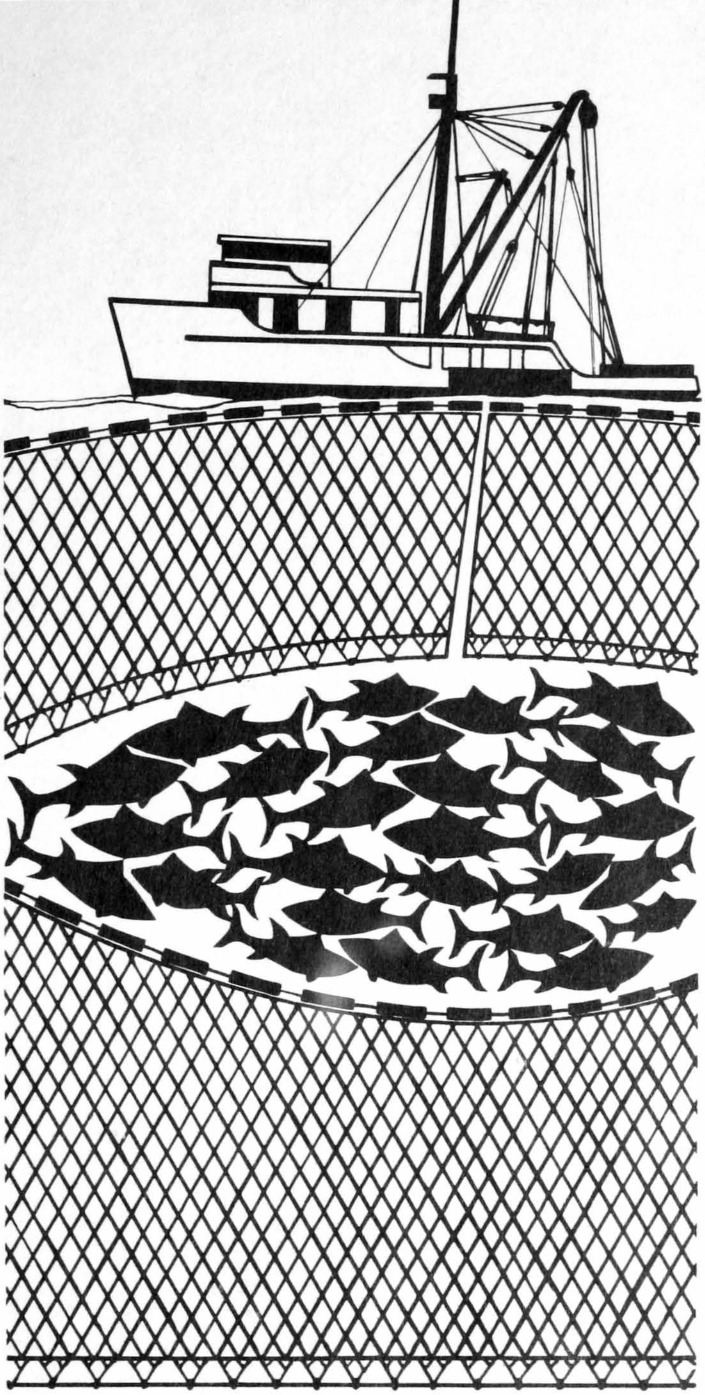

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FISHERY INDUSTRIAL RESEARCH

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Created in 1849, the Department of the Interior—a department of conservation—is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

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PROXIMATE COMPOSITION AND SODIUM AND POTASSIUM CONTENTS OF FOUR SPECIES OF TUNA

by

Neva L. Karrick and Claude E. Thurston

ABSTRACT

The following species of tuna were studied; albacore (*Germo alalunga*), bluefin (*Thunnus thynnus*), skipjack (*Katsuwonus pelamis*), and yellowfin (*Neothunnus macropterus*). Data are reported for the light and dark meat of the nape, center, and tail sections of the fish.

INTRODUCTION

Tuna support some of the most valuable and important fisheries of the world. They therefore have been studied extensively. Little has been published, however, on the proximate composition of raw tuna.

The National Canners Association (1950), Kochi and Era (1957), and Tarrland, Mathiesen, Øusthus, and Braekkan (1958) reported on the composition of canned tuna, but their results often are applicable only to the particular cans of tuna they worked with. Sometimes they were not able to report the kind of tuna analyzed.

The composition of canned tuna differs, of course, from that of the raw tuna. Precooking the tuna and adding oil to the can results in a decrease in moisture content and an increase in oil content.

A few papers have reported the composition of raw tuna. Carlson, Thurston, and Stansby (1960) reported the composition of small tuna in their description of a core-sampling technique. Kochi and Era (1959) analyzed yellowfin from the Arabian Sea. Mannan, Fraser, and Dyer (1961) separated light and dark meat of the bluefin for their analyses. They stated that the differences in composition of the various tissues made accurate analysis difficult. Takeda and Shimeno (1965b) analyzed bluefin caught during the spawning season between April and June. They found that the amount of oil and protein decreased considerably during this period. They (1965a) also analyzed *Thunnus maccoyii* caught in October and found great variation in the oil content. Roubal (1963) found that the oil content of raw tuna and of tuna canned without added oil were about the same. He also reported the composition of the fatty acids in the light

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and dark meat of albacore, bluefin, skipjack, and yellowfin.

In the Bureau's technological laboratory, we had analyzed specimens of tuna over a period of years and had noticed differences in composition, particularly in the amount of oil. We therefore decided to get a clearer picture of the differences.

The light and the dark meat of tuna are marketed separately — the light meat is used for human food and the dark meat is used for pet food. This report gives the results of analyses for proximate composition and for sodium and potassium in the light and dark raw meat of the nape, center, and tail sections of albacore, bluefin, skipjack, and yellowfin tunas.

I. ALBACORE

A. METHODS AND MATERIALS

Described in this section are the collection of specimens, the preparation of samples, and the methods of chemical analyses. (The methods of preparing the samples and of making the analyses were the same for all four species.)

1. Collection of Specimens

Seven lots of albacore were analyzed. Six lots were caught off the West Coast of the United States between Washington and Southern California during 1958 to 1961, and the seventh lot was caught from 200 to 700 miles east of Tokyo during May and June 1958. One lot was brine frozen on the vessel. The other lots were either iced or dry frozen.

Measurement of length and weight of the albacore (and of the other three species of tuna analyzed) are given in Table 1.

2. Preparation of Samples

Cross sections of the frozen fish were taken as steaks at three different points: the nape, just behind the head and gills; the center, at the center and thickest part of the fish; and the tail, at the point where the fish starts to taper off toward the tail. Light and dark meat of each section were separated and analyzed individually. Each sample was ground in a Hobart grinder[1], vacuum packed in ½-pound cans, and stored at −18° C. until analyzed. The belly flaps of a few of the fish were also separated and analyzed.

3. Chemical Methods

Each sample was analyzed in duplicate for moisture, protein, oil, and ash. Some samples from each species were analyzed for their sodium and potassium contents. The proximate composition was determined by the standard methods of the Association of Agricultural Chemists (1955). The methods for sodium and potassium analyses were those described by Thurston (1958).

[1] Use of trade names does not imply endorsement.

Table 1.—Measurements of tunas analyzed

Species	Fish in samples	Lots	Length		Weight	
			Range	Average	Range	Average
	Number	*Number*	*Inches*	*Inches*	*Pounds*	*Pounds*
Albacore (Eastern Pacific) .	60	6	21.9-34.5	27.2	7.0- 26.5	14.7
Albacore (Western Pacific)	8	1	30.7-35.4	31.7	19.5- 30.8	24.3
Bluefin	19	4	23.6-53.1	31.3	10.1-106.0	28.0
Skipjack	59	6	16.1-27.2	19.4	4.5- 15.9	7.9
Yellowfin	39	5	18.9-49.2	25.1	6.5-101.0	13.0

B. RESULTS

Data for the albacore are given in Tables 2 and 3 (proximate composition) and Table 4 (sodium and potassium).

The proximate composition of the albacore caught in the Western Pacific was so different from that of those caught in the Eastern Pacific that the two groups were not averaged together. The fish from off Japan had a higher

Table 2.—Proximate composition of 60 albacore caught off the West Coast of the United States, summers of 1958-61

Portion of fish	Moisture			Protein			Oil			Ash		
	Range	Average	σ[1]	Range	Average	σ	Range	Average	σ	Range	Average	σ
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Light meat:		64.4	3.5		25.5	1.2		10.3	4.39		1.24	0.15
Nape ..	55.6-67.8	62.3	3.3	22.3-26.6	24.6	1.0	7.37-21.10	13.16	3.96	1.02-1.58	1.19	0.10
Center .	58.4-70.2	64.3	3.1	23.2-27.4	25.6	1.0	3.76-17.54	10.20	3.77	1.06-1.36	1.23	0.09
Tail ...	61.1-71.4	66.6	2.8	24.0-27.8	26.2	1.0	1.96-15.09	7.47	3.42	1.04-1.96	1.29	0.20
Dark meat:		69.5	2.5		22.9	1.2		6.85	3.10		1.18	0.05
Nape ..	62.9-73.3	68.7	2.5	20.0-23.6	22.0	0.9	2.63-15.91	8.38	3.09	1.05-1.33	1.19	0.06
Center .	64.7-73.5	70.5	2.0	21.4-23.8	22.7	0.7	2.03-12.52	5.88	2.34	1.12-1.28	1.20	0.04
Tail ...	62.3-72.5	69.3	2.5	20.6-25.8	24.0	1.0	1.66-14.45	6.20	3.11	1.07-1.31	1.16	0.05

[1] σ = Standard deviation.

Table 3.—Proximate composition of 8 albacore caught 200-700 miles east of Tokyo, May-June 1958

Portion of fish	Moisture			Protein			Oil			Ash		
	Range	Average	σ[1]	Range	Average	σ	Range	Average	σ	Range	Average	σ
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Light meat:		72.0	0.9		27.5	0.9		0.77	0.36		1.34	0.04
Nape ..	70.7-74.1	72.0	1.0	25.6-29.2	27.4	1.0	0.49-1.83	0.88	0.43	1.27-1.46	1.35	0.05
Center .	71.1-73.8	72.0	0.8	25.9-28.6	27.5	0.8	0.48-1.20	0.69	0.23	1.31-1.42	1.36	0.03
Tail ...	71.1-74.3	72.0	1.0	25.6-28.8	27.6	0.9	0.44-1.39	0.75	0.35	1.28-1.40	1.33	0.04
Dark meat:		72.6	1.3		22.6	0.8		3.18	0.92		1.27	0.09
Nape ..	69.0-73.7	72.3	1.4	20.8-23.5	22.5	0.8	2.56-6.29	3.53	1.09	1.21-1.51	1.32	0.11
Center .	69.8-74.1	72.9	1.3	21.3-23.0	22.4	0.6	2.25-4.56	3.10	0.64	1.17-1.30	1.24	0.04
Tail ...	72.1-74.1	72.6	0.9	23.2-23.8	23.5	0.3	1.82-3.64	2.63	0.70	1.16-1.29	1.24	0.05

[1] σ = Standard deviation.

Table 4.—Sodium and potassium in dry-frozen albacore

Source	Sample		Sodium			Potassium		
	Portion of fish	Fish	Range	Average	σ[1]	Range	Average	σ
		No.	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*
West Coast of the United States, summers of 1958-61	Light meat:	30		45	8		354	49
	Nape		37-61	49	6	235-399	335	46
	Center ...		30-48	39	6	277-438	362	46
	Tail		34-60	47	7	282-438	364	49
	Dark meat:	30		60	6		347	17
	Nape		47-74	63	6	319-382	346	18
	Center ...		51-68	59	5	323-406	349	17
	Tail		47-66	56	5	311-384	347	17
200-700 miles east of Tokyo, May and June 1958	Light meat:	8		42	6		447	19
	Nape		37-56	43	6	416-465	444	15
	Center ...		34-46	38	4	420-473	454	17
	Tail		37-57	45	6	407-461	443	23
	Dark meat:	8		64	5		368	17
	Nape		59-77	67	7	347-424	373	22
	Center ...		58-65	62	2	344-382	364	11
	Tail		60-68	63	3	350-383	370	12

[1] σ = Standard deviation.

content of moisture, a somewhat higher content of protein in the light meat, and a much lower content of oil than had the fish from off the United States.

The albacore from the Eastern Pacific had the highest oil content of all the tuna analyzed. Although the oil was uniformly high in these fish, the oil content was higher in the nape than in the other sections. A comparison between the light and dark meat shows that the light meat contained more protein and oil and less moisture than did the dark meat.

Samples of belly flap were analyzed from two lots, one from Japan and the other from the United States. The fish from Japan had about the same concentration of oil in the belly flap as in the light meat — 0.73 percent. The concentration of oil in the lot of United States fish from which the belly-flap samples were taken was high — 9 to 17 percent; and the concentration of oil in the belly flaps was very high — 36 percent. The concentration of protein in the latter samples was low, averaging 18 percent.

The sodium content of the albacore was within the range of that required for dietetic foods. The sodium content of the dark meat was just slightly higher than that of the light meat. The values for potassium content covered a broad range, apparently with greater differences in the light meat than in the dark meat.

II. BLUEFIN

Only 19 bluefin (fewer than the number of samples from any of the other tuna) were analyzed. The fish were caught from Southern California to Ecuador and were dry frozen. Data for the bluefin tuna are given in Table 5 (proximate composition) and Table 6 (sodium potassium).

The amount of oil in the bluefin tuna was about half of that in the albacore from the Eastern Pacific. The light meat of the bluefin contained more oil than did that of the skipjack and yellowfin, although the dark meats contained about the same amounts. The oil content was variable. For example, the concentration of oil in one lot of 10 bluefin tuna taken in June varied from 3.5 to 9.5 percent. The oil content was both greater in amount and more variable in the light meat than in the dark.

The protein content was also higher in the light meat. A comparison among the different sections from the fish shows that the meat from the nape was highest in oil and lowest in protein, whereas the meat from the tail was the reverse.

The content of sodium in the light meat was, like that in the albacore, slightly higher in the dark meat. The content of potassium covered a fairly broad range.

Table 5.—Proximate composition of 19 bluefin tuna caught off Southern California and Mexico, 1958-61

Portion of fish	Moisture			Protein			Oil			Ash		
	Range	Average	σ [1]	Range	Average	σ	Range	Average	σ	Range	Average	σ
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Light meat		69.2	2.6		25.2	1.1		5.50	3.05		1.29	0.11
Nape	62.1-72.1	67.7	2.5	22.6-25.4	24.2	0.9	3.54-14.34	7.96	2.83	1.12-1.80	1.26	0.14
Center	64.9-73.7	69.5	2.2	23.3-26.7	25.4	0.8	1.71-10.13	5.14	2.15	1.20-1.79	1.31	0.13
Tail	65.4-74.3	70.6	2.3	25.0-26.9	25.9	0.5	0.73-8.43	3.42	2.17	1.21-1.40	1.29	0.05
Dark meat		70.3	1.3		24.2	1.4		4.61	1.30		1.32	0.09
Nape	67.4-72.8	69.8	1.5	21.9-25.6	23.3	1.1	3.61-8.16	5.76	1.27	1.19-1.54	1.34	0.10
Center	67.9-72.2	70.9	1.1	22.8-26.8	23.9	1.1	2.80-5.66	4.08	1.20	1.22-1.48	1.33	0.07
Tail	67.7-72.3	70.0	1.2	22.9-27.7	25.3	1.1	1.28-5.71	3.98	0.94	1.11-1.45	1.28	0.07

[1] σ = Standard deviation.

Table 6.—Sodium and potassium in 9 dry-frozen bluefin tuna caught off Southern California and Mexico, 1958-61

Portion of fish	Sodium			Potassium		
	Range	Average	σ [1]	Range	Average	σ
	Mg./100 g.	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*
Light meat:		53	11		368	29
Nape	46-74	54	8	326-386	355	18
Center	42-119	47	4	325-407	376	27
Tail	51-89	63	11	302-410	375	33
Dark meat:		80	12		328	25
Nape	64-106	88	13	300-350	317	22
Center	60-89	77	7	295-384	335	28
Tail	57-95	74	11	296-354	332	21

[1] σ = Standard deviation.

III. SKIPJACK

Six lots of skipjack were analyzed. They consisted of 59 fish caught during the summer of 1958 to 1961 from Southern California to Peru. Treatment of the fish on the vessel varied: three lots were brine frozen, two lots were dry frozen, and one lot was held in ice. Data for the skipjack are given in Table 7 (proximate composition) and Table 8 (sodium and potassium). Variation in proximate composition that occurred within lots was similar to the overall variation; no differences in composition can be attributed to differences in treatment except that the amount of ash was from 0.5 to 1 percent higher in the brine-frozen fish.

The oil content of the skipjack was lower than that of the albacore (United States) and the bluefin but was more than that of the yellowfin. The oil content was lower in the light meat than in the dark meat, but the protein content was higher in the light meat. A comparison of the different sections shows that the light meat in the nape, unlike that of the albacore and bluefin, did not contain more oil than the rest of the fish did. The dark meat in the nape, however, was higher in oil content than in the center or tail sections. The greater the amount of oil present, the greater was the difference in oil content between the meat in the nape and in the center. The samples of belly flap from the skipjack were from fish with a low oil content, and the oil content of the belly flaps was intermediate between that of the light meat and of the dark meat of the fish.

The light meat of brine-frozen fish absorbed large amounts of sodium. The smaller

Table 7.—Proximate composition of 59 skipjack tuna caught off the coast from Southern California to Peru, summers of 1958-61

Portion of fish	Moisture			Protein			Oil			Ash		
	Range	Average	σ [1]	Range	Average	σ	Range	Average	σ	Range	Average	σ
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Light meat:		70.9	1.5		26.5	0.6		2.13	1.65		1.66	0.53
Nape	66.9-73.5	71.1	1.4	25.3-27.7	26.4	0.6	0.44-7.44	2.06	1.43	1.23-3.31	1.61	0.39
Center	65.2-73.0	70.6	1.7	24.6-28.2	26.6	0.7	0.40-9.39	2.39	1.94	1.19-3.76	1.63	0.50
Tail	68.0-73.3	71.0	1.3	25.1-27.8	26.6	0.6	0.39-5.94	1.92	1.46	0.87-3.59	1.74	0.65
Dark meat:		69.2	2.2		24.1	1.4		5.07	2.28		1.36	0.16
Nape	61.1-73.0	68.6	2.4	21.5-26.0	23.8	1.3	2.10-13.08	5.86	2.54	1.17-1.97	1.37	0.14
Center	63.8-72.8	69.4	2.1	21.5-26.6	23.8	1.3	1.99-10.46	5.15	2.13	1.14-1.77	1.34	0.13
Tail	65.1-72.8	69.5	1.9	21.1-27.6	24.7	1.3	1.74-9.88	4.20	1.81	1.17-2.44	1.35	0.20

[1] σ = Standard deviation.

tail sections, as one would expect, absorbed greater amounts of sodium.

The amount of potassium in the different lots was not significantly different, although the variation in samples of the dark meat was greater and the amount of potassium may be slightly lower in the dark meat than in the light meat.

Table 8.—Sodium and potassium in dry- and brine-frozen skipjack tuna caught off the Coast from Southern California to Peru, summers of 1958-61

Samples			Sodium			Potassium		
Treatment	Fish	Portion of fish	Range	Average	σ [1]	Range	Average	σ
	Number		*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*
Dry frozen	19	Light meat:		48	9		376	17
		Nape	38-72	53	11	353-407	379	14
		Center	38-55	45	6	342-405	381	17
		Tail	36-57	45	6	334-402	370	16
		Dark meat:		59	9		355	38
		Nape	45-78	61	9	284-439	356	37
		Center	46-75	58	9	303-437	353	39
		Tail	42-68	54	8	287-439	353	38
Brine frozen	10	Light meat:		387	127		407	14
		Nape	229-339	293	36	388-429	405	11
		Center	253-613	377	108	394-439	416	14
		Tail	318-686	492	124	382-410	400	9
		Dark meat:		72	9		366	24
		Nape	58-82	73	7	341-400	365	23
		Center	56-78	67	7	335-416	367	26
		Tail	63-104	74	11	339-406	365	24

[1] σ = Standard deviation

IV. YELLOWFIN

Five lots of yellowfin were analyzed. They consisted of 39 fish caught from Southern California to Ecuador. Ten fish were iced, 7 were dry frozen, and 22 were brine frozen. Data for the yellowfin are given in Table 9 (proximate composition) and Table 10 (sodium and potassium). Two lots contained both dry-frozen and brine-frozen fish. The only difference between them was in the ash content, which was higher in the brine-frozen fish; the increased amount was almost exactly that calculated from the uptake of sodium chloride and potassium chloride.

Table 9.—Proximate composition of 39 yellowfin tuna caught off the Pacific Coast of Mexico and South America, 1958-61

Portion of fish	Moisture			Protein			Oil			Ash		
	Range	Average	σ [1]	Range	Average	σ	Range	Average	σ	Range	Average	σ
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Light meat:		72.9	1.4		25.5	0.9		1.22	0.97		1.77	0.42
Nape ..	70.3-75.6	73.1	1.3	23.2-26.7	25.3	0.8	0.53-3.92	1.31	0.95	1.30-2.27	1.64	0.29
Center .	69.9-75.7	72.9	1.4	23.4-26.9	25.6	0.8	0.46-4.10	1.21	1.01	1.29-2.53	1.76	0.37
Tail ...	69.5-75.9	72.6	1.4	23.0-27.5	25.6	1.0	0.47-4.27	1.15	0.95	1.27-2.66	1.92	0.52
Dark meat:		70.6	1.9		23.4	1.1		4.18	1.98		1.67	0.42
Nape ..	67.2-74.5	70.4	2.2	21.1-24.9	23.3	1.0	1.79-10.70	4.60	2.19	1.25-2.17	1.58	0.25
Center .	68.2-73.4	70.7	1.6	21.1-25.6	23.4	1.1	1.31-8.96	4.12	1.63	1.16-3.25	1.60	0.41
Tail ...	66.7-74.4	70.7	1.9	21.3-25.5	23.6	1.0	1.37-9.57	3.69	1.85	1.19-3.21	1.82	0.51

[1] σ = Standard deviation.

The amount of oil in the light meat of the yellowfin was the lowest of any of the tuna sampled from the Eastern Pacific. The oil content, nevertheless, was variable and was higher in the dark meat than in the light meat. The amount of oil in the dark meat was about the same as that in the dark meat of bluefin and skipjack.

Both the light and the dark meat of the brine-frozen fish absorbed large amounts of sodium. The absorption of sodium by the dark meat is probably not due to a species difference but is more likely to be a function of the concentration of brine, length of time in the brine, or both. The amount of potassium in the different lots was not significantly different, although the amount of potassium may be slightly lower in the dark meat.

Table 10.—Sodium and potassium in dry- and brine-frozen yellowfin tuna caught off the Pacific Coast of Mexico and South America, 1958-61

Samples			Sodium			Potassium		
Treatment	Fish	Portion of fish	Range	Average	σ[1]	Range	Average	σ
	Number		*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*	*Mg./100 g.*
Dry frozen	7	Light meat:		94	31		380	27
		Nape	36-97	81	20	357-429	383	22
		Center ...	41-114	87	22	356-408	383	17
		Tail	34-145	115	36	341-450	375	36
		Dark meat:		91	20		335	18
		Nape	65-100	86	13	286-355	330	21
		Center ...	60-112	85	18	308-355	337	16
		Tail	63-147	101	24	303-358	339	17
Brine frozen	12	Light meat:		384	110		401	33
		Nape	235-486	301	66	332-446	409	32
		Center ...	293-455	346	58	337-450	416	27
		Tail	441-706	506	72	303-408	379	26
		Dark meat:		279	145		361	41
		Nape	77-435	186	104	275-483	367	59
		Center ...	100-310	188	57	284-397	368	28
		Tail	372-532	449	56	270-377	348	27

[1]σ = Standard deviation.

GENERAL OBSERVATIONS ON THE FOUR KINDS OF TUNA

All the tuna had a very high content of protein, and the light meat had a higher content than the dark meat. The concentration of oil in these samples varied from 0.4 to 17.5 percent. The variation appeared to be due, at least partially, to differences in the species. The oil content has been thought to be higher in dark meat than in light meat. This was true for skipjack and yellowfin but not for albacore and bluefin.

The composition of tuna from the various areas did not differ, with the exception of one lot of albacore obtained from off Japan. Thus, worldwide samples are needed before any conclusion can be drawn about the effect of location of catch on the composition of tuna.

Most of the samples (88 percent) were obtained between June and September. Although no differences were noted in the three lots not caught during this period, the sampling was too small to be meaningful.

The amount of sodium found in the various samples depended on whether the fish were dry frozen or brine frozen. The amount of sodium in the dry-frozen fish was slightly higher in the dark flesh than in the light flesh. In the brine-frozen fish, which contained from 4 to 19 times more sodium, the light flesh absorbed considerably more sodium, however, than did the dark flesh. The smaller tail sections absorbed more sodium than did the thicker nape and center sections.

The amount of potassium was higher in the light meat than in the dark. In brine-frozen fish, more potassium was absorbed by the light meat than by the dark meat. Unlike the findings with sodium, however, the tail did not contain more potassium than did the rest of the fish.

SUMMARY

Light and dark raw meat of nape, center, and tail sections of albacore, bluefin, skipjack, and yellowfin caught over a 4-year period (1958-61) were analyzed to determine proximate composition and sodium and potassium contents.

All the tuna had a very high concentration of protein (20-29 percent), light meat having a higher percentage than dark meat. The greatest variation was found in the amount of oil, which ranged from 0.4 to 17.5 percent. Albacore from the Eastern Pacific had the highest oil content, followed by bluefin, skipjack, yellowfin, and albacore from the Western Pacific. Oil content in dark meat of skipjack and yellowfin was higher than in light meat, but this was not true for albacore and bluefin.

Brine-frozen tuna absorbed salt and contained from 4 to 19 times more sodium than dry-frozen fish did. Light meat absorbed a greater amount of sodium than did dark meat.

ACKNOWLEDGMENT

Clarence Carlson, Technology; and Lee Alverson and his associates, Exploratory Fishing and Gear Research, Bureau of Commercial Fisheries, Seattle, Washington, helped in obtaining specimens. Mabel A. Edwards and Dave H. Wieg also of the Bureau (Technology) assisted in the preparation and the analysis of the samples.

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MS #1728

USE OF SODIUM ACID PYROPHOSPHATE TO RETAIN NATURAL MOISTURE AND REDUCE STRUVITE IN CANNED KING CRAB (*Paralithodes* ssp.)

by

Robert Jones

ABSTRACT

Sodium acid pyrophosphate in varying concentrations was added at two levels of pH to king crab during canning. Salt also was added.

Adding 0.25 and 0.35 percent of sodium acid pyrophosphate increased the retention of moisture by almost 2 percent. Struvite either did not develop or developed very little during storage of the product for 1 year.

Addition of pyrophosphate in concentrations greater than 0.35 percent adversely affected the taste of the product. Addition of pyrophosphate in concentrations less than 0.25 percent did not improve the product.

INTRODUCTION

The quality of canned king crab can be improved by the elimination of struvite and by the retention of natural moisture. Struvite is common in this product even after short periods of storage. Although struvite is harmless, its resemblance to broken glass makes its presence undesirable in the canned product. The moisture that is lost from the tissues of the crab during the various steps of the processing of them represents losses in yield and results in adverse changes in texture and reduced juiciness.

One possible means to increase the retention of moisture and to reduce the formation of struvite is to add polyphosphate compounds to the crab meat. These compounds are commonly used in the red-meat industry to reduce losses of moisture in cooked meat. Sodium acid pyrophosphate has been approved for use in the tuna canning industry to control struvite (Federal Register, 1964). Japanese research (a series of 10 papers ending with those of Tanikawa, Nagasawa, and Sugiyama, 1957a, 1957b, 1957c) showed that the use of sodium hexametaphosphate and ethylenediaminetetra acetate will not only prevent the formation of struvite in canned crab meat but will also affect color, taste, and texture. This Japanese work also indicated that careful thermal control after retorting will reduce the size of struvite crystals but will not

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prevent them from forming. Although the Japanese have done considerable work on the development and prevention of struvite in canned king crab, their findings apparently have not been applied commercially.

The effectiveness of pyrophosphate in red meat to increase the retention of moisture and in canned seafoods to prevent struvite from forming led us to investigate its use to improve the quality of king crab products. This investigation was carried out in two main stages: The first stage consisted of model-scale studies and certain laboratory experiments. The second stage consisted of an experiment made in a commercial king crab cannery.

Model-Scale and Laboratory Studies

The model-scale experiments in the first stage of our investigation indicated that the retention of moisture can be improved in cooked king crab meat by the addition of sodium tripolyphosphate or sodium acid pyrophosphate together with salt. In these model-scale experiments, the pH, salt, and polyphosphate levels all influenced the binding of moisture.

Following the model-scale studies, we made several preliminary laboratory experiments to select the specific polyphosphate and to determine the levels of pH, salt, and polyphosphate for an in-plant study. In these laboratory experiments, polyphosphate solutions were added to the cans after they were packed with king crab meat and before they were retorted. We selected this point of addition because it would permit the polyphosphate to be added with brine just prior to seaming of the cans and would require no other change in the normal canning procedure. Commercial processors use either single-cook or double-cook methods in preparing the crab meat for canning. In the single-cook method, the cooking is completed while the meat remains in the shell. In the double-cook method, the meat is partially cooked in the shell (enough to firm the meat), the meat is extracted, and cooking is completed with the meat alone. In the laboratory, we used both methods. Sodium acid pyrophosphate and sodium tripolyphosphate were added in aqueous solutions that varied from pH 5.0 to pH 6.5 and in amount from 0.15 to 0.60 percent P_2O_5 (expressed as percentages of the fill weight of crab meat).

Results from these preliminary experiments indicated that sodium acid pyrophosphate was more effective in retaining moisture than was sodium tripolyphosphate. We found it to be most effective when the pH was adjusted between 6.0 and 6.2 in the presence of about 1.0 percent added salt. The method of cooking was not a factor — that is, neither the single-cook nor the double-cook method influenced the effectiveness.

Commercial Cannery Studies

This paper reports on the second stage of our investigation. This second stage consisted of an experiment carried out in a commercial king crab cannery under controlled production conditions based on the model-scale and laboratory studies. The purpose of this second-stage experiment was to determine the feasibility of adding sodium acid pyrophosphate ($Na_2H_2P_2O_7$) to canned king crab in order to produce a product of better quality.

In making this determination, we approached the problem from two points of view — quantitative and qualitative. The quantitative aspects studied were the effects of sodium acid pyrophosphate on yield and on changes in pH. The qualitative aspects were its effect on struvite, on blueing and sulfide blackening, and on taste and texture.

I. QUANTITATIVE ASPECTS

In this in-plant experiment to can king crab with the addition of sodium acid pyrophosphate under commercial conditions, variations in pH and of the added components were restricted to relatively narrow limits, owing to the adverse flavor changes that accompany excessive use of sodium chloride, sodium acid pyrophosphate, and high acidity. In this study, as was indicated earlier, we determined both the yield and the changes in pH.

A. YIELD

1. Procedure

The concentrations of pyrophosphate used were expressed in terms of P_2O_5 as a percentage of the fill weight of king crab. The concentrations were obtained by adding stock solutions to the cans to result in 1.00, 0.75, 0.45, 0.35, or 0.25 percent phosphate by weight of the total fill (weight of crab meat plus topping fluid). These stock solutions were adjusted to pH 6.0 and 6.2. Reagent-grade sodium chloride was added to all experimental samples at a concentration of 1.1 percent (based on the total fill) in place of commercial brine.

For comparison with the experimental lots, three control lots were prepared: (1) a lot with 1.1 percent of sodium chloride added, (2) a lot with regular brine containing salt and citric acid added, and (3) a lot with water only added. Enough water was added to each experimental and control sample so that the weight of additional solution added to each can containing 200 grams (7.05 ounces) of king crab meat was 35 grams (1.23 ounces) in each sample. The solutions were added just before we vacuum seamed the cans.

We prepared the canned king crab by using the usual commercial canning procedure, varying only the topping fluid. Live king crab were butchered and cooked in water at 165° F. (74° C.) for 10 minutes. After the shells were removed and the meat examined for extraneous material, the meat was cooked a second time in steam for 10 minutes. The cooked meat was again inspected, sorted, cut to size, and filled into cans. The cans, after being filled by cannery personnel, were selected at random and were:

(a) Filled with fresh water and allowed to stand for 10 minutes.

(b) Inverted on a screen and allowed to drain for 10 minutes.

(c) Adjusted to 200 grams (7.05 ounces) net weight by the addition or removal of drained crab meat.

(d) Filled with 35 grams (1.23 ounces) of the appropriate experimental or control solution.

(e) Seamed.

(f) Retorted for 55 minutes at 240° F. (116° C.).

(g) Cooled to about 100° F. (38° C.).

The experimental pack was sent from the cannery to the laboratory, where cans of each lot were opened periodically for examination. We determined the drained weights by spreading the crab meat on a screen with 8 meshes per inch (8 meshes per 2.54 centimeters) and by allowing the meat to drain for 2 minutes. We calculated the yields by taking the drained weight as a percentage of the 200.0-gram fill weight of crab meat.

2. Results

Figure 1 shows how adding the pyrophosphate affects the retention of moisture of canned king crab meat. The yield was determined after 1 month's storage, by examining 12 cans representing each treatment. Samples containing the pyrophosphate generally gave higher yields than did the controls.

By considering each of the 13 lots as a different treatment and by using the method described by Snedecor (1956), we found that the water control differed from all pyrophosphate-treated samples and from the salt control at the 95-percent level of confidence. On the basis of the same method, the yield from 6 of the 10 pyrophosphate-treated samples exceeded the yield from the normal plant brine samples significantly. Other comparisons among single means were not significant. The means for all pyrophosphate treatments exceeded those for water and plant-brine controls. Also 8 of the 10 treatment means exceeded that for the salt control. Table 1 shows the complete data.

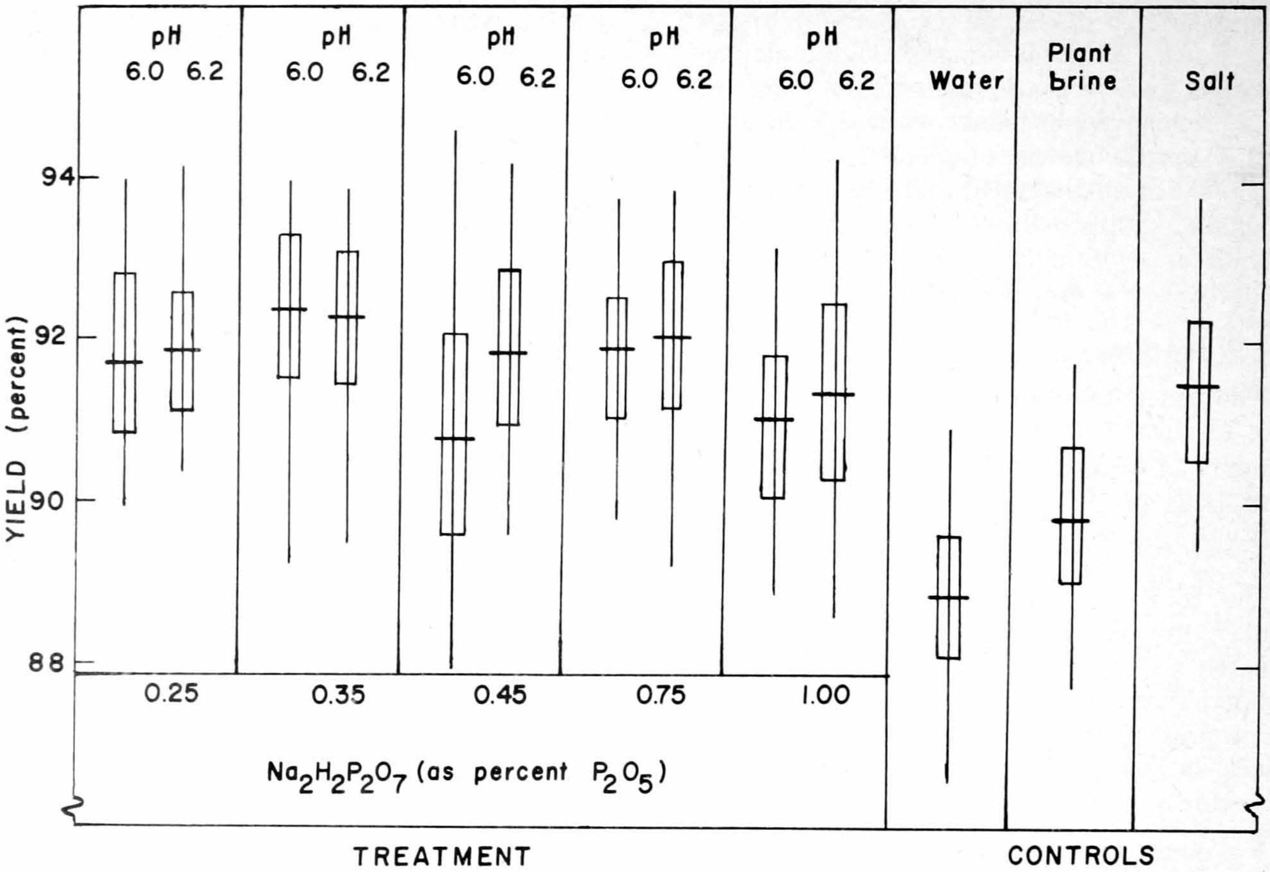

Figure 1.—Yield of drained king crab meat canned with addition of sodium acid pyrophosphate.

Table 1.—Yield after 1 month of storage of canned king crab containing sodium acid pyrophosphate and salt

Replicate	Yield												
	Pyrophosphate added at pH 6.0 in the following concentrations:					Pyrophosphate added at pH 6.2 in the following concentrations:					Control samples		
	.25%	.35%	.45%	.75%	1.00%	.25%	.35%	.45%	.75%	1.00%	Water only	Plant brine	Salt 1.1%
No.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	94.0	93.3	91.7	90.3	91.0	91.1	92.1	90.8	90.2	91.7	89.5	91.6	91.2
2	92.4	92.0	90.8	93.4	91.4	92.0	93.0	90.7	92.1	91.1	90.9	91.5	91.8
3	93.8	92.2	92.3	92.8	91.7	94.0	93.5	93.1	91.3	92.8	90.3	89.5	93.7
4	93.2	93.6	94.5	92.3	91.2	91.1	93.6	91.6	89.2	89.7	--	90.3	90.7
5	93.2	92.2	90.0	92.5	89.3	92.7	91.1	90.9	93.6	94.2	88.7	89.1	89.3
6	90.0	92.1	88.5	89.9	92.6	93.3	93.1	90.0	91.8	91.2	89.1	88.7	90.8
7	90.7	89.2	87.9	91.3	90.7	92.0	91.6	91.6	92.5	92.5	88.8	90.8	92.9
8	90.0	91.2	88.5	93.7	90.2	90.6	89.4	91.9	93.8	92.4	88.0	88.4	91.2
9	90.1	91.7	91.3	91.7	91.9	90.3	92.1	93.7	90.9	89.3	87.8	89.8	91.3
10	90.2	93.8	91.9	90.9	93.0	91.2	91.4	89.6	91.3	90.0	88.5	90.4	89.5
11	92.7	93.8	92.1	91.0	89.5	91.2	93.8	93.3	92.6	92.2	88.9	89.4	92.5
12	91.4	92.6	90.1	91.0	88.9	92.1	91.6	94.0	92.5	88.6	86.5	87.8	90.4
Mean	91.7	92.3	90.8	91.7	91.0	91.8	92.2	91.7	91.9	91.3	88.8	89.8	91.3

Since the individual pyrophosphate-treatment means did not differ significantly from one another, the pyrophosphate-treated samples were combined for comparison with the control samples. The yield from the pyrophosphate-treated samples exceeded that from the normal plant-brine samples by 1.8 percent. Statistical analysis showed that the mean difference of 1.8 percent was significant at the 99-percent level of confidence.

In addition to the examination after 1 month, three cans of each control and treatment lot were again examined for yield after storage at room temperature for 6 months and for 12 months. Yield data from the stored samples confirmed those from the 1-month examination.

B. pH

After the drained weight was determined as described in Section A, the pH of the fluid drained from each can was measured by a Beckmann pH meter.

The pH values of the fluids drained from the finished products indicated a decrease in pH with increasing concentration of pyrophosphate (Table 2). The samples with solutions added at pH 6.0 remained more acidic than did those with solutions added at pH 6.2. Finished-product pH values in samples containing pyrophosphate were lower after storage for 6 and 12 months than were those for the control samples. The buffering properties of the pyrophosphate solutions were evident.

Table 2.—pH of fluids drained from king crab canned with sodium acid pyrophosphate and held in storage

Pyrophosphate added at:		pH after:		
pH	Concentration	1 month	6 months	12 months
	Percent			
6.0	0.25	6.77	6.76	6.82
	0.35	6.70	6.79	6.76
	0.45	6.67	6.77	6.69
	0.75	6.58	6.66	6.57
	1.00	6.52	6.64	6.51
6.2	0.25	6.78	6.99	6.80
	0.35	6.75	6.90	6.78
	0.45	6.71	6.89	6.72
	0.75	6.63	6.80	6.65
	1.00	6.60	6.70	6.58
Controls	Water	6.93	7.00	--
	Salt (1.1%)	6.88	7.00	--
	Plant brine (Salt & citric acid)	6.80	6.89	--

II. QUALITATIVE ASPECTS

Each can used in the determination of drained weight described in Section 1A was examined by the author for struvite, blueing, and sulfide blackening. In addition, the product was tasted, and its texture evaluated by the author or a member of the laboratory staff.

A. STRUVITE

Struvite was present in all control samples in moderate to severe degrees at the 6-month and 12-month examinations (Table 3). In contrast, after 6 months of storage, struvite was not found in any can with added pyrophosphate. After 12 months, struvite was barely detectable in 2 of the 24 cans examined that had pyrophosphate added.

B. BLUEING AND SULFIDE BLACKENING

The storage data (Table 3) also suggest that the incidence of blueing and sulfide blackening was more pronounced in control samples than in pyrophosphate-treated lots.

C. TASTE AND TEXTURE

At higher concentrations (0.75 and 1.00 percent), pyrophosphate could be detected by taste in the finished product, but at the lower concentrations it could not be detected. The texture of the samples containing sodium acid pyrophosphate and of the controls did not differ noticeably.

[1] Use of trade names does not imply endorsement.

Table 3.—Occurrence of struvite, blueing, and sulfide blackening in king crab canned with and without addition of sodium acid pyrophosphate

Treatment	Cans showing:											
	Struvite after:				Blueing after:				Sulfide blackening after:			
	6 months		12 months		6 months		12 months		6 months		12 months	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
No pyrophosphate added (controls)	8 of 8	100	8 of 8	100	5 of 8	63	6 of 8	75	4 of 8	50	6 of 8	75
Sodium acid pyrophosphate added	0 of 29	0	2 of 24	8	11 of 29	38	13 of 24	54	4 of 29	14	10 of 24	42

SUMMARY AND CONCLUSIONS

This experiment indicates that the addition of sodium acid pyrophosphate, under certain specific conditions, slightly improves the retention of moisture by canned king crab meat as compared with that by king crab meat canned with regular commercial addition of salt and citric acid. No significant difference in the retention of moisture was noted between samples to which the solutions had been added at pH 6.0 and 6.2. The means indicated, however, that addition of solutions at pH 6.2 was slightly more effective. The lower concentrations of sodium acid pyrophosphate appeared to be more effective than did the higher concentrations, although the difference was not statistically significant. The addition of this compound under these conditions at concentrations of 0.25 and 0.35 percent resulted in no detectable change in flavor or texture from that of current commercial king crab packs. Storage tests for 1 year indicated the almost complete protection of struvite in cans containing sodium acid pyrophosphate.

The results of this experiment indicate that by the use of sodium acid pyrophosphate and the procedure presented here, the formation of struvite will be inhibited for at least a year. They also indicate that the yield of canned king crab will not be reduced and that blueing and sulfide blackening and taste and texture will not be changed adversely.

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MS #1754

MECHANIZED HAUL SEINE FOR USE IN FARM PONDS

by

Kenneth L. Coon, Alfred Larsen, and James E. Ellis

ABSTRACT

Present methods of harvesting fish from farm ponds are time consuming, laborious, and wasteful of water. This paper supplies information on a mechanized system in which a haul seine and associated equipment are used to capture fish in farm ponds and a conveyor and associated equipment are used to load and weigh the fish into trucks for shipment to market. The mechanized seine works well both in ponds of small or large size and water as deep as 8 feet.

CONTENTS

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INTRODUCTION

The Bureau of Commercial Fisheries is engaged in research and development aimed at the improvement of commercial fisheries in flooded rice fields, farm ponds, and reservoirs in the bottom lands of the lower Mississippi River in the South Central States. These activities relate to methods of harvesting, processing, and storage, preparation of consumer products, and market development and promotion.

The commercial farm-pond fishery has relied solely on primitive methods for catching and handling fish (Figures 1 and 2) since its beginning in the early 1950's. Because these methods are laborious and have often cost more than the value of the fish taken, the development of effective and efficient harvesting and handling techniques is important.

In current practice, extensive preparations usually are required to ready ponds for harvesting the fish. Draining a pond and preparing for final harvesting operations by means of sumps or ditches require several days. In this process, valuable amounts of water are wasted. Coordinating production with market demands is difficult under these conditions. Harvesting the fish often must be limited to periods of the year when it does not conflict with other activities on the farm.

Figure 1.—Hand-dipping buffalofish from bar ditch of a drained woodlot reservoir. After about 500 pounds of fish are placed in the "John-Boat," it is pushed through the debris-filled bar ditch about 3/4 mile to a loading point.

Figure 2.—Part of a seven-man crew seining brood catfish from main pond for planting in holding ponds. The operation took 7 hours.

Investigations of fishing methods and equipment that would help solve these problems led to the development of a mechanized haul seine for use in ponds and reservoirs that have relatively smooth bottoms. The purpose of this report is to make available information that we obtained on this haul seine between September 1963 and February 1965. The report is divided into two main parts: the first part describes this haul seine and the second part gives the results of testing the seine under practical field conditions.

I. DESCRIPTION OF THE MECHANIZED HAUL SEINE

The complete mechanized haul seine consists of a number of component parts, each with a distinct function in setting the net, retrieving the net, and handling the fish, so the seine represents a complex system. We consider first the equipment in this system — that is, the various components used — and then its operation — that is, the technique used to catch fish and then get them into trucks for transportation to the market.

A. EQUIPMENT IN THE HAUL—SEINE SYSTEM

Under equipment, we consider (1) that associated with the seine itself and (2) that used in the handling of fish.

1. Seine Equipment

The seine equipment consists of (a) the seine components — that is, the various parts

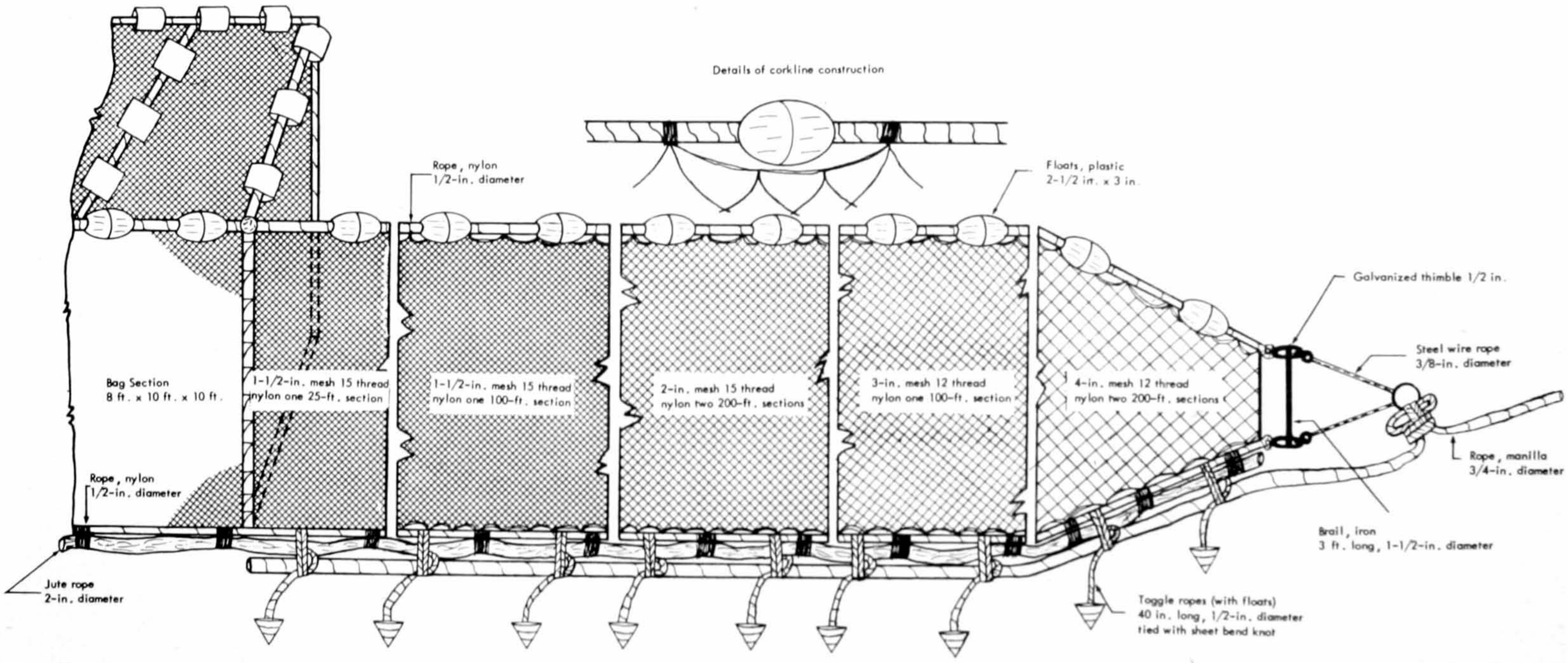

Figure 3.—Construction details of 2,060- by 10-foot farm-pond haul seine showing the bag and the left wing.

of the seine net — and (b) the seine-handling components — that is, the equipment that is needed to set and to retrieve the seine.

a. Seine components.—The seine is constructed of nylon twine. It consists of two wings and a bag section (Figure 3).

(1) Wings.—Each wing is made up of six sections of various length and mesh sizes[1] to facilitate rigging the seine to fish ponds of different areas. Mesh sizes range from 4 inches at the wing end to 1½ inches at the bag (Figure 3). Large-sized meshes are used in the leading wing section to reduce resistance to drag during hauling. The ends of each section are provided with galvanized thimbles on the top line and on the bottom line to allow the sections to be joined together by either shackles or cordage. Perpendicular breast lines at the ends of adjoining sections are laced together. Bridles and brails at the leading edge of each wing help to keep the seine wings open vertically and are used also for attaching the hauling lines. Jute rope, which soaks up water and which is attached to the bottom line of the wings and bag, weighs the bottom line down without causing the seine to dig into bottom mud during hauling.

(2) Bag section.—The bag section of the seine consists of a bag, 8 feet wide, 10 feet deep, and 10 feet long, with wing extensions, 25 feet long and 10 feet deep, on each side of the bag (Figure 3). The bag section is of 1½-inch mesh.

b. Seine-handling components.—We have now seen that the seine is flexibly constructed — that is, its length can be changed to adapt it to most ponds. The longer the seine the heavier and harder to handle it becomes. We therefore look next at the equipment to set and retrieve it.

(1) Seine-setting components. — The seine-setting components consist primarily of a seine barge for carrying the net and of blocks for guiding the hauling lines of the net around the edge of the pond and thereby helping to place the net so that it can catch as many fish as possible.

(a) *Seine barge.*—The seine barge (Figure 4) is a pontoon-type craft with an 8- by 20-foot plywood platform. The barge has a 10-horsepower outboard motor in a well at the stern; a steering and throttle console on the right side; and an aluminum net roller, 53½ inches long, with a 3-inch-diameter core, and 15-inch-diameter flanges, on the deck near the stern to allow stacking and setting of the net over the outboard motor. When moved overland, the barge rides on four retractable 7.50- by 15-inch, 4-ply automobile tires mounted between the pontoons midway fore and aft. The wheels are raised and lowered by a screw and gear box. A trailer hitch on the front of the barge allows hauling by truck or tractor.

(b) *Blocks.*—The blocks are made of steel. They are 8 inches in diameter and have a slot in one cheek to facilitate the insertion or removal of a hauling line (for an illustration of the kind of blocks used, see the blocks guiding the cable in Figure 5).

(2) Seine-retrieving components.—The seine is retrieved, together with any fish caught, by means of (a) the hauling line attached to the bottom of the seine and (b) a mechanical seine puller for pulling in the hauling line and the attached heavy seine net.

(a) *Seine-hauling line.*—The hauling line is ¾-inch diameter, medium-lay manila line (see Figures 3 and 4), which is made up into two 2,400-foot lengths. It is attached along the length of the seine by 40-inch toggle ropes of ½-inch diameter manila tied to the seine bottom line at 25-foot intervals. Each toggle rope has a 1½- by 2½-inch white tapered wooden float on the free end to facilitate sighting and retrieving the hauling lines. These toggle ropes are untied from the hauling lines when the seine reaches the seine puller.

(b) *Seine puller.*—Two kinds of seine pullers were developed for pulling in the seine-hauling line — a wire-cable puller and a rope-line puller.

[1] All mesh sizes are stretched measurements.

Figure 4.—Mobile pontoon barge used for hauling and setting farm-pond haul seine.

Figure 5.—Bureau-designed haul seine puller, using cable for hauling lines. Earlier tests were made with the puller mounted on a trailer.

(b.1) Wire-cable puller.—The wire-cable puller had a double drum winch for pulling steel-cable hauling lines (Figure 5). This puller did not work well because the cable tended to dig into the bottom and also tended to twist.

(b.2) Rope-line puller.—Because the wire-cable puller was not satisfactory, a rope-line puller was developed. This rope-line puller took two forms: one was a combination puller and fish conveyor; the other was a separate puller without the attached conveyor.

(b.2.1) Combination puller and conveyor.—The combination device consists of a seine puller mounted on the supporting frame beneath a fish conveyor and powered by a 4-horsepower gasoline engine (Figures 6 and 7). In this way, two pieces of equipment are combined into a single compact unit.

To avoid the possibility of injury to a person who may become entangled in the hauling lines and be pulled against the fair leads, safety lines were attached to the spark-plug wire of the puller engine within reach of both men who untie the toggle ropes from the hauling lines. Thus, if a worker becomes entangled in the haul line, a slight pull on the safety line will disconnect the spark-plug wire and stop the engine.

Figure 6.—Seine puller mounted on support frame beneath fish conveyor, combining seine puller and conveyor into single compact unit.

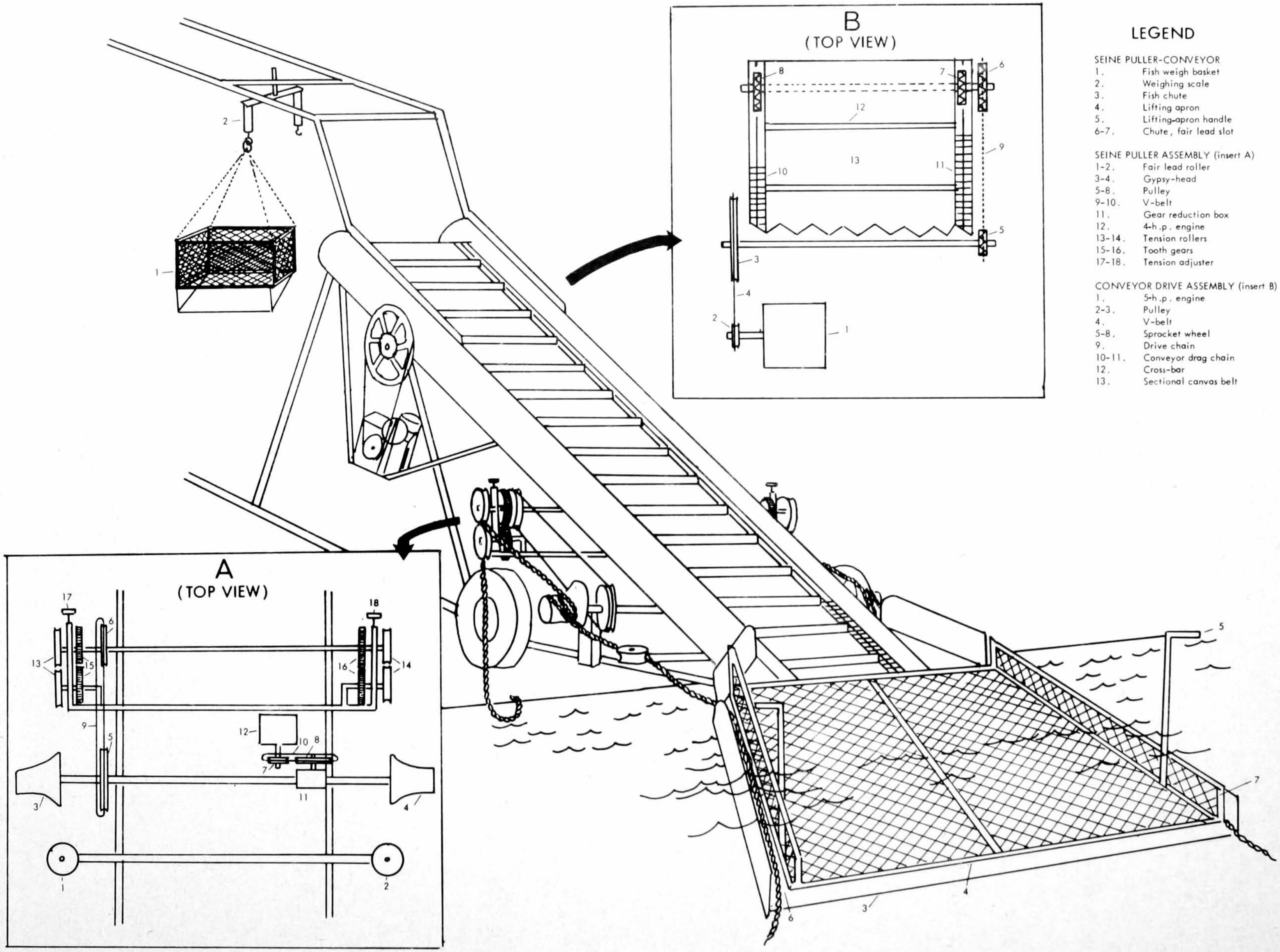

Figure 7.—Schematic drawing of combination seine puller and fish conveyor showing the main components of the system and the method of attaching hauling lines.

(b.2.2) Separate puller.—A separate seine puller, similar in design to the combination puller, was built on a trailer to provide a smaller, more mobile unit to be used when the conveyor was not needed (Figure 8).

2. Fish-Handling Equipment

Having described the seine and the equipment used to handle it, we now consider the equipment for handling the fish. This equipment consists of a conveyor and a means for weighing.

a. Fish conveyor—A portable grain conveyor, powered by a 5-horsepower gasoline engine, was modified to load fish (Figures 6 and 7). The speed of the conveyor track was about 165 to 175 feet per minute, with or without load.

The unit has a hinged fish chute and lifting apron attached to the receiving end of the conveyor for loading fish from the seine (Figures 6, 7, and 9). The chute is 6 feet 6 inches long, and tapers from 7 feet 5 inches wide at the far end to 4 feet 8 inches at the base. The sidewalls are 6 inches high. The chute and lifting apron fold back onto the conveyor during transit and are lowered into the water during operation. Slots between the inside walls of the fish chute and lifting apron serve as fair leads for the hauling lines (Figure 7). A sectional canvas belt attached to the drag chain between the metal cross bars or buckets prevents fish from being caught under the cross bars when the conveyor is operated.

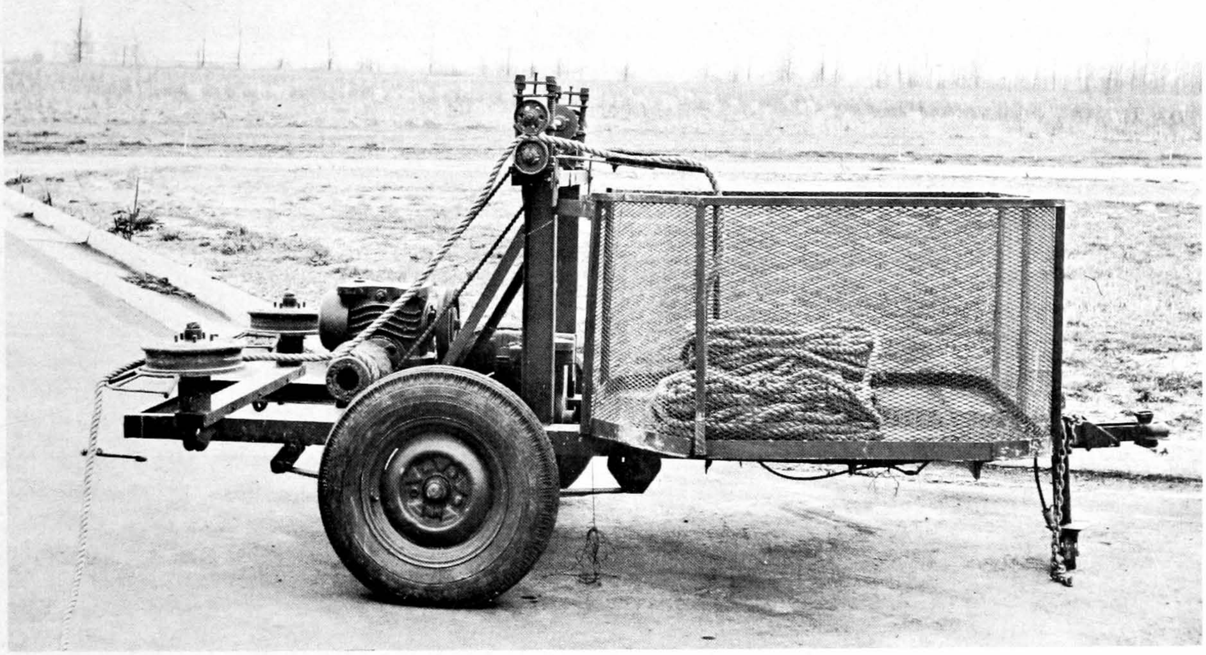

Figure 8.—Improved trailer-mounted seine puller. This equipment fills the requirements for an independent and compact unit.

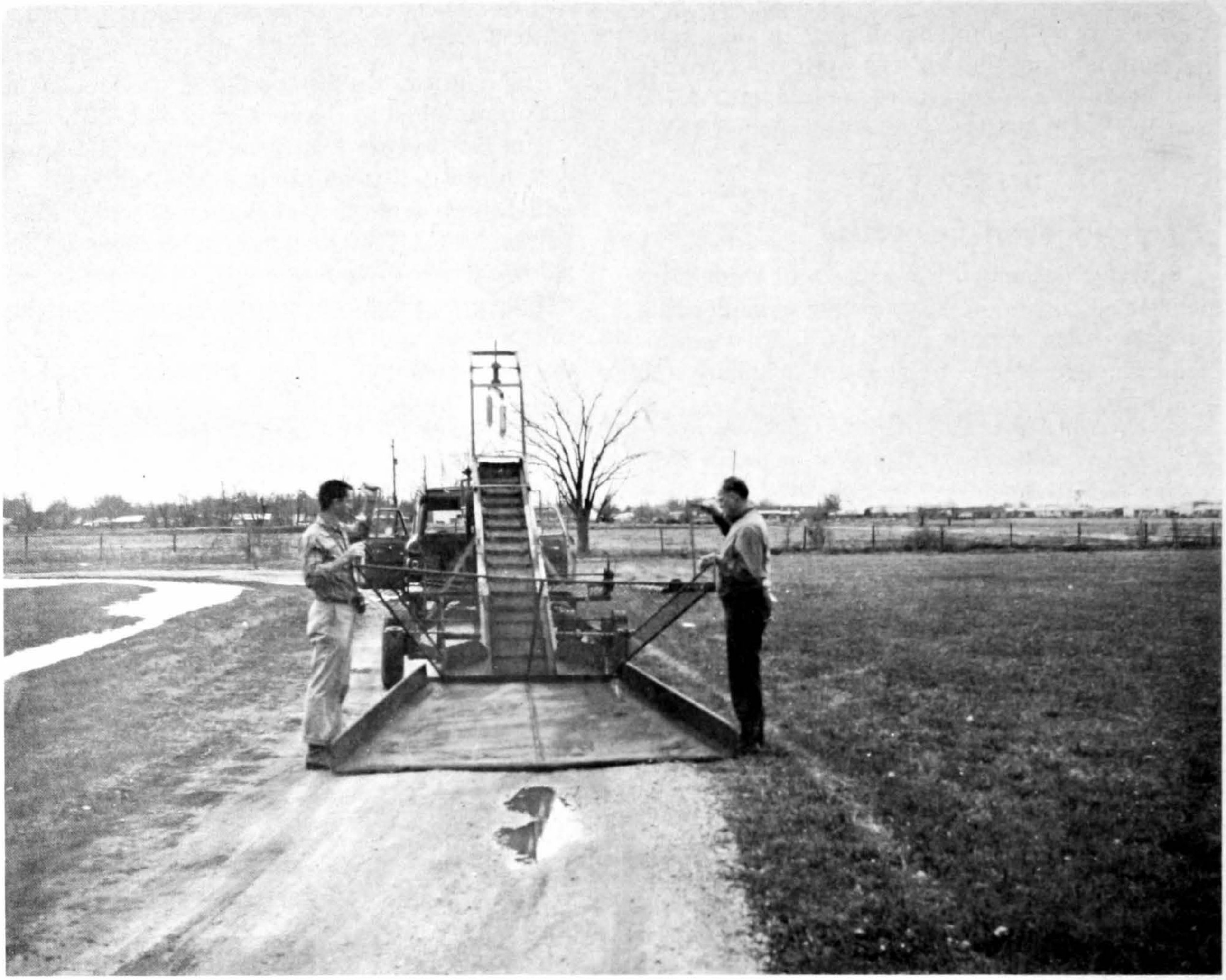

Figure 9.—Modified grain conveyor used to load fish after the haul seine has been beached.

Future conveyor models could be improved by:

1. Use of lightweight construction material such as aluminum that would reduce the weight of the conveyor and thereby permit its easier handling at pond sites.
2. Use of design features that would allow the conveyor to be readily shortened or lengthened to meet loading requirements.
3. Use of a rubber conveyor belt with rubber cleats to eliminate bruising of fish, especially those destined for live markets or pay lakes (ponds where sport fishermen pay a fee for the privilege to fish).

b. Catch-weighing equipment.—Two 24- by 24- by 13-inch baskets of $1\frac{1}{2}$-inch mesh expanded steel attached to the upper, or exit, end of the conveyor receive the fish, where they are weighed (Figure 10). A tripping mechanism allows one side of the bottom of each basket to drop 10 inches and the fish to slide through the opening into a truck. The weighing baskets, each with a spring scale of 160-pound capacity, are mounted on a revolving bar so that while one basket is being filled, the other is being weighed and emptied.

B. OPERATION OF THE HAUL SEINE

In the preceding Section A, we saw what the seine itself and the seine-handling equipment is like and what the fish-handling equipment is like. In the present Section B, we shall see how to use the equipment to catch the fish and to handle them up to the point where they are weighed and are ready for transportation to market. We consider first the method of using the seine to catch the fish and then that of removing the catch from the seine, weighing the fish, and dumping them into a truck.

1. Getting the Catch

Getting the catch involves two steps: the primary step consists in getting the setting and retrieving equipment ready, and the secondary step consists in actually capturing the fish.

a. **Readying the equipment.**—The primary step involves five substeps, which are carried out as follows:

1. Stack the seine net on the barge with the hauling lines attached to the bottom line of the seine (Figure 11). Stack

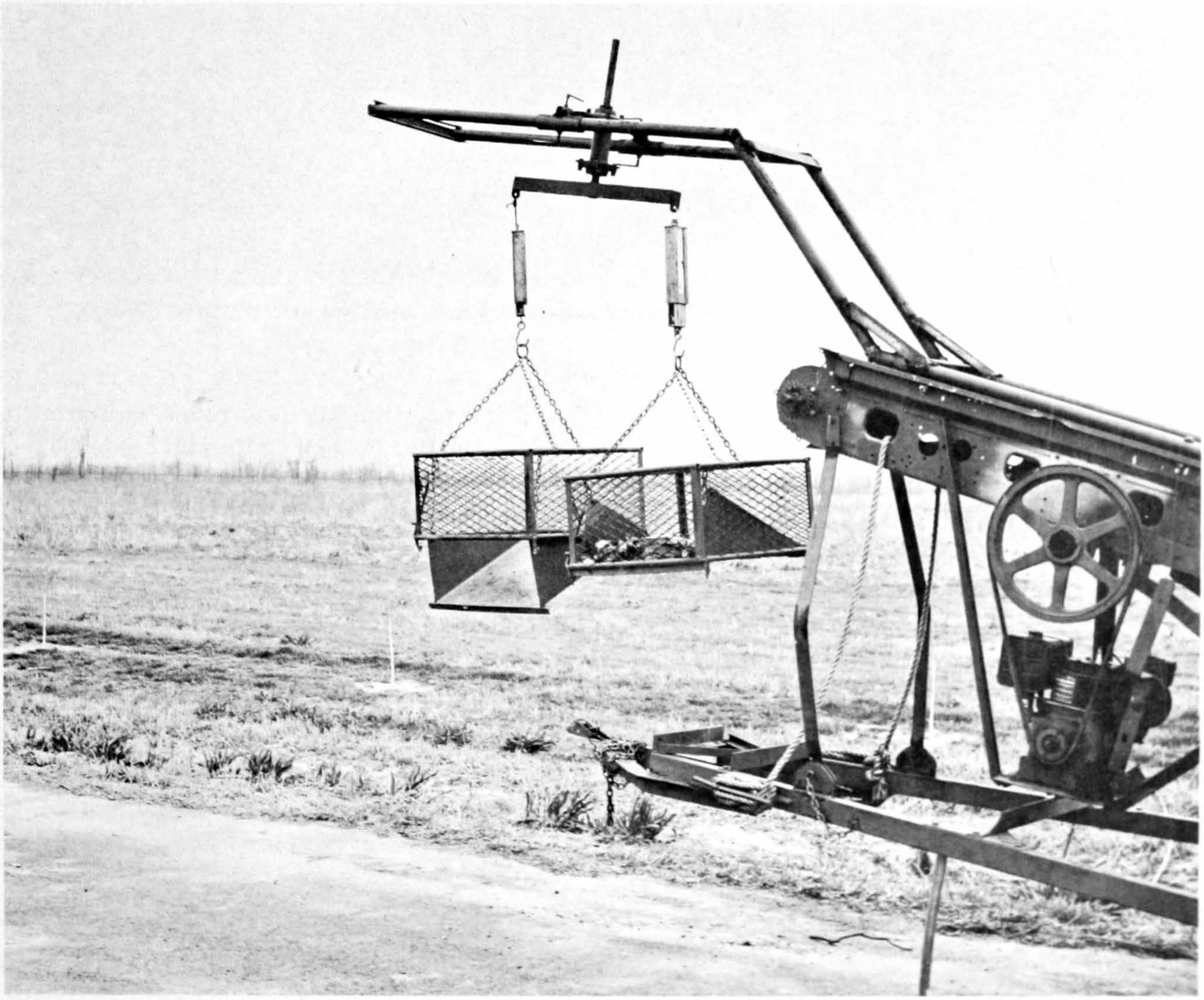

Figure 10.—Revolving fish baskets at exit end of fish conveyor used to weight catch. Each basket has a tripping mechanism and 160-pound-capacity spring scale. While one basket is being filled, the other is being weighed and emptied into the loading truck.

Figure 11.—Nylon haul seine stacked on pontoon barge and ready to be set over the stern roller.

it to facilitate setting — that is, stack it in the sequence: left hauling line, left wing, bag section, right wing, and right hauling line.

2. Position the seine puller or combination seine puller and conveyor on the bank of the pond in the harvesting area. When the puller-conveyor is to be operated, place the receiving end of the conveyor near the water's edge and lower the fish chute into the water.

3. Stake a steel block to the bank at each proximal corner. If the pond is of considerable length (over 400 feet), add a second block on each side of the pond.

4. Launch the barge with the seine aboard and position the barge directly in front of the puller.

5. Fasten the leading end of the right hauling line to the winch head, draw it past the fair-lead roller, and around the fair lead all on the right side (when facing the pond) of the seine puller (Figure 7).

b. Capturing the fish.—Having readied the equipment by loading the seine barge, positioning the puller-conveyor, staking the steel blocks in position, etc., we now can take the secondary step of capturing the fish by setting the net and then hauling it in.

(1) Setting the net.—The hauling lines and net are payed out as follows while the barge travels counterclockwise around the perimeter of the pond (Figure 12):

1. Pay out the right hauling line over the seine roller of the barge while propelling the barge toward the block staked at the near right corner of the area to be seined.

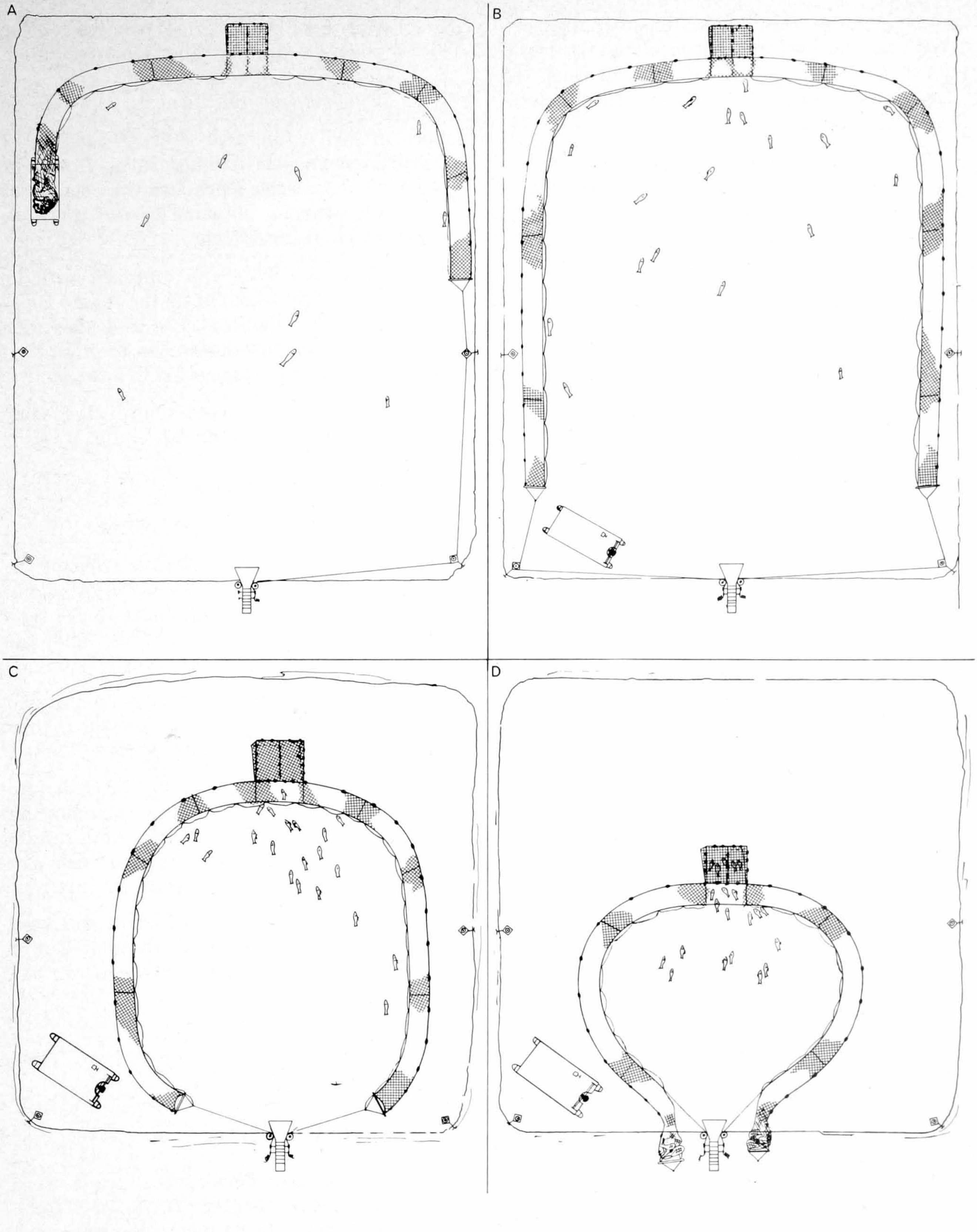

Figure 12.—Operation of farm-pond haul seine.

2. Put the line through the corner block, and propel the barge along the right side of the pond to the second block (if used), and attach the hauling line to the block.

3. Continue propelling the barge down the right side of the pond, paying out the hauling line over the seine roller. Then, when the seine net is reached, set out the seine and the line simultaneously while propelling the barge around the pond in a semicircular pattern (Figure 12A).

4. Continue propelling the barge around the pond paying out the hauling line, and attach it to the left-side block (if used) and the corner block.

5. Upon returning the barge to shore, put it on the beach or otherwise set it out of the way.

6. Run the remaining hauling line through the fair lead, or by the fair-lead roller, and around the winch head on the left side of the seine puller to complete the setting operation.

The net is now ready for hauling (Figure 12B).

(2) Hauling the net.—The net is hauled as follows:

1. Start the seine-puller engine, and wrap each of the two hauling lines three turns around the nearest winch head and thread each line between the tension rollers on its side of the puller.

2. Start hauling. Retrieve the hauling lines at about 25 feet per minute, and coil them on the ground by the tension rollers. [In the trailer-mounted puller, the lines are coiled automatically in a rope-storage bin beneath the tension rollers (Figure 8).]

3. Remove the hauling lines from the blocks at the sides and the corners of the pond as the wing tips of the seine reach them (Figure 12C).

4. When the wing tips approach near the chute fair leads, untie the toggle ropes from the hauling lines and stack the seine just off shore on each side of the puller (Figure 12D).

5. Continue the process until the seine bag is hauled to the fish chute.

2. Removing the Catch

The catch is removed as follows:

1. After the bag reaches the front of the chute, draw the wings of the bag along the inside of the fish chute in the slots formed by the chute walls and the lifting-apron walls (Figure 7).

2. Pull the seine bag partly up the fish chute (the fish, being crowded, then swim over the lifting apron).

3. Lift the apron and dump the fish into the conveyor. Two men standing on opposite sides of the fish chute can do this. (About 100 pounds of fish can be fed onto the conveyor per lift.)

4. Weigh the fish deposited in the wire fish baskets located at the exit end of the conveyor, and load them into the transporting vehicle.

II. TEST OF THE MECHANIZED HAUL SEINE

In Part I, information was presented that would enable us to build and then operate the mechanized haul seine. The question now is: How well does it work in practice?

Forty-seven gear-development trials were made with different lengths (200 to 1,900 feet) of the haul seine. In 34 ponds, the seine was pulled mechanically; in 13 ponds, it was pulled manually.

A. MECHANIZED SEINING TRAILS

The average catch from the 34 mechanized seining trials was 3,973 fish weighing 4,401 pounds (Table 1). The catches ranged from 0 to 33,375 pounds per haul. The average catch per man-hour was 374 pounds. Table 1 shows an average of 25 percent of the fish present as being caught; however, this average is based on an assumed 100-percent survival of the stocked fish, which rarely is true. Thus, the actual percentage caught undoubtedly was higher.

A number of problems caused low catches in some ponds. The main difficulties involved the seine snagging on bottom obstructions or the seine digging into the bottom mud, or both (Table 1). In addition, the equipment malfunctioned several times; however, these malfunctions, which were minor, did not decrease the catches appreciably.

Of the 34 mechanized seining operations, the cable seine puller was used in 10 trials; the rope seine puller, in 24 trials. The gear was tested 28 times in catfish (*Ictalurus punctatus, I. furcatus*) ponds (Figure 13), 2 times in buffalofish (*Ictiobus cyprinellus, I. bubalus*) ponds (Figure 14), and 4 times in ponds containing several species. These ponds ranged

Table 1.—Catch results from 34 mechanized haul seine trials

Trial	Seine length	Haul length	Pond size	Average depth	Proportion of pond fished	Species	Estimated fish present	Total catch		Proportion of fish caught	Catch per man-hour	Coded remarks
	Feet	*Feet*	*Acres*	*Feet*	*Percent*		*Number*	*Pounds*	*Number*	*Percent*	*Pounds*	
1	1,860	1,000	30	2.0	65	Buffalofish	3,500	4,600	1,470	42.0	766.0	a1, h
2	1,360	1,000	30	2.0	65	Buffalofish	2,200	1,400	462	21.0	350.0	a1, h
3	400	650	8	4.0	50	Channel catfish	12,000	7	7	0.1	0.0	a1, b, h
4	400	700	8	4.0	60	Channel catfish	12,000	810	625	7.0	147.0	a1, b, h
5	460	625	9	4.0	60	Channel catfish	11,700	1,000	1,600	14.0	200.0	a2, h
6	660	625	9	4.0	60	Channel catfish	11,700	250	400	4.0	45.0	a2, b, h
7	860	625	9	4.0	70	Channel catfish	11,700	1,500	1,500	13.0	254.0	a2, h
8	260	625	9	4.0	20	Channel catfish	11,700	160	150	1.0	70.0	a2, e, h
9	260	625	9	4.0	20	Channel catfish	11,700	28	39	0.3	16.0	a2, e, h
10	260	500	4	5.0	100	Several species		544		Unknown	91.0	a2, d, h
11	1,060	625	9	4.0	80	Channel catfish	11,700	350	350	3.0	80.0	a2, f, i
12	1,060	625	9	4.0	80	Channel catfish	11,400	4,000	4,878	35.0	1,600.0	a2, i
13	1,060	400	16	3.5	50	Blue catfish	18,900	12,000	12,000	64.0	1,765.0	a1, i
14	1,060	400	16	3.5	50	Blue catfish	6,900	400	400	6.0	114.0	a1, i
15	1,060	625	9	4.0	80	Channel catfish	11,400	2,000	2,500	22.0	625.0	a2, i
16	1,060	625	9	4.0	80	Channel catfish	11,400	2,500	3,049	27.0	585.0	a2, i
17	1,060	625	9	5.0	90	Channel catfish	9,790	810	988	10.0	124.0	a2, b, i
18	1,860	1,178	25	4.0	80	Several species		1,500		Unknown	124.0	a2, d, i
19	1,860	1,200	25	4.0	100	Several species		840		Unknown	50.0	a2, d, i
20	1,060	625	9	4.0	90	Channel catfish	9,059	3,917	4,896	54.0	509.0	a2, i
21	1,060	625	9	3.0	90	Channel catfish	8,142	973	1,187	15.0	120.0	a2, i
22	1,060	625	9	3.0	90	Channel catfish	6,955	2,514	3,066	44.0	381.0	a2, i
23	660	625	9	4.0	90	Channel catfish	16,889	6,133	5,842	35.0	625.0	a2, i
24	460	625	9	3.5	80	Channel catfish	16,739	3,000	6,000	36.0	222.0	a2, i
25	660	625	9	4.5	40	Channel catfish	16,339	8	13	0.0	0.8	a2, c, i
26	900	625	9	3.5	0	Channel catfish	16,200	0	0	0.0	0.0	a2, g, i
27	900	625	9	4.0	60	Channel catfish	16,200	4,250	4,292	26.0	590.0	a2, i
28	1,060	600	13	2.0	60	Channel catfish	18,000	5,000	3,846	28.0	221.0	a2, c, i
29	1,060	1,000	13	2.0	65	Channel catfish	17,445	5,200	4,000	30.0	448.0	a2, c, i
30	1,060	500	5	3.0	70	Channel catfish	8,500	2,250	2,812	33.0	137.0	a2, c, i
31	1,900	2,500	50	3.0	60	Channel catfish	75,000	25,000	31,250	60.0	620.0	a1, i
32	1,900	1,200	40	3.0	70	Blue catfish	26,000	21,000	11,500	44.0	820.0	a1, i
33	1,900	1,000	25	3.5	90	Several species		2,300		50.0	95.0	a2, i
34	1,900	1,500	40	3.0	75	Blue catfish	24,750	33,375	14,511	58.0	1,264.0	a1, i
Average	1,034	782	14	3.6	70		14,436	4,401	3,973	25.0	374.0	

a1 Irregular shape pond
a2 Regular shape pond.
b Snag encountered
c Mud encountered
d Number fish in pond unknown
e Gear development trials only
f Seine wings hauled alternately
g Net preservative caused seine to float
h Cable puller
i Rope puller

Figure 13.—A 12,000-pound catch of channel catfish in seine bag is being beached. This catch was made in one haul of the mechanized seine from a 16-acre pond. Note the full water level of the pond, which ensures that the captured fish will be landed in good condition.

from 4 to 50 acres, averaged 3½ feet deep, and had relatively smooth bottom. In all but two ponds, the water was not drawn down. Most trials were made in square or rectangular ponds with regular outlines. Seine hauls were made, however, in nine ponds with odd shapes and irregular outlines.

B. MANUAL SEINING TRIALS

Manually seined ponds were generally drawn down to concentrate the fish for harvesting, whereas the mechanized seine operations usually took place in ponds at full-water level. Owing to the limitations of the producers' equipment, the general practice was not to attempt to seine completely a full pond larger than 4 or 5 acres. Table 2 shows the results of 13 fishing trials of the haul seine pulled manually. Lengths of seine ranged up to 1,060 feet. The ponds were from 1 to 16 acres. For the 13 trials, catches were from 177 to 15,000 pounds and averaged 2,064 pounds. The average catch per man-hour was 456 pounds. To reiterate, these high averages are due largely to the fishes being concentrated in collecting basins by the draining of the ponds.

To compare the efficiency of the mechanized haul seine with that of the manually operated seines is difficult because manually seined ponds are small or, as was just indicated, are drawn down to concentrate the fish.

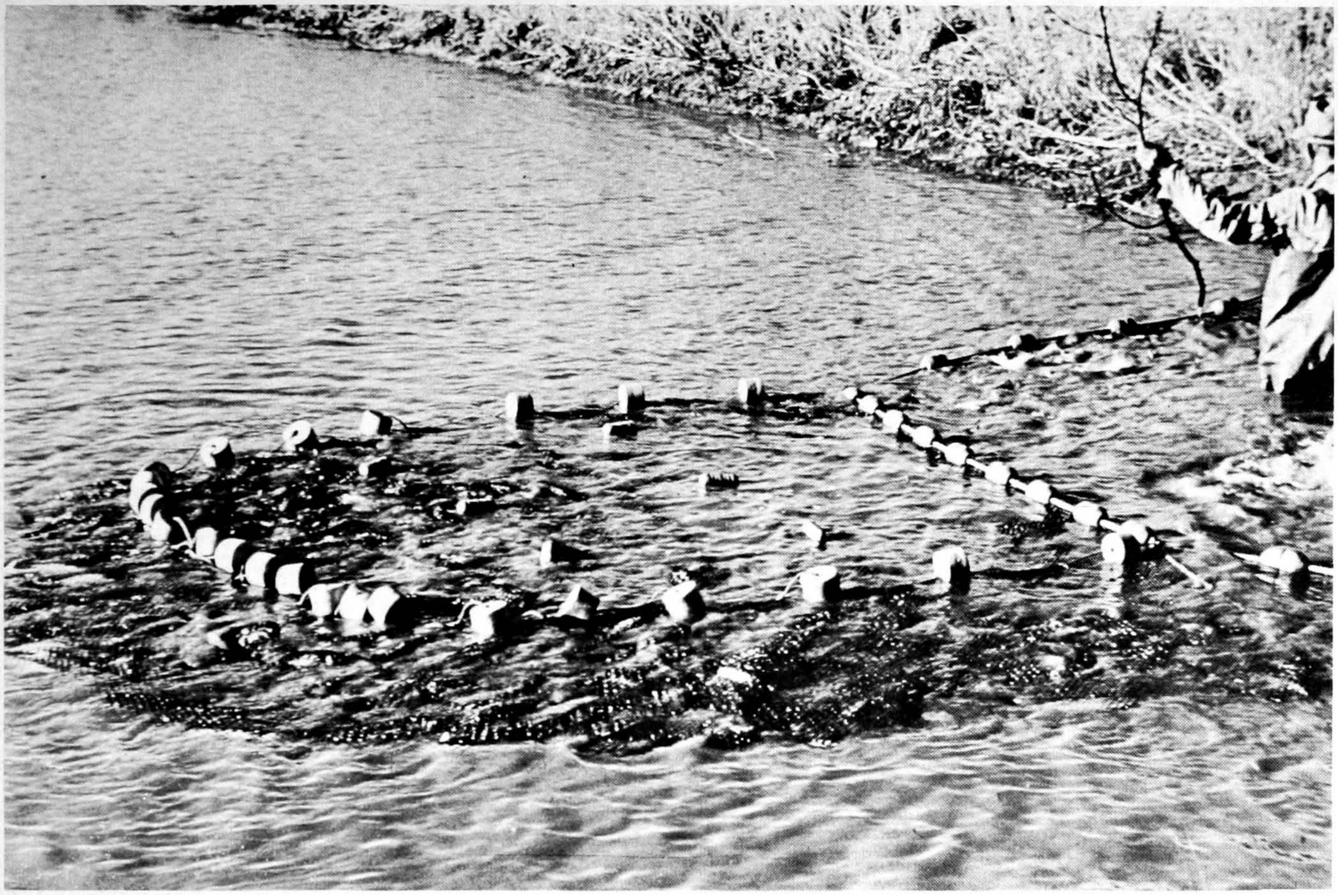

Figure 14.—Part of a catch of 4,600 pounds of buffalofish taken with one set of the haul seine in a 30-acre pond.

Table 2.—Catch results from 13 manual haul seine trials

Trial	Seine length	Haul length	Pond size	Average depth	Proportion of pond fished	Species	Estimated fish present	Total catch		Proportion of fish caught	Catch per man-hour	Coded remarks
	Feet	*Feet*	*Acres*	*Feet*	*Percent*		*Number*	*Pounds*	*Number*	*Percent*	*Pounds*	
1	260	300	3	3.5	100	Blue catfish	4,500	3,150	3,130	70	1,575	a2
2	1,060	500	14	2.5	40	Buffalofish		2,475	616	Unknown	337	a1
3	1,060	500	14	6.0	10	Bass, crappie, bream, buffalofish		314	516	Unknown	26	a1
4	1,060	500	16	3.5	50	Blue catfish	24,000	15,000	15,000	63	1,327	a1
5	300	500	3.5	3.0	100	Blue and channel catfish	6,000	2,457	2,125	35	279	a2
6	200	360	4	3.0	20	Buffalofish, bass, channel catfish		670	138	Unknown	119	a1
7	300	600	7	2.0	90	Blue catfish	9,000	177	177	2	25	a2
8	200	400	1	2.0	100	Blue catfish	8,823	1,381	1,381	16	552	a2
9	200	210	1.7	1.5	100	Blue catfish	3,792	2,541	3,792	100	254	a1
10	200	150	2	2.0	80	Blue catfish	10,000	5,000	5,000	50	1,190	a1
11	660	250	9	8.0	80	Albino channel catfish, buffalofish		1,622	2,837	Unknown	225	a1
12	660	250	9	8.0	20	Buffalofish		220	404	Unknown	7	a1
13	660	250	9	8.0	20	Albino channel catfish, buffalofish		220	404	Unknown	40	a1
Average	525	344	7.1	4.0	58		9,445	2,064	2,707	48	456	

a1 Irregular shape pond
a2 Regular shape pond

CONCLUSIONS

1. Factors affecting the use of the mechanized equipment include: (a) the design and condition of access approaches to ponds, (b) the overall configuration and design features of the ponds, and (c) the presence of woody or herbaceous aquatic plant growth in the ponds. Fortunately, most of the ponds are relatively flat bottomed with little or no plant growth that interfere with seining, or they easily can be made suitable for seining.

2. The ability of the haul seine to capture about 63 percent of the populaution of buffalofish in a 30-acre pond in two hauls and 58 percent of the population of catfish in a 40-acre pond in one haul (Table 1) indicates that the seine is highly efficient for harvesting farm ponds that are suitable for this type fishing. This conclusion is especially true in view of the fact that the shape and the condition of these two particular ponds were not ideal for haul seining.

3. Because of the nylon webbing of the seine, it is exceptionally easy to handle during stacking and setting. An added advantage of this synthetic netting material is its resistance to deterioration, which allows the seine to be stored wet.

4. A properly designed net can be used in ponds ranging from 1 to 160 acres or larger, depending upon the dimensions of the pond. The 2,060-foot seine is capable of harvesting ponds up to about 1,600 feet wide. Larger ponds could be fished by merely adding sections to the wings and using a more powerful puller. The 10-foot deep seine can be used in ponds of varying depths. Hence, the net can be used in a wide variety of water depths, ranging from sump basins or ditches to ponds that are 6 to 8 feet deep.

5. An average of four hauls per 8-hour day could be made with the gear in ponds having ideal seining conditions, thus allowing fish in various amounts to be available for shipment on not more than 24-hour notice.

6. A two-man crew can set and haul the 2,060-foot seine, whereas at least a six-man crew is needed to set and haul a seine of this size manually.

7. The net is suitable for harvesting either buffalofish or catfish — the two species most commonly produced.

8. Less handling of fish is involved with this method than with conventional methods, and the fish removed from the undrained ponds are in excellent condition, unmuddied, and alive.

9. Three men can efficiently load and weigh the fish with the conveyor system described.

10. The mechanized seine eliminates the necessity of drawing down ponds, thereby conserving water.

SUMMARY

Research and development by the Bureau of Commercial Fisheries Gear Research Station, Rohwer, Arkansas, are aimed at improving methods and equipment for harvesting commercial food fish produced in flooded rice fields and farm ponds in the South Central States. A 2,060-foot haul seine of variable length and mechanized means for handling the net and catches have been designed, fabricated, and tested with good results in ponds ranging from 4 to 50 acres. During experimental and demonstration trials, buffalofish, catfish, and mixed species as high as 33,375 pounds per set were caught with seine lengths as great as 1,900 feet. The mechanized haul seine makes it possible to harvest fish from large undrained ponds, and its advantages include conserving valuable water, having fish stocks readily available for short-notice market requirements, maintaining excellent quality of fish (even for live transfer), and reducing cost of operations.

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