A STUDY OF CERTAIN PHYSICAL FACTORS INVOLVED IN CANNING OF GREAT LAKES CISCO, LEUCICHTHYS ARTEDI (LE SUEUR)

Thesis for the Degree of M. S.

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This is to certify that the

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Roy E. Marshall
Major professor

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by

King Fong Wong

A THESIS

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A STUDY OF CERTAIN PHYSICAL FACTORS INVOLVED IN CANNING OF GREAT LAKES CISCO, LEUCICHTHYS ARTEDI (LE SUEUR)

INTRODUCTION

The Great Lakes cisco, Leucichthys artedi (Le Sueur), ranks first in poundage among the fishes caught commercially in the Michigan Waters of the Great Lakes. While this important fishery resource ranks first in weight, it is outranked in dollar value by both the Lake Trout and Lake Whitefish. This is due, in part, to the seasonal nature of the annual harvest resulting in an uneven supply to the market.

Table 1

Production of the State of Michigan Waters of the Great Lakes in 1944

From the Biennial Report of Michigan Department of Conservation

Species	Total pounds	Value
Great Lakes cisco	6,157,565	$ 335,770.37
Lake Trout	5,672,285	19,928,508.70
White and redhorse suckers	2,327,786	137,779.46
Lake Whitefish	1,974,709	726,398.77
Carp	1,782,235	73,421.55
Yellow Pike Perch	1,447,657	259,964.13
Yellow Perch	879,391	128,198.59
Chubs	731,486	138,763.59
Catfish	363,852	71,010.10
Longnose suckers	224,025	11,018.86

Table 2

Production of the State of Michigan Waters of the Great Lakes in 1945

From the Biennial Report of the Michigan Department of Conservation

Species	Total pounds	Value
Great Lakes cisco	6,910,394	$ 634,190.84
Lake Trout	4,963,165	2,208,014.06
Carp	2,901,163	177,631.45
White and redhorse suckers	2,593,729	214,798.36
Lake Whitefish	1,882,490	908,357,57
Chubs	1,356,635	318,499.23
Yellow Pike Perch	990,839	279,181.22
Yellow Perch	824,959	160,378.13
Catfish	432,126	113,944.59
Longnose suckers	430,871	23,825.74

Table 3

Catch of Great Lakes cisco by month in thousands of pounds in the State of Michigan Waters of the Great Lakes in 1944

From the Biennial Report of Michigan Department of Conservation

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Lake Michigan	42	62	34	17	21	134	139	42	12	42	70	18
Lake Superior	52	145	199	59	258	205	33	-	41	120	2,318	1,010
Lake Huron	8	-	-	10	53	32	32	18	20	49	130	87
Saginaw Bay	-	-	-	1	11	45	18	10	-	44	438	57
Total	102	207	233	87	343	416	222	70	73	255	2,956	1,172

CHART 1

Monthly production of Great Lakes cisco in Michigan in 1944

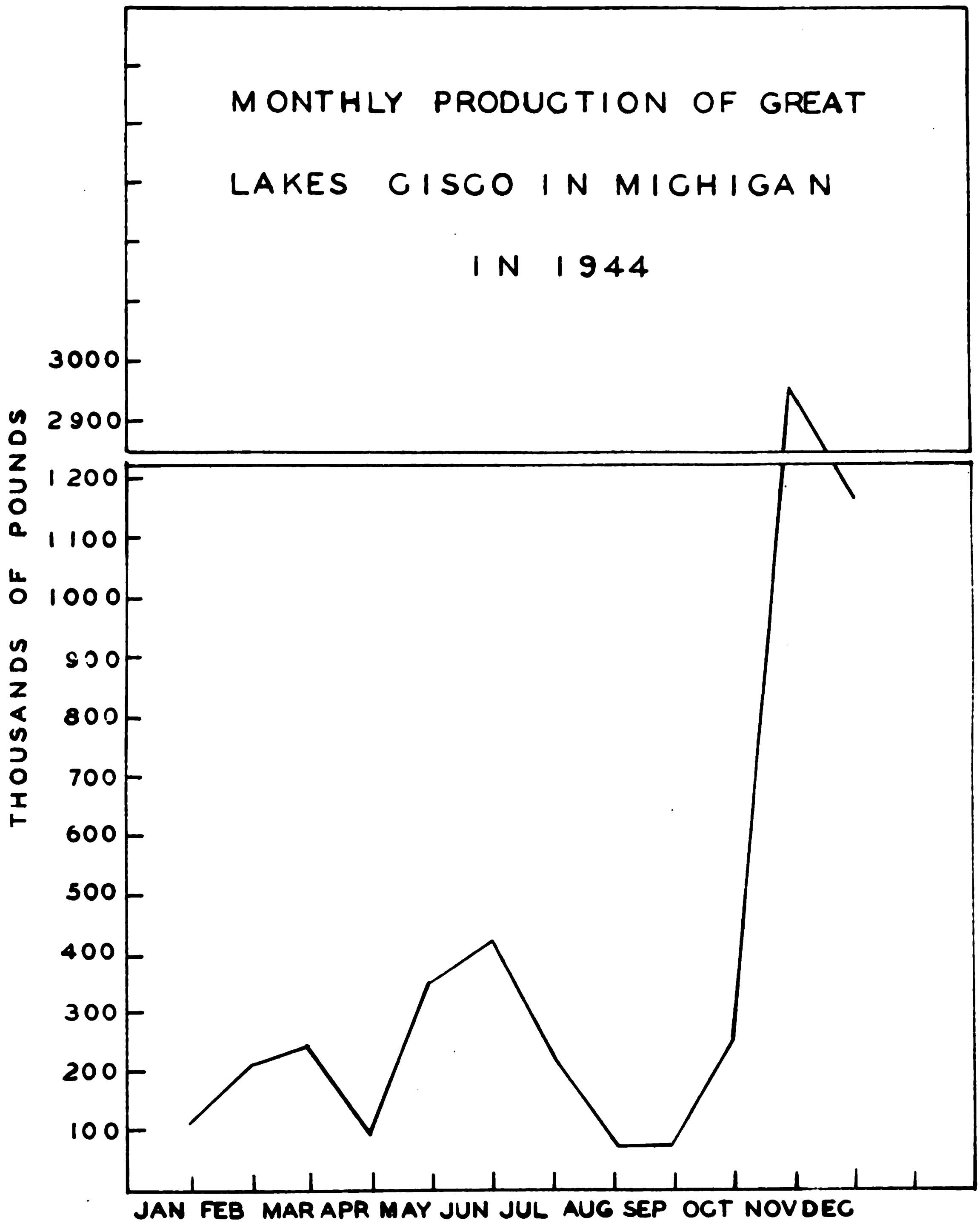
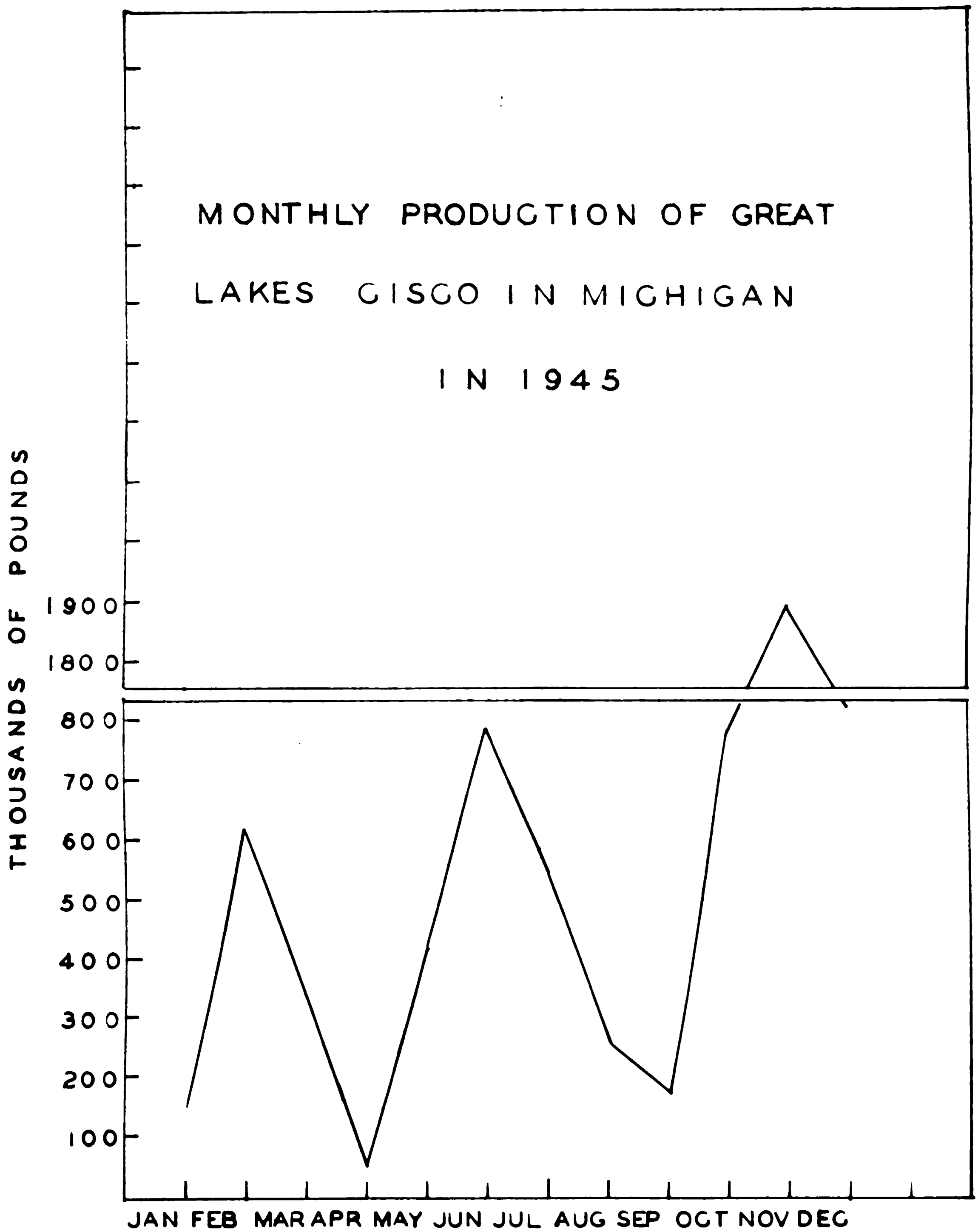

MONTHLY PRODUCTION OF GREAT LAKES CISCO IN MICHIGAN IN 1944
THOUSANDS OF POUNDS
3000
2900
1200
1100
1000
900
800
700
600
500
400
300
200
100
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

CHART 2

Monthly production of Great Lakes cisco in Michigan in 1945


MONTHLY PRODUCTION OF GREAT
LAKES CISCO IN MICHIGAN
IN 1945
THOUSANDS OF POUNDS
1900
1800
800
700
600
500
400
300
200
100
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

During the high production months of November and December, the fish congregate on the fishing grounds. The commercial fishermen harvest and market an enormous quantity of the cisco, which may result in glutting the market during these months. Conforming to the law of supply and demand, the market price is consequently greatly lowered. Late in December, the fish move into deep water and weather conditions prevent effective fishing, hence the supply becomes less abundant in the market, resulting in a price rise. This is illustrated quite well by prices on the Chicago Market as reported by the Fish and Wildlife Service, Market News Service.

Table 5

Chicago Wholesales Market Price in cents per pound in 1944 and 1945

From U.S. Fish and Wildlife Service, Market News Service,

Monthly Review of Prices on the Chicago Wholesale Market.

	1944		1945	
	Range	Average	Range	Average
January	9-15	12.0	7-20	13.5
February	12-16	14.0	18-20	19.0
March	15-23	19.0	15-22	18.5
April	13-25	19.0	17-24	20.5
May	10-19	14.5	22-26	24.0
June	5-13	9.0	22-26	24.0
July	7-13	10.0	15-28	21.5
August	4-13	8.5	14-25	19.5
September	8-20	14.0	10-19	14.5
October	5-17	11.0	5-19	12.0
November	5-10	7.5	5- 9	7.0
December	5-10	7.5	7-12	9.5

CHART 3

Monthly average market price of Great Lakes cisco

on the Chicago Market during 1944

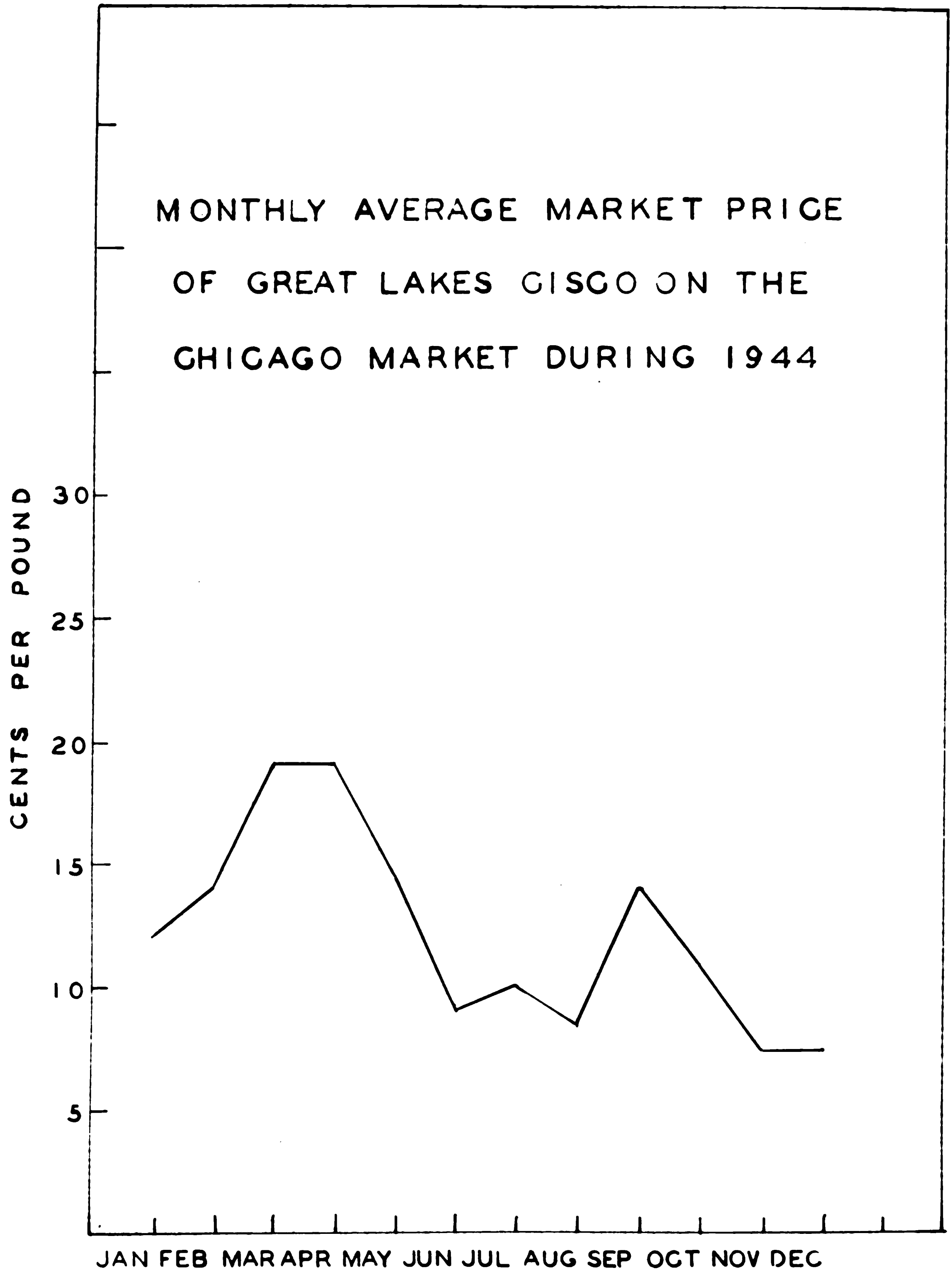

MONTHLY AVERAGE MARKET PRICE
OF GREAT LAKES CISCO ON THE
CHICAGO MARKET DURING 1944
CENTS PER POUND
30
25
20
15
10
5
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

CHART 4

Monthly average market price of Great Lakes cisco

on the Chicago Market during 1945

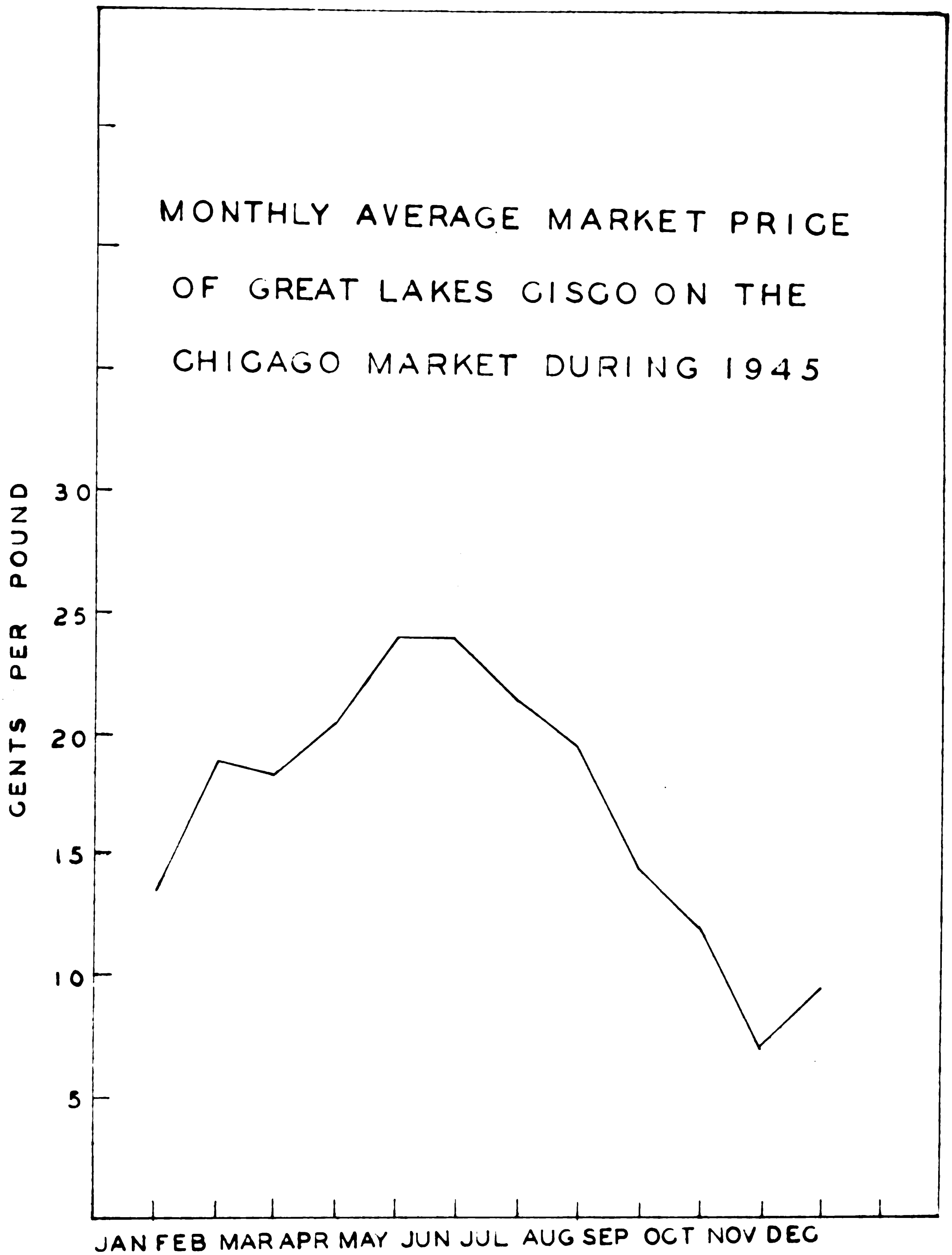

MONTHLY AVERAGE MARKET PRICE
OF GREAT LAKES CISCO ON THE
CHICAGO MARKET DURING 1945
CENTS PER POUND
30
25
20
15
10
5
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Table 5 shows that during November and December, the months of highest production, the commercial fishermen glut the market with an enormous quantity of the cisco, and the price may fall to the ridiculously low sum of 5 to 6 cents per pound. At such times, the producers may resort to selling large quantities to fur farmers for 2 to 3 cents per pound at the docks or they may freeze large quantities for sale either on the wholesale market or to the fur farmers later when prices have improved. Moderate quantities are also purchased at this time by processors who fillet and freeze them for the frozen food market.

In spite of the efforts to spread the marketing of these fish over longer periods of time, the prices still drop to levels that are not profitable to the commercial fishermen.

The Great Lakes cisco is a member of the Whitefish family, and in common with the Lake Whitefish, it has a tender, white, flaky flesh which when fresh and properly prepared, has a delicate flavor. The great abundance and low price of this species often results in poor handling practices which adversely affect the quality of the product as it appears on the market. This coupled with its inherent highly perishable nature may result in losses of all or parts of some shipments which are not sold at once.

It appears that the seasonal nature of the harvest of the Great Lakes cisco results in unfortunate marketing arrangements which in turn deprive the consumer of a uniform supply of high quality fish at a reasonable price. With this in mind, the present study was undertaken in an attempt to supply information necessary to process these fish for marketing in a more orderly and satisfactory way.

Canning offers a means of distributing the marketing of this species over the entire year, preserving them as a high quality product for use during the months of low production, making the final product more attractive and appealing to the consumers , and poor handling of the product may be completely avoided.

MATERIALS AND METHODS

The fish used in this study were purchased from the commercial fishermen of the Great Lakes with funds provieded for fisheries research by the Zoology Section of the Michigan Agricultural Experiment Station. They were shipped in the usual commercial manner by packing 35 pounds of round or whole fish in crushed ice in a wooden box. A total of about five hundred pounds of fish was used in this study. The size of the fish ranged from 9 to 12 inches.

Cleaning and dressing.

The fish were cleaned and dressed on a work table provided with running tapwater which served to wash the fish before they were dressed and to carry away the scales, blood and entrails as they were removed from the fish. The fish were scaled thoroughly with an electric rotary fish scaler. Special attention was given to scale removal to insure a clean scale-free fish for canning purposes. In places where the electric scaler could not efficiently remove the scales, a knife was used to finish the process. The fins often raised the scaler head enough to allow some scales in this region to remain untouched thus necessitating close inspection and hand work. Following the scaling process, the head and entrails are removed with special attention to thoroughness. The kidney does not come away with the remainder of the entrails, but must be removed separately. It is necessary to insure complete removal of the kidney to prevent it imparting a disagreeable flavor to the canned product. After the fins are removed the fish is again thoroughly washed in running water and set aside to drain before being placed in the brine.

Brining

A salt solution testing 96° salinometer at 17° F was prepared by adding 311.3 grams of sodium chloride (fine salt) per liter of water. The salinometer reading of 96° was used instead of 100° because the former accomplished the same result and saved the extra time required to make a saturated brine in open containers. Stainless steel containers of 12 liters capacity were used for holding the brine solution and about 60 fishes were placed into each container. The cisco were separated and immersed in liberal quantities of brine to prevent contact between the fish, thus insuring complete, even penetration of the salt.

Filling, exhausting, sealing and processing cans.

After the fish were immersed for certain periods of time in the brine, they were taken out of the brine and were cut to lengths of 3-3/4 inches and packed by hand into No. 1 standard cans (211 x 400) coated with C enamel. The cans containing the fish were placed in the steam chest where they were precooked or exhausted with live steam for 35 minutes. The cans were then sealed by a hand-operated can sealer. An experimental pressure retort was used for processing the cisco for 70 minutes at 240° F or 10 pounds pressure. Then they were cooled inside the retort by admitting cooling water under pressure to take away the heat.

Installation of thermocouples

In order to measure the rate of heat penetration into the canned cisco, thermocouples were made from gauge No.20 copper-constantan duplex glass insulated wire. The measuring junction was made by welding the copper and constantan wire together at one end. A hole measuring 1/4 inch in diameter was made in the middle of the side of the can wall.

A 3/8 inch pipe bushing was soldered over the hole. Then the thermocouples were inserted in such a way that the welded measuring junction lay exactly at the geometrical centre of the can. The thermocouple wire was then wound with asbestos valve stem packing and this was held in place and compacted by use of a pipe cap drilled to pass the thermocouple wire. The pipe cap was tightened enough to prevent leakage into or out of the can. The cans were then placed in the retort for processing. The thermocouple wires were passed through a packing gland in the retort so the free ends of the thermocouples were outside the retort. The sealing of the thermocouples described above was after the method suggested by M. Heerdt, Jr., F. Hoyos, and M. Cantillo, (1947), and modified by P.I. Tack.

The thermocouples were calibrated using the Leeds and Northrup Standard conversion tables in which the temperature readings in degrees fahrenheit were changed from millivolt readings. Distilled water ice was used for obtaining a temperature 32° F. A chemical thermometer was also used to register the temperature of the ice water in which the reference and measuring junctions were inserted. The millivolt readings on the potentiometer corresponded to the temperature reading of 32° F in the conversion table. This procedure was duplicated at 96° F, and the thermocouples were found to correspond with the tabulated values for the temperatures used.

Six thermocouples were connected in parallel, with their measuring junctions inside the retort and the reference junction in ice water. The cans were subjected to the processing temperature, and the rate of heat penetration was measured by a Leeds and Northrup Potentiometer. The amount of electromotive force set up by the difference of temperatures in the thermocouple circuit was measured in terms of millivolts which could be converted to temperature readings by referring to the said conversion table.

BRINING

Brining is one of the most important steps in the processing of the cisco, because brining improves the general quality of the fish, as well as the flavor and aroma of the product. If the cisco are canned without brining, the products are likely to become insipid and unsatisfactory. Brining improves the texture, making the flesh firmer as a result of withdrawing of water from the product by the more concentrated brine. It improves the keeping quality of the fish, as the number of bacteria is greatly reduced. According to Tanner, 1944, brining has bactericidal effect on the canned products, and the growth of Clostridium Botulinum was retarded at 10 per cent concentration of salt.

During 1942, the National Canners Association, the American Can Company, and the U.S.Fish and Wild Life Service conducted a cooperative study on the canning of Maine Sea Herring (Clupea harengus). They summarize the results of brining of Sea Herring as follows :-

" 1. Brining both large and medium fish in a 100° brine for 90 minutes was found to give the most satisfactory results.

2. Brining from 90 minutes to 6 hours does not seem to give the fish an excessive salt flavor, but fish brined for longer periods were both fibrous and salty.

3. Fish brined for periods shorter than 90 minutes, or in 70° brines, had a fresh or flat flavor and seemed slightly softer in texture."

The materials used in brining have been described under Section 11, Materials and Methods. Concentration of the brine solution was 96° salinometer. The cisco were soaked in the brine for different lengths of time, so as to obtain different degrees of salt penetration. At the end of different intervals of time, separate lots of fish were taken out from the brine, while the rest was allowed to continue the brining treatment. The range of time of brining varied from 15 minutes to 4 hours.

Two experiments were carried out for brining the cisco. In the first experiment, the time of brining was 1/2 hour, 1 hour, 2 hours and 4 hours, while in the second experiment, the time of brining was 15 minutes, 20 minutes, 25 minutes, 30 minutes, 35 minutes, 40 minutes, 45 minutes, 50 minutes, 55 minutes and 60 minutes. In both experiments ten fish were used in each treatment in order to fill duplicate cans, one of which served as check.

The brined cisco were then filled into cans and labelled and were subjected to the same canning procedure described under Section 11, Materials and Methods.

To evaluate the results of the brining experiment, the cans were opened and the fish served to a panel of judges who scored each sample for saltiness, texture and aroma and other factors. The cans were identified by code in order to insure unbiased judgement.

The scores of the individual judges were tabulated and are given in Table 6

Table 6

Evaluations of preliminary brining test on Great Lakes cisco.

	1/2 Hour	1 Hour	2 Hours	4 Hours
Brine	Acceptable	Acceptable	Acceptable	Too salty
Firmness of flesh	Acceptable	Acceptable	Acceptable	Too firm
Flavor	Acceptable	Slightly salty	Salty	Much too salty
Aroma	Acceptable	Acceptable	Acceptable	Strong and mask the taste
Softness of bone	Soft	Soft	Soft	Soft

Those cisco brined from one to four hours were inferior in general quality to those brined for half an hour. The latter fish had a pleasing flavor and aroma. Hence for commercial pack, it seems that the right period of brining should approximate one half hour in duration. As regards the softness of bone and firmness of flesh, all seemed to be satisfactory except those brined for 4 hours which were too firm and fibrous. Another experiment was carried out to determine within a narrower range the acceptable brining time. The results of this experiment are found in Table 7.

Table 7

Evaluations of second brining test on Great Lakes cisco

	15 mins.	20 mins.	25mins	30 mins	35 mins	40 mins.	45 mins.	50 mins.	55 mins.
Brine	+	+	+	+	+	+	+	+	+
Firmness of flesh	+	+	+	+	+	+	+	+	+
Flavor	Insipid	++	+++	+	+	+	x	x	x
Aroma	Flat	+	+++	+	+	+	+	+	+
Softness of bone	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft

+++ indicates excellent

++ " superior

\+ " acceptable

x " not acceptable

The results of the second brining experiment indicate that a period of immersion of 25 minutes in 96° brine yielded a canned product which was rated satisfactory by a panel of judges. Those brined for 15 minutes were insipid and flat. Those brined for 30 minutes were good but slightly more salty than those brined 25 minutes and the former were scored as satisfactory by the judges. The reason for adopting 25 minutes for the brining period instead of 30 minutes is to keep the saltiness low to accomodate those persons with low salt tolerance. It is simpler to add salt than to withdraw it, consequently the brining period is purposely kept low. It is possible that a larger panel of judges might include persons with a lower salt tolerance than was true of the limited group. Before going into commercial production, this should be further tested on a pilot plant run involving a large number of persons.

FILL OF CANS

The cisco after being brined for 25 minutes were taken from the brine, and cut into 3-3/4 inch lengths as described under Section 111, BRINING. They were then packed into the cans by hand.

Fill of cans is one of the important physical factors of the general quality of fish, because it affects the amount of headspace, cut out weight, and vacuum of the product. Cans which are slack-filled are liable to have large headspace and the product might be classified as sub-standard under the McNary - Mapes Act. On the other hand, overfill of cans tends to reduce the amount of vacuum and retard the rate of heat penetration and, consequently, the product might be understerilized. The fullness of the can is also very important from the economic view point, as we can determine the cost per can by calculating the weight of fish put in.

To insure well filled cans, and a neat appearing product, the tails and heads of the fish were alternated. About five fish were used to fill a can. It soon became easy to select fish of the correct size to fill the cans properly.

The packer must develop some skill in selecting and arranging the fish. The bodies taper toward the tail making it necessary to alternate the heads and tails so the fish will pack tightly into the cylindrical can. The thicker forward part of the fish also had the body cavity opened and it is necessary to pack the fish in such a way that the tail portion of one fish fits into the body cavity of the alternating one so as to prevent large unfilled spces in the can.

Cans considered as properly filled were found to vary from 322-336 grams in net weight. Those cans having 328 grams or more were found to be well packed after processing, This is the equivalent of 11.5 ounces.

Since canned products are usually rated by food inspectors on the basis of cutout weight, these cans were drained after processing and the cutout weight was found to vary from 302 grams to 322 grams. Those with 311 grams or more cutout weight were considered as being satisfactory. For commercial purposes this should probably be set at 312grams or 11 ounces, since all weights are in terms of ounces in commercial work.

Table 7

The weight relations of canned Great Lakes cisco

Can number	1	2	3	4	5	6	7	8	9	10	11	12
Can weight (grams)	53	55	54	53	54	55	53	53	54	53	54	53
* Fill weight (grams)	329	327	329	328	324	318	319	325	332	320	329.5	328
* Net weight (grams)	333.5	332	334	336	326	324	325	328	335.5	322	333	330
Cutout weight (grams)	310	310	322	315	306	305	302	309	319	303	316	315

* Fill weight = weight of fish packed in can while net weight includes fish plus liquid.

Table 8

Summary of evaluations of canned Great Lakes cisco

Can number	1	2	3	4	5	6	7	8	9	10	11	12
Appearance of container	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Vacuum (inches)	7	11	11	10	12	13	9	10	8	13	11	8
Headspace (inches)	5/16	6/16	5/16	5/16	5/16	5/16	6/16	7/16	5/16	1/2	5/16	6/16
Fill- Good, average, poor	Good	Good	Good	Good	Good	Poor	Average	Good	Good	Poor	Good	Good
Texture- Firm, slightly soft, soft	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Color- Clear, average, discolored.	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Cleaning- Good, average, Poor	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Odour- Normal, Stale, tainted.	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Flavor- Good, Average, poor	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Salt- Insufficient, good, excessive	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Lequid- Normal, slightly turbid, turbid	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Net weight- (grams)	333.5	332	334	336	326	324	325	328	335.5	322	333	330
Cutout weight (grams)	310	310	322	315	306	305	302	309	319	303	316	315

Results and discussion

Table 7 shows that the average weight of the cisco required to fill a No. 1 can is 325.7 grams or 11.48 ounces, and the number of fish to fill each can is 5.

After the fish were processed, they were scored for flavor, aroma, and texture by a panel of judges, and were found to be satisfactory in these respects. The fill was good on the whole, except one with a slight hole and one poorly filled on account of poor arrangement in alternating the heads and tails. Therefore, by experience, the size or the uniformity of the fish should be so chosen that they will make a compact pack when the tails and heads are alternated. The average vacuum as shown by the vacuum gauge was 10.2 inches; and the average headspace was 5/16 inch. (See table 8)

HEAT PENETRATION

Thermal processing is necessary in canning to destroy the most heat resistant organisms which may cause spoilage in canned foods. The time necessary to sterilize the canned Great Lakes cisco at a given temperature is governed in part by the rate at which lethal heat is transmitted to the slowest heating portion of the filled and sealed container, and the food at the geometrical center of the container is the slowest to attain any given temperature and is most difficult to sterilize.

Heat is transferred either by conduction or by convection, or by combination of both methods. Conduction is the transferrence of heat in a solid, while convection is the transferrence of heat in a liquid or gaseous medium.

Since the rate of heat transfer depends on the physical character of the food, and since it is different for different products and for different can sizes, the present study was undertaken to determine the rate of heat penetration in canned Great Lakes cisco.

The equipment used in obtaining the data of heat penetration had been described under Section 11, MATERIALS AND METHODS. Two runs were made. In the first run 6 thermocouples were used, while in the second run, only 5 thermocouples were used. The products were weighed carefully before processing to get their net weights and drained weights. The processing temperature used was 240°F at 10 pounds steam pressure. The data was taken at intervals of every two minutes at the beginning of processing until retort temperature was reached, then the data was taken every five minutes. The readings were recorded in millivolts which were later converted into temperature readings in degrees Fahrenheit by means of the standard conversion table. When the temperature inside the cans rose no further and remained constant for ten minutes, the steam was turned off, and cooling began by turning in cold water. At the beginning of cooling, readings were taken every two minutes and then every five minutes. The rate of heat penetration in relation to time was plotted on the semi-logarithmic paper. All the eleven sets of data were plotted on the same paper with the result that a kind of frequency distribution was presented. The curve was carefully drawn so that it represents the mean value for each group of observations.

<u>Heat penetration factors "fh", "j" and "I"</u>

The factors "fh", "j", and "I were adopted by Ball (1923, 1928) to describe the semi-logarithmic heating curves :

"<u>fh</u>".- The factor "fh" represents the slope of the heating curve, being measured as minutes on the abscissa equivalent to a change of one logarithmic cycle on the ordinate.

"<u>j</u>".- The factor "j" is an arbitrary factor which, when taken together with fh, defines the constants of the semilogarithmic heating curve. The value "j" is obtained by dividing the difference between the retort temperature and pseudo-initial temperature by the difference between retort temperature and actual initial temperature. It might be illustrated as follows :-

$$J = \frac{RT - ps.\ IT}{RT - IT}$$

RT = Retort temperature

IT = Actual initial temperature

ps.IT = Pseudo initial temperature

= the temperature indicated

by the intersection point between the extension of the straight line portion of the curve and the vertical line which represents the beginning of the process in zero time.

"I".- The factor "I" represents the difference in degrees between the retort temperature and the initial temperature of the food.

Table 9

Heating and Cooling Curve Data (1)

Time(mins.)	Millivolts	Temperature°F	Time(mins.)	Millivolts	Temperature°F
- 6	2.50	142	102	4.88	237
- 4	2.55	144	104	4.83	235
- 2	2.64	148	106	4.71	230
0	2.69	150	108	4.46	220.5
5	2.88	158	110	4.45	220
10	3.05	165	112	4.20	210
15	3.38	178	115	3.94	200
20	3.69	190	120	3.63	188
25	4.04	204	125	3.30	175
30	4.20	210	130	2.93	160
35	4.40	218	135	2.79	154
40	4.47	223	140	2.57	145
45	4.63	227	145	2.33	135
50	4.73	231	150	2.17	128
55	4.79	233			
60	4.83	235			
65	4.86	236			
70	4.88	237			
75	4.895	237.5			
80	4.91	238			
85	4.925	238.5			
89	4.93	239			
95	4.93	239			
100	4.93	239			

Table 10

Heating and Cooling Curve Data (2)

Time(mins.)	Millivolts	Temperature°F	Time(mins.)	Millivolts	Temperature°F
- 6	2.55	144	102	4.895	237.5
- 4	2.59	146	104	4.86	236
- 2	2.64	148	106	4.76	232
0	2.69	150	108	4.57	225
5	2.93	160	110	4.50	222
10	3.05	165	112	4.27	213
15	3.43	180	115	4.06	205
20	3.69	190	120	3.81	195
25	4.04	204	125	3.48	182
30	4.20	210	130	3.18	170
35	4.40	218	135	3.00	163
40	4.52	223	140	2.81	155
45	4.62	227	145	2.57	145
50	4.745	231.5	150	2.45	140
55	4.595	233.5			
60	4.83	235			
65	4.86	236			
70	4.88	237			
75	4.895	237.5			
80	4.91	238			
85	4.925	238.5			
89	4.93	239			
95	4.93	239			
100	4.93	239			

Table 11

Heating and Cooling Curve Data (3)

Time(mins.)	Millivolts	Temperature°F	Time(mins.)	Millivolts	Temperature°F
- 6	2.52	143	102	4.89	237.5
- 4	2.57	145	104	4.86	236
- 2	2.61	147	106	4.76	232
0	2.66	149	108	4.57	225
5	2.83	156	110	4.45	220
10	3.03	164	112	4.22	211
15	3.33	176	115	4.06	205
20	3.63	188	120	3.69	190
25	3.99	202	125	3.43	180
30	4.14	208	130	3.20	171
35	4.37	217	135	2.93	160
40	4.50	222	140	2.79	154
45	4.675	226.5	145	2.59	146
50	4.725	230.5	150	2.40	138
55	4.775	232.5			
60	4.825	234.5			
65	4.845	235.5			
70	4.88	237			
75	4.89	237.5			
80	4.91	238			
85	4.925	238.5			
89	4.93	239			
95	4.93	239			
100	4.93	239			

Table 12

Heating and Cooling Curve Data (4)

Time(mins.)	Millivolts	Temperature° F
- 6	2.50	142
- 4	2.52	143
- 2	2.57	145
0	2.61	147
5	2.79	154
10	2.98	162
15	3.28	174
20	3.58	186
25	3.94	200
30	4.20	210
35	4.37	217
40	4.55	224
45	4.615	226.5
50	4.71	230
55	4.725	231.5
60	4.81	234
65	4.845	235.5
70	4.895	237.5
75	4.91	238
80	4.925	238.5
85	4.93	239
90	4.93	239
95	4.93	239
100	4.93	239
102	4.88	237
104	4.83	235
106	4.71	230
108	4.55	224
110	4.47	221
112	4.30	214
115	4.01	203
120	3.65	189
125	3.35	177
130	3.08	166
135	2.85	157
140	2.64	148
145	2.45	140
150	2.33	135

Table 13

Heating and Cooling Curve Data (5)

Time(mins.)	Millivolts	Temperature°F
- 6	2.64	148
- 4	2.66	149
- 2	2.71	151
0	2.79	154
5	2.93	160
10	3.18	170
15	3.43	180
20	3.74	192
25	4.06	205
30	4.27	213
35	4.45	220
40	4.57	225
45	4.68	229
50	4.76	232
55	4.81	234
60	4.86	236
65	4.88	237
70	4.895	237.5
75	4.91	238
80	4.925	238.5
85	4.93	239
90	4.93	239
95	4.93	239
100	4.93	239
102	4.925	238.5
104	4.88	237
106	4.83	235
108	4.65	228
110	4.52	223
112	4.40	218
115	4.11	207
120	3.86	197
125	3.53	184
130	3.30	175
135	3.08	166
140	2.85	157
145	2.66	149
150	2.55	144

Table 14

Heating and Cooling Curve Data (6)

Time(mins.)	Millivolts	Temperature°F
- 6	2.50	142
- 4	2.55	144
- 2	2.64	148
0	2.69	150
5	2.85	157
10	3.08	166
15	3.365	177.5
20	3.69	190
25	4.01	203
30	4.25	212
35	4.47	221
40	4.57	225
45	4.65	228
50	4.73	231
55	4.775	232.5
60	4.83	235
65	4.86	236
70	4.88	237
75	4.91	238
80	4.925	238.5
85	4.925	238.5
88	4.93	239
90	4.93	239
95	4.93	239
100	4.93	239

Time(mins.)	Millivolts	Temperature°F
102	4.86	236
104	4.76	232
106	4.62	227
108	4.32	215
110	4.20	210
112	3.99	202
115	3.69	190
120	3.30	175
125	3.00	163
130	2.69	150
135	2.50	142
140	2.24	131
145	2.07	124
150	1.93	118

Table 15

Heating and Cooling Curve Data (7)

Time(mins.)	Millivolts	Temperature° F	Time(mins.)	Millivolts	Temperature° F
- 6	2.66	149	102	4.87	236.5
- 4	2.69	150	104	4.78	233
- 2	2.76	153	106	4.68	229
0	2;83	156	108	4.45	220
5	2.98	164	110	4.27	213
10	3.23	174	112	4.06	205
15	2.63	188	115	3.81	195
20	3.84	196	120	3.43	180
25	4.11	207	125	3.05	165
30	4.32	215	130	2.85	157
35	4.50	222	135	2.59	146
40	4.615	226.5	140	2.38	137
45	4.71	230	145	2.19	129
50	4.775	232.5	150	2.05	123
55	4.825	234.5			
60	4.86	236			
65	4.895	237.5			
70	4.91	238			
75	4.925	238.5			
80	4.925	238.5			
83	4.93	239			
85	4.93	239			
90	4.93	239			
95	4.93	239			
100	4.93	239			

Table 16

Heating and Cooling Curve Data (8)

Time(mins.)	Millivolts	Temperature°F	Time(mins.)	Millivolts	Temperature°F
- 6	2.59	146	102	4.88	237
- 4	2.61	147	104	4.81	234
- 2	2.67	149	106	4.67	229
0	2.74	152	108	4.47	221
5	2.96	161	110	4.30	214
10	3.18	170	112	4.06	205
15	3.40	179	115	3.81	195
20	3.72	191	120	3.45	181
25	4.04	204	125	3.10	167
30	4.27	213	130	2.90	159
35	4.45	220	135	2.64	148
40	4.57	225	140	2.43	139.5
45	4.67	229.5	145	2.26	132
50	4.76	232	150	2.09	125
55	4.81	234			
60	4.86	236			
65	4.88	237			
70	4.89	237.5			
75	4.91	238			
80	4.925	238.5			
85	4.93	239			
90	4.93	239			
95	4.93	239			
100	4.93	239			

Table 17

Heating and Cooling Curve Data (9)

Time(mins.)	Millivolts	Temperature° F	Time(mins.)	Millivolts	Temperature° F
- 6	2.50	142	102	4.895	237.5
- 4	2.55	144	104	4.83	235
- 2	2.60	146.5	106	4.71	230
0	2.64	148	108	4.52	223
5	2.79	154	110	4.40	218
10	2.93	160	112	4.20	210
15	3.23	172	115	4.09	206
20	2.58	186	120	3.63	188
25	3.94	200	125	3.30	175
30	4.14	208	130	3.00	163
35	4.365	216.5	135	2.76	153
40	4.50	222	140	2.50	142
45	4.60	226	145	2.31	134
50	4.68	229	150	2.14	127
55	4.76	232			
60	4.81	234			
65	4.84	235.5			
70	4.88	237			
75	4.895	237.5			
80	4.91	238			
85	4.925	238.5			
90	4.93	239			
95	4.93	239			
100	4.93	239			

Table 18

Heating and Cooling Curve Data (10)

Time(mins.)	Millivolts	Temperature°F	Time(mins.)	Millivolts	Temperature°F
- 6	2.69	150	102	4.84	235.5
- 4	2.71	151	104	4.83	235
- 2	2.77	153	106	4.71	230
0	2.81	155	108	4.57	225
5	3.02	164	110	4.45	220
10	3.25	173	112	4.32	215
15	3.58	186	115	4.04	204
20	3.84	196	120	3.69	190
25	4.11	207	125	3.35	177
30	4.33	215	130	3.13	168
35	4.50	222	135	2.85	157
40	4.62	227	140	2.69	150
45	4.73	231	145	2.50	142
50	4.78	233	150	2.28	133
55	4.82	234.5			
60	4.86	236			
65	4.895	237.5			
70	4.91	238			
75	4.925	238.5			
80	4.925	238.5			
84	4.93	239			
90	4.93	239			
95	4.93	239			
100	4.93	239			

Table 19

Heating and Cooling Curve Data (11)

Time(mins.)	Millivolts	Temperature° F	Time(mins.)	Millivolts	Temperature° F
- 6	2.57	145	102	4.87	236.5
- 4	2.61	147	104	4.83	235
- 2	2.66	149	106	4.71	230
0	2.69	150	108	4.58	225.5
5	2.825	155.5	110	4.45	220
10	3.03	164	112	4.40	218
15	3.25	173	115	4.14	208
20	3.76	193	120	3.80	194.5
25	4.04	204	125	3.40	179
30	4.27	213	130	3.15	169
35	4.45	220	135	2.88	158
40	4.57	225	140	2.76	153
45	4.71	230	145	2.55	144
50	4.74	231.5	150	2.33	135
55	4.795	233.5			
60	4.83	235			
65	4.86	236			
70	4.88	237			
75	4.91	238			
80	4.92	238.5			
85	4.93	239			
90	4.93	239			
95	4.93	239			
100	4.93	239			

CHART 5

Heating and Cooling Curve of Great Lakes cisco

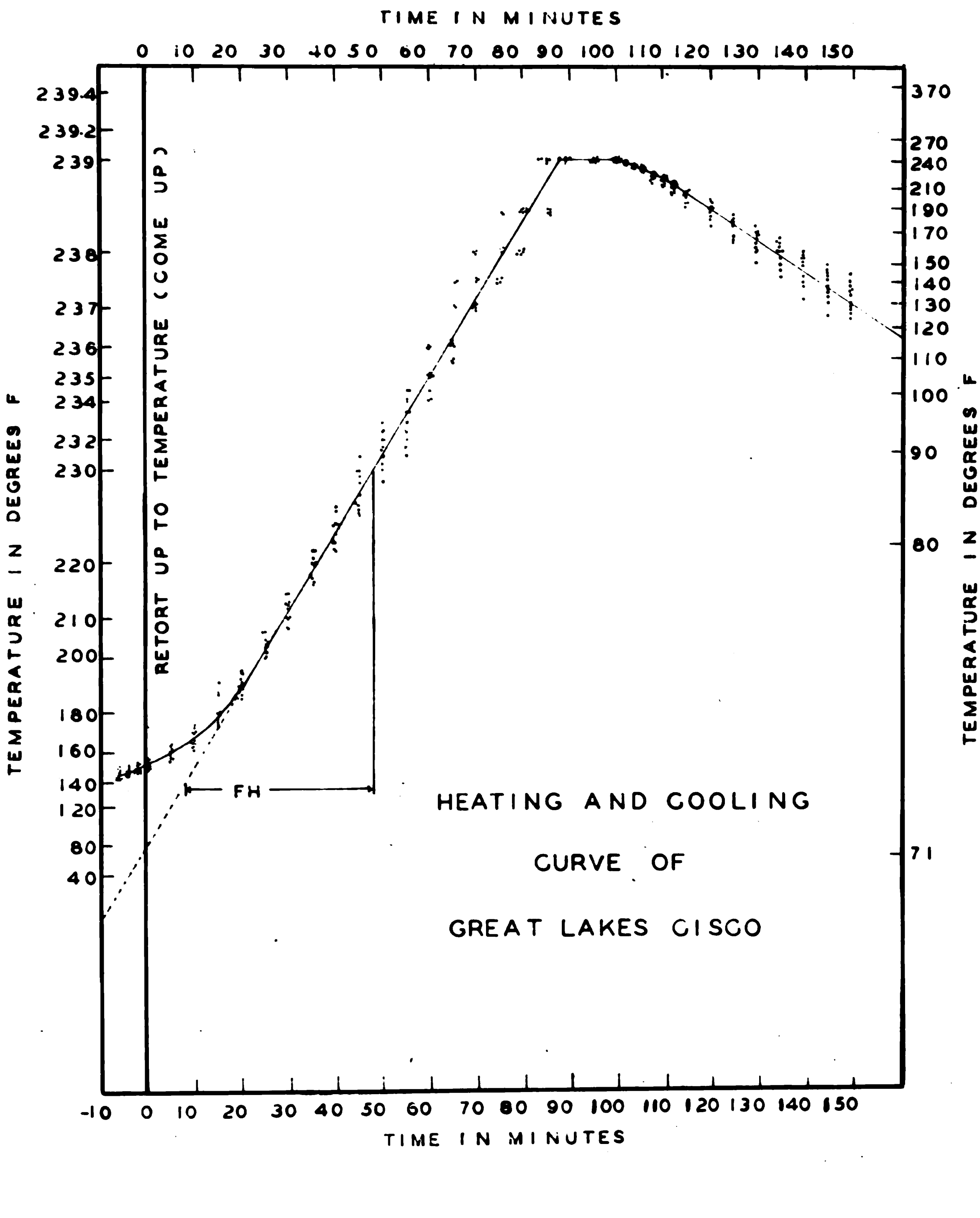

TIME IN MINUTES
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
239.4
239.2
239
238
237
236
235
234
232
230
220
210
200
180
160
140
120
80
40
TEMPERATURE IN DEGREES F
RETORT UP TO TEMPERATURE (COME UP)
FH
370
270
240
210
190
170
150
140
130
120
110
100
90
80
71
TEMPERATURE IN DEGREES F
HEATING AND COOLING
CURVE OF
GREAT LAKES CISCO
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
TIME IN MINUTES

Table 20

Weight data for heat penetration experiment of Great Lakes cisco

Can number	1	2	3	4	5	6	7	8	9	10	11
Can weight (grams)	89	90	89	91	88.5	91	89	90	89	91	88.5
Net weight (grams)	299	299	306	299	292.5	301	298	299	303	304	293
Drained weight(grams)	290	298	298	297.5	287.5	298.5	292	297	301.5	300	288

Table 21

Summary of heat penetration data of Great Lakes cisco

Type of pack	Can		No. of test	No.of Couples	Average Weight(grams)		Heating Curve	
	Size	Dimension	made	used	Net	Drained	fh	j
Brine	No.1 standard	200x411	11	6	299.4	295.3	40	1.68

Calculation of the thermal process

The calculation for the theoretical time of processing of canned cisco was based on the heating and cooling curve obtained above and the thermal death time curve of Clostridium botulinum established by Esty and Meyer (1922). From the curve of Esty and Meyer, the values F and Z which were necessary to determine the processing time were obtained. The value "F" is the number of minutes required to destroy the organism at 250°F, and it was found to be 2.78 minutes. The value "Z" signifies the slope of the curve expresses as degrees on the abscissa, equivalent to a change of one logarithmic cycle in time on the ordinate. The methods used for the calculation were after Ball (1928), and the result of the calculations is the number of minutes required to destroy the most heat resistant spores of Clostridium botulinum.

RT = 240°F

IT = 145°F

Ps.IT = 80°F

$$j = \frac{RT - Ps.IT}{RT - IT} = \frac{240-80}{240-145} = 1.68$$

I = RT - IT = 95

jI = 95 x 1.68 = 159.60

fh = 40

F = 2.78 (obtained from the curve of Esty and Meyer, 1922)

Z = 18° (obtained from the curve of Esty and Meyer, 1922)

F' = 3.594 (obtained from F' :Z tables, see Ball 1928)

U = FF' = 3.594 x 2.78 = 9.991

$$\frac{fh}{U} = \frac{40}{9.991} = 4.0$$

Cw = Cooling water temperature = 70°F

m+g = RT-Cw = 240 - 70 = 170

g = 4.547 (obtained from $\frac{fh}{U}$: g curves ; see Ball 1928)

Applying the formula,

$$Bb = fh \log \frac{jI}{g}$$
$$= fh (\log jI - \log g)$$
$$= 40 (2.20303 - 0.7725)$$
$$= 40 \times 1.4305$$
$$= 57.22 \text{ minutes (Process time)}$$

But the come-up time is 6 minutes and Ball has shown this to have a value of .42 x 6 or 2.52 at retort temperature and this may be subtracted from the calculated heating time, i.e. 57.22 - 2.52 or 54.70 minutes. Therefore the total heating or process time would be 54.70 + 6 or 60.70 minutes.

Discussion

The heating curve had a short thermal lag of six minutes at the beginning of the process, and then it was followed by a straight line curve on a semi-logarithmic paper. The slope of the curve and other related values were described in terms of fh and j values in Table 21.

In the calculation of the theoretical process time, the heat resistances of Clostridium botulinum in the canned food have been used from the curve established by Esty and Meyer, and the methods used were after Ball (1923,1928)

The process time calculated was the minimum time required to sterilize the canned cisco in question under the retort temperature of 240°F. Since this was a preliminary experiment on process evaluation, the writer suggests that a safety factor of 10 per cent of the theoretically

Calculated value should be arbitrarily added.

SUGGESTED COMMERCIAL PROCEDURE FOR CANNING

Securing the raw materials

The cisco is captured by different types of commercial fishing gear. The most common types are the small mesh gill net, the pound net, and the trap net, according to the biennial report of the Michigan Department of Conservation.

Table 22

Catch of Great Lakes cisco by gear in thousands of pounds in 1945

From the Biennial Report of Michigan Department of Conservation

	Small-mesh gill net	Large-mesh gill net	Pound net	Deep trap net	Shallow trap net
Lake Michigan	94	1	2,316	-	14
Lake Superior	3,079	-	11	-	-
Lake Huron	41	-	203	4	280
Saginaw Bay	80	-	1	1	759
Total	3,294	1	2,531	5	1,053

Receiving and transportation

The commercial fishermen usually place the fish in wooden boxes aboard the fishing vessel for convenience in unloading and handling. These boxes of fish are unloaded and taken to the packing house as soon as the boats reach the dock. The fish are then packed in new boxes measuring approximately 30 inches long by 22-1/2 inches wide by six inches deep. These boxes are lined with waxed paper or building paper and partly filled with cracked ice before the fish are packed. After the desired weight of fish are packed in the box it is filled with ice and the cover nailed in place. They are then ready to be shipped. The packing could be simplified unless they had to be shipped a long distance to the cannery. If they were to be canned immediately, it would not be necessary to pack them in new boxes or to line the boxes with paper. They could be packed in ice as at present without covers on the boxes.

Grading

Grading the cisco for size would be desirable if canning became a part of the marketing process. The larger fish could be marketed fresh at a better price than the small ones thus leaving the smaller fish to be packed in cans. This would be more efficient than trying to can the larger fish which would make filling the cans more difficult and result in a higher loss in trimming the longer fish to the size of the can. The exact lengths of fish that might be put into the canning or fresh marketing grades remains to be established and would probably vary with the seasons and place since the different schools of cisco vary considerably from year to year and from day to day within the season.

Dressing and cleaning

Scaling.- After the fish are graded, those chosen for canning must be scaled. In scaling, thoroughness is essential so that no scales remain on the fish to be included in the cans, where they detract from the quality of the product. Scaling machines like the rotary scaler and the flexible shaft scaler can be used. Hand scaling is also practiced to a certain extent by some fish canneries. Inspection is necessary to ensure thoroughness of scaling.

Beheading.- Beheading of the cisco is done either by machine or by hand. In larger operations, cutting machines that remove the head and tail and leave the trunk part the correct length could be used to advantage.

<u>Eviscerating and cleaning</u>.- After the fish are scaled and beheaded, it is necessary to remove the viscera. This may be done by hand labor but machinery for this operation is available. If the volume of work is great enough, the machines would doubtlessly be more satisfactory. The fish should be inspected after this operation to insure complete removal of the intestinal tract and kidneys. The kidneys, especially, affect the flavor of the canned product adversely and they also turn a dark brown after processing and spoil the appearance of the pack. The fins should be completely removed at this time.

<u>Washing</u>.- After cleaning and eviscerating is completed the remaining piece of fish should be thoroughly washed in liberal quantities of running water and then placed in brine. It is well to avoid washing the fish in tanks since the accumulation of slime and waste makes a good medium for bacterial growth with consequent innoculation of fish with large quantities of spoilage organisms unless chlorination is practiced.

<u>Brining</u>

A salt solution testing 95-100° salinometer should be used and the cisco should be immersed in the brine for about 25 minutes to obtain satisfactory flavor. They should be immersed in liberal quantities of brine to insure complete, and even penetration of the salt.

<u>Exhausting and sealing</u>

Exhausting consists of heating the can and contents before sealing to remove air from the contents of the can and thereby reduce corrosion of the tin plate, since corrosion is favored by the presence of oxygen. Another object is to create a vacuum to reduce gaseous spoilage.

The exhausting of the cisco is accomplished by immersing the filled cans in steam or in hot water in an exhaust box at 212°F for 30 minutes before sealing them.

Processing

Processing is the heating or sterilization of canned foods. The object of processing the cisco is to render the product stable against spoilage by microorganisms and to improve the texture, flavor, and appearance by cooking. Pressure retorts are commonly used. They are processed at 240°F at 10 pounds steam pressure. The range of time used by canners is from 30-90 minutes. The research laboratory of the National Canners Association reccommends the following for canning of brine packed Sea herring:

Can size		Process time (minutes at 240°F)
No.1 Standard	211 x 400	70
No.1 Tall	301 x 411	75
No.300	300 x 407	75
No.2	307 x 409	80

The required processing time calculated for the cisco is 60.7 minutes, or approximately 61 minutes. If a safety factor of 10 per cent is allowed, the processing time for these fish should be 67 minutes which approaches very closely the time reccommended for the Sea herring.

SUMMARY

1. The Great Lakes cisco, Leucichthys artedi reaches a peak of production during the months of November and December in the Michigan waters of the Great Lakes. During this time, the market price drops to very low levels due to glutting of the market by an enormous quantity of the cisco. Consequently the product is poorly handled and often wasted. For these reasons canning is recommended.

2. The concentration of sodium chloride (fine table salt) used for brining was 96° salinometer. The range of time of brining used was from 15 minutes to 4 hours. The 25 minutes brining was found to be suitable for comercial brine pack.

3. Cans having 11.5 ounces fill-in weight were found to be well packed after processing, and for commercial purposes the cutout weight should probably be set at 11 ounces.

4. The measurement of the rate of heat penetration was made by the use of copper-constantan thermocouples introduced into the centre of a can placed in the experimental retort after the fashion of M. Heerdt, et al (1947), and the rate of heat penetration was plotted on semilogarithmic paper. The value of the slope of the fh was 40, and the value j was 1.68, and the initial temperature was 145°F. This heat test was used as one of the two types of data for determining the calculated thermal process of the product. The writer also used the destruction time curve of Clostridium botulinum established by Esty and Meyer (1922). The method of calculation for the retort process was after Ball (1928,)

5. The theoretical process time was found to be 60.7 minutes to which the writer suggests adding a safety factor of 10 per cent, because the data was obtained under controlled conditions, and uncontrollable varying

factors might exist in commercial packing. Therefore, this calculated process merely serves as a guide for experimental packs.

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