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SOME PROCESSING AND TECHNOLOGICAL METHODS IN THE JAPANESE FISHERIES

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PREFACE

In the autumn of 1948 the Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service, initiated a project to have a team of fishery scientists make a reconnaissance of the Japanese pelagic tropical and subtropical fisheries. The team, composed of two fishery biologists and a technologist, was integrated into the Fisheries Division of the Natural Resources Section of SCAP and operated under Mr. William C. Herrington, the chief of the Fisheries Division. The primary objective of this reconnaissance was to gather information on all phases of the Japanese tuna fisheries which would (1) enable the Pacific Oceanic Fishery Investigations to more effectively plan the exploratory and investigational operation of the high seas fisheries of the Territories and island possessions of the United States in the tropical and subtropical Pacific Ocean, and (2) be useful in the administration by SCAP of the Japanese fisheries.

The primary concern of the fisheries technologist during the Japanese Reconnaissance was to gather information on the Japanese method of preserving and handling the tuna, fish-processing techniques, the various types of byproducts, and their fisheries technological research work. Tuna canneries were visited in Yokosuka, Kurihama, Yaizu, and Shimizu, but unfortunately most of the canneries were not in operation when they were visited during the months of December and January. Fish-liver oil plants in the vicinity of Tokyo were visited, and meetings were held with research workers at the fisheries experimental stations, private companies, and the universities.

Interviews with Japanese scientists did not prove too fruitful, mainly due to the language barrier. When interpreters were provided, they were satisfactory for the common, everyday type of conversation; but since they did not have a technical background, they were unable to interpret the more detailed and technical conversation. The Japanese scientists would describe their work briefly, and further questioning would not reveal the more specific description of their methods of research and results.

A great many of the research workers are engaged in limited and detailed studies that are of little significance in solving some of the problems confronting the Japanese fishing industry. There is a great deal of duplication of research work among the various institutions and individuals, and a great many of them are not familiar with the works of others or with the literature in their own field. The research program has been also somewhat limited because it has not been possible to replace some of the laboratory equipment destroyed during World War II.

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Written reports and articles on fishery technology published in the various journals were secured whenever possible in order to supplement the information obtained by interviews. Since these reports are written in Japanese, they must be translated into English before they can be studied and evaluated. There was no outstanding piece of research work among the limited number of publications, which included an English abstract.

Data on the Japanese fishing industry given in this report were obtained from as many independent sources as possible and were also checked for reliability, whenever possible, with information already on file with the Fisheries Division of the Natural Resources Section. It was not possible, however, for the Fisheries Division to make a check on all of the data included here.

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JAPANESE TUNA INDUSTRY

INTRODUCTION: The writer's observation of the Japanese methods of handling and processing tuna was limited due to the short stay in Japan and to the fact that only a few of the canneries were in operation at the time the visits were made. Only the landing and handling of fish caught in the winter tuna fishery were observed, and thus it is not possible to give an accurate description of the year-round operation. It was quite evident, however, that handling methods and processing techniques used by the American tuna industry are far more advanced than those in Japan. In his report entitled, "Survey of Processing Methods and Inspection Standards of Fisheries Products in Japan" for the Fisheries Division, Natural Resources Section, General Headquarters, SCAP, J. C. Lightburn states: "Observations disclosed that the processing techniques and handling methods in the Japanese fishing industry are outmoded. It is very apparent that no technological improvement of consequence has been made in the Japanese fishing industry for years. The only justification that appears possible for the use of the present methods is that they have been handed down from generation to generation." One of the contributing factors in this outmoded condition is that the Japanese use hand labor in many of the operations because labor is plentiful, whereas the American industry has mechanized the production lines and is constantly seeking ways to increase the operating efficiency and thus cut the cost of production.

HANDLING AND PRESERVATION OF FISH ABOARD THE TUNA VESSELS: The Japanese use ice to preserve the fish aboard the tuna vessels. Some of the larger tuna vessels have mechanical refrigeration with coils extending around the holds for the purpose of preserving the ice until needed, but none of the vessels has the necessary equipment for freezing the fish.[1/] At one time the Japanese experimented with freezing tuna by holding the fish in eutectic brine (around -6° F.), but they did not adopt this method commercially because of salt penetration of the flesh. The freezing of

1/ THE BANSHU MARU, A REFRIGERATED MOTHERSHIP, WAS USED WITH A FLEET OF THREE TUNA CATCHER BOATS FOR ONE MONTH DURING THE SUMMER OF 1948 AS AN EXPERIMENT TO DETERMINE THE PRACTICABILITY OF USING A MOTHERSHIP IN THE TUNA FISHERY.

fish also has been avoided partly because the Japanese consumers prefer eating raw "fresh" tuna and because the skipjack is used mainly for manufacturing katsuobushi (dried skipjack sticks).

In the summer fisheries, when the trips are less than twenty days in duration, the tuna and skipjack are usually chilled and preserved in a mixture of sea water and ice. When this method is used, 30-pound blocks of ice are loaded into the holds of the vessels. As the fishing operation begins, an empty hold is partially filled with sea water and large chunks of ice; and the sea water is cooled to approximately 32° F. Much more ice is added to the well at intervals during the process of lowering the body temperature of the fish from about 65° F. to approximately 32° F. In most cases the fish are held in the chilled sea water for the duration of the trip; but in other instances, especially with the yellowfin tuna, the cooled fish are transferred to another hold and packed in crushed ice.

When a mixture of sea water and ice is used to hold the fish, some salt penetration of the flesh may occur, but the fish can be cooled more rapidly and evenly as a result of better heat transfer than if only crushed ice were used. The appearance of the fish remains good because the fish is kept relatively free of slime and is less apt to be crushed by the weight of other fish.

Crushed ice is used primarily to chill and to preserve the tuna in the winter fisheries when the trips take more than 20 days. The holds can be partitioned with shelves three to five in number, with each shelf carrying two layers of fish surrounded with crushed ice. At the present time many of the boats do not use the partitions, but use the entire hold as a single unit. Generally speaking, in the prewar days the fish were handled with greater care. Some of the boats used 5 percent by weight of salt with the crushed ice, while a few boats iced the fish individually in wooden boxes, which were packed in tiers in the holds.

Tuna, other than albacore, which weigh over 30 pounds are eviscerated aboard the fishing vessels; the albacore tuna are usually left in the round.[2/] When the long-line method of fishing is used, the large fish are eviscerated as soon as they are hauled aboard the vessel; but when the pole and line method is used, the big fish are selected for evisceration after the fishing operation has slowed down or stopped.

In the several fish unloading operations observed at the dock, four or five of the fish were tied together by the tails, hoisted out of the hold with a winch, dumped onto the deck, and tossed down a wooden ramp to the dock where they were sorted according to species, weighed, and graded.

A relatively small percentage of the iced tuna landed is in sufficiently good condition for either freezing or canning for export to the United States. Approximately 10 to 20 percent of the albacore tuna observed at the fish docks during November and December were of good quality; the remainder of the fish were in fair to very poor condition. Statistics for the 1948 albacore tuna season showed that only about 35 percent of the total catch was suitable for freezing purposes. The following are some of the factors which contributed to the spoilage of fish:

1. Fishermen remain on the fishing grounds longer than they should because fuel oil is allotted to them on the basis of the amount of fish landed. Quality of the fish is not taken into consideration in making

2/ IT HAS BEEN POINTED OUT BY CLAUDE M. ADAMS, CHIEF OF THE PRODUCTION AND PROCESSING BRANCH FISHERIES DIVISION, NRS, SCAP, THAT ONLY THE LARGE FISH INTENDED FOR DOMESTIC CONSUMPTION ARE EVISCERATED AND THAT NO EVISCERATED FISH ARE ACCEPTED FOR FREEZING OR CANNING FOR EXPORT.

the fuel oil allotment; however, efforts are now being made to establish a system to distribute fuel oil on a basis of the amount of fish landed in edible condition. Most of the fish considered not to be of proper quality for export purposes is used for domestic consumption.

2. There is no incentive for delivery of high-quality fish since there is no differential in price between fish of excellent quality and those in fair or poor condition. Fishermen are paid the ceiling price for all fish in edible condition and about half the ceiling price for fish fit only for use as fertilizer.

3. Fish destined for domestic consumption are handled roughly and crudely. They are hooked indiscriminately and, too often, dragged over rough floors, and tossed onto vehicles or conveyors. Fish intended for export, however, are handled with great care.

4. Because available equipment and materials are scarce and inferior, there has been a shortage of proper refrigeration and ice-making facilities. For example, ammonia leaks are frequently noted and attributed to the substitution of ordinary pipes for the scarce seamless pipes when repairs on the existing refrigeration installations were necessary. Continual overloading of the system and improper maintenance were evident from the thick layers of frost on the refrigeration pipes and around the door sills at many of the cold-storage plants visited. In prewar days, the ice supply was more plentiful and the boats were able to take on additional ice at the Bonin Islands and at Formosa. Even then, the majority of the fish were only in fair condition in comparison with the present high United States standards.

PREPARATION AND PROCESSING OF TUNA AT THE CANNERY: There is no regular inspection of tuna at the cannery after they have been purchased and designated for

FIGURE 1 - WASHING ALBACORE TUNA BEFORE PROCESSING FOR CANNING.

canning purposes. The highest-quality fish are frozen either for export to the United States or for canning during the off-season. All these fish are frozen in the round. When the frozen fish are to be canned, they are thawed in large wooden tanks with running fresh water.

Butchering: Tuna to be canned are eviscerated and heads cut off. The heads are removed in order to decrease the size of the fish and to increase the capacity of the equipment for pre-cooking the edible portion. The Japanese claim that the appearance of the cooked meat is improved by cooking without the heads because of better drainage of the blood. The raw heads are used for bait or are cooked later with the entrails for fertilizer.

The fish are washed with fresh water and are ready for the pre-cook. The Japanese say that it is desirable to do the washing with salt water, and at one cannery the fish are actually held for 20 minutes in a 3-percent brine solution prior to the pre-cook.

Pre-cook Procedure Used: Pre-cook conditions as described by the company officials differed from cannery to cannery, but they fall into one of the several groups for which descriptive data are given here.

1. Pre-cook conditions were unchanged for each of the several species of tuna processed, but they did differ in certain respects based on weight of the fish as shown in the following tabulation:

Weight of Fish	Pressure	Temperature	Time of Cook
Pounds	Lbs./Sq. Inch	° F.	Hours
8-25	0	210.0	3
25-37	2	218.5	3½
37-50	3	221.5	4
Over 50	3	221.5	4½

A groove is cut along the middle of each side of those fish which are above 25 pounds in weight. Very large fish are also cut down the back to the backbone before the pre-cook.

2. The conditions for the pre-cook were adjusted for the species of tuna and for the size of fish within each species to be processed.

Albacore Tuna

Weight of Fish	Pressure	Temperature	Time of Cook
Pounds	Lbs./Sq. Inch	° F.	Hours
Up to 25	2	218.5	3
25-33	3	221.5	3½-4
33-42	3	221.5	4-5

Katsuo (Skipjack)

Weight of Fish	Pressure	Temperature	Time of Cook
Pounds	Lbs./Sq. Inch	° F.	Hours
Under 8.3	2	218.5	2

Yellowfin tuna are cut longitudinally into four strips and are pre-cooked as in the case of the katsuo (skipjack) mentioned above.

3. All fish are pre-cooked for 3½ hours at 4-pounds pressure. Larger fish have grooves cut down the back and along the sides so that they may be cooked the same length of time as the smaller fish.

During the tour of the tuna canneries the author did not have the opportunity of observing the pre-cook operations. It has been pointed out by Claude Adams, however, that the Japanese canners do not place proper emphasis on this important step in the process; and while the tables given on the previous page show the proper pre-cook time and temperature and pressure to be used, generally these conditions are not followed closely by most canners. Also, the bring-up time is insufficient to allow the fish to heat up to the normal pre-cook temperature of the retort.

FIGURE 2 - JAPANESE LABORER LOADING ALBACORE TUNA INTO A PRE-COOK RETORT.

Tuna-Cleaning Procedure: The special cleaning knife used to trim the tuna loins has no handle and is merely a metal blade about eight inches long and half-an-inch wide. The cutting portion of the knife is about three inches long and is on the edge of the blade which angles off and meets the opposite edge at a point. The tip of the cutting end of the blade is curved to one side.

After allowing the cooked fish to cool overnight, the skin is scraped away, the body is split longitudinally into two halves, the exposed backbone and rib bones are removed, and each half is split longitudinally again into two halves. The dark meat and any blood spots are carefully removed from the loins with the cleaning knife. The bones and skins are used for fertilizer, the dark meat and trimmings are packed in jars for the domestic market, and the top quality light meat is canned for export purposes.

FIGURE 3 - THE DARK MEAT AND BLOOD SPOTS ARE REMOVED FROM THE ALBACORE TUNA LOINS.

TUNA-CANNING PROCEDURE: Hand Packing: The trimmed loins are cut with a knife by hand in a wooden cutting block. The crumbling of the meat during the cutting process is kept at a minimum by this method. A minimum of 165 grams of meat is weighed out in a small pan, and these pans are passed along to the packers. Cotton-

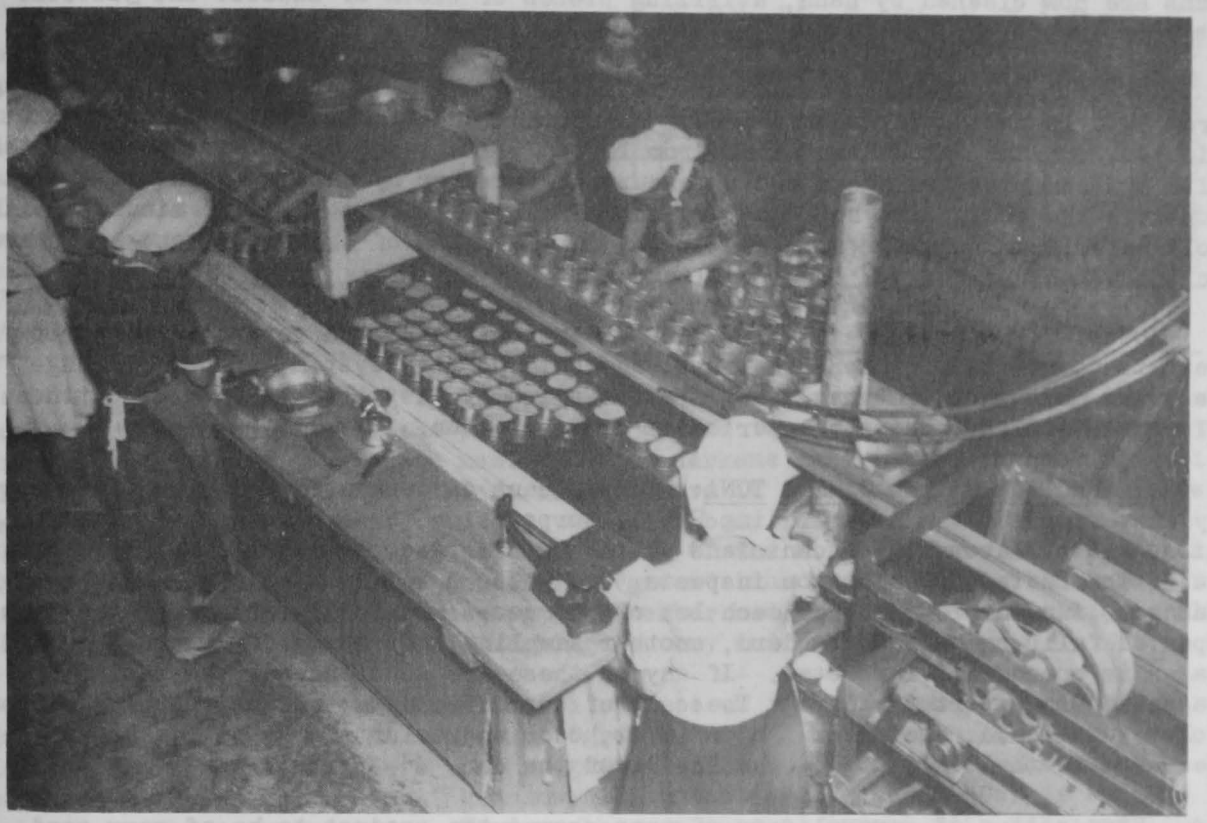

FIGURE 4 - PACKING CANS WITH ALBACORE TUNA AND CHECKING THE WEIGHT BEFORE SEALING.

seed oil imported from the United States is added to the empty cans, the amount of oil added varying from a small quantity to about 16 grams. Specifications require that the acid value of the cottonseed oil be less than 1.0; the oil being used now has an acid value of around 0.1. Next, the meat is packed into the cans very carefully by hand. One momme (3.75 grams) of salt is added with a standard spoon. The can is placed on a hand scale, and the remainder of the cottonseed oil is added with a dipper to bring the net weight of the contents to 200 grams. The cans are closed in vacuum-closing machines, which operate at capacities averaging between 50 to 60 cans per minute. One company passed the cans for five minutes through an exhaust box 60 feet long and then through the vacuum-closing machine. This company believes that the use of both the exhaust box and the vacuum-closing machine helps to remove any undesirable odors from the canned fish; however, the vacuum of the closing machine must be carefully regulated in order to prevent the loss of the cottonseed oil as the cans pass through the closing machine.

FIGURE 5 - PACKING DISCARDED SCRAPS OF ALBACORE WITH SOYA SAUCE IN TALL CANS FOR CONSUMPTION IN JAPAN.

Can-Cleaning Procedure: Formerly the cans went from the vacuum-closing machine through a mechanical can washer, which consisted of two large brushes rotating in a solution of steam-heated water and a special soap. These can washers are not being used at the present time due to the shortage of soap and to the lack of brushes. The cans are now cleaned by hand, utilizing pieces of cloth or sawdust and gasoline or other solvents.

Retorting: The canned tuna are retorted for 80 minutes at pressures ranging from 8 to 10 pounds per square inch. The "bring up" time varies from 10 to 20 minutes, and the "blow down" time from 10 to 25 minutes. The retorts are equipped with a steam pressure gauge and a mercury thermometer by which the retort operator controls the cook. The hot cans are cooled initially from 15 to 30 minutes with cold water from sprayers attached to the inside walls of the retort and are placed in the warehouse for the final cooling.

Generally speaking, the canneries have poorly equipped retorts. Many of the retorts do not have condensate traps, adequate cooling system, proper drainage outlet, nor more than one vent; they are not properly installed to insure continuous flow of steam throughout the period of sterilization.

INSPECTION OF THE CANNED TUNA: Sample cans of tuna are opened for examination by inspectors of the Food Trading Public Corporation, a semi-governmental organization, and by laboratory technicians of the Canning Association (Kan Binzume Kyokai Bu). The latter organization inspects 5 to 10 cans selected at random for each 100 cases of tuna or 20 cans for each lot of 500 cases examined. If one of the cans inspected falls below the standard, another sampling consisting of 20 cans per 100 cases is opened and inspected. If any of these are substandard, the whole lot is rejected for export purposes. The cans of tuna are inspected for vacuum, headspace, volume of liquid, drained weight of meat, odor and color of the juice, and the appearance of the tin plate on the inside of the can.

Examination of several cans of tuna showed the product to be of very good quality. The meat showed good color, normal flavor and odor; a sufficient amount of salt and good qualtity cottonseed oil were added; the cans registered from 2 to 14 inches of vacuum. It was noted, however, that the cans had no code marks on the lids by which such information as the date of pack could be determined.

TUNA-PROCESSING YIELD DATA: Data on the utilization of raw albacore tuna at one of the canneries during 1948 as submitted by the Japanese are as follows:

Item	Summer Pack	Winter Pack
	Percent	Percent
Fancy pack	26.0	31.6
Domestic-consumption pack	27.0	21.5
Heads (for fertilizer)	13.0	10.0
Viscera	4.7	2.3
Waste (bones, skins, etc.)	11.3	1/

1/No data available.

The pre-cook shrinkage loss is not listed and probably accounts for that percentage of the whole which is lacking.

A more detailed report on the utilization of the albacore tuna was obtained from another company which began packing tuna in July 1948. The fancy and flake packs are put in half-pound cans, and the trimmings canned for domestic consumption are packed in one-pound cans. Processing yield data for one day per month is included in the tabulation on the following page:

Date	Aug.5,1948		Sept.6,1948		Oct.5,1948		Nov.6,1948	
Number of fish	45 (frozen)		35 (frozen)		65 (iced)		48 (iced)	
Weight of fish	2,170 lbs.		1,849 lbs.		3,753 lbs.		1,992 lbs.	
	Wt. (lbs.)	%	Wt. (lbs.)	%	Wt. (lbs.)	%	Wt. (lbs.)	%
Waste (viscera, head, etc.)	491	22.6	374	20.2	668	17.8	316	15.8
Dressed fish	1,679	77.4	1,475	79.8	3,085	82.2	1,676	84.2
Shrinkage during pre-cook	432	19.9	369	19.9	513	13.7	267	13.4
Fish after pre-cook	1,247	57.5	1,106	59.9	2,572	68.5	1,409	70.8
Fancy-pack meat	1/	1/	479	25.9	1,128	30.1	541	27.2
Flakes	1/	1/	20	1.1	422	11.2	306	15.4
Domestic consumption	924	42.6	579	31.4	881	23.5	442	22.2
Waste (bone, skin, etc.)	2/	2/	28	1.5	141	3.7	120	6.0

1/323 pounds or 14.9 percent were used for the fancy and flake packs.
2/It is noted that no allowance is made for waste.

"GREEN" TUNA PROBLEM: The companies canning albacore landed during the winter months are confronted with the problem of "green" tuna. The so-called "green" tuna are winter albacore, the white meat of which darkens during the pre-cooking period. The "green" tuna differ from the normal albacore in that they are thinner; have smaller livers and lower oil content; and have body juice with a higher pH. It is estimated that approximately 30 to 40 percent of the albacore tuna landed during the winter months are "green" tuna. The "green" tuna are landed in the greatest number during the periods of October to December and March through April; a smaller number of "green" tuna are landed during January and February.

Although the Japanese made limited studies on this problem before World War II, no concrete evidence on the causes of "green" tuna seems to have been uncovered. However, several reasons have been suggested. The poor quality of the meat is associated with low-oil content, and low-oil content during the winter is said to be related to the spawning time. Summer albacore tuna is caught with pole and line and is landed aboard the vessel immediately after being hooked. The winter albacore tuna, on the other hand, is caught by the long-line method, and some people believe that a chemical change, which is responsible for the discoloration and poor flavor of the cooked meat, takes place in the fish as it struggles to free itself from the hook. It has also been noted that the discoloration is not always evenly distributed throughout the fish, but is more prevalent near the tail portion. Some people believe that these poor qualities occur only in fish in the process of decomposition, while others believe it has no relationship with the degree of freshness of the fish. Until a scientific investigation is made, the true conditions which are responsible for the "green" tuna cannot be determined.

CHEMICAL AND ORGANOLEPTIC TESTS ON ALBACORE TUNA: The Japanese have made chemical analysis of the winter albacore tuna and some of their results are given in tables 1-6. It should be noted that all of the tables are as submitted by the Japanese; no attempt has been made to check for any discrepancies.

The data in table 1 indicate that fish of low-oil content having body juice of a high pH are not desirable for canning because the cooked meat has an off-flavor, rancid odor, and a bluish color.

Glass-like crystals of magnesium ammonium phosphate are found in some cans of winter albacore tuna processed from fish caught offshore by the long-line method; no crystals have been found in tuna canned from the inshore catch. It should be noted that the crystal formation is related to high pH of the body juice and to low-oil content (table 2).

Table 1 - Results of Chemical and Organoleptic Tests on Winter Albacore Tuna

Caught by Pole and Line[1]	pH of Body Juice	Percentage of Protein	Fat	Ash	Quality of Meat[2]
		%	%	%	
1	6.100	90.91	6.03	3.55	Good
2	6.052	92.00	7.55	3.14	"
3	5.965	85.18	12.52	2.67	"
Caught by Long Line					
4	6.755	96.40	1.03	3.54	Poor
5	6.520	96.31	1.58	3.06	"
6	6.285	96.08	1.51	2.81	-
7	6.240	94.53	2.98	3.20	-
8	6.195	89.34	8.31	2.85	Good
9	6.150	88.23	11.03	3.20	"
10	6.130	84.12	12.98	3.29	"
11	6.100	84.50	11.78	2.95	"
12	6.083	78.66	21.07	2.83	"
13	5.980	77.43	20.60	2.67	"

1/Numbers in this column identify samples consisting of one fish each.
2/Quality is based on appearance, odor, and flavor of the canned meat.

A comparison of the quality of albacore tuna canned aboard a vessel with that canned in a shore cannery shows no significant difference (table 3).

Table 2 - Relationship of Crystal Formation to Body Juice pH and Fat Content of Winter Albacore Tuna

Caught by Pole and Line[1]	pH of Body Juice	Percentage of Fat	Crystal Formation
1	6.100	6.03	No
2	6.052	7.55	"
3	5.965	12.52	"
4	5.875	23.55	"
Caught by Long Line			
5	6.755	1.03	Yes
6	6.520	1.58	"
7	6.415	4.29	"
8	6.330	7.64	"
9	6.295	7.62	"
10	6.100	11.78	No
11	6.000	24.27	"
12	5.980	20.60	"

1/Numbers in this column identify samples consisting of one fish each.

Comparison of canned albacore tuna caught by the long-line method and by the pole-and-line method shows no distinct difference in the color of the meat; however, a distinct difference in flavor can be noted. Also, the canned meat of the inshore tuna is of good quality even if the oil content is low, although it is slightly bluish in color.

PRESERVATION OF BAIT FISH: Anchovies and sardines are used as bait for skipjack fishing; sardines, flying fish, sauries, anchovies, cuttlefish and small

macherel are used for tuna fishing. Whenever possible live fish is used for bait. These fish are also preserved by freezing or by salting and are used to supplement

Table 3 - Comparison of Albacore Tuna Canned Aboard Ship and in Shore Cannery

Sample Number[1]	pH of Body Juice	Percentage of Fat	Quality of Canned Meat[2]	Fishing Method
		Canned Aboard Ship		
1	6.370	3.67	Poor	Long line
2	6.360	7.32	"	" "
3	6.310	12.86	"	" "
4	6.170	1.67	"	" "
5	6.160	1.33	"	Pole and line
6	6.055	14.85	"	" " "
7	6.030	5.97	Good	Long line
8	5.921	7.29	"	" "
9	5.915	4.28	"	Pole and line
10	5.910	2.23	"	Long line
11	5.890	13.25	"	" "
12	5.880	6.14	"	" "
		Canned in Shore Cannery		
1	6.785	0.91	Poor	Long line
2	6.475	1.12	"	" "
3	6.420	0.92	"	" "
4	6.155	1.50	"	" "
5	6.145	11.77	Good	" "
6	6.080	3.57	"	" "
7	5.925	8.54	"	" "

1/Numbers in this column identify samples consisting of one fish each.
2/Quality is based on appearance, odor, and flavor of the canned meat.

the live bait or at times when live bait is not available. The best quality fish are selected and are placed belly up in a pan for freezing. They are frozen in blocks of about 30 pounds in weight and are kept in cold storage until needed. Prior to the beginning of the fishing operation, the block of frozen bait fish is thawed by immersion in water or by exposure to the air. In pole-and-line fishing, the fish are used directly after thawing; but in long-line fishing, it is necessary to salt the thawed fish in order that disintegration will not be too rapid after the hooks have been baited and placed in the sea. The fresh bait fish may also be dry-salted directly; the salted fish are then kept in cold storage until needed.

Table 4 - Summary of Observations Based on Studies of Winter Albacore Tuna

Physico-Chemical Observations	Fish Taken Mainly By Pole and Line	Fish Taken Mainly By Long Line
pH of body juice	Less than 6.0	Greater than 6.3
Color of cooked meat	Pink	Bluish
Flavor	Good	Off
Odor	Normal	Off
Fat content	High	Low
NH_3 content	Small	Appreciable
Crystal formation	A little	Appreciable
Discoloration of can	Slight	Appreciable

Table 5 - Chemical Analysis of Raw and Pre-cooked Albacore Tuna

Item	Fresh Whole Fish	Fresh Fish, Back Portion	Pre-cooked Whole Fish	Pre-cooked Back Portion	Spoiled Whole Fish[1]
	%	%	%	%	%
Water content	66.47	71.21	56.5	65.1	-
Solids	35.53	28.76	43.5	34.9	-
Total nitrogen	4.422	4.610	4.459	4.432	4.503
Hot water soluble N	1.527	1.475	0.7899	0.9512	1.106
Amino nitrogen	-	0.0576	0.0818	0.108	0.1791
Ammonia N	0.0219	0.0165	0.0207	0.019	0.0898
Lactic acid	0.215	0.3517	0.1758	0.2315	0.5442

1/Albacore tuna was landed at Ishinomaki on July 11 and stored for three days at 28° C.; the spoiled fish had a putrid odor.

Table 6 - Chemical Analysis of Different Portions of Pre-cooked Albacore Tuna

Item	Light Meat	Dark Meat	Back Portion	Belly-Flap Portion
	%	%	%	%
Water	65.33	62.96	66.94	63.72
Total nitrogen	5.076	4.731	4.761	5.390
Pure protein	3.838	4.060	3.822	3.854
Cold water soluble N	0.739	0.798	0.668	0.811
Amino nitrogen	0.0415	0.0358	0.0281	0.0549
Ammonia N	0.0302	0.0550	0.0336	0.0267
Ash	2.005	2.355	1.760	2.250
Fat	4.102	3.402	3.320	4.884

SOME JAPANESE SPECIALTY FISH PRODUCTS

FIGURE 6 - PLACING A BASKET OF SKIPJACK FILLETS INTO A COOKING VAT FOR STEAMING. THESE ARE THEN SMOKED AND DRIED FOR MAKING "KATSUOBUSHI."

KATSUOBUSHI: The most valuable product from the skipjack is the "katsuobushi," or dried skipjack sticks. The method of processing the skipjack sticks is about the same as the one described by Shapiro.[3/] The procedure is as follows:

Skipjack which weigh over one kan (8.267 pounds) are usually filleted into four pieces and are called "hombushi." The smaller fish are filleted into two pieces and are called "kamebushi." The fillets are placed in a cooking basket about two feet in diameter and are steamed for one hour. The cooked fillets are smoked with hardwood smoke and dried each day for a period of about three weeks. This reduces the weight of the fillets by 20 to 30 percent. The smoked fillets are scraped to remove the blackened surface and dried in the sun for one day. The removal of fat and the dehydration of the fish are ac-

3/THE JAPANESE TUNA FISHERIES, REPORT NO. 104, NATURAL RESOURCES SECTION, GHQ, SCAP. U. S. FISH AND WILDLIFE SERVICE FISHERY LEAFLET 297, P. 18, APRIL 1948.

complished by placing the fillets in a barrel where normal growth of Aspergillus form on the surface, scraping off the mold, and drying in the sun. This is repeated until the skipjack sticks are completely dehydrated, at which time growth of the mold ceases. The dried skipjack sticks can be kept rather indefinitely at room temperature without spoiling. The sticks are shaved, and the shavings are used to make soup stocks and to flavor other dishes.

FIGURE 7 - SMOKING BOILED SKIPJACK FILLETS. FILLETS ARE PLACED IN WIRE-BOTTOMED WOODEN RACKS AND STACKED FOR SMOKING ON TOP OF BRICK FIRE-BOX.

SHIOKARA: Skipjack viscera are used to make "shiokara," a Japanese food product. The viscera are washed, cut into small pieces, and placed with some acetic acid and salt in wooden vats. The mixture is allowed to stand until fermentation has begun. The product is then ready for sale.

JAPANESE BYPRODUCTS

SQUALANE ($C_{30}H_{62}$): Squalane is a special lubricating oil produced by the hydrogenation of an unsaturated hydrocarbon, squalene ($C_{30}H_{50}$), which is extracted from the livers of shark living in the deep seas. The manufacturer claims the following properties for squalane:

a. Colorless, odorless, neutral reaction.
b. Pour point -61° C.; solidifying point below -65° C.
c. Viscosity (Centi-stokes) at 0° C. 131.0
30° C. 26.9
50° C. 12.9
d. Viscosity index 224 (Viscosity pole-height 1.6)
e. Viscosity ratio in Indiana Oxidation Test 1.08
f. Flash point (Pensky-Maltens) 190° C.
g. Boiling point 248° C. (5 mm.)
262° C. (10 mm.)
272° C. (15 mm.)
h. Specific gravity d_4^{15} 0.8115
i. Evaporation loss at 110° C., 6 hours 0.39 percent
j. Refractive index n_d^{15} 1.4530

The hydrogenation of squalene takes place over a 4-hour period at a temperature between 198° C. and 200° C. and at a pressure of between 5 to 10 atmospheres; nickel precipitated on silica sand is used as the catalyst. Approximately 300 liters of hydrogen are used per kilogram of liver oil. The hydrogenated oil is treated by vacuum distillation, and the distillate boiling between 240° C. and 260° C. is taken as

the desired fraction of the product. This oil fraction is treated with aqueous caustic soda to neutralize the fatty acids after which it is cooled to -10° C., filtered, and washed with ethyl alcohol. Finally the purified material is redistilled under a vacuum of 5 mm. of mercury, and the distillate boiling at 248° C. constitutes the finished product.

"Squalube B" is manufactured through a special treatment of squalane by which the viscosity is increased. "Squalube B" has the following properties:

a. Neutral reaction
b. Viscosity (Centi-stokes)

-20° C.	1460
0° C.	259.1
50° C.	24.4
100° C.	6.7

c. Viscosity index 147
d. Pour point -55° C.

The principal uses for squalane and "squalube B" are:

1. Lubricant for aeronautical instruments, meters and observation instruments for high altitude meterology, medical implements, watches, and other general precision machinery.

2. Standard viscosity oils.

3. Base oil for anti-freezing grease.

4. Preparation of "squalin," which is squalane activated biochemically and which is used as a medicine for tuberculosis.

INSULIN: One company has been producing insulin as a byproduct for about ten years, and at the present time it produces about 60 to 70 percent of the total Japanese production. This insulin is extracted from the islands of Langerhans of skipjack, salmon, cod, and tuna. An islet weighs about 0.03 grams, and about one international unit of insulin can be obtained from each fish. After the islands of Langerhans are picked out from the internal organs of the fish, they are preserved in a saturated solution of picric acid until the time of processing for the insulin. The method for processing insulin is as follows:

Add silica sand and a small quantity of acetone to the islands of Langerhans; then grind the mixture thoroughly and filter. Repeat this step using successive small volumes of fresh acetone until an amount equivalent to about eight times that of the weight of the solids has been used. The combined acetone extract is held at room temperature for two to three hours and then centrifuged at 3,000 r.p.m. for 15 minutes. The liquid layer is separated from the precipitate, which is discarded.

Next, the acetone is removed from the liquid layer under vacuum at 40° C. to 42° C. As the acetone is being removed, picric acetate and fat separates from the residual solution. This mixture is centrifuged, the liquid layer is discarded, and the remaining precipitate of picric acetate and fat is dissolved in a solution composed of 25 parts of N HCl and 75 parts of ethyl alcohol. This alcohol-acid solution is centrifuged.

The clear solution from the centrifuge operation is poured slowly, with stirring, into pure acetone, and hydrochloric acetate of insulin is precipitated. This

precipitate is filtered, washed first with acetone, then with ethyl ether, and dried in a vacuum dessicator. The washing with acetone and ether and the drying steps are repeated. The hydrochloric acetate of insulin is dissolved in distilled water, the pH is adjusted to 5.0 with hydrochloric acid, and the final product is put into ampules.

VITAMIN A OILS FROM FISH LIVERS: Sources: Vitamin A oils are extracted from the livers of many different species of fish. In table 7 are listed the chief sources of vitamin A oils. The minimum and maximum vitamin A potencies were obtained from the analysis of a limited number of livers in the laboratory. The vitamin A potencies listed under the heading "average" are the values obtained by averaging the data from the analysis of the vitamin oils submitted for export and local sale and do not represent the average value of the livers analyzed in the laboratory.

Table 7 - Oil and Vitamins A and D Content of Fish Livers

Item	Percent of Round Weight	Oil Content	Vitamin A Content in I.U. Per Gram of Oil			Vitamin D Content I.U. Per Gram of Oil
			Minimum 1/	Maximum 1/	"Average" 1/	
	%	%				
Albacore	-	6	26,900	44,900	34,000	-
Bluefin	-	13	32,900	429,900	100,000	-
Bonito	1.0	5	9,900	68,100	12,000	30,000
Bream	0.8	20	-	-	100,000	-
Cod	4.0	35-55	800	2,400	1,600	150
Fin whale	-	5	-	-	55,000	-
Flounder	1.9	20	3,900	42,900	22,000	-
Halibut	-	9	-	-	30,000	-
Hammerhead shark	-	25-35	2,700	44,100	22,000	-
Hiragashira (shark)	-	35	-	-	12,000	-
Horse mackerel and hokke	0.9	3	-	-	50,000	5,000
Jewfish	-	10	319,000	1,393,300	388,000	-
Mackerel	1.2	4-5	5,200	67,000	25,000	500
Mebachi (big-eyed tuna)	-	8	59,200	88,300	44,000	-
Meji (small tuna)	-	5-8	33,900	51,400	33,000	-
Menuki	-	10	39,000	440,000	88,000	-
Spearfish	-	8	-	-	50,000	-
Sperm whale	-	8	40,000	100,000	70,580	-
Swordfish	-	8	52,000	178,000	88,000	-
Yellowfin tuna	-	8	30,600	84,900	44,000	-
Yellowtail	0.9	7-15	6,600	14,000	10,000	10,000

1/ Minimum and maximum potencies were obtained from laboratory analysis of livers. Average potency was obtained from analysis of vitamin oils prepared for export and local sale.

Purchasing Procedure for Fish Livers: The liver-oil producers purchase the fish livers on a speculative basis. Livers are separated according to species and are placed in 5-gallon cans. Buyers from the processing plants examine the livers, guess at their value, and make a bid. The purchased cans of livers are usually frozen at the receiving stations or at the company's cold-storage plant.

Processing Procedure: At the liver-oil plant, the frozen livers are thawed, put through a meat chopper, and then a disintegrator. The ground liver material is diluted with one-half to one part by volume of water. The companies visited add enough sodium hydroxide so that the pH of the mixture is between 9.0 and 11.0. The mixture is heated with steam up to the digestion temperature, which varied from 40° C. to 90° C. depending upon the kind of liver and upon the ideas of the company doing the processing. The digesting material is stirred with the aid of paddles, which rotate at speeds varying from 30 to 40 r.p.m., for a period of 30 to 60 minutes.

Cod, shark, and pollock liver oils are used as pick-up or "wash" oil for livers of low-oil content to assure maximum yield of vitamin A from the raw material. These oils have a vitamin A potency of about 1,000 to 10,000 units per gram of oil. Usually 10 percent by weight of pick-up oil is used for each "wash," but up to 20 percent has

been added on occasions. The "wash" oil is usually added to the mixture to pick up the vitamin A after the digestion, but one company added the oil before the digestion.

The oil and aqueous liver material are allowed to separate by gravity; then the oil is siphoned off. Some of the companies repeat the "washing" step with new pick-up oil. Finally, the aqueous liver material is further diluted with hot water and sent through centrifuges to recover the vitamin-containing oil.

Each batch of oil is tested for free fatty acid content, and if necessary there is a treatment with a 15 percent solution of caustic soda to neutralize any excess free fatty acid. This mixture is centrifuged to separate the aqueous soap solution from the refined oil which is stored in large drums or tanks until sold.

Vitamin-A Tablet Manufacture: Several of the companies producing vitamin oils from fish livers also manufacture vitamin-A tablets. The livers are ground and dehydrated in an oven under a vacuum of 600 mm. of mercury for three hours at a temperature between 70° C. to 80° C.; two rotating rods mix and break up the liver material during this dehydrating process. Next, sugar, milk, starch, stearic acid, water, and spices are mixed with the liver powder for thirty minutes. This mixture is dried in a vacuum oven for approximately two hours, and stamped into tablets which are then covered with a sugar coating. Part of the vitamin A in the raw material is destroyed before the product is finished due to the processing conditions.

Report of Vitamin-A Research Projects: Research work on vitamin A has been carried out at the fisheries experimental stations and at the universities. Experiments are being carried out in the following projects:

1. Vitamin A content of the different portions of the fish is being determined for the various species of fish. It is reported that the oil from the intestines has a disagreeable taste. The vitamin-A content of the pyloric caeca is generally high.

2. Work is being carried out on vitamin A concentration by the molecular distillation method. The Japanese are using Hickman's apparatus and are now advanced to the pilot-plant stage.

3. Studies are being made on the destruction of vitamin A during the processing and refining stages of current manufacturing procedures.

4. Studies are being made to correlate vitamin-A deficiency with diseases. There is a high rate of incidence of vitamin-A deficiency among the tuberculosis patients.

5. Research on synthetic vitamin A and on antioxidants is being carried out, but no details on the work are available for this report.

FISH MEAL: Since the writer did not visit the fish meal plants in northern Jap the following is abstracted from a report on the processing methods for fish meal i Japan by the Fisheries Division, Natural Resources Section, SCAP.

The fish reduction industry in Japan, in many instances, is very primitive and wasteful of both meal and oil. There are 5,809 fish reduction plants in Japan with average annual capacity of 4.6 tons of oil and 100 tons of meal per plant. Only 2 of the plants can produce more than 4.4 tons per 10-hour day. The processing of fi into meal and oil products is useful when gluts of (normal) distribution channels

occur. Regardless of the quality of the meal and oil, this end use is considerably better than using the fish for fertilizer in a raw state. When fish are buried in the ground as fertilizer, the oils present in the fish make proteins less available and retard the disintegration of the fish flesh. Generally five tons of fish are required to produce one ton of fish meal. Oil is obtained only in proportion to the amount of oil present in the body of the fish. This varies greatly according to the species.

One of the most prevalent methods of manufacture of fish meal in use in Japan is that of the small family-type of processing plant. These consist, in their simplest form, of a cast iron pot about 3 feet to 4 feet in diameter and 3 feet deep bedded in the sand at the edge of the beach, with a fire hole dug below the pot. A wooden press is required, as well as a few rice straw mats and buckets. The fish are placed in the pot, water is added and the whole cooked, allowed to cool, and the oil skimmed off. The solids are pressed in the wooden press, which is merely a flat base with a rectangular frame rising from it. A large screw with a flat base of the same shape of the rectangular frame is suspended from the top. The screw is turned by a wooden lever and presses the fish. This is very similar to hand-operated grape presses for extracting juice for the manufacture of wine. The stickwater and oil extracted from the fish settles in a pan under the press, and the oil is skimmed off. The oil is collected in buckets, and the meal spread on the rice straw mats on the beach to dry. The meal is used as fertilizer, but as all of the oil has not been extracted, it is of poor quality. In some areas, where large fish catches occur, this type of plant may be found located within 100 yards of another plant.

The larger factories vary considerably in type and efficiency, but all are relatively crude in design and poor in performance by comparison with reduction plants of other countries. Description of some of the larger plants are as follows:

1. A three-stage cooker complete with screw conveyor and continuous screw press. This plant should be able to produce meal with 5 to 6 percent oil. Actual tests show the meal contains 13 to 18 percent oil. This plant has three rotary driers 36 feet long and 6 feet in diameter. These are direct-heat driers, the heat being derived from a coke furnace. The meal is passed through two of the driers before it is ready for grinding. Fuel consumption of this plant is one ton of coke per ton of meal. The capacity of the factory is 37 tons of herring or 55 tons of sardines or mackerel per day. The yield of meal is 18 percent of the raw fish weight.

2. An intermediate type plant is one in which the fish is boiled with steam in open vats, pressed in hand-operated worm screw presses and dried on trays with wire bottoms of graded wire mesh. Flues run beneath the floor. In one plant the sides of the drying shed were open, resulting in a considerable loss of heat. The oil is recovered in settling pans.

3. A plant which produces fish meal and oil as byproducts to a patented process for production of imitation soybean sauce. The fish are boiled with water in steam heated vats with mechanical agitation to give a thick grey slurry. Boiling is at 90° C. for 30 to 60 minutes. The solids are removed in basket centrifuges and dried in rotary driers heated by coke flues. Some burning of the meal occurs at times in this type plant. Some soot particles may contaminate the meal. The oil is recovered by Sharples-type centrifuges; the heavy stickwater is treated with 2 percent hydrochloric acid, pressed in hydraulic presses and allowed to settle for 2 to 3 days. From this mixture the imitation soy sauce is made.

POISONOUS FISH OF THE SOUTH SEAS

Dr. Yoshio Hiyama, professor at Tokyo University, participated in the study of poisonous fish in the Marianas and Marshalls area during the period from July to December 1941. The following information was obtained from interviews with Dr. Hiyama and from a translation by W. G. Van Campen[4/] of Hiyama's book, Report of an Investigation of Poisonous Fishes of the South Seas.

Since it was impossible to test all of the numerous species of fish found in the Marianas and Marshalls areas, tests were made only on those which had been reported poisonous, on those which closely resembled the reportedly poisonous species, and on all species which appeared promising as food fish because of their abundance and large size. The parts of the fish used in the animal-feeding tests were cooked in a covered alumite cooker with an equal quantity of water. Mice, cats, and some puppies were used as the experimental animals.

In view of the high temperatures prevailing and the lack of sufficient refrigeration facilities in the South Seas, a study was made of the relationship between putrefaction of the fish and toxicity. Muscle tissues varying in condition from fresh to putrid from six species of fish generally considered mildly toxic were fed to animals. Although some ill effects on the animals were observed, none of the animals died in any case. A study of the case histories of fish poisoning in humans showed that some incidences of poisoning occurred even when the fish were eaten soon after they had been caught. Dr. Hiyama concluded that the poison is not produced by the decomposition of the fish.

The organs which could be segregated and the various sections of the muscle tissues from the fish being studied were fed to the animals. No definite results were obtained which would limit the location of the poison in the fish. It was also found that the poison is easily extracted from the muscle tissues with water or alcohol and that the strength of the poison in most cases was not affected by heating at 100° C. for 20 minutes.

Dr. Hiyama stated that a popular belief--that some species of fish which are edible in Japan are poisonous in the South Seas--has a very wide circulation. However, he found species of fish in the South Seas which closely resemble those found near Japan, and only by careful comparing of specimens was he able to distinguish the difference between them. In most cases, the fish which closely resembled each other were of the same genus but of entirely distinct species.

Another theory attributes the poison to the food that the fish eat. Since many of the poisonous fish are found around the coral reefs, some people believe that fish which feed on coral or eat coral animals are poisonous. Of the 45 reportedly-toxic species studied by Dr. Hiyama, some fed on coral, some on small fish, others on large fish, and still others on shellfish. No definite connection could be found between the feeding habits of any poisonous fish and its toxicity.

Other workers have reported that in a number of species the toxicity of the poison varied with the age of the fish and with the locality where they were caught. The toxicity of some fish is reported to vary with the season, and it is attributed to some physiological causes related to spawning. Dr. Hiyama was unable to gather information to either prove or disprove these reports during the short period of time of his investigation.

4/ TRANSLATOR, PACIFIC OCEANIC FISHERY INVESTIGATIONS, FISH AND WILDLIFE SERVICE.

Chemical studies have been made of the poisonous fish caught in the vicinity of Japan, and the reports were written in Japanese. A few of the articles were translated into English and a digest of the articles are given here.

1. A report by Takahashi and Inoko.

The poison found in the ovary of the globefish, S. vermicularis is easily dissolved in water and slightly soluble in dilute alcohol. It is not soluble in the following: absolute alcohol, ether, chloroform, petroleum ether, and amyl alcohol. The poisonous substance is not precipitated by lead acetate nor by several kinds of alkaline reagents; it passes through animal membrane easily. The poison is destroyed when heated for a long time in either an alkaline or acid solution. The poison is not like an enzyme, toxalbumin, nor other organic bases. The procedure for the extraction of the poisonous substance is:

> Wash fresh ovaries of globefish several times with ether and absolute alcohol. Grind the ovaries and mix with distilled water at room temperature. Add some lead acetate; filter and discard the precipitate. Remove the excess lead acetate in the filtrate by passing hydrogen sulphide gas through it and filtering off the precipitate. To remove choline, add phosphotungstic acid and mercuric chloride; filter and discard the precipitate. Evaporate the filtrate to dryness under vacuum. Wash the dried residue several times with absolute alcohol to remove impurities. The product is a yellowish non-crystal substance, insoluble in absolute alcohol, very poisonous, and contains a little inorganic matter. The substance has not yet been identified.

2. Work done by Professor Tawara, Kyushu University.

The poison tetrodonin is found in the ovaries of S. chrysops, S. rubripes, and S. lacepede. Tetrodonin is a colorless, neutral, needle-shaped crystal.

Tetrodoron acid is a white, resin-like substance, which is easily melted. It is soluble in dilute alcohol; slightly soluble in absolute alcohol; and insoluble in ether, chloroform, and carbon disulfide.

The procedure for extraction of tetrodotoxin from ovaries of S. porphyreus Sieb and S. vermicularis Sieb is:

> Grind the ovaries of the fish and mix with hot water. Add acetic acid to precipitate the protein, and filter. Concentrate the filtrate, and filter. Add lead acetate and dilute ammonium hydroxide; the poison is precipitated as a lead compound. Wash the precipitate with ammonia solution. Remove the excess lead with hydrogen sulfide. Concentrate the solution at a temperature below 60° C. Add absolute alcohol to precipitate the poisonous substance again; dry under vacuum. The residue is a brown resin-like substance. Dissolve this residue in water and remove the water-insoluble substances and decolorize the solution with activated carbon. Treat with the alcohol and ether. The residue is a yellow resin-like substance.

Tetrodotoxin is similar to tetrodoron acid, except that the former is about twice as poisonous as the latter. In order to be fatal, 4 mg.

of tetrodotoxin is required per each kilogram of body weight of the rabbit; 7 mg. of tetrodoron acid is required.

When tetrodotoxin is dissolved in a small quantity of water and allowed to stand, neutral crystals which have a slightly sweet taste are precipitated out. This substance has been identified as $C_6H_{10}O_5$ and is named tetrodopentose; it is quite similar to inosit $C_6H_{12}O_5$ reported by Scheer and Gallois. After removing the tetrodopentose, add AgCl to remove tetronin $C_{11}H_{11}N_9O_2$. Tetrodonin and tetrodopentose are not poisonous so that removal of these two leaves a purer and stronger poison--tetrodotoxin.

Another method of extraction:

Chop the ovaries of globefish and soak in a 3 percent formalin solution. Heat to 80° C. to coagulate the protein and filter. Lead acetate and dilute ammonium hydroxide are added to the filtrate in order to precipitate the poison as a lead compound. Filter and wash. Remove the excess lead with hydrogen sulfide. Concentrate the filtrate using vacuum. Add about three times as much methyl alcohol and filter. To the filtrate add a solution of saturated lead acetate and methyl alcohol and keep the solution neutral by adding ammonium hydroxide. Filter the precipitate. To the filtrate add a little ammonium hydroxide and an excess of methyl alcohol saturated with lead acetate to precipitate the poison. Dry the precipitate at a temperature under 60° C. Dissolve the precipitate in water and filter to remove the water-insoluble impurities. Remove the excess lead with hydrogen sulfide. Decolorize the solution with activated carbon. Evaporate the solution until syrupy. Add alcohol and ether, and tetrodotoxin is precipitated as a white, pure substance.

3. An article by Y. Suyehiro.

All types of animals were injected with tetrodotoxin. The globefish were not affected by the injections, but poisonous spiders were killed. When a solution of tetrodotoxin was poured on the shell of a hermit crab, it left its shell. The octopuses are killed by the injection but other mollusca are not; neither are the animals of a lower order than the mollusca. Snails are put into a coma but are not killed even if the amount injected is large.

The tetrodotoxin is carried by the blood stream after it is injected into an organism. The author tied the leg of a frog so that the blood circulation was stopped. The frog was injected with tetrodotoxin but it did not die. When the string was cut and the blood allowed to circulate, the frog died.