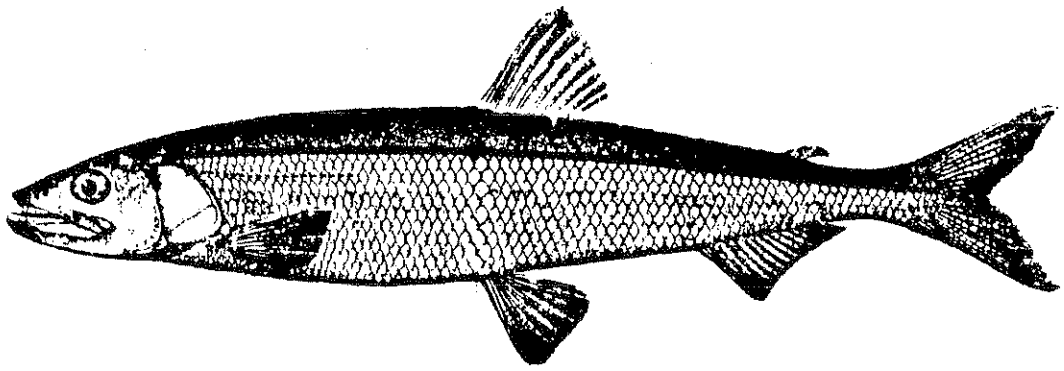
SMELT MANAGEMENT PLAN



PREPARED BY

THOMAS S. SQUIERS

LEWIS FLAGG

LAWRENCE AUSTIN

MAINE DEPARTMENT OF MARINE RESOURCES

Section 1
Completion Report
Project #AFSC-13/FWAC-2
Segments 22 and 24

Statewide Comprehensive Fish, Wildlife and Marine Management Plan

1976

SMELT MANAGEMENT PLAN

A History

Description:

The rainbow smelt is an elongate slender fish with a deeply forked tail. Like its close relative the Atlantic salmon, it has soft rayed fins and an adipose fin. The smelt has a large head, well developed jaws, and canine teeth. It has relatively large cycloid scales. Color varies from an iridescent olive green to bottle green dorsally shading to silvery on the sides and ventrally. The fins and sides generally are pigmented with fine dark spots.

The rainbow smelt, Osmerus mordax (Mitchell), is a member of the family Osmeridae which is in the order Salmoniformes.

Geographic Distribution:

The anadromous rainbow smelt is an inshore species whose range extends from Labrador to New Jersey (Bigelow and Shroeder, 1953). Landlocked populations of smelt are present in Lakes of Maine, New Hampshire, New Brunswick, Nova Scotia, Quebec, and New York. Landlocked smelt are also abundant in the Great Lakes after having been introduced into Crystal Lake in 1910.

Life History:

Smelt, like other anadromous species such as Atlantic salmon, alewives, and shad attain most of their growth in the marine environment, but ascend coastal streams to spawn in freshwater.

In the summer, smelts are found in the inshore areas of the coast

and may be found in bays and estuaries if not forced out by high water temperatures.

In early autumn schools of smelt move into bays, estuaries, and the lower tidal reaches of rivers where they feed through the winter months.

Smelt ascend to freshwater to spawn as the ice goes out and the water temperatures increase.

There is a wide range of variation in the timing of runs and types of spawning areas used. Some smelts spawn immediately after ice-out in the deeper waters of the main rivers, while others spawn in the tributary brooks and streams (Flagg, 1972).

McKenzie (1964) found that smelt in the Miramichi River (New Brunswick) arrived at head of tide in the main branches and larger tributaries as temperatures reached 4-5°C. whereas they did not enter the smaller streams and tributaries until temperatures reached 6-7°C. Flagg (1972) has observed spawning to occur in Maine streams from 0-6°C. to 11°C. peaking between 4°C. to 9°C.

It is very unlikely that the time of spawning is controlled by one factor such as temperature; but is probably the cumulative effect of a number of both intrinsic and extrinsic factors.

Spawning occurs in a variety of habitats ranging from swift water to deadwater pools and on a variety of substrates from silt to gravel and rock ledge (Bigelow and Schroeder, 1953). Spawning takes place mostly at night, although limited spawning has been observed during daylight hours (McKenzie, 1964).

The eggs are adhesive and become attached to sticks, stones, gravel, or other submerged objects by means of a "stickfast", a stalk

formed by the outer coat of the egg (Bigelow and Schroeder, 1953).

Percentage hatch is probably dependent on a number of variables such as substrate, temperature, stream flow, and density of egg depositions. McKenzie (1964) found with increasing egg densities that the percentage hatch decreased. At 487 eggs 1 ft.^{2} he found a 3.6% hatch and at 180,200 eggs 1 ft.^{2} a 0.03% hatch. The most larvae produced per square foot occurred at a density of 12,000 eggs 1 ft.^{2}. Concentrations as high as 180,200 eggs 1 ft.^{2} are commonly found below obstructions. Hulbert (1974 m.s.) found that eggs incubated on substrates with flat surfaces such as sand may experience more severe fungal infection than eggs on substrates with large interstitial spaces such as gravel.

Hatching usually occurs in 15 to 30 days depending on water temperatures. McKenzie (1964) found that hatching in the Miramichi River took 29 days at 6-7°C., 25 days at 7-8°C. and 19 days 9-10°C.

Smelts are not able to negotiate a vertical drop of more than 6 to 8 inches (McKenzie, 1964). Thus much of the potential spawning habitat of coastal streams is inaccessible due to natural or artificial obstructions and some areas are only accessible at high tide.

Age composition of smelts on the spawning run is predominantly two and three year olds. The age composition and mean length of smelt sampled from the Penobscot and Kennebec River systems can be found in Table 1.

The main diet of smelt in the marine environment consists mainly of planktonic and benthic crustaceans. The dominant food item of smelts sampled in Casco Bay consisted of euphausid shrimp. Other food items were caprellids, polychaetes, insects, fish remains, and plant debris.

The dominant food item of smelt collected in the lower reaches of the Kennebec River was gammarids, particularly Gammarus oceanicus (Flagg 1974).

Former Abundance and Value:

Formerly smelt were abundant along the entire coast of Maine. In numbers they were probably more abundant than any other anadromous species native to Maine.* The only statistics available to indicate the former abundance of smelt in the 1800's are the commercial landings of the 1880's and 1890's. Although these landings reflect other factors such as market and weather conditions in addition to abundance, they provide a minimum estimate of abundance. The average annual landings for the six years for which recorded landings were available during the 1880's and 1890's was 1,114,000 lbs. (Table 2).

* Catch on landings

TABLE 1

Mean Length and Age Composition of Smelts From the Kennebec and Penobscot River Systems.

River Systems		Age 2	Age 3	Age 4	Age 5	Total Sample Size
Penobscot River	1972	15.94 (52.1)	19.70 (41.4)	22.64 (6.5)		169
"	1973	16.93 (47.1)	20.50 (35.3)	22.60 (17.6)		34
"	1974	16.64 (42.1)	19.44 (39.1)	22.48 (17.3)	25.85 (1.5)	133
"	1975	16.40 (17.3)	19.77 (67.7)	22.76 (14.2)	26.9 (0.8)	127
Kennebec River Abagadasset River						
"	1970	16.99 (34.7)	19.52 (50.0)	21.19 (13.3)	23.1 (2.0)	98
"	1975	16.28 (41.4)	19.55 (55.2)	21.70 (3.4)		29
Eastern River	1970	16.83 (40.4)	18.78 (53.5)	20.4 (6.1)		99
"	1972	17.90 (3.2)	19.38 (45.2)	20.57 (45.2)	22.35 (6.4)	31
"	1973	15.83 (28.6)	20.59 (61.9)	21.80 (9.5)		21
"	1975	16.46 (56.7)	19.10 (40.0)	22.4 (3.3)		30
Cathance River	1971	17.1 (8.3)	19.79 (58.3)	21.90 (33.4)		12

*Figures in Parenthesis Represent Percent of Total Sample.

*Mean Lengths are in Centimeters.

TABLE 2

Maine Commercial Fishery Landings for Smelt

Date	Pounds landed	Value	Price/lb.	Reference
1887	1,205,150	84,977	.07	Commissioners Report
1888	1,279,550	94,927	.07	"
1889	1,045,385	74,077	.07	"

1897	1,121,385	67,960	.06	"
1898	1,156,684	80,314	.07	"
1899	880,106	66,682	.08	"
1900	1,017,434	77,074	.08	"
1901	686,328	56,930	.08	"
1902	1,001,762	95,833	.10	"
1903	1,029,900	101,720	.10	"
1904	981,140	97,769	.10	"
1905	770,391	86,588	.11	"
1906	921,521	107,206	.12	"
1907	790,034	86,437	.11	"
1908	926,718	110,186	.12	"
1909	953,954	110,004	.12	"
1910	1,088,454	115,107	.11	"
1911	1,168,092	125,011	.11	"
1912	990,145	106,351	.11	"
1913	563,135	40,776	.07	"
1914	509,535	64,569	.13	"

1916	537,633	63,679	.12	"

1919	524,000	----	---	"

1924	627,707	137,430	.22	U.S. Bur. Fisheries

1928	832,216	176,189	.21	"
1929	852,280	183,828	.22	"
1930	720,708	126,399	.18	"
1931	567,422	90,587	.16	"
1932	270,327	36,546	.14	"
1933	529,990	56,827	.11	"

1935	682,800	79,648	.12	"

1937	608,200	66,643	.11	"
1938	692,800	58,302	.08	"
1939	308,100	25,442	.08	"
1939	62,384	5,187	.08	Biennial Report
1940	455,500	34,373	.08	U.S. Bur. Fisheries

TABLE 2 (Continued)

Maine Commercial Fishery Landings for Smelt

Date	Pounds Landed	Value	Price/lb.	Reference
1940	330,308	28,773	.09	Biennial Report
1941	271,552	19,611	.07	"
1942	348,100	27,964	.08	U.S. Bur. Fisheries
1942	179,199	22,939	.13	Biennial Report
1943	578,800	144,170	.25	U.S. Bur. Fisheries
1943	239,402	42,964	.18	Biennial Report
1944	743,800	153,621	.21	U.S. Bur. Fisheries
1944	511,391	92,050	.18	Biennial Report
1945	968,300	199,946	.21	U.S. Bur. Fisheries
1945	752,618	156,770	.21	Biennial Report
1946	738,400	153,510	.26	U.S. Bur. Fisheries
1946	572,575	126,269	.22	Biennial Report
1947	599,800	139,602	.23	U.S. Bur. Fisheries
1947	599,626	139,608	.23	Biennial Report
1948	542,236	137,291	.25	Maine Landings
1949	160,776	40,003	.25	"
1950	151,139	42,050	.28	"
1951	101,397	26,879	.26	"
1952	144,213	33,328	.23	"
1953	92,767	17,573	.19	"
1954	107,427	24,650	.23	"
1955	127,143	38,566	.30	"
1956	102,102	27,233	.27	"
1957	166,963	37,895	.23	"
1958	133,919	38,568	.29	"
1959	67,742	21,474	.32	"
1960	66,279	20,089	.30	"
1961	70,105	22,189	.28	"
1962	100,292	26,907	.27	"
1963	145,831	39,871	.27	"
1964	184,816	41,095	.22	"
1965	199,264	45,786	.23	"
1966	254,755	48,927	.19	"
1967	158,361	33,315	.21	"
1968	86,446	18,221	.21	"
1969	115,144	28,733	.25	"
1970	82,025	18,339	.22	"
1971	77,885	18,460	.24	"
1972	73,490	16,587	.23	"
1973	92,479	38,179	.41	"
1974	67,661	26,712	.39	"
1975	92,237	28,165		

Assuming a harvest of 25 to 50% of the total population, and an average size of 10 smelts to the pound, the total population was probably between 22 and 44 million smelts. By the 1880's many, if not most of the coastal streams had been dammed and the probable amount of spawning habitat had been reduced by at least 25%.

In the late 1800's the smelt fishery assumed a dominant role in the fisheries of Maine due to their high demand and resultant comparatively high price per pound landed value. The smelt population at that time was less affected by man's activity than other anadromous species such as Atlantic salmon, american shad, and the alewife, whose major spawning habitat is in the upstream reaches of the rivers and streams which had been dammed in the early and mid-1800's.

The importance of the smelt fishery was based on its economic value as can be seen in Table 3. Its importance was recognized by Whitten (1894) as he stated in the Commissioner's Report, "This branch of the fisheries not only gives employment to many of our worthy citizens, but there is also a large revenue derived from it. It is considered a shore fish whose value to the state is second only to the lobster, herring and clam."

The methods by which smelt were captured was by handlining, seines, bag nets, and weirs. The amount taken by county and the gear utilized can be found in Table 4. During the late 1800's and early 1900's the majority of smelts were landed in the counties of Washington, Hancock, Lincoln, and Cumberland. Handlining and weirs provided for most of the catch in Washington County; bagnets and weirs in Hancock County; handlining, bagnets, and weirs in Lincoln County; and haul seining in Cumberland County.

From 1900 to 1950 there was a gradual decline in the commercial landings of smelts (Figure 1 and Table 2). The average annual landings for the 1930's and 1940's were approximately one half the average landings of the 1890's. The decreased landings were probably the result of a decline in the total population of smelts coupled with an insufficient increase in demand (value) to compensate for a reduced catch/unit of effort. The decrease in the smelt population was undoubtedly the result of increasing pollution in the major systems and the loss of spawning habitat in the smaller coastal streams resulting from obstructions created by road crossings and dams.

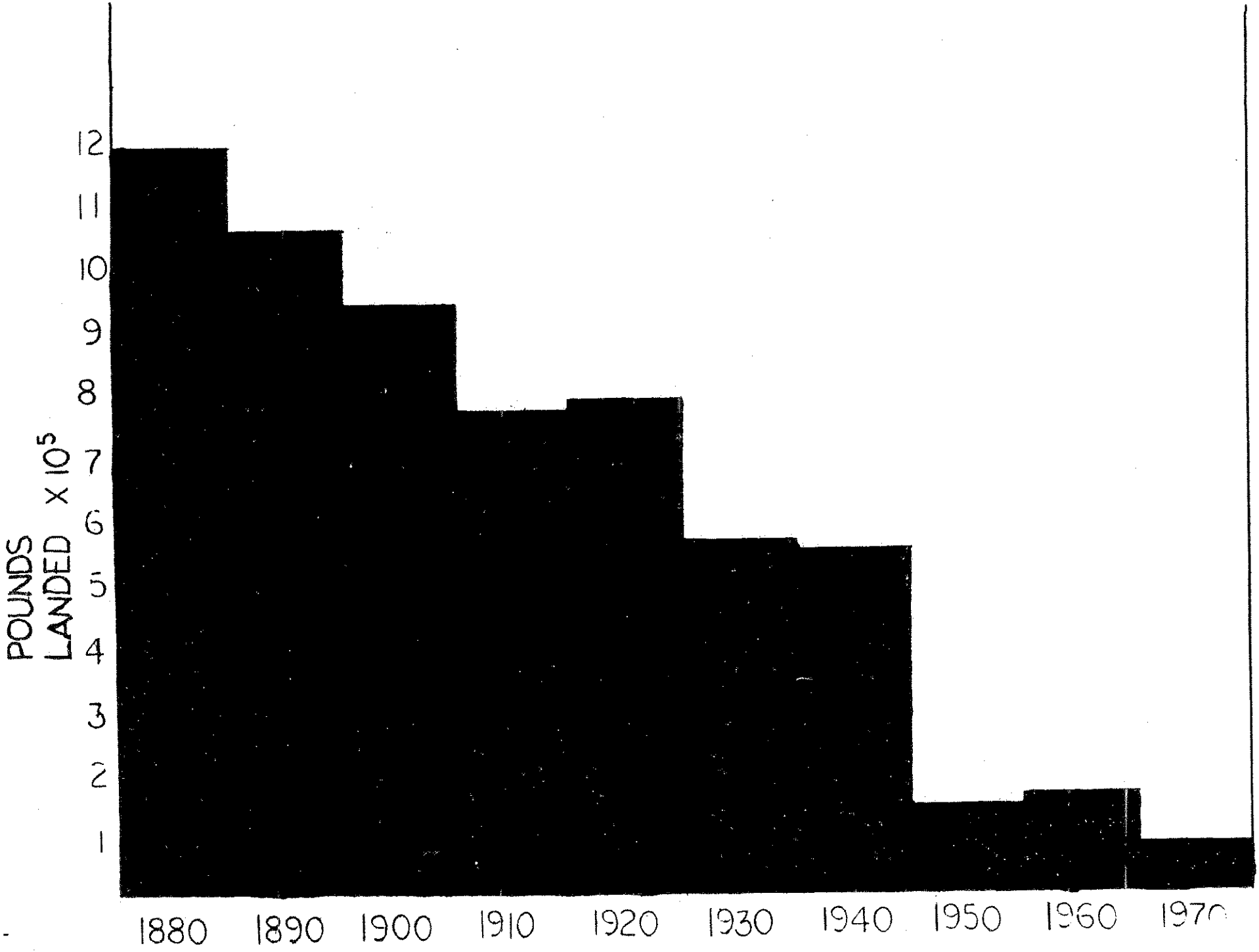


FIGURE 1 AVERAGE ANNUAL MAINE LANDINGS PER DECADE OF SEA RUN SMELT

TABLE 3

Comparative Maine Landings of Anadromous Species in the Late 1800's.

YEAR	SALMON	SHAD	ALEWIFE	SMELT
1887	185,637 ($36,398)	1,095,720 ($27,330)	1,906,281 ($28,156)	1,205,150 ($84,977)
1888	205,149 ($41,209)	839,256 ($24,368)	1,933,989 ($30,103)	1,279,550 ($94,927)
1898	33,869 ($8,500)	1,152,400 ($23,720)	2,423,682 ($22,672)	1,156,684 ($80,314)
1899	55,014 ($9,257)	706,975 ($19,587)	2,039,600 ($13,951)	880,106 ($66,682)

Table #4

Detailed Statistics of the Smelt Fishery of the State of Maine for the Year 1898, By Counties.

COUNTY	FISHERMAN	CATCH LBS.	VALUE	# BOATS	VALUE BOATS	# NETS	NETS VALUE	# WEIRS	VALUE WEIRS	CAMPS	VALUE CAMPS
Washington	118	117,875	9995	60	600	-	-	50	1500	176	1760
Hancock	207	150,852	9051	60	650	30	2100	39	2950	-	-
Waldo	71	68,790	4167	20	3090	-	-	-	-	-	-
Knox	25	16,200	689	10	100	-	-	-	-	-	-
Lincoln	233	339,200	27,496	30	350	20	1000	-	-	-	-
Sagadahoc	320	92,576	4,629	13	125	40	3250	12	1250	185	925
Cumberland	105	368,000	23,872	56	9450	-	-	-	-	-	-
York	16	3,191	415	12	925	-	-	-	-	-	-
Total	1095	1,156,684	80,314	261	15,290	90	6350	101	$5700	361	2,685

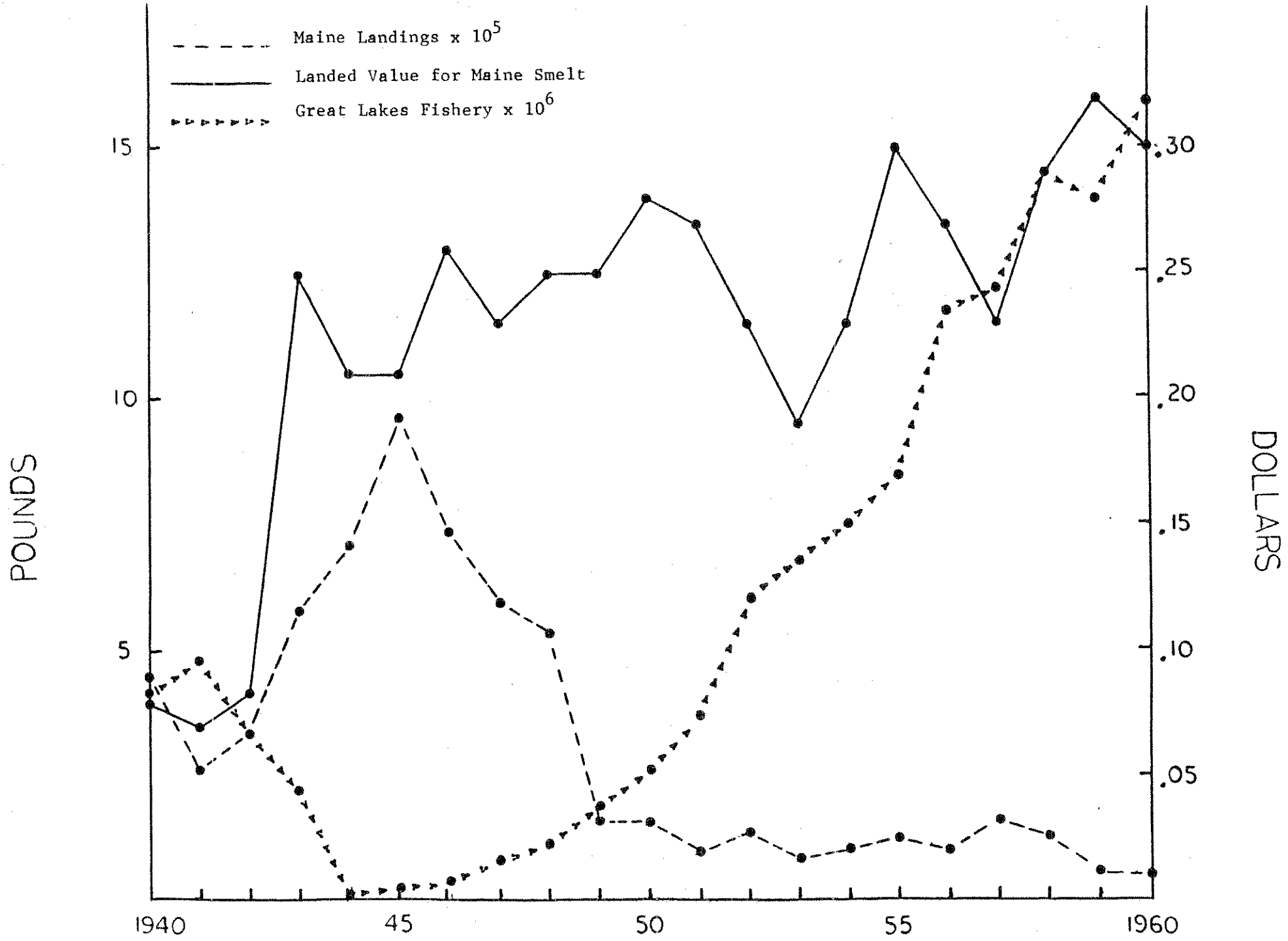


Figure 2 Comparison of Maine and Great Lakes Smelt Landings

Beginning in 1949 there was a drastic reduction in commercial landings. The average annual landing for the 1940's was 582,943 lbs. compared to 119,481 lbs. in the 1950's and 139,029 lbs. in the 1960's and 78,708 lbs. in the early 1970's. During the 1940's handlining and haul seines accounted for 77% of the average annual catch of 582,943 lbs. The average annual landing by haul seines in the 1940's was 192,518 lbs. as compared to 24,075 lbs. in the 1950's, 175 lbs. in the 1960's and none in the 1970's. The haul seine fishery took place mainly in Casco Bay. The collapse of this fishery was the result of a drastic decline in the smelt population in this area (McIntosh, personal communication). The average annual landing by handliners in the 1940's was 256,072 lbs. as compared to 34,036 lbs. in the 1950's 67,247 lbs. in the 1960's and 26,112 lbs. in the early 1970's. The reason for the decline in landings by handlining is not clearly evident.

There was most likely a decline in the smelt population due to increased pollution in the major river systems resulting from Post World War II industrial expansion. The job market expanded at the same time, probably reducing the number of fishermen in this seasonal fishery.

The decrease in Maine landings of smelt in the 1950's coincided with a dramatic increase in smelt landings from the Great Lakes (Figure 2 and Table 5). The United States and Canadian landings of smelt from the Great Lakes increased from 4,500 lbs. in 1944 to 21,915,000 lbs. in 1962. The average price received by United States fishermen for smelt landed from the Great Lakes during the 1950's and 1960's was $.038 per pound compared to $.25 per pound received for smelt landed in Maine. Price competition from the Great Lakes fishery was responsible

for reduced prices for Miramichi smelts (New Brunswick) and resulted in a reduced fishing effort (McKenzie, 1964). The price competition from the Great Lakes was probably at least partially responsible for reduced fishing effort in Maine, although the price received for Maine smelt, which showed considerable fluctuations in price, increased dramatically (Figure 2). Landings of smelt from the Canadian Maritime provinces do not appear to affect the fishery in the State of Maine as increases in the Maritime catches coincided with increased catches in Maine (Figure 3), although a few commercial fishermen attribute the decline in the 1950's to duty free imports of smelts from the Maritime provinces. Restrictive laws were probably not responsible for the decline in smelt landings in the 1950's as most of the laws were passed in the late 1800's and early 1900's.

While the commercial use of the smelt resource has been declining, the sportfishery use has been increasing since the late 1940's. Although there is little data to document the increase, Flagg (1972) estimated the total fishing pressure in the winter sportfishery of 1968-69 to be 36,750 man days based on reports from wardens and creel census sampling. The catch was estimated to be approximately 200,000 lbs. The spring smelt fishery was believed to be as intensive or more intensive, than the winter fishery. The total catch in both the winter and spring fishery was estimated to be approximately 400,000 lbs. (Flagg, 1972).

Management:

Management of the smelt resource in the past mainly been limited to passing laws and regulations governing the method of capture,

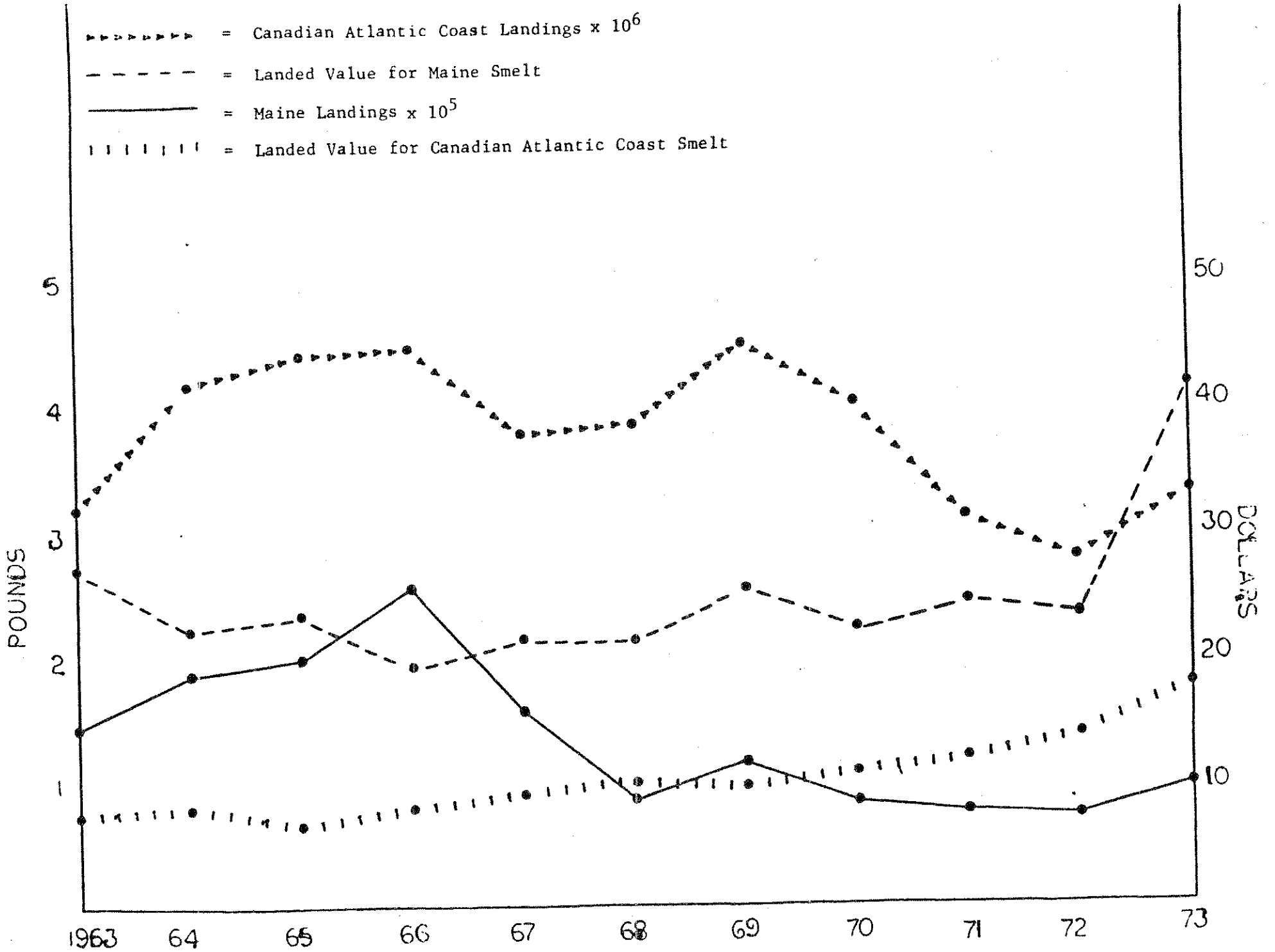


FIGURE 3 Comparison of Maine and Canadian Atlantic Coast Smelt Landings

time of capture, and daily possession limits. After investigating the life history of sea run smelt in Maine, Department biologists found many of the laws and regulations were not based on sound biological principles and in many cases unnecessarily limited the use of this valuable resource. Based on recommendations of Department biologists most of these laws and regulations have been repealed.

PRESENT

Habitat and Abundance:

The smelt is distributed along the entire coast of Maine inhabiting the inshore marine waters during most of its life cycle. The amount of smelt habitat of the inshore coastal waters is not presently known.

One of the major factors limiting the abundance of smelt is the amount of suitable spawning habitat available. Streams with existing anadromous smelt runs were documented in 1971 by Flagg (1971). Smelt streams are distributed along the entire coast. About 54% of the 134 documented smelt streams are located in Hancock and Washington counties (Table 6). The total amount of spawning habitat available has not been determined.

To be of value, estimates of abundance should be made on a stock basis. Assuming smelt exhibit a strong homing tendency to their stream, there are a minimum of 134 seperate stocks. The only estimate of abundance available is for one fishable stock (comprised of least five spawning stocks) in the Penobscot River. The size of the stock subject to the commercial bagnet fishery on the Penobscot River is approximately 2 million smelt. This figure represents only that portion of the stock which is vulnerable to the fishing gear and thus does not include juveniles, one year olds, and a percentage of two year olds.

In the late 1800's landings from the Penobscot River represented approximately 8% of the total smelt landings. Assuming the Penobscot River stock represents 8% of that total smelt population in Maine, it is estimated the total abundance is 25 million smelt or 2.5 million pounds.

Supply and Demand:

Flagg (1972) estimated the sport catch, both winter and spring fishery, to be approximately 400,000 lbs. The combined sport and commercial catch approaches one half million pounds annually. This represents 20% of the total stock if the conservative estimate of total abundance (2.5 million pounds) is utilized. Assuming 50% of the total stock could be harvested annually with no detriment, the total supply available for harvest would be approximately 1.25 million pounds.

Demand Versus Available Supply:

At the present time it appears that the available supply statewide exceeds demand. Although supply exceeds demand statewide, there are individual stocks where demand exceeds available supply or is in equilibrium with available supply.

THE FUTURE

Habitat and Abundance:

The amount of marine habitat will probably remain unchanged or may increase by a slight extent if pollution abatement goals are met for Maine estuaries. It is difficult to predict the extent of change in the amount of spawning habitat available over the next 14 years. It may be that the increase in amount of spawning habitat in Maine's larger rivers made available by pollution abatement may be offset by losses of habitat in smaller streams resulting from physical altera-

tion due to coastal development. Under existing levels of management it appears that abundance will remain relatively unchanged.

Supply and Demand:

The available supply for harvest over the next 14 years will probably be in the range of that found at present or approximately 1.25 million pounds. If commercial fishing effort and sportfishery effort doubled over the next 14 years demand would be approaching available supply.

Demand Versus Available Supply:

Statewide the demand will probably be in equilibrium with available supply. A greater number of the smaller stocks will fall into the category of demand exceeding available supply.

Alternate Goals:

I. To limit commercial and sportsfishery effort to present levels to insure the present estimated harvest of one-half million pounds is not exceeded.

A. Capability of Habitat

It is within the capability of the habitat to support a smelt population large enough to meet the above objective.

B. Feasibility

The above objective could be met by imposing restrictions such as creel limits, shorter seasons, and gear limitations to freeze effort at current levels.

C. Desirability

This objective is the least desirable because it is probable that demands will at least double over the next 14 years. Limiting harvest and effort at present levels will not satisfy demand.

D. Problems

1. Present statistics on stock abundance, sportfishery, harvest, and commercial harvest are inadequate to effectively manage the resource.

2. There may be a conflict of resource use between commercial and sport fishermen.

3. Although the present smelt population will satisfy the goal of a half million pound harvest, some stocks of smelt are presently or will be overfished.

II. To allow a Harvest of One Million Pounds.

A. Capability of Habitat

It will be within the capability of the habitat over the next 14 years to support a smelt population large enough to insure a one million pound harvest.

B. Feasibility

This goal is feasible but will require intensive management to insure fishing pressure on each stock is properly regulated.

C. Desirability

This goal will probably satisfy the demand for this planning period.

D. Problems

1. Same as I-D 1 and 2.

2. If not properly managed the demand will exceed available supply for more stocks than under Goal I.

III. To Increase Available Supply by 50% by Increasing Abundance of a few Selected Stock.

A. Capability

It should be possible by removal of tidal dams on a few of

of the larger river systems coupled with habitat improvement on smaller coastal streams to meet the above objective.

B. Feasibility

Removal of low head tidal dams should be justifiable on the basis that the benefits to be derived from increased runs of anadromous species outweigh benefits to other users. The amount of power generated, if any, by these low head dams is insignificant when compared to the total energy needs of the State of Maine. Removal of these dams would not only result in increased runs of smelt but also Atlantic salmon, alewives, shad, and sturgeon. It might also be possible to reestablish striped bass populations in the Kennebec and Penobscot Rivers.

It is also feasible to increase the size of smelt runs in some of the smaller coastal streams by removal of small natural falls, clearing streams of debris, and replacing road culverts which obstruct the upstream migration of smelt.

C. Desirability

This is the most desirable goal as it allows management by a stock basis. The available supply could be increased for stocks where demand exceeded available supply.

D. Problems

1. Same as I-D (1) and (2). The conflict of use between the commercial fishery and sport fishery could be minimized in some cases by increasing the available supply to meet the needs of both fisheries.

LITERATURE CITED

Bigelow, H. B., and W.C. Shroeder. 1953. Fishes of the Gulf of Maine. U. S. Fish and Wildlife Serv. Fishery Bulletin. 74, Vol. 53. 577pp.

Flagg, L. N. 1971. Striped Bass and Smelt Survey. Maine Department of Marine Resources, Final Report, Project AFS-4.

Flagg, L. N. 1972. The Anadromous Smelt Fishery of Maine. Maine Department of Marine Resources. Research Bulletin #33.

Hulbert, P. J. Factors Affecting Spawning Site Selection and Hatching Success in Anadromous Rainbow Wmelt (Osmerus mordax, Mitchell). M. S. Thesis, University of Maine, Orono, 44pp.

McKenzie, R. A. 1964. Smelt Life History and Fishery in the Miramichi River, New Brunswick. Fishery Res. Bd. Com. Bulletin #144, ix + 77 pp.

Whitten, D. R. 1894. Commissioners Report, Sea and Shore Fisheries, 1894, 38pp.