunas occur in quantity and are at least equal in quality to overseas tunas. In more northerly waters the northern bluefin (Kishinoella tonggol) is known to occur, and also the yellowfin (Neothunnus macropterus) and the little tunny (Euthynnus alleteratus). There is not sufficient information concerning their occurrence or quantity to make definite recommendations for suitable cannery sites. The other scombroids include mackerel (Scomber australis) which occurs in quantity in South Australian waters; yellowtail or kingfish (Seriola grandis),

which is fairly general in occurrence; bonito (Sarda australis), occurring in New South Wales and Queensland waters; and the Spanish mackerel (Scomberomorus commersonii), which is abundant in Queensland waters but probably brings too high a price as a fresh fish to warrant canning. The others mentioned, or closely allied species, are canned commercially in America. Mackerel (Pneumatophorus australasicus) is brined and canned salmon-style in the United States and is an important commodity. The other scombroids are canned tuna-style and have their own distinctive flavour.

The method of catching these fish at present is by trolling from small vessels, but lampara or purse seine nets may yet be used in some areas where the weather is sufficiently moderate. This type of fishing requires men with initiative and knowledge who are willing to try out various types of gear, and to modify these if necessary. The striped tunny, and probably other tunny species, can be caught by live bait, using anchovy and possibly pilchards, sprats, or tommy ruffs.

Mullet are caught by beach seines and occur in considerable quantities for several months of the year. In Western Australia they bring too high a price in the fresh fish trade to warrant canning except perhaps at Shark Bay, but canneries might be established at Coff's Harbour or the Clarence River, and if market regulations would permit, at Wynnum and possibly Maryborough in Queensland. Mullet can well, but a difficulty is to obtain supplies at an economic price for canning.

Pilchards occur in schools along the coast of New South Wales and in South Australian waters in sufficient numbers to warrant canning. A report on their occurrences is in preparation by another officer of this Division. It might also be possible to can southern herring (common in estuaries north of Sydney), and Murray Island herrings occurring in large numbers in northern waters, as sardines.

Crayfish are present in the waters of New South Wales, Victoria, South and Western Australia, and an extension of the canning of these is to be expected, possibly in conjunction with other products. The extent of these occurrences is not known exactly, but they appear to be considerable.

The local market is said to be somewhat restricted, but it is possible that an overseas market may be found, as it was in France for the South African crayfish.

Crabs might occur in sufficient numbers for canning purposes in North Queensland, but their canning would be recommended only as an adjunct to a cannery producing other varieties of canned foods, at least until the quantity available can be ascertained.

The possibilities of shrimp canning are unknown.

In addition, there are a number of other species of fish which have a more or less restricted distribution but which might be canned in limited quantities as a war-time measure. Some experiments concerning these species are being carried out at this laboratory.

VI. THE OBJECTS OF CANNING.

Canning is essentially a method of producing a commodity which is nutritious, palatable, and easy to serve, and at the same time can be preserved almost indefinitely where ice, refrigeration, or other means of keeping are unavailable. It also allows fish to be brought to the public economically in regions where that species is unknown as a fresh fish. Further, as in the case of the tunnies and bonito, it often transforms a fish which is not highly prized in the fresh state into a valued article of diet.

The aim of the canner should be to retain all the vitamins and proteins as far as possible, and it may be said that canned fish containing bone, if this has been softened, is superior to many foods, and in some respects equal to milk in nutritive properties. It contains calcium and phosphorus, so important for bone formation (Nilson and Coulson, 1939), and also iron, copper, magnesium, and iodine. The last mentioned is especially abundant in lobsters and crabs; fatty fish have a higher content than lean fish. Cooking has little effect on the iodine content of fish (Jarvis, 1928 and 1929). Fish also

contain vitamins A and D,and the latter is not materially affected by processing (Aschehoug, Kringstad, and Lunde, 1939). It may be concluded then that fish is a highly nutritive food, more so weight for weight than meat, and that canned fish is in some respects slightly inferior, and in others superior, to fresh fish.

The first part of the canning process, that of scaling, heading, and eviscerating, is not, of course, confined to the cannery, but the canner usually carries them out in a more efficient manner than others, as, for some reason, his product is subject to greater criticism than that afforded to the fresh fish trade. For this reason he introduces mechanical appliances wherever possible, and some of these show considerable ingenuity. They might well be adopted by some of the larger wholesalers in the fresh fish trade.

The canner is also concerned with speed of operation, and this speed has a twofold result. It cheapens production, and it results in a fresher product. It may safely be said that the product of a well run cannery reaches the consumer in a much fresher condition than the majority of other fish products.

The packing into cans or jars is the first departure from general methods of handling, and this is usually accomplished by hand labour, women commonly being employed. Then comes the preparation for the table and sterilization by heat, which is the means of preservation used. Before the lid is put on the can, it is necessary to remove air. If this is not done, the air in the headspace of the can expands with increase of temperature or decrease of pressure and causes "swells","springers", or "flippers". Exhausting is done either by a preliminary heating in an exhaust box or by a vacuum chamber in the seaming machine.

The next step in the process is the seaming of the can. In older processes the lid was sealed on with solder, and a hole left, which was plugged with solder after exhaustion of the can. This operation was known as "brogueing". It has now been superseded by the use of the "sanitary can", in which the lid is treated with a rubber solution which, after the mechanical seaming of the can, makes a perfectly air-tight joint. More up-to-date plants

overseas use a vacuum seamer in place of the older exhaust box, which is essentially a steam heated box by means of which the air in the can is caused to expand and to become partially replaced by steam just prior to seaming. The vacuum seamer exhausts and seams in one operation.

Retorting, or processing, is the next step, to which the others are merely preliminaries. For this the cans on trays are placed in long steel retorts built to withstand a pressure of 10 to 25 lb. per square inch. The doors are closed and screwed tight, and the steam is turned on till the desired pressure is reached. This pressure, to which temperature is directly related, is maintained until all bacteria and their spores are killed, or until all the bones are softened, whichever is the longer, and then released rapidly and with sudden cooling in the case of cans, and slowly in the case of glass jars.

Finally come labelling and packing the cans in cases or cartons. Labelling is an important process as labels can promote or retard sales. Careful thought should always be given to the design of a label, and it is as well to call in the services of a good commercial artist for this work. Colour, style, design, balance, and legend are important in producing an attractive label. The name of the product must be distinctive, and if possible informative, and capable of incorporation in sales propaganda. This is more important in marketing a new product, where the quality of the goods, however high, cannot be relied on to bring early custom. In Australia some fish which have not a good name as fresh fish give an excellent canned product, better in quality than other fish which sell on their name alone, so in this case a trade name might be adopted, with the consent of the authorities, using also the generic name, which is not associated with the prejudice. Mullet is a case in point. Sold under the name of mullet, marketing would be almost impossible, while, under another name, its undoubted quality would produce a ready sale.

Cannery Control.

It is now recognized that the practical canner can be aided by research work.

For this a central organization is usually relied on with, if possible, a chemist or control officer on the premises. Such organizations are the Bureau of Fisheries of the U. S. A. and the Fisheries Research Board of Canada, but America has also the National Canners Association, which employs a staff of control officers who standardize and supervise the pack of its individual members, and can condemn suspected packs. It has also formed a research section which carries out laboratory studies of the problems of the canner. The results of the work of some of these bodies are summarized below, and may be of value to the Australian canner. Where specific problems arise, the technological staff of the Fisheries Division of the Council for Scientific and Industrial Research are available to endeavour to find a solution.

VII. CANNING METHODS.

1. General - Technological Studies on Canning Processes.

(a) Brining.

Many marine foods are brined at some time or another prior to packing, and brining is usually beneficial owing to the fact that it removes water and stiffens the flesh, whilst strong brines tend to kill many bacteria on the surface of the flesh. In general, canned fish contains 1 to 2 per cent. of salt, though pickle, when it is added, is of the order of 2.5 to 3 per cent., as is seawater. This has little effect on the keeping qualities and causes some dehydration and solution of proteins (Boury, 1938), but it whitens the flesh.

(b) Spoilage. Fellers (1926, 1937) points out that the bacterial flora of raw salmon is essentially similar to that found in canneries, and to that responsible for spoilage. The present writer (1940) confirms the finding that the bacteria of the slime are essentially those responsible for spoilage. Fellers also shows that much of the non-gaseous spoilage is due to decomposition prior to canning, and that sporing aerobes of the Bacillus cereus-mesentericus group

are very heat-resistant. These by anaerobic growth can spoil a pack, which shows their action only by altered texture or odour, otherwise the cans will be apparently normal with a good vacuum. This primary spoilage is even more serious in the case of crustaceans, where as little as four hours is sufficient to produce ammonia and hydrogen sulphide which will later completely spoil the pack by "blue meat" or "smut". In the case of fresh fish, the hydrogen sulphide produced by heating is removed by the fish itself, but in stale fish this is not the case. On the other hand, it is customary for Atlantic tuna to be hung for a time to allow a certain amount of mellowing which, however, is mainly biochemical.

(c) Odours of petrol etc.

These are due to the constitution of the rubber seal of the "sanitary" can. A metallic odour is due to imperfections in the tin plate.

(d) Metallic impurities.

A considerable amount of work has been done on this subject, especially by Lunde and his co-workers at Stavanger. It has been shown, for example, that sardines heated by frying or steaming frequently have a lead content of up to 40 parts per million, and evidence was adduced (Lampitt and Rooke, 1933) to show that this is due not to the can but to lead on the grills used for frying or steaming. The adoption of monel metal grills overcame this.

Further work has been done on the cause of corrosion of cans, especially in relation to crayfish canning. It has been shown that blackening is due to the production of sulphides of tin and iron as a result of the production of hydrogen sulphide in the flesh. The can becomes pitted and finally "flowers", and flesh and can become black and unsightly, while the hydrogen released causes "hydrogen swells". The method of combating this is to limit the headspace of the can, to adjust the acidity of the liquor to prevent the formation of the sulphides (Gire, 1938), and to use only the freshest fish.

Aluminium as a metal for can manufacture has been seriously studied and commercially adopted in Norway. It is found that, though a certain proportion of aluminium is dissolved from the can by the product, and is thus ingested

by the person eating the fish in question, the aluminium salts are non-toxic and are quantitatively excreted, so that there is no danger to health from the use of aluminium cans.

(e) Lacquering of cans and use of parchment linings.

For the cheaper grades of fish, where a rapid sale is assumed, lacquering or lining the cans is not economical, and probably not necessary. For higher quality products the lacquered can is preferable, and, in the case of crustaceans, essential. Clayton (1937) has worked out a process of depositing lacquer electrophoretically by using a colloidal suspension of lacquer in weak ammonia solution using the can as anode. He claims that this process gives much more uniform films than spraying or dipping, and that the film is sulphide-proof. Moreover, the cans can be lacquered outside and inside simultaneously. The factors for the deposition of a satisfactory film are: (1) Concentration of the lacquer in the emulsion; (2) current density; (3) direction; (4) grain of the emulsion. Parchment linings are advisable in addition to double lacquering of cans in the canning of crustaceans.

(f) Vacuum.

The purpose and efficacy of the vacuum in cans has been given considerable prominence in canning literature. Hess (1933a) has published figures relating to lobsters as follows: To achieve a vacuum of 8 inches, it is necessary to exhaust at 210°F. for 3 to 5 minutes in the case of ¼ lb. cans, and 15 to 20 minutes for 1 lb. cans.

Goard and Charnley (1937) discuss the subject in rather more detail. They point out that cans which are perfectly wholesome may become "springers" or "flippers" (i.e. the ends tend to spring from the normal concave position to the convex) if the cans are shipped to placed at sea level but at higher temperatures than at the place of canning (e.g. Alaska salmon to Cairns), to places at high altitudes (fish canneries are naturally situated at sea level), or to places with high temperatures and altitudes. To prevent this, a low vacuum is necessary, but the amount of headspace is important. When the headspace is of the order of 0.3 cu. ins. a variation in headspace contributes only slightly to produce "springers" between 68° and 104°F. If fish are

canned at 68°F. at sea level, to insure less than 0.5 per cent. springers at 104°F. and 5,000 feet altitude there are needed the following vacuums.

Cans	Mean (in.)	Standard Deviation (in.)	Lower limits	
			Av. of 12 (in.)	Av. of 6 (in.)
1 lb. talls	11.1	3.2	8.3	7.2
½ lb. flats	9.3	3.5	6.3	5.1
¼ lb. flats	12.2	4.0	8.7	7.2

Steaming a ½ or 1-lb. can for 15 to 20 minutes at 212°F. and seaming immediately gives a vacuum of approximately 9 to 10 inches, but the vacuum is not appreciably increased by longer steaming. in other words, there is an optimum steaming time below which the vacuum is poor and above which efficiency decreases.

(g) Retorting.

The time of retorting is very important. To obtain economy of working and the most palatable nutritious product, the retorting time should be as short as possible. It must be long enough, however, to soften any bone present (usually 1½ hours at 10 lb. for ½ and 1-lb. cans), and to sterilize the contents. In the case of crustaceans the time must be shorter or the temperature must be lower to give a good product. The flesh of these animals is apparently easier to heat, so that this reduction is possible. The temperature of the retort is not reached by the fish at the centre of the can for some time, but, at the same time, once reached, that temperature is maintained at the centre longer than at the sides and ends of the can. As rapid cooling is usually employed, this latter effect is minimized. This rapid cooling is required to minimize "springers" and for economy in time.

The methods of evaluating the required time are:-

1. Temperature measurements - the temperature of the centre of the can is measured continuously during retorting by means of thermocouples, and the time it takes for the heat to penetrate the flesh is discovered. This will differ for different kinds of fish muscle.

2. The time required to kill bacterial spores, which are much more resistant to heat than vegetative forms, is found by retorting cans of fish containing such spores, until the centre of the can has been at the required temperature long enough to kill them all. Clostridium botulimum, a food poisoning organism, is usually employed for this test. The time of processing is that required for the centre of the can to reach the temperature of the retort, plus the time required to kill all the organisms present with a slight margin for safety. The usual retorting temperatures are 230°, 240°, and 250°F. which correspond with 7, 10, and 15 lb. pressure respectively. Too great a destruction of food materials is brought about at temperatures above 250°F., and, despite more rapid sterilization at this temperature, 240°F. is more usual. More efficient sterilization is given by processing at 240°F. for ½ to 1 hour and at 230°F. for the rest of the period. A thermometer as well as a pressure gauge should be mounted on the retort.

(h) Storage.

The temperature of storage is important (Hess, 1933b). Lobster for example keeps best at 32°F., and at 50°F. the white meat becomes greyish yellow and the red meat is dulled. Generally speaking, the lower the temperature of storage the better the product will keep. This, of course, must be consistent with economy.

(i) Failures in canning.

Sufficient research has now been done to indicate measures necessary to obviate most of the causes of failure which must usually be due to faults in cannery practice. There are, however, certain undesirable effects which may be seen in canned fish, and these include the production of curd. This is due to the solution in water of certain proteins (albumins) similar to the proteins of egg white, and the subsequent coagulation of them by heat. The method suggested to overcome this, but which has not yet been found completely effective in this laboratory, is to brine the fish prior to canning in a 70 saturated brine, 18 per cent. by weight, or in brine plus 1 per cent. disodium phosphate.

This is to precipitate the protein within the tissues and so prevent curd. The addition of disodium phosphate to the brine has been found fairly efficient. Alternatively, acetic acid may be used, but this causes a milky liquor due to the presence of histones (Denstedt and Bailey, 1934). It is not as satisfactory as the phosphate brine.

"Glass" or "Struvite" crystals may also occur. These are crystals of ammonium magnesium phosphate, and are shown to be due to ammonia produced by the decomposition of the flesh. Bedford suggests bacteriological cleanliness as a control measure against "glass crystals". Their formation is also affected by degree of acidity. Carter (1933) blames slow cooling after retorting.

(j) Testing the canned product.

A number of methods of testing canned fish have been tried (see bibliography), including multiple needle penetrometers, analyses of gases in the cans, acid value, formic acid number, volatile acid number, etc. Probably the best tests are the occurrence of dents, swells, and blows, the appearance and general texture of the fish, and the bacterial count. Strict supervision of the pack should be made at all times by the cannery officials, and, if possible, at regular intervals by a disinterested examiner. Results for each pack should be entered on a sheet and checked.

NOTE. The attention of fish canners is drawn to an article in the "Atlantic Fisherman" of February, 1940, p.25, regarding the "Naturalpak" process for preserving foods. This consists essentially of packing the food in a "pliofilm" package, heat-sealing the open end, placing the package in a steam tight chamber, and retorting the chamber containing the packages. The bags can, if desired, be packed in cartons ready for shipment prior to retorting. The advantages of the method are that the packages are ready for cooking or for table as desired, allow of saving in retorting spaces and in freight owing to a reduction in size and weight compared with cans, and are not subject to the formation of metallic sulphides. The exhaust box and can seamer are dispensed with, but bag making and sealing machines must be provided. Some preliminary experiments have been tried by this Division, but it is too early yet to discuss results.

It appears that it may be difficult to tell when a package is completely airtight, but this would have to be carefully studied before a pronouncement could be made. Owing to the possibility of inadequate supplies of tinplate, it is thought desirable to study the use of "pliofilm", although there are at present difficulties about its importation. In case of need these might be overcome, or manufacture commenced in Australia. For the sake of appearance, "pliofilm" laminated to paper would need to be employed.

(k) Economics.

The economics of the industry are studied closely by American packers, and much valuable information concerning the statistics of the industry are given annually in the "Pacific Fisherman". Campbell (1939) gives some interesting figures showing graphically the relationship between price, cost of living, and consumption.

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2. Clupeoid Fish.

The canning of Clupeoid fish (e.g. sardines) in Australia seems to be a distinct possibility. In America, canning of these fish is supplementary to their use for meal and oil production, a distinct advantage from the point of view of costs. It would appear from preliminary studies made by this Division, that the establishment of a meal and oil industry comparable with American industry will be attended by difficulties, so that the canning industry will possibly have to stand alone. For this reason, it may be advisable to establish the industry with a view to canning other products such as crayfish, mullet, or scombroids during the slack season. The area of operations which suggests itself at the moment for pilchards is that between Sydney and

Trial Bay, and there may be possibilities in southern waters of Victoria or South Australia in an area not yet defined. Possibilities in Western Australia have not been investigated.

The southern herring Harengula castlenaui gives a well flavoured product canned after a preliminary brining or brined and smoked, sardine style. It is rather bony and the bones are difficult to soften, being barely soft after 2 hours at 10 lb. pressure.

Methods.

European procedure is to can a fried or smoked product, and this was true for America until recent years. Latterly, a raw pack has been adopted. The methods are described in full in the publications listed at the end of this section, but will be summarized here.

The fish, on arrival at the cannery, are taken by a conveyor or fluming to a rotary washer and scaler which consists of a rotating wire drum set on an angle. The fish are scaled by rubbing against one another and the sides of the drum, and the scaling is accelerated by jets of water. After this their treatment varies.

(a) Canned smoked sardines. Norwegian and English style, The fish are brined in 20° brine for 20 minutes, and placed on rods by an ingenious device. A split metal bar is provided, hinged below, with a hole running along the split, and 22 cup-like depressions arranged vertically. The fish are placed by hand with their heads in the cups and the rod is passed through the horizontal hole so that it passes through the head of each fish. 27 of these rods are placed on the frame for smoking. One operative can fill 50-60 frames per day. The fish are then smoked for 30-40 minutes. In Norway, the fish are passed through horizontal kilns of patented design, fitted with baffles so that the process is continuous. The fish are then headed mechanically and packed in olive oil or tomato sauce, these being added hot to the exhausted can.

(b) Fried Sardines. The fish are headed, gutted and brined, large pilchards in 85-100 per cent. saturated brine for 60-90 minutes, small in from 40-80 per cent. saturated brine for 10-30 minutes - Australian fish would probably all be classed as small. The fish are dried in the open air or preferably

in driers of special design, and cooked in boiling olive, cotton-seed, or refined sardine oil for periods of from 2-15 minutes. They are then drained and packed.

The driers used are usually tunnel driers, in which the fish are carried on wire flakes on belts, and hot air is passed over them. The time of drying is controlled by the rate of the conveyor belts, and the temperature by that of the steam heating coils. The time is from 30-60 minutes in air at 90°-120°F., with a velocity of 500-1500 feet per minute. The loss of weight is 3-6 per cent. and the result is a necessary toughening of the skin (Beard, 1927). The dried fish are carried through an oil bath in wire baskets for 7-15 minutes, the oil being held at 200°-260°F. by steam coils. The oil floats on water. The baths should be covered over the active part, and the depth of the oil should be just sufficient to cover the fish. The baskets, stacked on racks, are allowed to drain, and the fish packed in cans. The cans are exhausted, and tomato sauce or olive oil are added just prior to seaming.

The advantage of this method is that the fish are easy to handle on the packing tables, but the disadvantage is that the oil is soon diluted by sardine oil, and becomes dark and thick, imparting an undesirable flavour, unless the oil is frequently changed. This results in higher production costs, with poor flavour as an alternative. Accordingly other methods have been tried and are in use.

(c) Other Methods. Bowers (1934) describes a method of continuous broiling, the fish being brined and packed into cans. The cans proceed through a rotating oven of special design, where the fish are broiled by dry heat from a gas-fired furnace and drained by mechanically inverting the can. Salt and sauce are added hot, and the can is seamed. By this process, the cans are in the retort less than 4 hours after the fish reach the eviscerating machines.

The fish, by whatever method they are prepared for processing, are retorted at 240°F. for 75-90 minutes. Experiments in this laboratory show that a higher temperature (245°F.) or a longer time (120 minutes) is desirable to soften the bones.

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3. Tuna.

The canning of tuna in Australia seems, on present indications, to be a very promising venture. Existing canneries have found difficulties in obtaining supplies of fish, but that is chiefly due to lack of boats suited to the specialized fishery, and to some extent to a dearth of fishermen who are accustomed to handling the gear required. Three main methods of catching are available - (1) purse-seining; (2) trolling; (3) live bait fishing.

Purse-seining is difficult in these waters owing to the limited time during which the seas are calm enough to allow of the operation of this type of gear, and to the limited aggregation of the shoals. It is thought better to concentrate on the other two methods since they can be applied.

Trolling in small boats is quite effective, and bluefin, striped tunny, and albacore can be caught by this method, which is recommended where the fish are thick and relatively close inshore.

Live bait fishing has been successfully tried by this Division for striped tunny, using anchovies as bait, and bluefin can be caught in this way. Problems of bait supply, and the efficacy of the method, are at present engaging the attention of the research vessel.

It might be possible to attract fishermen from the barracouta fisheries of Victoria and Tasmania or from the Spanish mackerel fishery of Queensland, but a cannery must, as a first atep, make sure of its supply of fish. If live bait fishing is found profitable, it may be necessary to import both boats and crews from the Pacific coast of America

as a preliminary step. The tuna clipper is a specialized craft, and it would not be desirable to adapt existing craft to this purpose. The necessity for an adequate study of the commercial catching of the fish before the commencement of cannery operations cannot be stressed too much, especially as it is not possible, as in other fisheries, to rely on an extension of an industry already in operation.

Data are at present being prepared on the design of fishing craft, and also a paper on the occurrence of tuna; readers who are interested are referred to these papers.

The market for tuna is a matter which also requires consideration. In America, where salmon are plentiful, the tuna industry has threatened the supremacy of red salmon, and there is no reason why, in a country where red salmon do not occur, there should not be a ready and ever growing demand for a high grade canned fish. The possibility of overseas markets should also be considered, as higher production costs if they existed might be more than offset by the closeness of supply to the cannery.

Methods.

It is easy to produce a high grade tuna pack, the plant required, in addition to the usual, being refrigeration for holding the catch until it can be treated, and retorts for precooking the fish. A very full description of tuna canning is given by Roedel (1938). It has been found in the Port Hacking laboratory of the Fisheries Division that precooking times may, with advantage, be shorter than those given by Roedel. Striped tunny up to 10 lb. weight appear to give best results when cooked for ¾ to 1¼ hours, bluefin up to 20 lb. weight should be cooked for 2¼ to 3¼ hours, and larger fish correspondingly longer. If cooked too little, the flesh does not leave the bone easily, and if cooked too long it becomes soggy and tough.

Fish are landed fresh or frozen from the boats and carried by conveyor to the cannery, where they may be either frozen, chilled, or treated directly, as required. They should be bled as soon as possible after catching, and after gutting are washed by a hose at the cannery. Heads and gills are left on, and the fish stacked bellies down on racks which are run into the pre-cooker. Here the fish are cooked

in retorts made of heavy sheet iron. These may be from 13-20 feet in length, and hold 5 or 8 racks. The fish are brought gradually up to cooking temperature - 15 to 60 minutes according to the size of the fish - and cooked at 214 to 220°F. for the necessary time. The racks are then removed, and the fish allowed to cool for 8 to 24 hours. When cool enough to be handled, they are removed from the racks, the skin scraped off, the heads broken free, the body broken in half longitudinally, and the bones removed. Next, the halves are split, and the red meat removed by scraping. The white meat is cut up to the required size by mechanical means, and the portions of meat packed in the cans. Quarter pound, half-pound flats, and pound talls are used, and a 4-lb. pack put up for restaurants and hotels. Refined cotton-seed oil is added (about 1½ oz. per ½-lb. can), and a small teaspoon of salt, and the cans exhausted, seamed, and retorted for 75 minutes at 10 lb. 240°F. The oil may be added at once, or part before and part after packing. Care must be taken that the best grade deodorized oil is used in the pack. A very satisfactory oil is obtainable in Queensland, so that all ingredients are available in this country.

Quantities of salt and oil (from Roedel).

¼-lb. can	2.83 grammes salt.	½oz. oil
½-lb. can	3.54 grammes salt.	1½oz. oil
1-lb. can	4.25 grammes salt.	2 oz. oil

Unlacquered cans are the rule, but some American firms use lacquered cans especially for albacore. Occasionally aluminium cans are used for the "fancy" pack. There are three grades recognized: "solid" consisting only of large pieces of selected meat; "standard" with a proportion of flake meat; and "salad or "flake" consisting of small pieces and flakes. A 3/16 inch headspace is allowed for.

Solid pack tuna with olive oil is marketed as "Tonno", and is popular in Italian communities. In this, there should be little or no water to exude and cloud the oil. More dark meat may be used in this pack, and a double ration of salt is added.

In America only albacore is sold as "white meat tuna", and bluefin and yellowfin as "light meat tuna"; yellowtail, bonito are sold as "light meat yellowtail, bonito". Australian southern

bluefin, which is a different species from the American bluefin, has a texture and flavour resembling that of albacore, though the colour is not so light. These facts should be considered if an attempt is ever made to compete on the American market. The South Australian canned tuna appears to have a slightly better flavour and texture than the tuna of the eastern coast. This is not due to any difference in the pack, but appears to be inherent in the strain of fish.

Losses in Tuna Canning.

Yellowfin tuna between 6 and 20 lb. lose about 36 per cent. of weight in the preliminary cleaning and cooking, after 10 hours cooling, while striped tunny of 3½ to 10 lb. lose 34 per cent. (Fry, 1932). After final cleaning there remains 31 to 40% of the live weight. Mackerel tunny and Kishinoella lose approximately the same as striped tunny (i.e. 70%) but bluefin loses only about 60%. The rest of the fish goes to the fish meal plant. It has been found in this laboratory that the fish lose 8 or 9% of weight in the first hour of cooking, about the same in the second hour, and about 3 per cent. in the third hour of precook in the case of 10 lb. fish (mackerel tunny). The loss consists mainly of water, with a small amount of oil which is almost constant, and substances which should be useful for fish glue.

The canning of albacore is essentially the same as that for the other species, but greater cleanliness is observed owing to the higher price which is paid for this fish.

If varnished cans are used, care must be taken to keep the acid value of the oil below 1.4. Acid value increases with the age of the fish, this applying to the tuna oil and not to the vegetable oil added. The iodine value remains constant and can be used to determine the proportions of natural and vegetable oil in the can.

The food value of canned tuna is high, and the flavour somewhat resembles that of rabbit or turkey. It is an economical fish to use, owing to its high food and vitamin value (A and D are both present) and to the fact that a ½-lb. can makes an adequate meal for three people, with average appetites.

Bluefin, striped tunny, albacore, and mackerel tunny have been canned experimentally in this laboratory, and all have their virtues. Mackerel tunny is rather stronger in taste than the others, but is excellent for sandwiches, savouries, and made-up dishes, especially if mustard is added. The different species will appeal to different palates, and there is no general agreement as to which is most delectable, except in the case of albacore.

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4. Other Scombroids etc.

Fish of this class which are available in any great quantity in Australian waters include Spanish mackerel (Scomberomorus commersonii), bonito ("horse mackerel" in N.S.W.); frigate mackerel or leadenall (Auxis thazard); kingfish or yellowtail (Seriola grandis). In addition, there is the "school mackerel" of Queensland waters, and the common mackerel (Pneumatophorus australasicus), which is at times present in pilchard schools and is plentiful in Victorian and South and Western Australian waters.

(a) Spanish Mackerel.

This fish has a white firm-textured flesh, and is caught by trolling in Queensland waters, and as far south as Geraldton in Western Australia. It ranges from Coff's Harbour at least to Cooktown. Fishing boats follow it north, and most of the catch is sold fresh, bringing up to 8d. per lb. at the Brisbane market. It seems impossible to obtain it

from the fishermen at a lower price than 3d. per lb. This Division has little information on the possible expansion of the fishery, nor has the fish been canned. It yields a beautiful product when smoked, superior to any fish tested at this laboratory, and, by analogy with other scombroids, should can very well. Supplies would have to be available at 2d. to 3d. per lb. at the factory in order to make canning profitable, especially as a market for the canned product would have to be created, and it would not have the ready sale of salmon, sardines, etc., however superior it might prove. This Division would hesitate to recommend the formation of a canning project for Spanish mackerel, except perhaps in Western Australia, though it might be possible to organize the fishery and market it as a side-line from a cannery with an established name for some other fish. The long and somewhat rapid migration would make a constant supply of cheap fish rather difficult.

(b) Bonito.

Bonito is canned tuna style in California. A precook of from 25 to 40 minutes has been found sufficient for this fish, which occurs in its season in large shoals. Its flesh when canned is pinkish, and the texture and flavour are good and somewhat characteristic. It can also be packed salmon style and has much the appearance and flavour of pink salmon. This fish could be adequately handled in factories equipped for tuna canning, and could be used to fill in. As it is at present of no commercial value, it should be obtained cheaply. It is usually caught by trolling, but other methods might be found if the demand warranted them.

(c) Frigate Mackerel or Leadenall.

This is not canned commercially overseas. It occurs at times in schools off the New South Wales coast.

(d) Common Mackerel.

These are related to the chub mackerel of American waters, which are canned extensively in America. There, the fish are brought up from the boats by belt conveyors to the weighing machine, and flumed or belted to the cutting tables. If the fish are not to be used immediately, they are iced or kept in chilled brine. Most canneries have cutting and cleaning machines in which the heads, tails, or viscera are removed.

In some factories, the fish are brined for 1½ to 2 hours, but some packers have discarded brining and pack the fish raw. Packing is done by hand. The cans pass by belt conveyor to an automatic salt dispenser, and thence in turn to exhaust box seamer and retort. The exhausting time for 1-lb. tall cans (17 oz. fish gives a firm pack) is 20 minutes, and retorting time 90 to 95 minutes at 240°F. The yield from small or large fish is 17 cases of 48 cans each per ton of fish, and from medium fish up to 24 cases, the average being 20 cases per ton. The flesh of horse mackerel is firmer and lighter than that of common English mackerel (Scomber scomber). Common mackerel might well be canned in slack periods in regions where they abound. The fish are abundant in southern waters of Australia, but have not yet been commercially exploited. They provide a very pleasant pack when canned American style, being superior to Australian salmon. They must be tightly packed to allow for shrinkage.

(e) Kingfish or Yellowtail.

Yellowtail also makes a very pleasing pack, and is canned tuna style in California. Its flesh is white or cream. The smaller fish do not pack well in ½-lb. flats, and the larger fish tend to flake somewhat. Its flavour rather resembles tuna but is not so distinctive.

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5. Australian Salmon.

This fish is already being canned successfully by one company in New South Wales, and another company is about to commence operations. The existing cannery was successfully marketing its product prior to the war at 8½d. per 1-lb. can, and buying the fish at ¼d. to ½d. per lb. The product corresponds in quality to American chum salmon, and is useful mainly for made-up dishes, or for a cheap and nutritious meal of fish. There appears to be a steady demand, which exceeds the present supply. Its advantages are that it appears to be plentiful and is easily caught, occurring in large schools for a greater part of the year.

The fish are caught by beach-seines, and taken direct to the cannery or kept alive in pens for periods up to three months. They are scaled by mechanical scalers of a sturdy type, headed and gutted by hand, the gut cavity cleaned by mechanical means. The fish are then washed and cut to fit the cans. For the ¼ or ½-lb. cans, the dark flesh is removed. Addition of sodium nitrite causes the coloration of the outer flesh, but does not readily diffuse through the muscle if used in allowable quantities.

The red meat may be bleached to some extent by the use of potassium metabisulphide. Salt or brine are added to the filled cans, which are then exhausted for 15 minutes, seamed, washed in lye, and retorted. It is necessary to retort for 90 minutes to soften the bone, and even longer is desirable for the 1-lb. cans.

A considerable amount of work has been done at this laboratory to improve the salmon pack, but complete success in this direction has not yet been achieved. The addition of a small quantity of Australian anchovy, or of liquid smoke, improves the flavour somewhat, and filleting is regarded as an advantage by this laboratory, though such measures are a departure from the typical salmon pack to which the public has become accustomed. A further improvement is made by canning as "chicken haddies" as described elsewhere in this paper. By this means the flavour and texture can be improved, but the expense is higher, and it is possible that the quality of the fish would not warrant the extra expense.

It is felt that, owing to the great abundance of this fish, it is desirable to continue a study to improve canning methods.

6. Tommy Ruff.

This fish, which gives an excellent kipper, is being canned to some extent at Port Lincoln. It could be canned as a kipper or as a tomato sauce pack. The abundance of the fish from the canning point of view is not yet known.

7. Barracouta.

The extent of the occurrence of barracouta has not been ascertained as there are no statistics from which inferences could be drawn, but it is considered that an industry could be established which would double the present catch to produce perhaps 5,000 tons of canned fish. Centres of the industry would obviously be Hobart and Melbourne, Geelong, or possible Queenscliff or Port Fairy, though the migrations of the fish coupled with good facilities for road transport make it appear that the two former cities would be most suitable.

Methods. The fish have been experimentally canned at this laboratory, and several high quality packs prepared. The fish can be processed straight as for a salmon or mackerel pack, or canned in tomato sauce. A high class product has been packed as follows:-

The fish is filleted, skinned, and immersed in 60° brine for ¼ to ½ hour. It is then dried for an hour, and smoked over a fairly hot fire for 1 to 1½ hours. With the addition of a little anatto, prior to brining, the colour and appearance resemble that of smoked barracouta. The fish are then canned in rectangular 1-lb. cans, exhausted, and processed at 240°F. for 90 minutes. The fillets should be packed in 2 layers of three fillets each, with the insides on top and bottom of the can for appearance. Flavour, colour, texture, and the appearance of liquor are very good, and the fish should find a ready market. It has been found that curd presents a difficulty which can be largely overcome by adding 1 per cent. disodium phosphate to the brine.

There will be a prejudice in some quarters against this fish, but this should be overcome when the quality of the product is realized by the public. It could be a substitute for herrings, and possibly for all but the best salmon packs. With Australian salmon in the cheaper grades, barracouta, and tuna, there is no reason why Australia should not be self supporting as regards canned fish. Barracouta should easily hold after the war any market it may now attain.

8. Mullet.

Mullet canning in Australia has not so far proved successful. This fish is to a large extent seasonal, and brings moderate to good prices as a fresh fish. These factors militate against economically successful canning, but the canned product is regarded by all who have tasted fish packed at this laboratory as equal to if not superior to any other Australian fish. The appearance of the pack is excellent, and the flavour delicate. It is a product which should appeal to the busy housewife, as it can be served direct from the can and makes a delicious fish course. It is not canned overseas, but as an export and possibly even as a local product it would be limited by the fact that the supply of fish is not inexhaustable.

In Western Australia, ruling market prices for fresh mullet are so high that its canning there does not seem possible. In the eastern states, Coff's Harbour and Brisbane are good centres; at the former the cannery could probably operate on other fish, such as pilchards, tuna, and yellowtail, during the off season. At Brisbane it might be possible to encourage fishing during the run of sea mullet, but marketing arrangements might need modification. Canning at Pialba might be possible by a small organization on co-operative lines, and it might be possible to base a cannery at Gladstone, though it is found that the fish here are frequently spent. A mullet cannery would have to be either a small cannery run on co-operative lines, or a cannery using mullet in season and relying on other fish for the rest of the year. It is considered that on the whole mullet is possibly being overfished, especially in the case of the younger fish, and this fact makes one chary about advocating

an extension of the industry until investigations are completed. There is a similar prejudice against mullet to that against barracouta, but this is quite unfounded, at least as regards the canned product.

Methods.

Mullet packs readily in ½-lb. flat cans. A preliminary brine dip in saturated brine and 1 per cent disodium phosphate for 5 minutes tends to minimize "curd", and adds flavour to the pack. It can be canned straight, in tomato sauce with liquid smoke, or with vinegar or acetic acid. The tomato sauce pack requires inversion of the can after exhausting to remove excess liquid and avoid diluting the sauce, unless a very strong puree is used. Hot sauce is added just prior to seaming. The retorting time is 90 to 100 minutes in order to soften the bone.

9. Shellfish.

Shellfish canning is well developed overseas, especially in Japan and America. In the latter country, the fish are canned fresh, smoked, or as soups or chowders. The last mentioned are very popular in the United States. Oysters, scallops, and clams of various types are packed, and the shellfish industry is far in advance of that in Australia. In fact, there seems little prospect of a successful shellfish canning industry till methods are greatly improved, and areas of cultivation increased. The Sydney rock oyster has been canned at Port Stephens, and experimental packs both fresh and smoked were very good. It should be possible to found an oyster canning industry on imported spat grown on our own grounds as is done with Pacific oyster in America. Scallops are canned to some extent in Tasmania, but there seems no prospect at present of greatly extending the scallop fishery.

The canning process for all shellfish is rather similar, differing in detail and in amount of mechanization. The shellfish are landed at the cannery, washed in rotary washers with strong water jets or on vibrating screen washers, opened by steaming, and the meat removed by hand. They are then washed again to remove any sand or mud, brined in the case of oysters in 1.5 to 2 per cent. brine for a short time, and may

be preheated for 45 to 60 minutes up to 160°F. The cans are washed and drained, and meat packed to within ½ inch of the top of the can. The hot nectar from the preheating vats is used to fill the can to within ½ inch of the top, lids are crimped, cans exhausted for 15 to 30 minutes, seamed, and retorted for the following times: 1-lb. cans 45 minutes at 10 lb. - 240°F.; ½-lb. cans for 25 minutes at 10 lb. - 240°F. The time required to reach pressure is an additional 15 to 20 minutes. At the end of the process, the steam is blown off slowly for the first 5 lb., and as quickly as desired for the last 7 lb. The cans are then inspected and washed. They must come below 100°F. in less than 12 hours, or so-called "glass" crystals are formed (see above).

Razor clams are treated by a continuous process, which is illuminating in that it is very largely mechanical, and some of the equipment is very ingenious.

Scallops require certain special precautions. The cans should be packed tightly and closed without pickle or liquor or with only a small amount. Additional firmness is gained by dipping the clams into hot vegetable oil at 420°F. for 15 to 20 seconds. Processing at 230°F. for 40 minutes is recommended by Hess (1934), in order not to darken the meat. The hot cans should not be handled unduly.

Shrinkage in clam canning is minimized by controlling the length and intensity of steaming live clams, by the liquor added, and by the length of retorting time. Well drained meat shrinks less than wet meat. There is least shrinkage when undiluted clam liquor is used rather than diluted liquor or brine.

Japan has marketed canned smoked oysters which are very suitable for savouries. Recently, Sunderland (1939) has published a report which gives a successful method for this pack. The oysters are steamed for 30 minutes at 240°F. to open them; rinsed in 10° brine and smoked on oiled wire trays at 120°F. for 4 hours. At this laboratory 20 minutes was found sufficient for Sydney rock oysters. The cans are filled, and 1 to 1¼ oz. of salad oil are added to each ½-lb. can, which is then exhausted and retorted at 240°F. Further details will be found in the papers referred to below.

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10. Crustaceans.

Some previous attempts at canning crayfish have been made in Australia, as mentioned above (section II), but none of these have been successful. Experimental packs of shrimp by both wet and dry process were very good (T. C. Roughley, private communication), but the price of shrimps on the fresh fish market was considered too high to warrant further investigation. No attempts have been made at crab canning and the possibilities thereof can only be guessed at.

(a) Crab.

The two main species of crab occurring in Australia are Leptunus pelagicus or "blue swimmer", and the Queensland "mud crab". The full extent of their occurrence is not known. Large numbers of blue swimmers are reported from the head of Spencer's Gulf, South Australia, Wallis and other lakes in New South Wales, and at Paynesville in Victoria. This crab is small, and would require a lot of handling in comparison with larger forms. The mud crab occurs in North Queensland, notably in Hinchinbrook Passage, and possibly in other areas. It is possible that an industry similar to the Alaska crab industry (Jarvis, 1937) might develop here. The Alaska industry uses the crab Cancer magister. The crabs are caught in traps similar in principle to the crab pots used in Queensland, 150 traps are handled each day by a boat crew of two men, and these may land 1500 crabs per day in the height of the season. The carapace is removed by hooking the edge of the shell over a fixed hook. The crab is then

halved by bringing the body down over a stationary knife blade, the viscera are removed, and the body washed with water jets. The crabs are cooked in water with ½ lb. baking soda to 40 gallons of water for 20 minutes. Atlantic crabs (Callinectes sapidus) are cooked in a protective brine dip containing aluminium salts and lactic acid (Fellers and Harris, 1939). This, it is said, prevents blue meat. The meat is picked while hot, body and leg meat being kept separate. Alaska crab is dipped in a solution of acetic acid, 2 oz. per gallon , washed and dipped in 100° brine, pressed, drained, and packed with ¼ oz. salt per can.

Retorting times are: ½-lb. flats 70 minutes at 5 lb. 228°F.; 1-lb. and No. 2 cans 80 minutes at the same temperature, or 30 minutes at 15 lb. and 250°F.

A cold pack is also put up. This is steamed 20 minutes with the temperature rising to 212°-222°F., packed in No. 10 cans, and sealed without vacuum. It is shipped in ice or under refrigeration.

(b) Lobster or Crayfish.

The crayfish which is prevalent in Australian waters affords a good canned product, and it is possible that, with the development of canning industries in suitable areas, crayfish will be profitably canned in conjunction with other fish. South African crayfish, Jasus lelandi, brings a high price on the French market, though the demand seems to be lessening. There seems to be only a limited market for crayfish, and some publicity will be necessary to increase this.

Methods.

There are two methods of canning lobster and shrimp, the wet pack in which 0.5 to 3 per cent. brine is added, and dry pack in which no liquor is added. Wet pack is regarded by Hess (1937) as superior to dry pack in that the shrinkage of meat is less, and the occurrence of struvite crystals is minimized.

The lobsters are kept alive at the cannery in crates until required for canning, when they are boiled with steam in coils at 90 lb. pressure for 40 minutes, picked, washed, and packed as rapidly as possible. Shelled meat should be canned within 4 hours (Harrison & Hood, 1923). Hess

recommends the exhausting of cans as follows:-

¼-lb. cans, 3-5 min. at 210°F.; ½-lb. cans 5-10 mins., and 1-lb. cans 15-20 mins. The optimum temperature for retorting the wet pack is 239°F. (Hess, 1937).

Shrinkage is one of the major problems of lobster canning; 7 oz. freshly boiled meat shrinks to 6 oz. dry meat (dry meat is that left after draining for 1 to 1½ minutes). The amount of shrinkage is decreased by increasing the viscosity of the pickle, and by exhausting. The amount of dry meat increases after the first 12 hours storage, and there is a further increase in maturing (Hess, 1929).

(c) Shrimps.

Shrimps have been successfully canned by Mr. T. C. Roughley and Mr. Royle of the former Port Stephens Canning Company. It is suggested that with the use of otter trawls from motor boats the shrimp industry might be put on a sounder basis, if the occurrences are sufficiently large. Johnson and Lindner (1934) give a full description of the South Atlantic shrimp industry.

Method.

Shrimps are chilled on ice when caught, the heads and viscera being removed as soon as possible to delay spoilage. On arrival at the cannery, the shell is removed, and the meats received and weighed. They are washed by agitation in tanks or in rotary washers, and boiled in 50° salinometer brine to toughen the flesh. The external humidity governs the length of this precook, which ranges from 4 to 7 minutes for wet pack, 7 to 11 minutes for dry pack. The brine is changed after 4 batches have gone through. The meats are then cooled on wire trays or conveyors with blowers, and the meats repicked and graded. Mechanical graders may be used. The cans are packed by hand.

Wet pack shrimps are covered with hot 2.5 per cent. brine, and sealed. Canned shrimps should be exhausted. The retorting times are: No. 1 can 60-75 mins. for dry pack, 10-12 mins. for wet; No.2, 75-80 mins. for dry, 14-15 mins. for wet pack; glass, 13-18 for wet. The cans are allowed to stand for 10 days to detect swells. Lacquered cans and paper liners are used.

No. 1 cans should contain 5 oz. dry or 5¾ oz. wet drained weight; 1½-lb. talls 8¼ of dry or 9¾ oz. of wet; and ¼-lb. cans 4 to 4½ of dry or 4 oz. of wet meat.

An iodoform odour is frequent when shrimps have been feeding on Balanoglossus.

(d) Special Problems.

The canning of crustaceans presents several problems:

(i) Struvite or "glass" crystals. These are harmless, but affect the marketing of the pack. Their formation is due to bacterial action prior to or during storage, and is favoured by an alkaline medium. The use of lactic acid in the brine used for boiling should minimize their formation. The control is rapid handling of the material (see above).

(ii) Blue meat. This is regarded by Hess and by Harrison and Hood as due to the action of the copper present in the blood of crustacea with the ammonia given off from the flesh during bacteriolytic or autolytic action. Acetic acid, and 3 per cent. brine, sodium tartrate solution at pH 5.8, and latterly, aluminium salts plus lactic acid are used to prevent this.

(iii) Blackening or smut. This is due to the liberation of hydrogen sulphide from the meat, and its interaction with the tin or iron of the can to produce tin and iron sulphides. Parchment linings do not prevent this, and it is necessary to use lacquered cans, or preferably double lacquered cans - the lacquering of the finished can being preferable to lacquering cans in the sheet. Continuous parchment linings are an additional precaution. Aluminium cans may also be used.

It is suggested that the canning of crustaceans be undertaken merely as an adjunct to that of other fish products. They might be canned at Coff's Harbour, Flinders Island, Melbourne or Geelong, and Port Lincoln, and are about to be canned in Western Australia, where they occur in large numbers and are landed at a low cost.

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11. Fish Pastes.

Fish pastes are prepared by mincing and grinding fish fillets and adding thereto certain spices or flavourings, colouring matter and butter or lard, and at times a small amount of flour. The fat is used to bring the paste to the desired consistency, and the flour has a similar function if the ground fish is too moist. The writer suggests that if flour is added it be oaten flour, as this would have the advantage of being an antioxidant, and would tend to slow down rancidity changes in pastes made from fatty fish. At the same time starchy matter tends to stimulate mould growth. Starch is frequently used as a filler and in inferior pastes may reach 20 per cent. of the paste. In Canada, 5 per cent. farinaceous matter (dry starch) is allowable, but in Australia a declaration of such addition is required. Better quality paste should have a fish content of 97 per cent. with 3 per cent. of butter, lard, or seasoning (Manley, 1935), and no starch. The addition of starch is detectable microscopically; starch X 1.7 = moist bread content.

A number of precautions are necessary in the manufacture of fish paste. In the first place, it is necessary that the colouring matter used, and this is usually necessary, must be heat stable. In some places, Armenian Bole (ferrous sulphate) is used, but this is not permissible in Australia. Next, it

is necessary that the raw materials must be of first quality or flavour will be impaired. Thirdly, grinding must be even or spreading will be affected. Fourthly, the fat content must be approximately constant; lean fish require added fat, and fat fish may give a sufficiently smooth paste. A satisfactory paste contains fat 12.3 per cent.;moisture 65.4 per cent; starch up to 2.5 per cent.; protein 16.8 per cent; salt and flavourings 3 per cent. Air should be removed before processing, to avoid darkening through oxidation. This air is beaten into the paste in mixing, and is more easily occluded by a stiff paste. It may be removed by squirting the paste through a fine nozzle. The can or jar should be filled to within 1/16 inch of the top, and the vacuum of 20 inches applied slowly. Glass jars should be placed in a cold retort, and processed for 90 minutes while raising the temperature to 235°F. kept at 235°F. for 90 minutes, and cooled slowly during a further 90 minutes. They must be left in the retort till room temperature is reached. Some pastes are not retorted, the 10 per cent. salt content being relied on to keep the paste. If such a paste contained much farinaceous matter it would be very susceptible to mould growth. Pastes are usually made up to secret formulae, but usually consist of a fish as base, and a strongly flavoured fish to give character.

Bloater Paste. This contains red herrings as a flavouring and other smoked fish such as mullet, salmon, and kingfish, as a body. Salt, spices, and colouring matter are added in accordance with the formula of the firm concerned.

Anchovy Paste. This contains salt anchovies as a flavouring and a base of mullet, salmon, etc.

Salmon and Shrimp Paste. This should contain 85 to 90 per cent. salmon and 10 to 15 per cent. peeled shrimps. Pepper and butter or lard are added.

Lobster Paste. This is usually made from the waste from canning. Cooking and grinding intensifies the desirable red colour. Paste requires 1¼ times the retorting time for lobster meat.

Tuna Paste. The red meat of the little tunny and of other tunas makes a delicious paste, much resembling anchovy

paste in flavour. The meat is saved after the precook, and a little butter or lard and salt added.

The Smoking of Fish for Paste.

Fish used as a body for bloater or anchovy should be heavily brined - say 1 to 1½ hours in an 80 per cent. pickle, the time depending on the size of the fillets. They are then smoked over a slow sawdust fire for 10 to 12 hours to a moisture loss of about 25 to 30 per cent. This gives a dry product with a high salt content which will keep well at 32°F. until it can be made up, and the strong smoked flavour adds to the piquancy of the paste. Mullet smoked in this way has a flavour resembling that of red herring, and tommy ruff should be even more like herring.

It is suggested that Australian anchovies may be used as a substitute for the imported anchovy. These fish can be caught in large quantities on the south east coast of Australia, and have been landed by the research vessel at Twofold Bay in quantity by means of a lampara net, and by using a large ring net and a submarine light, in the early hours of the morning.

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12. Canned "Chicken Haddies".

"Chicken haddies" as known on the Atlantic coast of Canada are prepared for canning as follows: Fish (haddock, hake, or cod) are gutted, washed, and skinned, then brined for 10 minutes in saturated brine. They are then rinsed in clean water, spread on wire net trays, and loaded into a steam box, where they are steamed 15 to 25 minutes. They are then allowed to cool, and the flesh is removed. The flakes are packed in flat enamelled cans with parchment linings. The cans are then exhausted for 15 minutes, seamed, and retorted at 10 lb., (240°F.) for at least 70 minutes.

The average yield of cooked meat is approximately 40 per cent. of the raw weight of the fish. The skins can be salted for glue manufacture, and 36 per cent. of the other waste is suitable for meal.

This type of pack, as mentioned elsewhere, is well suited to Australian salmon. Being boneless it is suited to invalids or children, and for a fish salad. It should appeal to the Australian public.

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