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Volume 1

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Physical - Chemical Study

Use Study

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Phase I, Fish Studies

by

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ABSTRACT

The purpose of this portion of the project was to inventory the fishes inhabiting the Manahawkin Bay - Little Egg Harbor System.

Eighteen seine, 21 trawl and 8 gill net stations located in various creeks and lagoons as well as the bay itself were sampled for finfish.

Sixty-six species of fish in various stges of their life cycles were collected during the survey period. Water quality parameters of the following ranges were recorded: salinity <1 to 31.8 0/00, water temperature -1.0°C to 29.9°C and D.O. 0 to 14.34 mg/l.

INTRODUCTION

This is the final report of a survey of the fishes of the Little Egg Harbor-Manahawkin Bay System. Work was begun in July 1973 and concluded at the end of May 1975. See Table 1 for species list and Figure 1 for a map of the area.

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METHODS AND MATERIALS

Three types of fishing gear were utilized to sample fish in the system: gill nets, seines and trawls.

The gill net used was an experimental monofilament model of the following dimensions: five panels 25' x 6', one each of 1/2", 3/4", 1", 1 1/2" and 2" square mesh.

Three seines were used during sampling: a 25 ft. bag seine 5 ft. deep with a 5' x 5' x 5' bag, all 1/2" stretch mesh knotless nylon netting; an 80' x 6' bag seine (1/2" mesh) with a 6' x 6' x 6' bag (3/8" mesh); and a 150' x 10' bag seine (5/8" stretch mesh) with a 10' x 10' x 10' bag (3/8" stretch mesh).

Trawling was done with a 16 foot semi-balloon trawl of the following dimensions: 16' head headrope, 19' footrope, body 1 1/2" mesh No. 9 thread, codend 1 1/4" mesh No. 15 thread, innerliner 1/2" stretch mesh No. 63 thread knotless nylon netting; doors 24" x 12" x 1" mahogany with 3/8" nylon rope, 100' on each door. (wt. —)

The trawl was towed by a 17' Boston Whaler for five minutes, warp length was adjusted for depth. Two tows were made at each station under normal conditions.

Data was collected as follows. The catch was speciated, each species was weighed, measured and counted if numbers allowed. Aliquot samples were taken when individual numbers of any species were so great as to make processing the entire catch impractical. The subsamples were counted and weighed and the data was adjusted accordingly.

SEINING RESULTS BY STATION

Tables two through nineteen give species and numbers taken at each station. See Figures one and two for station locations.

Station 1 was located at the southern tip of Long Beach Island near Beach Haven Inlet. Depth was about 5' with a sand bottom. It was sampled once in July 1973. Recorded salinity was 26.50 0/00, water temperature, 23.0°C and D.O., 9.61 mg/l.

Five species numbering 684 specimens were taken. While it ranked 16th in species, it was 10th in specimens even though sampled only once. The Atlantic silversides accounted for 680 of the 684 individuals taken. This was probably due to the station location, a sandy beach; the sampling gear, a 150' x 10' seine and the month, July. A 2 cm. butterfish was also taken. The only other butterfish was trawled at T-5 near Barnegat Inlet.

Station 2 was on the southwestern end of Marshelder Island. The bottom is sand and mud and the depth ranged from 2' to 4'. It was sampled thirteen times with the 150' seine. Salinities ranged from 24.00 0/00 to 29.87 0/00, water temperature from 4.0°C to 25.0°C and D.O.'s from 5.44 mg/l to 11.23 mg/l.

This station ranked first in the number of species and specimens, 30 and 8,957 respectively. More than three times as many specimens were taken here than at Station 6, which ranked second. The five most abundant species were: fourspine stickleback, Atlantic silverside, bay anchovy, mummichog and tidewater silverside. They made up 96% of the catch. Seven small mojarras of unknown species were taken here in September, 1973. These were the only ones taken during the survey. Eight of nine young gray snappers were also taken at Station 2.

Station 3 was located on Flat Island. The bottom is primarily silt, clay and fine sand about 5' deep. It was only sampled in July, 1973. Salinity, when sampled, was 22.00 0/00, water temperature, 25.8°C and D.O., 9.90 mg/l.

Five species totaling 606 specimens were taken, 580 of which were Atlantic silversides. The station ranked 16th in species and 13th in specimens. The 150' seine was used.

Station 4 was located on Sandy Island. The bottom is mud and sand with peat banks and the depth ranged from 3' to 4'. It was sampled with a 150' seine five times; during July, August and September, 1974 and April and May, 1975. Recorded salinities ranged from 16.5 0/00 to 27.01 0/00, water temperatures ranged from 14.2°C to 25.0°C and D.O.'s from 5.22 mg/l to 9.48 mg/l.

It ranked third in species taken (22) and eleventh in specimens taken (667). The Atlantic silversides made up 46% of the catch, totaling 304 specimens. The rest of the top five in descending order were: northern pipefish (77), silver perch (55), bay anchovy (53) and the fourspine stickleback (35). Together they account for 78% of the total catch at Station 4. The silver perch were all taken in one haul in September.

The winter flounder ranked eighth at this station, with 21 specimens (7-9 cm. long) taken in July and August.

Station 5 was located on ~~Clam Island~~ the northern tip of Long Beach Island. The bottom is medium and fine sand, the depth about 5'. It was sampled during October and November, 1974. Recorded salinities were, 28.01 0/00 and 29.43 0/00; water temperatures, 20.5°C and 11/5°C and D.O.'s, 8.81 mg/l and 8.61 mg/l.

Ten species and 866 specimens were taken, fourteenth and eighth in rank. Three species made up 99% of the catch: the Atlantic silverside, 739 specimens - 85%; American sand lance, 75 specimens - 9%; and the striped killifish, 40 specimens - 5%.

Station 6 was located in the Little Egg Harbor near ~~Beach~~ Big Thorofare. The bottom composition ranges from pebbles on shore through medium, fine and very fine sand to silt and clay, reaching a depth of about 5'. It was sampled with the 150' seine four times in 1973. Recorded salinities ranged from 24.00 0/00 to 29.04 0/00, water temperatures from 9.0°C to 25.5°C and D.O.'s from 6.43 mg/l to 12.13 mg/l.

Ten percent of all fish taken seining were taken at this station. It ranked second in both specimens and species, twenty-five species numbering 2,518 specimens. The five most abundant species were: Atlantic silverside, bay anchovy, silver perch, northern sennet and spot. They made up 95% of the total catch, with the Atlantic silversides alone constituting 70%.

One of two inshore lizardfish and 67 of 73 northern sennet taken during the survey were taken at this station.

Station 7 was at the upper end of Thompson Creek in a small cove. The bottom is primarily silt and clay with some medium and very fine sand. Sampling depth was 4'. It was seined three times in 1973 with the 150' seine. Recorded salinities ranged from 18.25 0/00 to 23.48 0/00, water temperature from 9.0°C to 26.2°C and D.O.'s from 5.96 mg/l to 8.51 mg/l.

It ranked fifth in species and specimens. Twenty species numbering 1,660 specimens were taken. The five most abundant species were: bay anchovy, spot, mummichog, naked goby and crevalle jack. The crevalle jack does not usually place in the top five. Only 70 of them were taken during the entire survey. Its high ranking here is due to the fact that 60 juveniles were taken in one haul on July 23, 1973.

Station 8 was a tidal pool on the marsh north of the mouth of Dinner Point Creek. The bottom is silt and clay with a lot of fine detritus. It was sampled August and October of 1973 and January, 1974. Recorded water quality was: salinity, 25.44 0/00, 30.32 0/00, and 15.81 0/00; temperature, 33.0°C, 17.0°C and 6.5°C; D.O., 6.86 mg/l, 5.04 mg/l and 5.00 mg/l.

Four species numbering 250 specimens were taken. Fifty-three percent (132) were mummichogs and 33% (82) were sheepshead minnows. Twenty-two tidewater silversides and 14 rainwater killifish finish the station.

Station 9 was located in a cove at the end of lagoon complex B in Beach Haven West (see Fig. 2). The bottom grades from pebbles shoreward to very fine sand offshore. There is a shelf which slopes to about 3' and then the bottom drops rapidly. In the center of the cove, the depth is about 24'. It was sampled eleven times with the

150' seine. Recorded salinities ranged from 7.61 0/00 to 24.96 0/00, water temperatures from 4.0°C to 27.0 °C and D.O.'s from 6.64 mg/l to 10.79 mg/l.

This station ranked fourth in species (21) and third in specimens (2,445). Two species made up 84% of the catch. They were the bay anchovy, 1,325 specimens - 54% and the tidewater silverside, 744 specimens - 30%. Rounding out the top five were the blueback herring (90), Atlantic silverside (73), and Atlantic menhaden (55). These five species constituted 93% of the catch at station 9.

Station 10 was located in Manahawkin Bay at the end of Morris Boulevard in Beach Haven West. The bottom is medium and coarse sand and peat, the depth about 4'. This station was sampled 18 times. Recorded water quality ranges were: salinity, 19.70 0/00 to 25.95 0/00, temperature, 2.0°C to 28.5°C ; and D.O., 5.88 mg/l to 12.30 mg/l.

Sixteen species numbering 842 individuals were taken. The five most abundant species were: Atlantic silverside, tidewater silverside, bay anchovy, mummichog and blueback herring. The two silversides made up 89% of the catch. Altogether, these five accounted for 97% of the catch at this station.

One of three northern kingfish taken seining was taken here in September, 1974. Also, the only smallmouth flounder and striped searobin captured by seine were taken at this station.

Station 12 was located in Upper Dinner Point Creek. The bank is peat and drops vertically 2-3' to a soft, sticky bottom, consisting of silt, clay and fine, medium and coarse sand. It was sampled 15 times. Recorded salinity ranged from 5.54 0/00 to 22.48 0/00, water temperature from 5.0°C to 25.5°C and D.O. from 0 mg/l to 9.70 mg/l.

This station ranked 15th in number of species (6) and last in number of specimens (214). The tidewater silverside made up 66% of the catch and the mummichog 26%. The other species taken were Atlantic silverside, banded killifish, naked goby and rainwater killifish.

Station 13 was located on the northeastern bank near the mouth of Dinner Point Creek. The bank is peat and the bottom primarily silt and clay with some medium, fine and very fine sand. Sampling depths ranged from 2-4'. It was sampled 16 times. Recorded salinities ranged from 21.15 0/00 to 27.29 0/00, water temperatures from 4.0°C to 26.0°C and D.O.'s from 6.71 mg/l to 12.50 mg/l.

It ranked eighth in species (18) and 12th in specimens (663). The Atlantic silverside was most abundant making up 60% of the catch. The bay anchovy was next at 24%. The six most abundant species accounted for 96% of the catch.

Station 15 was located at the end of lagoon #100 off Mill Creek in Beach Haven West (see Figure 2). This lagoon was bulkheaded on both sides and across most of the distal end with houses behind the bulkhead. The bank is very steep and consists of gravel grading into sand. The depth ranged from 3-6'. It was sampled eight times. The station was dropped in August, 1974 because the bulkheading was completed, eliminating the seining area. Recorded salinities ranged from 2.80 0/00 to 19.15 0/00, water temperatures from 3.0°C to 29.0°C and D.O.'s from 6.73 mg/l to 12.17 mg/l.

This station ranked 12th in species (15) and 17th in specimens (220). The five most abundant species made up 85% of the catch. They are: tidewater silverside, banded killifish, bay anchovy, mummichog and fourspine stickleback.

Station 16 was located on the northern bank of upper Mill Creek (see Fig. 2). It is a sloping beach consisting of pebbles and very coarse, coarse and medium sand. Sampling depth ranged from 3-6'. It was sampled 17 times. Recorded salinities ranged from <1 0/00 to 8.91 0/00, water temperatures from 2.0°C to 28.0°C and D.O.'s from 0.78 mg/l to 12.51 mg/l.

Station 16 ranked ninth in species (17) and 14th in specimens (559). The most abundant species was the banded killifish. They made up 60% of the catch. Next in order of abundance was the tidewater silverside, 180 specimens making up 23% of the catch. The rest of the top five are: fourspine stickleback, Atlantic silverside and bay anchovy. The only representative of the genus Notropus taken during the survey period was taken at station 16 in August 1974. Also, this station accounted for 62% of all banded killifish taken during the survey.

Station 17 was located at the distal end of lagoon #77 off Mill Creek in Beach Haven West opposite S-15. The edges of this lagoon are not bulkheaded and there are no houses. The bottom consists of fine, medium and coarse sand. Depths in the area seined ranged from 3-15'. It was sampled 16 times. Recorded salinities ranged from 2.81 0/00 to 16.26 0/00, water temperatures from 3.0°C to 29.0°C and D.O.'s from 7.35 mg/l to 13.20 mg/l.

This station ranked ninth in species (17) and seventh in specimens (1,095). The five most abundant species made up 90% of the catch. The mummichog was first followed by tidewater silverside, banded killifish, Atlantic menhaden and Atlantic silverside. This station accounted for 27% of all banded killifish taken during the survey, stations 16 & 17 together accounted for 89%.

Station 18 was located on the northern shore of lower Mill Creek. The bottom consists of pebbles, coarse and medium sand with pieces of peat protruding. Sampling depths were 2-4'. It was sampled 15 times. Recorded salinities ranged from 4.45 0/00 to 26.65 0/00, water temperatures from 7.0°C to 28.0°C and D.O.'s from 6.80 mg/l to 11.45 mg/l.

This station ranked sixth in both species (19) and specimens (1,178). The only species taken in any numbers were the Atlantic silverside (674) and the mummichog (365). The striped killifish ranked third with 28 specimens, followed by the naked goby with 19 and spot with 18.

Station 19 was located at the distal end of lagoon #43 (see Fig. 2). The bottom is primarily medium sand, silt and clay with some coarse and fine sand. Depths swept by the seine ranged from 3-14'. It was sampled 17 times. Recorded water quality ranges were: salinity 19.52 0/00 to 25.08 0/00; water temperature 2.0°C to 30.5°C ; and D.O. 4.45 mg/l to 12.0 mg/l.

Nineteen species totaling 1,720 specimens were taken, placing the station sixth and fourth respectively. The bay anchovy was the most abundant species with 872 specimens, followed by the Atlantic silverside with 520 specimens. Together they made up 81% of the catch. The rest of the top five are: tidewater silverside, rainwater killifish and mummichog. Forty percent of all rainwater killifish taken during the survey were taken at station 19 in October, 1973. None were taken here before or after that date.

Station 20 was located in system A near lagoon #7 (see Fig. 2). This is one of the older developed areas in Beach Haven West. The station was moved to position S-20b when construction of a home

on the original site made it impossible to seine there. The bottom is primarily medium sand with lesser amounts of coarse and fine sand. Sampling depths ranged from 2-12'. It was sampled 16 times. Recorded salinities ranged from 12.07 0/00 to 27.90 0/00, water temperatures ranged from 1.0°C to 28.0°C and D.O.'s from 5.22 mg/l to 12.50 mg/l.

Station 20 ranked 13th in species (12) and 15th in specimens (518). The two most abundant species, Atlantic silverside (220) and tidewater silverside (209) made up 82% of the station catch. The next three species combined only made up 14% of the catch. They are: mummichog, 43 specimens; rainwater killifish, 17 and white mullet, 15. All the mullet were taken on October 23, 1974.

DISCUSSION

Eighteen stations were sampled at various times during the survey. Forty-eight species of finfish numbering 25,662+ specimens were taken. A list of the ten most abundant species, their number and percent of the total seine catch is found in Table 20. The Atlantic silverside was the most abundant species; 9,135+ specimens constituting 36% of the catch. It was taken year round and at all stations except station 8; which is a tidal pool on the marsh. It ranked first at nine stations making up from 42% to 99% of the catch at these stations.

The bay anchovy ranked second with 5,004 specimens making up 20% of the catch. None were taken from December through March and only one specimen was taken in November. It was captured at 13 stations and ranked first at three: S-7, S-9 and S-19.

The fourspine stickleback (4,044) was third in abundance making up 16% of the total catch. It was taken year round and at 15 stations. Station 2 accounted for 94% (3,817) of all fourspine sticklebacks taken.

The fourth most abundant species was the mummichog; 2,264 specimens constituting 9% of the catch. It was taken year round and at 16 stations. It did not appear at station 1 or 3. However, these stations were only sampled once in July, 1973. Mummichogs ranked first in abundance at stations 8 and 17.

The tidewater silverside ranked fifth; 1,953 specimens making up 5% of the seine catch. It was taken year round and at 13 stations. They were the most abundant fish at stations 12 and 15. Almost four times as many specimens were taken at station 9 than at any other station.

The banded killifish was sixth in abundance with 544 specimens making up 2% of the catch. They were taken during eleven months and at 9 stations. None were taken in December. Eight of the nine stations were located in the Beach Haven West complex. Two of the stations, S-16 and S-17, accounted for 89% of the banded killifish taken.

Spot ranked seventh with 530 specimens constituting 2% of the catch. They were taken June through October at 13 stations. Station 7 accounted for 62% (329 specimens), all taken during July, 1973.

Silver perch were eighth in abundance with 324 specimens constituting 1% of the catch. They were taken July through October and at 6 stations. Sixty-two percent were taken at S-6.

The northern pipefish was the ninth most abundant species with 166 specimens making up 1% of the catch. They were taken April through October and at 10 stations. A single specimen was also taken in February, 1975 at station 20. Stations 2 and 4 accounted for 76% of the total northern pipefish taken.

Tenth in abundance was the sheepshead minnow with 154 specimens making up 1% of the catch. They were taken June through January and in March. They appeared in the catch at 10 stations. Fifty-three percent were taken at S-8, a tidal pool on the marsh near the mouth of Dinner Point Creek (see Fig. 1).

TRAWL RESULTS BY STATION

Tables 40 through 60 list water quality, species and specimens by station. See Figure 1 and 2 for station location. Station 2 was located off the northwestern side of Marshelder Island. The bottom is sand and mud and sampling depths ranged from 2.5' to 7'. It was trawled 11 times. Recorded salinities ranged from 25.30 0/00 to 30.82 0/00, water temperatures from 7.0°C to 26.0°C and D.O.'s from 7.32 mg/l to 11/48 mg/l.

The station ranked fifth in species (20) and seventh (591) in specimens. The fourspine stickleback was the most abundant species, 506 specimens comprising 86% of the station's catch. In contrast the second most abundant species was the silver perch with 16 specimens making up 3% of the catch. Rounding out the top five are the northern pipefish (14), the winter flounder (11), the weakfish (10) and the oyster toadfish (10).

As has been mentioned, 20 species were taken here. Some of the more unusual ones were: gray snapper, pinfish, planehead filefish, red hake and striped burrfish. This is the only trawl

station where the gray snapper appeared. Also, eight of nine gray snappers taken seining were taken at S-2 which was located on the southwestern end of Marshelder Island.

Station 4 was located southeast of Sandy Island near FL R 8 ft. "82" in the Intracoastal Waterway. The bottom is medium and fine sand. Sampling depth ranged from 5.0' to 14.0'. The station was sampled 11 times. Recorded salinities ranged from 16.56 0/00 to 31.22 0/00, water temperatures from 5.5°C to 26.5°C and D.O.'s from 5.44 mg/l to 10.94 mg/l.

Ten species and 204 specimens were taken, placing this station 17th and 12th respectively. Most abundant was the bay anchovy (113) constituting 55% of the catch. The next four species were the winter flounder, fourspine stickleback, oyster toadfish and northern pipefish. Together they made up 40% of the catch.

Station 5 was located in Double Creek Channel near Barnegat Inlet. The bottom is fine sand, silt and clay and the depth ranges from 5.0' to 8.0'. It was sampled nine times. Recorded water quality ranges were; salinity 20.19 0/00 to 30.10 0/00, water temperatures 6.5°C to 24.0°C and D.O. 6.59 mg/l to 10.40 mg/l.

This station was unusual in that it ranked fourth in species (21) and 17th in specimens (147). Ninety specimens of winter flounder made up 60% of the catch. The next five species only accounted for 24% of the catch. They were: spot, lined seahorse, northern pipefish, black seabass and scup.

The station's proximity to the inlet probably accounted for its high species rank. Two species were taken only at station 5; a single bluespotted cornetfish, 36 cm. long in September, 1973; and two pollock, 4 cm. long, one in April and one in May, 1975. Two of

three American sandlances taken trawling were taken here, as well as the only butterfish, three of four cunner, eight of ten lined seahorses, three of four planehead filefish, one of three red hake and one of two threespine sticklebacks.

Station 6 was located in lower Barnegat Bay in the area of FL R 8 ft. "68". The bottom is very fine sand, silt and clay. Sampling depth was 7.0' to 9.0'. The station was sampled four times in 1973, September through December and then dropped. Recorded salinities ranged from 25.14 0/00 to 26.92 0/00, water temperatures from 6.0°C to 19.5°C and D.O. from 7.52 mg/l to 10.30 mg/l.

It ranked 14th in species and 10th in specimens. The five most abundant species were; bay anchovy, fourspine stickleback, spot, winter flounder and northern pipefish. These species accounted for 96% of the station's catch. The bay anchovy alone made up 81% of the station's catch. A single blue runner, the only one over the survey period, was taken here in October.

Station 7 was located in Manahawkin Bay off Main Point (see fig. 1). The bottom is primarily silt and clay, the sampling depth 5.0' to 7.0'. It was sampled 10 times. Recorded salinities ranged from 18.08 0/00 to 27.11 0/00, water temperatures from -0.5°C to 27.0°C and D.O. from 6.98 mg/l to 12.56 mg/l.

It ranked 19th in both species (9) and specimens (80). The bay anchovy ranked first in abundance, making up 36% of the catch. Second was the winter flounder, with 22 specimens constituting 28% of the catch.

Station 8 was located in Manahawkin Bay off the mouth of Mill Creek. Both developed and undeveloped lagoons branch off the upper part of this creek. They are part of the Beach Haven West

complex. The bottom here is primarily silt, clay and fine sand. Depths sampled ranged from 3.0' to 13.0'. The station was trawled 15 times. Recorded water quality ranges were; salinity, 18.08 0/00 to 30.86 0/00, water temperature, -0.5°C to 27.5°C and D.O.'s 5.94 mg/l to 12.67 mg/l.

This station ranked sixth in species (19) and fifth in specimens (802). Again the bay anchovy was most abundant, 536 specimens constituting 68% of the catch. Second was the oyster toadfish with 73 specimens followed by the fourspine stickleback (45), northern pipefish (39) and winter flounder (29). One of two American shad taken during the survey was taken here in December, 1973. One of the two northern kingfish, one of four northern puffers and two of four striped burrfish taken trawling were taken at station 8.

Station 10 was located in Little Egg Harbor off the mouth of Meyers Creek. The bottom is silt, clay and fine sand and sampling depth ranged from 4.0' to 9.0'. It was sampled 14 times. Recorded salinities ranged from 19.89 0/00 to 28.19 0/00, water temperatures from 0.5°C to 28.0°C and D.O.'s from 6.43 mg/l to 12.87 mg/l.

It ranked sixth in species (19) and eighth in specimens (537). The bay anchovy was most abundant, 243 specimens constituting 45% of the catch; followed closely by the spot, with 192 specimens making up 36% of the catch. The rest of the top five are the fourspine stickleback, winter flounder and Atlantic silverside. One each of the lined seahorse, northern kingfish and northern puffer was taken here.

Station 11 was located in Little Egg Harbor off the mouth of Dinner Point Creek. Both sides of the navigable portion of this creek are lined with Spartina marsh. The bottom is mostly

fine sand, silt and clay; and sampling depths ranged from 5.0' to 8.0'. The station was sampled 15 times. Recorded salinities ranged from 20.35 0/00 to 31.80 0/00, water temperatures from 0°C to 27.5°C, and D.O. from 5.50 mg/l to 12.77 mg/l.

This station ranked first in number of species (24) and sixth in specimens (699). Once more the bay anchovy was most abundant, 500 individuals making up 71% of the station's catch. The second ranked blueback is represented by only 46 specimens (7% of the catch). The next three species are the fourspine stickleback, winter flounder, and Atlantic silverside. Of 155 sheepshead minnows taken during the survey, one was taken by trawl and that was at this station in November, 1973. One each of the lookdown, pinfish, striped burrfish and threespine stickleback was taken.

Station 12 was located in Little Egg Harbor near marker W or "X" (see fig. 1). The bottom is silt, clay, fine and very fine sand with a lot of detritus over it. Sampling depths ranged from 5.0' to 9.0' and the station was trawled 11 times. Recorded water quality ranges were: salinity, 23.06 0/00 to 29.22 0/00, water temperature, 7.0°C to 26.5°C and D.O., 5.66 mg/l to 10.20 mg/l.

This station was one of four tied for sixth place in species and ranked 16th in specimens. The bay anchovy ranked first in abundance with only 79 specimens composing 48% of the catch. The rest of the top five are, silver perch (25), northern pipefish (13), fourspine stickleback (10) and winter flounder (9). Five species are represented by a single specimen. They are cunner, lined seahorse, lookdown, red hake and striped anchovy.

Station 13 was located in a cove north of the mouth of Tuckerton Creek. The bottom is silt and clay with very fine sand. Sampling depths ranged from 4.0' to 6.0'. The station was trawled five

times. Recorded water quality ranges were: salinity 26.38 0/00 to 28.71 0/00; water temperature 6.5°C to 26.7°C and D.O. 6.14 mg/l to 9.14 mg/l.

It ranked 11th in species (14) and ninth in specimens (430). Seventy-three percent of the fish taken were bay anchovies. One of the six striped anchovies taken during the survey was taken here in September 1973.

Station 14 was located in Marshelder Channel off FL '7'. The bottom is primarily fine sand, with lesser amounts of silt, clay and very fine sand. Sampling depths ranged from 5.5' to 17.0'. It was sampled eight times. Recorded salinities ranged from 26.29 0/00 to 30.81 0/00, water temperatures from 8.0°C to 25.0°C and D.O.'s from 6.78 mg/l to 9.75 mg/l.

This station ranked 11th in species (14) and 18th in specimens (81). Forty-eight of the 81 specimens were bay anchovies. Second was the northern pipefish with seven individuals being taken. Five of the eight windowpanes taken during the survey were taken here, as were three of the six smallmouth flounder.

Station 15 was located in upper Mill Creek (see Fig. 2). The bottom is mostly silt and clay with fine and medium sand. Sampling depth ranged from 4.0' to 7.0'. It was sampled 14 times. Recorded water quality ranges were; salinity <1 0/00 to 14.49 0/00, water temperature from 0°C to 28.0°C and D.O. from 1.93 mg/l to 14.34. mg/l.

This station ranked second in species (22) and third in specimens (886). Number one in abundance was the mummichog, 324 specimens were taken in one haul on December 12, 1973. Only 7 other mummichogs were taken trawling. Second was the tidewater silverside

(194), followed by the bay anchovy (102), spot (99) and white perch (55). The brown bullhead, golden shiner, pumpkinseed and redfin pickerel were taken only at this station. In addition to these freshwater fish, saltwater species such as the Atlantic menhade, bluefish, crevalle jack, summer flounder and weakfish were also captured at this station.

Station 16 was located in Mill Creek just below the sewer plant (see Fig. 2). The bottom is primarily silt and clay with some medium and fine sand. Sampling depth ranged from 8.0'-15.0'. It was sampled 12 times. Recorded water quality ranges were; salinity from 7.36 0/00 to 27.29 0/00, water temperature from 6.0°C to 27.0°C and D.O. from 3.94 mg/l to 10.49 mg/l.

Fourteen species numbering 173 specimens were taken, placing the station 11th and 15th respectively. The five most abundant species were; bay anchovy (43), spot (30), hogchoker (20), fourspine stickleback (17) and winter flounder (14).

Station 17 was located off Mill Creek in system E lagoon #100. For a description of the surrounding area see S-15 under seining results. The bottom is silt and clay with some very fine sand. Sampling depths ranged from 7.0' to 16.0'. Fifteen samples were taken. Recorded water quality ranges were; salinity from 2.45 0/00 to 19.15 0/00, water temperatures from 3.0°C to 26.0°C and D.O. from 0 mg/l to 12/17 mg/l.

The station ranked 17th in species (10) and 12th in specimens (210). The fourspine stickleback made up 55% of the catch (113) followed by tidewater silverside (54), white perch (15), bay anchovy (13) and mummichog (6).

Nine of the 15 times this station was sampled no fish were taken. On four of those nine occasions the D.O. was <1.50 mg/l.

Station 18 was located off Mill Creek in lagoon #77 opposite station 17. For a description see S-17 under seining results. The bottom is primarily silt, clay and very fine sand, and sampling depths ranged from 6.0' to 12.0'. It was sampled 14 times. Recorded water quality ranges were; salinity from 3.78 0/00 to 16.26 0/00, water temperatures from 4.0°C to 28.0°C and D.O. from 0.47 mg/l to 12.60 mg/l.

The station ranked 16th in species (12) and 14th in specimens (174). One hundred and fourteen white perch made up 66% of the station's catch. Second in abundance was spot with 30 specimens. One of two American shad taken during the survey was taken here in April, 1975.

No fish were taken five of the 14 times the station was sampled.

Station 23 was located in mid Dinner Point Creek (see Fig. 1). The bottom is silt, clay, fine and medium sand and sampling depths ranged from 4.0' to 6.0'. The station could only be sampled at high tide. It was trawled 12 times. Recorded water quality ranges were; salinity 15.84 0/00 to 29.36 0/00, water temperatures 11.0°C to 27.0°C and D.O. 3.32 mg/l to 9.16 mg/l.

Seventeen species totaling 1,193 specimens placed this station 10th and second respectively. Spot ranked first in abundance with 472 specimens making up 40% of the catch. Bay anchovy ranked second with 448 individuals accounting for 38% of the catch. The rest of the top five were Atlantic menhaden, Atlantic silverside and weakfish.

Station 24 was located in lower Dinner Point Creek near the mouth. The bottom consists primarily of silt and clay with lesser amounts of medium and fine sand. Shell fragments are very common,

28 grams out of a one hundred gram sample. Sampling depths ranged from 3.0' to 5.0'. It was sampled 11 times, also at or near high water. Recorded water quality ranges were; salinity from 19.65 0/00 to 27.85 0/00, water temperatures from 11.6°C to 28.0°C and D.O. from 5.90 mg/l to 9.50 mg/l.

The station tied for second in species (22) and ranked fourth in specimens (843). The bay anchovy made up 82% of the catch with 695 fish. The next four most abundant species together made up only 11%. They were spot (44), Atlantic menhaden (26), weakfish (15) and fourspine stickleback (12). The only striped searobin taken trawling was taken here in June, 1974.

Station 25 was located in Westecunk Creek. The bottom is predominantly silt and clay, followed by fine and very fine sand. Sampling depths ranged from 4.0' - 9.0'. The station was trawled 12 times. Recorded salinities ranged from 6.73 0/00 to 27.83 0/00, wate temperatures from 9.0°C to 25.5°C and D.O. from 5.59 mg/l to 11.10 mg/l.

This station ranked sixth in species (19) and first in specimens (1,960). Its number one ranking was due to the bay anchovy which was present in all but one sample. Altogether 1,290 bay anchovies were taken constituting 66% of the station's catch. Next in abundance was the fourspine stickleback (306) followed by the Atlantic menhaden (124), silver perch (55) and Atlantic silversides (52). One of three red hake taken during the survey was taken here in June, 1974.

Station 26 was located in Thompson Creek. The bottom is primarily silt and clay with some fine sand and shell fragments. Sampling depths ranged from 3.0' to 6.0'. It was sampled four times and dropped after November, 1973.

Thirteen species and 228 specimens were taken placing the station 14th and 11th respectively. The five most abundant species were the bay anchovy (94), spot (64), fourspine stickleback (30), naked goby (19) and oyster toadfish (7).

Station 27 was locatd in Gunning River. It was sampled twice and dropped. It ranked last in species (4) and specimens (8). The species taken were: oyster toadfish, American eel, bluefish and winter flounder.

Station 28 was in Little Egg Harbor Bay off Thompson Creek. The bottom is primarily silt and clay, the depth, 5". It was sampled in October, 1973. Six species and 48 specimens were taken. They were the bay anchovy, silver perch, spot, summer flounder, weakfish and winter flounder.

DISCUSSION

Twenty-one stations were trawled at various times throughout the survey area. Fifty-four species of finfish totaling 9,730 specimens were taken. The ten most abundant species, their number and percent of the total catch is given in Table 61.

The bay anchovy ranked first in abundance, 4,730 specimens constituting 49% of the catch. They were taken March through November. In addition to being most abundant overall, they were also most abundant at 14 of the 18 stations at which they were taken.

Second most abundant fish was the fourspine stickleback, 1,180 specimens making up 12% of the catch. They were taken year round and at 18 stations. They were the most abundant species at T-2 and T-17.

Spot were third in abundance, 1,074 specimens constituting 11% of the catch. They were taken June through October and at 19 stations. Forty-three percent (472) were taken at T-23 in Dinner Point Creek, most of these (380) in July, 1974.

The mummichog ranked fourth, 331 specimens making up 3% of the catch. They were taken in December, 1973 and July, 1974; 330 and 1 specimens, respectively. Three hundred and twenty-four were taken in one haul in December at T-15.

The Atlantic menhaden ranked fifth, 316 specimens constituting 3% of the catch. They were taken in January and June through August and at six stations. The majority (312) were taken in June and July. T-23 and T-25 accounted for 275 specimens or 87% of the catch.

Winter flounder were sixth in abundance, 293 specimens making up 3% of the catch. They were taken year round and at 20 stations. Thirty percent, 90 specimens, were taken at T-5 where it was the most abundant species.

The tidewater silverside ranked seventh in abundance with 262 specimens making up 3% of the catch. They were taken in February, March, June (1), November (2) and December. They appeared in the catch at five stations; 194 specimens (74%) were taken at T-15 in December (64) and February (130).

The oyster toadfish ranked eighth with 198 specimens constituting 2% of the catch. It was taken April through December and at 15 stations. It ranked in the five most abundant species at six stations.

The ninth most abundant fish was the white perch with 193 specimens making up 2% of the trawl catch. It was taken year round and at six stations. It ranked first at T-18 and was in the top five at T-15 and T-17.

The Atlantic silverside ranked tenth with 188 specimens constituting 2% of the catch. They were taken year round and at 13 stations. They ranked in the top five at four stations.

GILL NET RESULTS

Gill net stations are indicated by a G preceding the trawl or seine station with which they were associated, e.g. GT-2 indicates the gill net station located near trawl station 2 off Marshelder Island.

Tables 78 through 85 list water quality data and fish taken at eight stations sampled during the second phase of the study. Tables 86 through 96 list the number of each species taken monthly at each station. Three gill net sets were also made during the first phase of the survey and the results are given in table 97.

Altogether, 614 specimens representing 21 species of finfish were taken. Two of these, the smooth dogfish and the striped bass were taken only by gill net.

The Atlantic menhaden was the most abundant species taken. Three hundred ten specimens were collected comprising 50% of the gill net catch. They were taken July through December and February through May at five stations.

Seventy-eight bluefish making up 13% of the catch were taken. They appeared July through October and at seven stations.

White perch ranked third, 73 specimens making up 12% of the catch. They were taken December through May and at three stations, two of which were located in the Beach Haven West lagoon system.

The fourth most abundant fish was the spot, 66 specimens constituting 11% of the catch. They were taken July through October and at 6 stations.

The alewife ranked fifth in abundance. Twenty-seven specimens making up 4% of the catch were captured. They were taken in January and again March through May and at two stations.

COMBINED RESULTS

Sixty-six species of finfish were taken in the study area. Table 98 lists the number of each species taken by each gear, over-all rank and percent of total catch each species comprises. Figures 3 through 10 show capture locations of selected species. Twenty-three species are represented by more than 100 specimens. Following is a short account of thirteen of these.

Bay Anchovy

The bay anchovy is a euryhaline forage fish found primarily in estuaries and coastal waters. During the survey 9,700+ specimens, comprising 27% of the total catch, were taken. Thirty-nine percent were taken at bay stations, 38% in the creeks and 23% in lagoons.

The catch was almost evenly split between seine and trawl, 51% and 49%. They were taken at 13 of 18 seine stations and 18 of 21 trawl stations. The catch/haul was 5.19 for the 25' seine and 10.97 for the trawl.

They appeared in the catch nine months overall. Three were taken trawling in March. April through November they were taken by both gear types. Bay anchovies were most abundant in the summer (July, August, September) 5,400 specimens constituting 55% of the total anchovy catch. September ranked highest overall (3,218 specimens) and seining (2,394) specimens). May was high month for the trawl catch with 1,650 specimens.

Recorded water quality parameters at which anchovies were taken were: salinity 2.20 to 21.22 0/00, water temperature 4.0 to 30.5°C and D.O. 1.93 to 12.75 mg/l.

Stomach analysis of 29 fish species taken in the area (Festa 1975) showed the bay anchovy to be an important diet item of three species. They were the bluefish, summer flounder and weakfish.

Conversely bay anchovy stomachs contained: fish eggs; Polychaetes - Nereis sp. and Polydora sp.; Crustaceans - Amphipods, Isopods, Tanaids and Caridean shrimp; Insects - Chironomidae larvae; and Nematodes.

Atlantic silverside

The Atlantic silverside is another important euryhaline forage species. It ranked second in abundance in the study area, 9,330 specimens comprising 26% of the catch.

Seining accounted for 98% of the catch and trawling 2%. It was taken at 17 of 18 seine stations and 13 of 21 trawl stations. Catch/haul was 11.39 for the 25' seine and 0.44 for the trawl.

They appeared in all months in both types of gear. Most (57%) were taken in the summer (July, August, September) followed by fall 30%, spring 9% and winter 2%. Water quality parameters recorded when Atlantic silversides were taken were: salinity <1 to 31.81 0/00, water temperature 0.5 to 30.5°C and D.O. 3.16 to 12.74 mg/l.

Regarding the food web study, the only positive identification of the Atlantic silverside was in striped bass stomachs. However, Menidia sp. were found in bluefish and northern sennet. Other species taken in the study area and known to feed on Atlantic silversides are the summer flounder and weakfish.

Atlantic silverside stomachs contained: Polychaete remains; Crustaceans - Amphipods, Decapods, Mysids, Calanoids and Harpacticoids; Nematodes; Hydrozoans and Diatoms.

Fourspine stickleback

The fourspine stickleback ranked third overall. 5,224 specimens constituting 14% of the total catch were taken.

Seventy-seven percent were taken seining and 23% trawling. They appeared at 15 of 18 seine stations and 18 of 21 trawl stations. The catch/haul was 0.54 for the 25' seine and 2.74 for the trawl.

They were taken in all months of the year by both gear types. Most were taken in summer (48%) followed by spring, winter and fall.

Recorded water quality parameters at the time of capture were: salinity 1.00 to 30.86 0/00, water temperatures -1.0°C to 29.0°C and D.O. 0 to 12.87 mg/l.

Fourspines were utilized as food by the following species; Atlantic needlefish, oyster toadfish, spotted hake, weakfish and white perch.

The fourspine stickleback fed on: fish eggs; Annelids - Polychaetes and Oligochaetes; Crustaceans - Amphipods and Isopods; mollusks - Gastropods and Bivalves and Platyhelminthes - Turbellarians.

Mummichogs

Mummichogs made up 7% of the total catch, 2,599 specimens.

Eighty-seven percent were taken by seine, 13% by trawl and 4 specimens in a gill net. 324 of the 331 mummichogs taken in the trawl were captured in one tow at T-15 in December, 1973. They appeared at 16 of 18 seine stations and 3 of 21 trawl stations. Catch/haul was 5.72 for the 25' seine and 0.77 for the trawl.

Mummichogs were taken year round seining and in July (1) and December trawling. Most (44%) were taken in spring (April, May, June) followed by fall, summer and winter.

Recorded water quality ranges for this species are: salinity 3.95 to 30.32 0/00, water temperature 3.0 to 33.0°C and D.O. 2.36 to 13.20 mg/l. Although no mummichogs were positively identified, Fundulus sp. were found in 10% of the mummichog and 3.5% of the white perch stomachs. Some other species known to feed on mummichogs are bluefish, striped bass, summer flounder and weakfish.

Mummichogs are omnivorous. Festa (1975) found other Fundulus species, Amphipods, Decapods, Nematodes and plant remains in mummichog stomachs.

Tidewater silverside

Fifth in abundance was the tidewater silverside, 2,215 specimens constituting 6% of the catch.

Seining accounted for 88% of the catch and trawling 12%. They were taken at 13 of 18 seine and 5 of 21 trawl stations. Catch/haul was 4.85 specimens for the 25' seine and 0.61 for the trawl.

They were taken in all months except March by seine and in February, March, July, November and December by trawl. 65% were taken in the fall, followed by summer, winter and spring.

Water quality parameters recorded when tidewater silversides were taken were: salinity 1 to 25.95 0/00, water temperature 1.0 to 33.0°C and D.O. 0 to 12.50 mg/l.

No tidewater silversides were positively identified in the fish stomachs studied, however Menidia spp. were found in bluefish and northern sennet. Striped bass, summer flounder and weakfish also feed on these silversides.

Stomachs of this species contained: fish remains, Gammaridean remains, Copepods, Cladocerans, Cumaceans, Acarians, Turbellarians, insect remains, Diatoms and other unidentified algae.

Spot

Spot were sixth in abundance, 1,760 specimens making up 5% of the catch.

Most were taken trawling (64%), 32% were taken seining and 4% by gill nets. They appeared at 13 of 18 seine stations, 19 of 21 trawl stations and 7 of 8 gill net stations. The catch/haul was 0.14 for the 25' seine and 2.49 for the trawl.

They were captured June through October, 90% being taken in the summer, followed by fall 8% and spring 2%.

Recorded water quality ranges were: salinity 4.69 to 29.88 0/00, water temperature 12.2 to 29.0^{o}C and D.O. 0.65 to 10.34 mg/l.

Spot were found in bluefish and oyster toadfish stomachs.

Spot feed primarily on Amphipods, especially Ampelisca spp. and other Gammarideans; Polychaetes; Copepods - Harpacticoids and Calanoids; and Mysids - Neomysis americana.

Captured spot ranged from 3 to 18 cm. The larger ones were in their second summer. Length frequencies for 620 spot are given in tables 99 and 100.

Atlantic menhaden

Atlantic menhaden ranked seventh, 798 specimens constituting 2% of the catch. Most of these were juveniles, ranging from 3 to 15 cm. See table 101 for length frequency.

Twenty-two percent were taken seining, 39% trawling and 39% in the gill net. They appeared at 7 of 18 seine stations, 6 of 21 trawl stations and 6 of 8 gill net stations. The catch/haul for the 25' seine was 0.44 and for the trawl 0.73.

They were taken in all months of the year. Nine specimens (1%) were taken in winter, one in January, one in February and seven in March. 48% were taken in spring, 42% in summer and 9% in fall.

Recorded water quality ranges for this species were: salinity 1.87 to 27.85 0/00, water temperature 4.0 to 29.0°C and D.O. 0 to 12.70 mg/l.

Atlantic menhaden were found in bluefish stomachs. They were also eaten by striped bass and weakfish.

All menhaden stomachs analyzed contained diatoms and other algal species; 20% contained Calanoid copepods.

Banded killifish

The banded killifish was eighth in abundance, 545 specimens making up 2% of the catch.

All except one specimen were taken by seine. They appeared at 9 of 18 seine stations and one trawl station. The catch/haul was 2.42 for the 25' seine.

They appeared 11 of 12 months, none being taken in December. 60% were captured during the summer; 35% in the fall, 2% in the winter and 1% in spring.

Water quality parameters at time of capture ranged from: salinity 1 to 27.90 0/00, water temperature 2.0 to 29.0°C and D.O. 0.78 to 12.74 mg/l.

Fundulus species were found in mummichogs and white perch stomachs.

Banded killifish stomachs contained: Polychaete remains, Gammaridean Amphipods, Isopods, Cumaceans, Nematodes and Diatoms.

Silver Perch

Silver perch ranked ninth, 492 specimens constituting 1% of the catch. Those measured were primarily young of the year. See tables 102 and 103 for length frequency.

Sixty-six percent were taken seining and 33% trawling; four specimens were caught by gill nets. They appeared at 6 of 18 seine stations, 12 of 21 trawl stations and 2 of 18 gill net stations. Catch/haul for the 25' seine was 0.19 and for the trawl 0.38.

They were taken July through November. Eighty-five percent were captured in the summer and 14% in the fall.

Recorded water quality parameters at time of capture were: salinity 22.43 to 30.41 0/00, water temperatures 7.5 to 25.5°C and D.O. 5.90 to 9.31 mg/l.

Silver perch were found in summer flounder stomachs.

They fed on unidentified fish, Gastropods - Bittium sp., Decapods, Crangon septemspinosa and Mysids - Neomysis americana.

Winter flounder

Winter flounder were tenth in abundance, 342 specimens constituting 1% of the catch.

Fifteen percent were taken seining and 85% trawling. They were captured at 9 of 18 seine stations and 20 of 21 trawl stations. None were taken at T-26 in Thompson's Creek. The catch/haul was 0.06 for the 25' seine and 0.68 for the trawl.

Winter flounder were found year round in the study area. Forty-three percent were taken in the summer, 22% in the fall, and 17% each in winter and spring.

Recorded water quality ranges were: salinity 1.25 to 31.80 0/00, water temperature -1.0 to 28.5°C and D.O. 3.94 to 12.56 mg/l.

Winter flounder stomachs contained: naked gobies; many species of Annelids and Nematodes; Amphipods, Decapods, Cumaceans, Mysids and Branchyuran crabs; and many Molluscs. Twenty-eight percent of

all winter flounder stomachs contained bivalve siphons, primarily Mercenaria mercenaria. A supplementary report on this is being prepared by P. Festa.

340 winter flounder were measured. They ranged from 5 to 37 cm. See tables 104 and 105 for length frequency tables.

White perch

White perch ranked twelfth in abundance, 293 specimens making up 1% of the catch.

They were taken by all three gear types: seine 9%, trawl 66% and gill net 25%. They were captured at 4 of 18 seine stations, 6 of 21 trawl stations and 3 of 8 gill net stations. The catch/haul was 0.10 for the 25' seine and 0.45 for the trawl.

Perch were taken year round trawling, primarily in the summer seining and in the winter by gill net. Overall 41% were taken in winter, 10% in the spring, 17% in summer and 32% in the fall.

Water quality parameters at which perch were taken were: salinity <1 to 30.86 0/00, water temperature 0.5 to 29.0°C and D.O. 0 to 10.72 mg/l.

While some fish and fish eggs were found in white perch stomachs, invertebrates made up most of their diet. Annelids, primarily Polychaete remains, were found in 28% of the stomachs examined. Crustaceans were the most abundant food item. In descending order those identified were: Mysids - Neomysis americana; Decapods - Crangon septemspinosa; Amphipods - Gammarus fasciatus and Leptocheirus plumulosus and Calanoid copepods.

Bluefish

Bluefish ranked 17th with 153 specimens.

They were taken by all three types of gear; seine 38%, trawl 11% and gill net 51%. Bluefish were captured at 11 of 18 seine

stations, 8 of 21 trawl stations and 7 of 8 gill net stations. The catch/haul was 0.08 for the 25' seine and 0.04 for the trawl.

They appeared June through October, 89% of these July through September and 50% of all bluefish were captured in August.

Recorded water quality ranges were: salinity 1 to 29.88 0/00, water temperature 12.5 to 28.5°C and D.O. 0 to 10.72 mg/l.

Fish remains were found in 54.5% of the bluefish stomachs examined. Those species identified are: bay anchovy, Atlantic menhaden, silverside spp. and spot. Invertebrates found include Nereis spp., Crangon septemspinosa, Palaemonetes vulgaris, Neomysis americana and Brachyuran crab larva.

Of 128 specimens measured, 124 were probably young of the year. See table 106 for length frequency.

Weakfish

Nineteenth in abundance was the weakfish with 139 specimens.

They were most abundant in trawl samples, 133 specimens (96%) being taken trawling. Three weakfish were taken seining and three in the gill net. They were taken at 3 of 18 seine, 17 of 21 trawl and 1 of 8 gill net stations. Catch/haul was 0.31 for the trawl.

They appeared August through October, with most specimens (94) being taken in August.

Water quality parameters at which weakfish were taken were: salinity 13.82 to 29.05 0/00, water temperature 14.01 to 27.0°C and D.O. 1.44 to 9.26 mg/l.

Fish remains were found in 50% of the weakfish stomachs examined; the only identifiable species being the bay anchovy. The three most important invertebrates in decreasing order are: Neomysis americana, Crangon septemspinosa and Ampilisca spp. Others are Callinectes sapidus and Xanthidean crabs ~~remains~~.

All but one of 137 weakfish measured appeared to be young of the year, ranging in length from 3 to 17 cm. See tables 107 and 108 for length frequency.

SUMMARY

The fish population of the Manahawkin Bay-Little Egg Harbor System was sampled July 1973 through May 1975. The following gear was utilized: a 25' x 5' bag seine, an 80' x 6' bag seine, a 150' x 10' bag seine, a 16' bottom trawl and an 125' x 6' experimental gill net.

Eighteen seine stations were sampled at various times. Seven of these were located in the bay, five in creeks, five in lagoons and one in a tidal pool on the salt marsh.

A total of 266 seine hauls were made. Forty-eight species of finfish numbering 25,662+ specimens were taken. The combined catch/haul was 96.5 specimens. Catch/haul for the 25' seine was 33.4 specimens, that for the 80' seine 77.5 and that for the 150' seine 447.9. The ten most abundant species numbered 24,118 specimens and made up 96% of the seine catch.

Twenty-one trawl stations were sampled. Twelve were bay stations, seven were creek stations and two lagoon stations.

Fifty-four species of finfish totaling 9,730 specimens were taken in 431 trawl hauls. Catch/haul was 22.6 specimens. The ten most abundant species totaled 8,765 specimens and constituted 90% of the trawl catch.

Eight gill net stations were located in the bay, one in Dinner Point Creek and four in lagoons.

Twenty-one species of finfish numbering 614 specimens were taken. Two of these, the smooth dogfish and the striped bass were taken only by gill net. The five most abundant species numbered 554 and made up 90% of the catch.

Altogether, sixty-six species of finfish totaling 35,980+ specimens were taken. The five most abundant species were: bay anchovy, Atlantic silverside, fourspine stickleback, mummichog and tidewater silverside. These five made up 80% of the total catch.

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Phase II, Physical-Chemical Studies

by

John F. Makai

ABSTRACT

The purpose of this portion of the study was to map and/or describe the physical and chemical attributes of the Manahawkin Bay-Little Egg Harbor System.

Thirty-four water quality stations were selected and scheduled accordingly to be sampled bimonthly, monthly and/or seasonally from July, 1973, until February, 1974 and from June, 1974 until May, 1975. The following parameters were measured: temperature, tidal stage, water depth, dissolved oxygen, salinity, pH, carbon dioxide, transparency, ammonia, nitrite-nitrate nitrogen, detergent, B.O.D., orthophosphate and total and fecal coliforms.

During the two survey periods, water temperatures ranged from -2.7°C to 30.5°C. Dissolved oxygen ranged from 0.0 to 17.1 mg/l. pH ranged from 5.7 to 10.0. Salinity ranged from .3 to 32.0 0/00. Carbon dioxide ranged from 0.00 to 36.3 mg/l. Secchi disk depth measurements ranged from 3 inches to 11 feet. B.O.D. levels ranged from 0.0 to >12.2 mg/l. Nitrite nitrogen ranged from 0.0 to .036 mg/l and nitrate nitrogen ranged from 0.0 to 3.98 mg/l. Ammonia levels ranged from 0.0 to .4 mg/l. Orthophosphate ranged from 0.0 to .17 mg/l. Detergent concentrations ranged from 0.0 to .34 mg/l. Bacterial analysis showed coliforms counts ranging from <3 to 4,600 MPN/100 ml, and fecal coliforms counts from <3 to 2,400 MPN/100 ml.

Slight traces of DDT and its metabolites were detected in 84.6% of the fish, with values ranging up to 17.0 ppb. Only 20% of the shellfish meat showed any traces. 76.6% of the sediment samples did show traces of DDT and its metabolites with concentrations ranging up to 69 ppb. The other insecticide observed was heptachlor epoxide, detected in 33.3% of the samples.

Heavy metal analysis of fish, shellfish and sediment samples showed that cadmium, chromium, lead, zinc and mercury were present. In the fish samples, only slight traces of cadmium and chromium (<0.01 ppm) were detected. Lead ranged from 0.0 to 6.1 ppm, zinc from 5.65 to 16.85 ppm and mercury from 0.0 to 0.4 ppm. In the shellfish meat, only slight traces of chromium (<0.01 ppm) were detectd. Cadmium ranged from <0.01 to 0.75 ppm; lead ranged from 0.0 to 5.7 ppm; zinc ranged 2.5 to 20.0 ppm and mercury from 0.0 to 0.29 ppm. In the sediment samples, cadmium ranged from 0.0 to 3.0 ppm; chromium from 3.0 to 50.0 ppm; lead from 0.0 to 297.5 ppm; zinc from 2.0 to 66.6 ppm and mercury from 0.0 to 2.75 ppm.

INTRODUCTION

Over the years, New Jersey's coastal areas have become a significant real estate frontier. The tremendous demands by individuals to have homes built near direct access to the water system had brought development to an all-time record. However, suitable construction sites have become exhausted and the trend now would be to dredge-fill wetlands to provide lagoon-type real estate. Lagoons are usually bulkheaded to prevent erosion and allow for boat dockage.

The importance of marshland in an estuarine ecosystem has been well documented. De la Cruz (1973) stated that every square meter surface of marsh, regardless of geographic location, produces

about the same amount of organic material annually and will supply the same biomass to detritus to the estuarine food chain. Therefore, it is evident that the secondary productivity of coastal waters manifested in the productive fisheries and shellfisheries is dependent on the biological process occurring on the marshes.

Gagliano (1974) determined that losses of marsh areas or disturbances of the marsh in ways which limit food production will cause reduction of stocks dependent on those food resources. The direct loss of good habitat with the rise of artificial areas (lagoons) had made it necessary to evaluate such an area as to what role this would now play in the food web chain.

The objective of this study would be to establish the importance of this estuarine system by determining population utilizations and conditions. A special emphasis was also being placed in comparing an artificial area to a natural condition. Such information could be used to help maintain coastl waters at a level which would allow their continued use as spawning, nursery and harvest areas.

ACKNOWLEDGEMENTS

A deep gratitude is extended to the personnel of the State of New Jersey Bureau of Shellfish Control for their cooperation in making it possible to conduct a bacterial program. Special thanks to Tom LaFisca, Chemist for the Bureau of Fisheries Laboratory, Lebanon, for his nutrient analyses of water samples, and the handling of all pesticide and heavy metal analyses on the fish, shellfish and sediment samples; to Senior Fisheries Worker Jeffrey Carlson and William Andrews for their fine effort in conducting most of the field work; and to Student Assistant Richard Lyons, who aided in the collection of water samples and analysis.

Materials and Methods

The Manahawkin Bay-Little Egg Harbor System Study area originally was planned to include all water acreage from Beach Haven Inlet (lower boundary) to Barnegat Inlet (upper boundary). It was felt that since the Studies of the Upper Barnegat System (1972), had ended at Barnegat Inlet, the new survey should continue from here. However, in December (during the first survey period), it was decided to reduce the study area and designate Sandy Island as the upper boundary.

Field sampling was conducted during July, 1973, through to February, 1974, and from June, 1974, through to May, 1975. During these two survey periods, thirty-four water quality stations were selected and scheduled accordingly to be sampled bimonthly, monthly and/or seasonally. A special emphasis was placed in comparing a habitat that has already been developed (artificial) to a natural area. This artificial system will be defined as wetland, and uplands that have, after dredge-fill operations, been created into lagoon-type real estate development.

Dinner Point Creek and the drainages from Meyer's Pond and Oyster Point were chosen as the "natural" area. It was felt that close proximity of the two systems would allow for a good comparison of habitat.

Location of all stations can be seen in Figures 11, 13 and 14. Due to the shallowness of this system, most bay stations were located in the channel of the Intracoastal Waterway. This allowed for both surface and bottom profile.

Sixteen chemical and physical parameters measured were divided as follows:

Hydro Run Surveys

Bi-monthly sampling of surface and bottom waters were conducted at 31 stations during maximum flood and ebbing tides. The survey area was divided into three sampling frequencies:

1. The entire bay region (9 stations) and the mouths of Dinner Point Creek, Mill Creek and Beach Haven West Complex;
2. Dinner Point (4 stations) and Mill Creek (7 stations); and
3. Beach Haven West Lagoon Complex (11 stations).

During this survey, the following parameters were measured: temperature, tidal stage, water depth, dissolved oxygen, pH, salinity, carbon dioxide and secchi disk depths.

Most of the thirty-one stations corresponded to the seining, trawling and gill netting stations selected in the Fish Study. The above water quality data was also collected during all field work of the fish survey.

Analyses of water samples were completed within 3 hours after collection.

Nutrient Collections

Surface water samples were collected monthly at 21 of the 34 stations during a falling tide. Two 1,000 ml polyethylene bottles were filled at each station. During the first survey period (July, 1973 - February, 1974), one bottle was fixed with 40 mg of mercuric chloride. Continuously high nitrate results forced a change in fixing agents (1 ml of H_2SO_4). Both bottles were stored in a cooler packed with ice during field collections. All samples were stored in a refrigerator or ice chest (depending on availability) and transported early the following morning to the Lebanon Laboratory for immediate analysis. Water samples were tested for ammonia,

nitrite-nitrate nitrogen, orthophosphate, detergent (all usually within 96 hours after collection) and B.O.D. levels.

Bacterial Monitoring Program

Seasonal sampling was conducted at 27 of the 34 water quality stations. Collections were taken 18" below the surface, in sterilized 6 oz. glass bottles, during a flood tide. Within 1 hour of completing the survey, samples were taken to the Bureau of Shellfish Control at Leeds Point for evaluation.

Tributary Survey

Five major tidal creeks situated within the study area were also chosen to be seasonally sampled during both a flood and ebb tide. Such systems were Tuckerton Creek, Thompson Creek, Parker Run, Westecunk (West) Creek, and Cedar Run. The parameters measured were temperature, water depth, tidal stage, salinity, pH, dissolved oxygen, secchi disk depth and carbon dioxide.

Twenty-four Hour Tidal Survey

A twenty-four hour monitoring program was conducted seasonably in Dinner Point Creek and Beach Haven West, System B - mouth of Lagoon #08. Parameters measured hourly were as follows: tidal stage, temperature, oxygen concentrations, salinity and secchi disk depths (as daylight permitted). Gill netting and plankton sampling were also included during this survey.

Pesticide and Heavy Metal Survey

Selected fish, shellfish and sediment samples were analyzed for both pesticides (chlorinated hydrocarbons) and heavy metal (mercury, cadmium, lead, chormium and zinc) concentrations. Species of fish chosen were: oyster toadfish, winter and summer flounder, white perch, menhaden and spot. Shellfish collected were the ribbed

mussels and hard clam. Composite samples (20 grams) of each species were placed in plastic (polyethylene) bags and kept frozen until time of analysis.

Sediment samples were collected periodically through the summer months (1974-1975 period) with a 6 inch Eckman bottom dredge. All samples were placed in plastic pint containers while in the field. Before 24 hours after collection, excess water was decanted from the sample. The remainder (mud) was placed in a drying oven at 70°C (15.8°F). The dry residue was then pulverized and stored in 6 oz. wide mouth glass jars until analysis.

Isohaline and Isotherm Distribution Study

Two simultaneous transects, initiating in Beach Haven Inlet and running north to Sandy Island, were conducted during two flood and ebbing tides. Surface water temperatures and salinity levels were measured during June and July at selected stations within the bay.

Water temperatures were recorded with a FT_3 Marine Hydrographic Thermometer and salinity levels were measured by titration with $AgNo_3$ (silver nitrate) for Chlorinity and convertide using Knudsen Tables.

Laboratory Equipment

Most of the equipment and procedures used in testing water samples have been described in Studies of the Great Egg Harbor System, 1971, and Studies of the Upper Barnegat System, 1972. However, there were some changes and shall be noted here.

All of the following analytical procedures are according to Standard Methods (13th edition, 1971).

Ammonia Distillation Method

Nitrite Nitrogen - Sulfanilic - Naphthylamine Acid Method

Nitrate Nitrogen - Ultraviolet Spectrophotometric Method

Orthophosphate - Stannous Chloride Method

Detergents - Methylene Blue Method (ABS)

B.O.D. (Biochemical Oxygen Demand) 5 day test

Total and fecal coliform counts - tests determined by New Jersey Bureau of Shellfish Control

Nitrate levels were detected on a Beckman DB-4V (visible spectrophotometer).

All other colorimetric tests were run with a Baush and Lomb Colorimeter Spectronic 20.

All pesticide samples (chlorinated hydrocarbons) were analyzed by the New Jersey Health Department with a Microtek 220 Electron Capture Gas Chromatograph equipped with a tritium detector. Samples were injected on three different columns: OU-17, SE-30 and OU-210 in order to verify and confirm the presence of pesticides in the sample. The method used to extract the pesticides in the sample is the official procedure found in the Methods of Analysis of the Association Official Analytical Chemist (A.O.A.C.), 12th edition.

All heavy metal levels (Pb, Cd, Cr. & Zn), except mercury, were measured on a Perkin Elmer Model 303 Atomic Absorption Spectrophotometer according to methods listed in Standardd Methods (13th edition). Mercury levels were detected with a Perkin Elmer Model 303 Atomic Absorption Spectrophotometer according to methods listed in A.O.A.C. (1973, Vol. 56, No. 2). Journal.

Transparency - Secchi disk (30 cm)

Seven Model D Waterproof Ryan Thermographs were used to record year-round water temperature data. This instrument has a recording span of 45 days and two centigrade ranges: -5^{o} to $+25^{o}$C and $+10^{o}$ to 40^{o}C. In order to change temperature ranges, the recorder had to be sent back to the company for calibration.

All recorders were housed in a protective pipe assembly (for detailes see Studies of Great Egg Harbor Bay and River, 1971). Only six recorder stations were selected and the seventh instrument was used as a spare. Location and depth were as follows: Beach Haven Inlet - Flashing Light, Red #92 (15 ft.); Little Egg Harbor - Long Point (14 feet); Manahawkin Bay - Flashing Light #6 (6 ft.); Lower Barnegat - Flashing Light #73 (7 ft.); Beach Haven West - System A, Lagoon #08 (7 ft.) and Dinner Point Creek (3 ft.).

Tidal data was obtained from the Coast and Geodetic Survey Tide Tables Atlantic Coast of North America. Coast and Geodetic Survey Charts with a scale of 1:24,000 and Nautical Chart 824-SC (1:40,000) were used for all bay and tributary morphometric measurements.

Linear measurements were obtained with the use of a map rotometer. All area measurements were computed with a Keuffel and Esser Compensating Polar Planimeter. Profiles were mapped with a Beckman Fathometer.

Description of Area

The Manahawkin Bay-Little Egg Harbor Watershed Study Area consisted of all water acreage of the Little Egg Harbor Bay, Manahawkin Bay, drainages of Dinner Point, Meyers Pond, Popular Point, Mill Creek, Beach Haven West Lagoon Complex and other tributaries such as Tuckerton Creek, Thompson Creek, Parker Run, Westecunk Creek and Cedar Run. This was a total of 26,247 acres surveyed; Little Egg Harbor-Manahawkin Bay comprising 97.4% of the total.

This estuarine system is located in the southern portion of Ocean County and is separated from the Atlantic Ocean by the land barrier Long Beach Island. The only access to the ocean from this area would be either through Beach Haven Inlet or Barnegat Inlet via Oyster Creek Channel and/or Double Creek Channel.

Islands and flats near Barnegat Inlet have restricted the amount of tidal water to enter or leave the Bay. Currents within this inlet are found to be rapid (4.2 ft/sec.). It was reported by Ichthyological Associates, 1972, that the tidal flow enters the inlet and splits into a northward flow to Bayhead and a southward flow to the Manahawkin causeway.

Beach Haven Inlet allows more tidal exchange as compared to Barnegat Inlet. Storm conditions are constantly altering the channel configuration in the Inlet and eventually effect the flow pattern. Such changes greatly determine the shape to the southern tip of Long Beach Island.

According to Charlesworth (1968) the flood current pattern in the Intracoastal Waterway channel behind the barrier Island is the major entering channel, as well as issuing channel, and Marshelder Channel is of intermediate importance. Some minor flow also passes through the numerous islands via Barrel, Middle and Hither channels.

Charlesworth also reported that the ebb current pattern in south Little Egg Harbor is interpreted to be that of a tidal drain, with the greatest centripetal drainage into the Intracoastal Waterway section behind the barrier island between Beach Haven and Holgate. Flow through Marshelder Channel from the southwest portion of Little Egg Harbor would be the next major drainage area. Table 109 lists maximum obseved current velocities in the vicinity of Beach Haven

Inlet. The tidal flow through Manahawkin Bay and Little Egg Harbor system is in a north-south direction. The tide is of the semi-diurnal type; there are two flood and two ebb tides in a normal day. Tidal influence extends to the Manahawkin causeway. The high water difference is 3 hours and 17 minutes from Little Egg-Beach Haven Inlet. Tidal range is 1.5-2.6 ft. North of the Manahawkin causeway, the tidal range is smaller - .8 - 1.5 ft.

The bay system is very shallow. At mean low water, the bay area ranges from 1/2 to 34 feet. From the 25,563 water acres, 88% are six feet or less in depth. Access through the 18 mile (statute) study area is provided by the Intracoastal Waterway which extends from Beach Haven Inlet northward along the eastern portion of the bay as far as channel light Flashing Red "34" (Brant Beach area). From here, it runs northwest to the Manahawkin causeway and changes again to a northeastern direction, which eventually leads to the lower Barnegat Bay region. A smaller channel running, parallel with the shore line, allows access to the western portion of the bay (Long Point northward to Manahawkin causeway).

The land barrier Long BeachIsland is approximately 21 miles long. The eastern bay shore is heavily developed; however, there are portions of this island that still contain undisturbed beaches, dunes and marshes. The only access to Long Beach Island is by the Manahawkin causeway. A great deal of the western bay shore still remains natural marsh. It is estimated that a total 15,922 acres of wetlands are located within the study area. Portions of this total acreage are part of the Great Bay Boulevard Wildlife Management Area (3,789 acres), and Manahawkin Wildlife Management Area (965 acres); both managed by the Division of Fish, Game and Shellfisheries.

Also included are Federally owned and/or managed property such as the wetlands extending south of Mill Creek (3,800 acres) and the Gunning River Refuge (3,506 acres) which is adjacent to the Manahawkin Tract.

Vegetation

According to the Wetlands Inventory conducted by the New Jersey Department of Environmental Protection, twelve plant species have been identified on wetland maps for the study area: Spartina alterniflora (tall and short salt marsh cordgrass), Spartina patens (salt meadow cordgrass), Iva Frutescens (hightide bush), Baccharis halimifolia (sea myrtle), Distichlis spicata (spike grass), Juncus gerardi (block grass), Parricum virgatum (switch grass), Scirpus olveyi (olvey's bulrush), Phragmites communis (common reed), Typha spp. (cattail) and Spartina cynosuroides (salt reed grass).

Marine Plants

There is very little information on the benthic flora for the Manahawkin Bay-Little Egg Harbor System. Studies have been conducted on marine algae for the Barnegat Bay system. Both Moeller (1964) and Loveland (1969 and 1972) have identified and listed marine algae for that system. Loveland (1969) reported that most algae in Barnegat Bay appear to be unattached and great masses of the dominant species drift with the currents along the bottom. From the total of 119 benthic algae species he identified, only 16 occurred over 50% of the time. The more dominant species included Ceramium fastigiatum, Gracilaria verrucosa, Ulva lactuca, Agardhiella temera and Codium fragile.

It has been reported by the New Jersey Department of Environmental Protection during a bay scallop population study that beds of

eel grass, Zostera marina, extend from Marshelder Island along the eastern portion of the bay northward into Barnegat Bay. During ecological studies conducted in the Little Egg Harbor area by Ichthyological Associates, 1973, it was reported the area off Beach Haven Heights to have sparsely rooted Zostera marina and Fucus sp. Floating mats of Ulva lactuca (Sea lettuce) were found to be very abundant. It was also reported the water area off 14th Street, Ship Bottom, to have both rooted (extensive beds) and floating Zostera. There were also some Entermorpha and Ulva present. Dr. McCurdy (1971) reported, during collection of sediment samples for his radiation surveillance program, finding both Zostera and Codium present in the waters near Surf City. Grasilana was also identified in the Tuckerton Cove area.

Along the western bay shore, Ichthyological Associates also reported Zostera beds near Cedar Run. Fucus was found along the banks and Ulva was observed floating throughout the area. Near the mouth of Parker Run, beds of Zostera were also present. Fucus was reported to be attached to the banks and Agarhiella sp. and Ulva were floating throughout the area. In Beach Haven Inlet, It was also reported Fucus, Zostera and Ulva to be floating, and not rooted.

Sisson (1968) reports that Codium fragile (Japanese Oyster weed) will attach itself to any hard stustrate including live oysters, oyster shells, mussels, sea scallop and bay scallops. It has caused mortality to the oyster and scallop population in Rhode Island waters. So far, it has become a nuisance on the clam beds of Barnegat Bay and Little Egg Harbor. The importance of Zostera and Ruppia being present within an estuary as noted by Odum (1961) that they are the primary producers providing food for aquatic organisms.

Marshland Development

Ever since the implication of the Wetlands Act of 1970, New Jersey has sought to control the permanent alterations or loss of remaining coastal wetlands. Ferrigno (1973) reported that during the past 20 years, 23.5% of the 263,000 acres of tidal marsh in New Jersey has been lost to development. Alteration may be several types; usually the most obvious is dredging and filling activities. The main purposes for dredge and fill operations are (1) to provide housing development and access near coastal bays and rivers (2) industrial development and access for transportation, and (3) navigation.

In a Lagoon Study conducted by Rutgers University (1972), it was reported that over 90% of the total development taking place along the New Jersey shore is located within Ocean County. Ferrigno (1972) reported from a total of 37,007 acres surveyed, 26,078 acres or 70.5% of the tidal marsh are still remaining.

Within the study area, there are 15,922 acres of tidal marsh-land (including all State and Federally owned land). This southern portion has had little development as compared to the remainder of the County. (see Studies of the Upper Barnegat System). Ferrigno (1974) reported that 2,139 acres of riparian land extending from Marshelder Channel to the Manahawkin Causeway (Route 72) had been filled. This development has been restricted primarily to the Manahawkin and Tuckerton areas. In this type situation, development is referred to as "lagoon type-single family summer dwelling".

It is interesting to note that within the Manahawkin area, Beach Haven West Lagoon Complex (Stafford Township) comprises 1,038.3 acres or 49% of the 2,139 acres of wetlands reported to

have been filled. In 1972, it was reported this area provided development for a total of 3,625 lots and 1,989 homes. Presently at least 3,000 homes have been constructed.

Of the sixty-two lagoon systems (Ocean County) identified by Rutgers University sixteen were situated within the study area. This would account for a total of 2,061.6 acres of lagoon systems. This would be 25% of the total lagoon development acreage that has taken place within this county. This was estimated to be 48,000 feet of developed shoreline. The total length of these lagoons was 221,950 feet and having the capacity for 7,106 homes. At present there must be nearly 4,000 built.

The Rutgers study also points out that Stafford and Little Egg Harbor Townships contain a relatively larger amount of lagoon development; Tuckerton and Long Beach contain a significant amount of lagoon development; while Union, Harvey Cedars, Ship Bottom and Beach Haven contain relatively little lagoon development. However, the only municipalities having shoreline but no lagoon development in this area, were Surf City and Eagleswood.

Sewage Treatment Plants

Lagoon type developments not only provide access to coastal areas, but as well accommodate a great number of people in relatively small areas. A great majority of these homes were originally constructed to provide recreational usage or summer housing. Treatment plants usually could handle year round loads. However, more of these summer homes are now being converted into permanent dwellings. The ever increasing number of people during the summer period as well as year round living has produced overloads that

septic systems and existing treatment plants cannot handle. This problem has been of great concern as to the water quality condition within our tidal bays and tributaries. Such conditions are a threat to the propagation and harvesting of shellfish within these waters. A very good example of this problem is the tidal waters of Raritan Bay.

The water quality of our coastal waters are now protected by the New Jersey Department of Environmental Protection and the U. S. Environmental Protection Agency. In the past most coastal homes were serviced by septic systems. State regulations covering the installation of wastewater facilities in critical areas, dated January 15, 1972, prohibit septic tank construction in New Jersey below elevation 10.0 (feet) U.S.C. and G.S. and other critical areas which are defined as those that at one time were below elevation 10.0 and have since been filled above elevation 10.0.

Some of the effects of Federal and State requirements in Ocean County are reported by Fellows, Reed, and Weber (1973):

1. Several areas in the county have been condemned for shellfishing.
2. Coastline communities which have in the past stored sludge during the summer for discharge to the ocean during the winter months have been placed under court order to stop this practice; and
3. The adoption of new stringent water quality standards by the State and the USEPA have precluded construction of even tertiary treatment plants which would discharge into the streams of the county.

At present time, Ocean County is in the process of updating existing treatment facilities, providing sewer lines and proposing

that all regional facilities (secondary treatment) will have ocean discharge. Ocean outfalls have been proposed for the Northern (via Mantoloking Boro) Central (via Berkeley Twp.) and Southern (via Surf City, Boro) areas within the County.

1. Barnegat Light and Harvey Cedars - A collection system has been proposed for the entire area of both boroughs.

2. Beach Haven - This Borough has been reported to be completely serviced with sewer lines. The existing primary treatment plant is servicing both the Borough of Beach Haven and the Holgate Section of Long Beach Island and discharging the effluent into the Atlantic Ocean. It is expected that the facility will be abandoned upon completion of the proposed regional system.

3. Ship Bottom and Surf City - These Boroughs are also completely serviced with sewer lines and the primary treatment plants which also discharge into the Atlantic Ocean will be abandoned. The Surf City treatment facility also serves the North Beach section of Long Beach Township.

4. Long Beach Township - This township has been divided into five sections and are as follows: High Bar Harbor, Loveladies, North Beach, Brant Beach and Holgate. Only the Brant Beach section is completely serviced with sewerage connection. This treatment facility (primary) which discharges into the Atlantic Ocean will be abandoned. The Holgate section is connected to the Beach Haven Treatment Plant and the North Beach section is connected to the Surf City Treatment Plants. Collection systems have been proposed for the remaining areas and will be linked to the regional system.

5. Union - This township has been reported to be in the process of forming a municipal utilities advisory group to plan the overall wastewater development of this area. Some of the existing developed areas are served by the Indianolo Treatment Plant in Ocean Township (see Studies of the Upper Barnegat System). An interim treatment facility has been approved by the County Sewage Authority of Barnegat Village, however this facility will be abandoned upon completion of the regional facilities.

6. Eagleswood - This Township is sparsely populated and there are no plans for construction of a collection system.

7. Stafford - The Township Municipal Utilities Authority is reported to operate a treatment plant which only services the Beach Haven West Lagoon Complex. This facility will also be abandoned.

8. Little Egg Harbor - It is reported that the majority of existing developed areas in the Township are serviced either by the Mystic Islands Treatment Plant (privately owned) or by the Tuckerton Municipal Utilities Authority. At present the Township proposing a master plan for wastewater management. The Mystic Island Facility will be abandoned upon completion of a regional system and there are plans to include a collection system with the regional facilities.

9. Tuckerton - The Municipal Utilities Authority operates a treatment plant (secondary) which is reported to serve the majority of the developed areas within the Borough as well as a small portion of Little Egg Harbor Township.

Table 110 lists data collected by Rutgers University on existing treatment plants that do provide service for developed (lagoon systems) areas situated within the study area. Table 111, also from this study, lists those particular systems that are now connected to these facilities. Approximately 56% or 9 out of 16 lagoon systems reported, are serviced by treatment facilities.

Shellfish

by Tom McCloy

On the basis of sewage pollution, this water system is one of the cleanest and most productive estuaries along the New Jersey coast. Of the 34,789 acres between Beach Haven Inlet and Barnegat Inlet only 2,480 acres are condemned for the harvest of shellfish. Another 902 acres are seasonally condemned, where harvest is permitted from January through April. This leaves a total of 31,407 acres, or 90% of this system, open to shellfishing throughout the year. Commercially important shellfish found within the system include the hard clam, Mercenaria mercenaria, bay scallop, Argopecten irradians, and blue mussel, Mytilus edulis. The soft clam, Mya arenaria and eastern oyster Crassoptrea virginica are also found within this system but are not of commercial importance.

Hard Clams, *Mercenaria mercenaria*

Hard clams are found in abundance in this estuary and support numerous commercial shellfishermen. This area also provides hard clams for thousands of recreational clammers (see Use Study). Harvest methods include: treading, tonging and raking. The areas harvested by the commercial shellfishermen extend from Cedar Run south to Tuckerton Cove, on the western side of the bay. A few commercial men also work in upper Manahawkin Bay. The seasonal water behind Long Beach Island is worked hard from January until the end of April. When it becomes warmer in the spring, wading becomes popular in the shallow areas of the bay that have high densities of clams.

In 1973 Ocean County produced 809,105 pounds of hard clam meats and in 1974, 923,530 pounds. Ocean County was responsible for 59.5% of the New Jersey hard clam landings in 1975 with a total of 964,785 pounds of meat. The majority of the landings in this county are harvested from within the Manahawkin Bay Little Egg Harbor system.

In the fall of 1972, an excellent set of seed clams were discovered on the flats behind Goosebar Sedge, in Little Egg Harbor. The flats are usually exposed at low water. Because of this fact it was felt a severe winter could destroy many of the clams if not harvested. To alleviate this problem, harvest of the legal size (1 1/2") clams was permitted until November. During this time most of the seed clams harvested were planted on leased ground in Atlantic and Ocean Counties. The clams originally taken from the Goosebar most likely contributed to the 1973 and 1974 hard clam landings in both Ocean and Atlantic Counties.

In the Manahawkin Bay-Little Egg Harbor system, there are over 1,500 acres of bay bottom leased to shellfishermen for the culture of shellfish. These grounds are used primarily as clam layout lots. Clams are planted on these layout lots and held for future use. The clammer may decide to hold the clams when the market is saturated or until their value increases. Some shellfishermen are experimenting with hatchery reared seed clams. Once the seed reaches a certain size it is planted on leased lots where they hopefully attain a marketable size. At present, this operation has not been successful.

Blue Mussel, *Mytilus edulis*

Blue mussel beds are found around the numerous islands in the southeast section of Little Egg Harbor. The most extensive beds are between Beach Haven Inlet and Foxboro Point. It is commonly found in the sides and bottom of channels and on marsh banks with hard substrates. This mollusk is a suspension feeder and depends on water currents to carry food particles to it.

Bay Scallop, *Argopecten irradians*

The bay scallop is another commercially important shellfish in Manahawkin and Little Egg Harbor Bays. They inhabit the extensive eelgrass beds from Marshelder Islands north into Barnegat Bay. Harvesting of bay scallops is accomplished by the use of dredges. Harvesting is restricted to the months from November through March and there is a daily limit. During the 1973-74 season the area from Marshelder Island north to Egg Island accounted for 100% of the bay scallop landings in New Jersey with a total of

76,889 pounds of meat. In 1975, bay scallops were not abundant enough to support a commercial fishery. Two hours required to catch one bushel as compared with the 1973-74 season when the ten bushel limit could be caught in three to four hours.

Soft Clams, *Mya arenaria* and Oysters, *Crassoptrea virginica*

There is a sparse scattering of soft clams on some of the sand bars throughout the bays. Most of the tidal creeks emptying into the system have remnant populations of oysters. Presently, there are no commercial quantities of soft clams or oysters within this system.

Figure 12 shows the distribution pattern of shellfish within the Manahawkin Bay-Little Egg Harbor system according to commercial value prepared by the U. S. Department of the Interior, Fish and Wildlife Service, 1963.

FINDINGS

Morphometric Data

Upper and lower boundaries of the Manahawkin-Little Egg Harbor Bay system were established arbitrarily for the purpose of survey and analysis as follows: (see Figure 4).

Upper Boundary: Farthest point north of Manahawkin Bay indicated by a line from the mouth of Gunning River across the Intracoastal Waterway to Harvey Cedars (channel flashing light R #2).

Lower Boundary: Indicated by a line across Beach Haven Inlet from Shooting Thorofare to the southern tip of Long Beach Island.

The data compiled included the following measurements and calculations according to Shuster 1959 and Welch 1948:

(1) Maximum Length (MXL):

15.9 Statute Miles; 13.8 Nautical Miles

Length of line connecting the two most extremities of the bay and crossing no land other than islands. In this case, a line from the tip of the Shooting Thorofare (Beach Haven Inlet) to Sandy Island (channel light #82).

(2) Maximum Effective Length (MXEL):

11.4 Statute Miles; 9.9 Nautical Miles

Length of straight line connecting the most remote extremeties of the bay along which wind and wave action occur without any kind of land interruption. In this case, it is a line from the cove adjacent to the southern tip of Long Beach Island north to the Manahawkin Causeway (U.S. Route 72).

(3) Maximum Width (MXW):

4.6 Statute Miles; 4.0 Nautical Miles

Length of a straight line connecting the most remote extremities of the bay and crossing no land other than islands. It is a line approximately at right angles to the maximum length axis. It is a line from the mouth of Tuckerton Creek (Flashing Red Light #17) to Holgate.

(4) Maximum Effective Width (MXEW):

4.2 Statute Miles; 3.7 Nautical Miles

Length of straight line connecting the most remote extremities of the width of the bay along which wind and wave action occur without any kind of land interruption. It is a line from the mouth of Thompson Creek to Liberty Thorofare.

(5) Mean Width (MEW):

2.5 Statute Miles; 2.2 Nautical Miles

The area of the bay divided by its maximum length.

(6) Maximum Depth (MXD):

34 feet; 10.4 meters; 5.7 fathoms

The maximum depth is known.

(7) Mean Depth (MED):

3.5 feet; .6 fathoms

The volume of the bay divided by its surface area.

(8) Mean Depth - Maximum Depth Relation (MED/MXD): 0.10

The mean depth divided by the maximum depth. This is expressed as a decimal value and serves as an index figure which indicates in general the character of the approach of basin shape to conical forms.

(9) Maximum Depth - Surface Area Relation (MXD/AS): .21

The maximum depth divided by the square root of the surface area. It is expressed as a decimal value and is an indication of the relation of depth to horizontal extent.

(10) Total Surface Area (AS)

39.9 Square Miles (Statute); 25,563 acres

Total surface area of the bay. Coast and Geodetic Survey Chart was divided into 14 sections to enable easier and more accurate handling of the planimeter. The results for each sector were combined to give the total area.

(11) Length of Shoreline (LSH):

East shoreline: 34.3 statute miles; West shoreline: 41.5 Statute miles; Total: 75.8 Statute miles.

The length of the shoreline enclosing the bay measured in statute miles.

(12) Volume (V):

3,861,946,790 cubic feet

28,889,370,202 gallons

Formula: $V=1/3\ (A_1 + A_2 + A_1A_2)h$

Where A is the area of the upper surface of a contour stratus and A_2 is the area of the lower surface of the same stratum, the height of the stratum is shown by h. The volume for each stratus is computed from the formula, the sum of the volumes being the total volume at mean low water (Reid 1961).

(13) Hypsographic Curve:

A curve constructed by plotting depth along the ordinate and area along the abscissa. Such a curve provides not only certain elements in the form of a basin, but it also provides a means whereby areas at any depth level may be determined (see Figure 15).

(14) Profiles:

These provide a pictorial representation of the basin configuration along a selected line. All the profiles selected were perpendicular to the ship channel and are illustrated in Figure 16.

Findings

All physical and chemical data collected from July, 1973 through February, 1974 and June, 1974 through May, 1975 are presented in Tables 1 to 188. This would also include all water quality data reported in the Fish Studies section.

Beach Haven Inlet

The inlet is relatively deep and narrow, permitting tidal water intrusion into the Little Egg Harbor - Manahawkin Bay system. Mud flats divide the area into two main channels (Marshelder Channel and the eastern channel) which parallel with the land barrier, Long Beach. Water depth within these channels at mean low water ranges from one-half foot to 34 feet. Currents within the inlet are found to be swift.

Station MB-1 was situated in the east channel, approximately 500 yards off the mouth of Big Sheepshead Creek. Water depth within the area ranged from 10 to 18 fet at mean low water with a bottom composition of hard sand.

Water temperatures at this station ranged from 3.5 to 24.0°C and air temperature from 1.0 to 31.0°C. (see Table 113). Salinity varied from 27.5 0/00 to 32.0 0/00. The pH readings were all basic (7.6 to 8.65). Dissolved oxygen concentrations ranged from 5.6 to 10.9 mg/l. Secchi disk depths ranged from three inches to ten feet.

B.O.D. levels ranged from .2 to 3.6 mg/l (see Table 147). Only traces of nitrite nitrogen were observed (<.005 mg/l). Nitrate nitrogen ranged from .28 to .65 mg/l. Ammonia levels were slight (0.0 to .3 mg/l). Orthophosphate levels ranged from 0.0 to .09 mg/l. Detergent levels ranged from .03 to .32 mg/l. All total and fecal coliform counts were <30.

Little Egg Harbor Bay - Manahawkin Bay

As was previously mentioned, the land barrier along the eastern portion of the bay extending from Beach Haven Inlet north to Barnegat Inlet is known as Long Beach Island. A great portion of this area

is developed (bulkheaded and filled in). On the other hand, the western portion of the bay still retains a great deal of natural shoreline and marshland (portions of which are Federal and State owned).

There were eleven water quality stations selected in the bay area, however two stations (MB-3 & -4) were dropped during the first survey period. See Figure 11 for the exact location of stations MB-2 to -11A. Depths ranged from half a foot to 25 feet at mean low water with bottom composition varying from hard sand to soft mud, detritus and submerged vegetation.

Water temperatures recorded ranged from -1.0 to 29.5°C and air temperatures from -4.0 to 35.0°C. (see Tables 114 to 124). Salinity varied from 19.8 to 30.8 0/00. The pH readings were all basic (7.1 to 8.45). Dissolved oxygen levels varied from 5.4 to 13.4 mg/l and percent saturation from 72 to 146%. Carbon dioxide values were from 0.0 to 13.4 mg/l. Secchi disk depths ranged from three inches to nine and one-half feet.

B.O.D. levels ranged from 0.0 to 5.8 mg/l (see Tables 148 to 154). Only slight traces of nitrite nitrogen were observed (<.005 mg/l). Nitrate nitrogen ranged from .22 to .94 mg/l. Ammonia levels were slight (0.0 to .3 mg/l). Orthophosphate levels ranged from 0.0 to .17 mg/l. Detergent concentrations ranged from 0.0 to .33 mg/l. Total coliform counts ranged from <3 to 750 and fecal coliform counts from <3 to 230.

Dinner Point Creek

This water system, along with the drainage from both Meyer's Pond and Popular Point, were selected as "natural" areas (all wetlands). Dinner Point Creek, the largest of the three streams is

located approximately four miles south of the Manahawkin Causeway (Rt. 72). Meyer's Pond and Popular are 2 and 1.7 miles, respectively. All three systems are tidally influenced from the upper portion of Little Egg Harbor Bay.

There were six stations selected in the "natural" area. Four were located in the main stem of Dinner Point Creek: DPC-1 (mouth), -2 (above the confluence of the second branch), -2A (approximately 950 yards upstream of station DPC-2) and -3 (end). Stations MP-0 (Meyers Pond) and PP-0 (Popular Point) were located at the mouth (see Figure 11). It should be noted that water quality measurements in these two systems included only the fish survey, bacterial and nutrient collections. Access to these areas was limited to high water. Dinner Point Creek was found to be extremely shallow; water depth ranging from 1/2 foot to four feet at mean low water. Bottom composition was soft mud, detritus and submerged vegetation.

Water temperatures recorded at these stations ranged from -.5°C to 30.0°C and air temepratures from -2.7 to 33.0°C. (see Tables 125 to 128). Salinity varied from 3.3 to 29.6 0/00. pH readings ranged from acid to basic (6.3 to 8.3). Dissolved oxygen levels varied from 0.0 to 12.3 mg/l and percent saturation from 0.0 to 124%. Carbon dioxide values were 0.0 to 36.3 mg/l. Secchi disk depths measured from six inches four to four and one/half feet.

B.O.D. concentrations ranged from 0.0 to 6.0 mg/l. (see Tables 155 to 158). Only slight traces of nitrite nitrogen were observed ($<$.007 mg/l). Nitrate nitrogen ranged from .04 to 3.98 mg/l. Ammonia levels were slight (0.0 to .3 mg/l). Orthophosphate

ranged from 0.0 to .11 mg/l. Detergent concentrations were from 0.0 to .34 mg/l. Total coliform counts ranged from <3 to 4,600 and fecal coliform from <3 to 750.

Mill Creek

This water system, although part of the artificial area, has been presented separately because it is the receiving waters for both the upland drainage of Manahawkin Lake and the effluent (secondary treatment) of the Stafford Municipal Utilities Authority.

The creek has been dredged to provide upstream access to lagoon housing. All lagoons along the upstream south shore are presently undeveloped (no bulkheading or housing present). All lagoons located along the upstream north area are developed (housing present although bulkheading may or may not be present).

Seven stations were selected in this water system. Stations MC-0, -1, -2, -3 and -6 were located in the main channel. Stations MC-4 and -5 were located at the distal end of an undeveloped and developed lagoon, respectively. See Figure 13 for exact locations. Bottom composition varied from soft mud to hard sand and detritus. Water depth measured ranged from 3 to 18 feet.

Water temperatures recorded at these stations ranged from -.5 to 30.5^{o}C and air temperatures from -4.0 to 33.5^{o}C (see Tables 129 to 135). Salinity varied from .3 to 27.1 0/00. pH values ranged from acid to basic (6.2 to 8.9). Dissolved oxygen concentrations ranged from 0.0 to 15.0 mg/l and percent saturation from 0.0 to 169 %. Carbon dioxide values were from 0.0 to 10.3 mg/l. Secchi disk depths recorded ranged from nine inches to five feet.

B.O.D. levels ranged from 0.0 to >12.2 mg/l (see Tables 159 to 162). Slight traces of nitrite nitrogen were observed (<.004 mg/l). Nitrate nitrogen ranged from .36 to .90 mg/l. Ammonia levels were slight (0.0 to .3 mg/l). Orthophosphate ranged from 0.0 to .06 mg/l. Detergent levels measured ranged from .03 to <.2 mg/l. Total coliform counts ranged from 3.6 to 4,600 and fecal coliform counts ranged from <3 to 2,400.

Beach Haven West Lagoon Complex

In order to simplify presenting data, this artificial area was sub-divided into the following: System A, B, C and D (see Figures 13 and 14). This complex is tidally influenced from Manahawkin Bay; none of these systems have any fresh water intrusion other than street runoff or housing effluent.

Almost all of the lagoons are developed (housing and bulkhead) with the exception of the lower portion of System D (area parallel to Mill Creek). At present homes are being constructed and the perimeter of this area will eventually be bulkheaded.

Eleven stations were selected within these systems and are as follows: System A - station BHW-7 was situated in the main channel and station BHW-8 was located near the mouth of lagoon #08. Station BHW-1 was situated below the confluence of Systems D & B. System B - station BHW-4 was located in the main channel whereas station BHW-5 was situated at the distal end of lagoon #15. Upstream station BHW-6 was mid-way in lagoon #24. System D - station BHW-2 was located at the distal end of undeveloped lagoon #43 whereas station BHW-3 was located in the main channel between lagoons #62 and #63. System C - station BHW-9 was located at the mouth and

station BHW-10 was upstream in the main channel, just below the mouth of lagoon #31. Station BHW-11 was located at the distal end of lagoon #37.

Water temperature recorded at these stations ranged from .4 to 30.0°C and air temperatures from 1.3 to 35.0°C (see Tables 136 to 146). Salinity ranged from 13.2 to 28.5 0/00. pH reading varied from slightly acid to basic (6.85 to 8.3). Dissolved oxygen levels were from 0.0 to 13.1 mg/l and percent saturation from 0.0 to 141%. Carbon dioxide values ranged from 0.0 to 11.2 mg/l. Secchi disk depths recorded ranged from one and one half to eleven feet and water depths measured were from four to 26 feet.

B.O.D. values recorded ranged from 0.0 to 6.2 mg/l (see Tables 163 to 169). Slight traces of nitrite nitrogen were observed (<.007 mg/l). Nitrate nitrogen levels ranged from .42 to 2.03 mg/l. Ammonia values were slight 0.0 to 0.4 mg/l. Orthophosphate ranged from 0.0 to .055 mg/l. Detergent concentration detected ranged from .09 to .30 mg/l. Total coliform counts ranged from 11 to 4,600 and fecal coliform from 3.6 to 1,500.

Tidal Creek Survey

Four out of the five tidal creeks selected were sampled during the two year study. Thompson Creek could not be worked into the schedule.

Tuckerton Creek

This water system is located in the lower western portion of Little Egg Harbor Bay. Saline water via Marshelder Channel greatly influences this region. The creek has been extensively developed and is the receiving waters from the upland drainage of

Tuckerton Lake and the effluent (secondary) of the Tuckerton Municipal Utilities Authority (see Table 110).

Seven stations were selected in this tributary. Station TC-0 was situated approximately 500 yards off the mouth. Stations TC-1 (Flashing Light "17"), -3 (near clam house), -5 (across from Hayes BP gas station), -6 (near Gulf Station) and -7 (below lake drainage) were located in the main stem and TC-2 (borrow pit) and -4 (near Daddy Tucker Drive) were in lagoons (see Figure 11).

Water temperatures recorded at these stations ranged from 2.0 to 27.0°C and air temperatures ranged from 2.0 to 27.0°C (see Table 170). Salinity varied from 1.6 to 29.8 0/00. pH readings ranged from slightly acid to basic (6.8 to 9.15). Dissolved oxygen concentrations ranged from 0.0 to 17.1 mg/l and percent saturation from 0.0 to 181 %. Carbon dioxide ranged from 0.0 to 25.5 mg/l. Secchi disk depths recorded ranged from one to six and one-half feet and water depths varied from three to 21 feet.

Parker Run

This tidal creek is located approximately 3 miles north of Tuckerton Creek. Most of the surrounding area remains in a natural state with the exceptions of an upstream site (partial upland and wetlands) along the southern shore and access road leading to a small developed region near the mouth (northern shore).

Six stations were selected in this system. Station PR-0 was located approximately 200 yards off the mouth. Stations PR-1 (Flashing Light "1") and -2 (near Cedar stakes) were situated in the main stem. Stations PR-3 (undeveloped cove), -4 (south branch) and -5 (end) were in the channel of the creek extensions (see Figure 11).

Water temperatures recorded in this system ranged from 3.0 to 24.0°C and air temperatures from 3.0 to 27.0°C (see Table 171). Salinity varied from 3.4 to 28.4 0/00. pH readings ranged from slightly acid to basic (6.8 to 8.72). Dissolved oxygen levels ranged from 0.0 to 16.9 mg/l and percent saturation from 0.0 to 170%. Carbon dioxide values ranged from 0.0 to 12.6 mg/l. Secchi disk depths varied from nine inches to seven feet. Water depth recorded ranged from three to 20 feet.

Westecunk (West) Creek

This tributary situated in Eagleswood Township is located about one mile north of Long Point (channel light #2). The south side of this creek has been extensively developed, however, most of the northern area still remains in a natural state. This system is the receiving waters of all drainage from the town of West Creek as well as the cranberry bogs further west.

Eight stations were selected in this system. Station WC-0 was situated approximately 150 yards off the mouth. Stations WC-1 (Flashing Light "3"), -2 (upstream of Flashing Light "6"), -3 (across from Texaco), -4 (bridge), -5 (adjacent to lagoon), -6 (above public launching ramp) and -7 (below Rt. 9) were all located in the main stream. See Figure 11 for exact locations.

Water temperatures recorded at these stations ranged from -.5 to 28.5°C and air temperatures from -1.5 to 34.0°C (see Table 172). Salinity varied from .4 to 28.6 0/00. pH values ranged from acid to basic (6.2 to 8.4). Dissolved oxygen concentrations ranged from 1.4 to 13.5 mg/l and percent saturation from 30 to 147%. Carbon dioxide levels ranged from 0.0 to 10.2 mg/l.

Secchi disk depths recorded ranged from one and one half to five feet and water depths sampled ranged from three and one-quarter to 10 feet.

Cedar Run

This water system is situated between Mill Creek and Dinner Point Creek. Except for some small homes, docks and an access road constructed along the northern shore, most of the surrounding area remains in a natural state (wetlands).

Six stations were selected in this system. Station CR-0 was situated approximately 600 yards off the mouth. Stations CR-1 to -5 were located in the main stream (see Figure 11).

Water temperatures in this system ranged from 1.0 to 28.3°C and air temperatures from -1.0 to 29.5°C (see Table 173). Salinity varied from 1.5 to 28.3 0/00. pH values ranged from acid to basic (6.0 to 8.3). Dissolved oxygen concentrations ranged from 3.2 to 11.9 mg/l and percent saturation from 45 to 114%. Carbon dioxide levels ranged from 0.0 to 11.7 mg/l. Secchi disk depths recorded ranged from one to four feet and water depths from one to eight feet.

Water Temperature

As was previously mentioned, six thermographs were placed in selected areas to record daily water temperatures over a 45 day period (see Figure 11). However, during the months of July and August and at some stations in September of the first survey period, data was lost due to time spent sending recorders back to the company for calibration. At the end of this first survey period (July, 1973 to February, 1974), the instruments were not pulled out while preparing an interim report. This allowed a complete recording of 12 months of data.

Figure 12 shows monthly mean, standard deviation and ranges of temperature for each station. This also shows that water temperatures during the survey periods, whenever recorded, ranged from -2.7°C to 29.4°C. It should also be noted that stations at Long Point, Manahawkin Bridge, and Lower Barnegat Bay during the month of August, 1973, water temperatures had exceeded the ranged on the tape (>25°C). This was due, as explained above, to a shortage of available instruments calibrated for the high range (+20 to +40°C) and the situation was not corrected until September.

Pesticide - Heavy Metal Analysis

Monthly fish collections showed it was very difficult to collect the same species consistently at selected stations. Even more so to collect a sufficient quantity of any species at a particular station. This was especially evident during the winter and some of the spring collections. Both sampling stations and fish species were selected according to their availability within specific areas.

Oyster toadfish, Opsomus tau, winter flounder, Pseudopleuronectes americanus, summer flounder, Paralichthys dentatus, Atlantic menhaden, Brevoortia tyrannus, white perch, Roccus americanus, and spot, Leiostomus xanthurus were the selected species in all chlorinated hydrocarbons and heavy metal analysis. The oyster toadfish and white perch made up 57 percent of the samples.

Hard clam, Mercenaria merceneria, and the Atlantic ribbed mussel, Modiolus demissus were the two shellfish species selected for the pesticide and heavy metal analysis. As was previously mentioned in the Shellfish Section, the hard clam is the most abundant and is consistently found throughout the bay system. The

ribbed mussel, on the other hand, is not commercially important but can be found along the sedge banks (intertidal) of most of the tributaries.

A total of 54 samples were sent to the State of New Jersey Fisheries Laboratory, Lebanon for analysis. Samples were analyzed for the chlorinated hydrocarbons L-BHC, lindane, aldrin, heptachlor, heptachlor epoxide, dieldrin, and DDT and its metabolites. Heavy metal analysis included cadmium, chromium, lead, zinc and mercury.

Results of residue analysis for the chlorinated hydrocarbons found in fish, sediment and shellfish are listed in Table 180 to 184. The data from these analyses are reported in microgram/kilogram (ppb). Results of heavy metal concentrations detected in fish, sediment and shellfish are listed in Tables 185 to 187. All data are reported in milligram/kilogram (ppm).

Slight traces of DDT and its metabolites were detected in 34.6 percent of the fish samples with values ranging up to 17 ppb. Only 20 percent of the shellfish samples showed any traces. None of the other insecticides were detected in either the shellfish or fish meat.

The chlorinated hydrocarbons insecticides, generally speaking are the most toxic to acquatic life. They are known to be very stable compounds and found to be very difficult to control once exposed to the environment. Some of the organochlorine pesticides, including some of their metabolites, are directly toxic at concentrations of less than 1 mg/l.

DDT and its metabolites were detected in 76.6 percent of the sediment samples. Concentrations ranged up to 69 ppb. The only other insecticide observed was heptachlor epoxide; detected in 33.3 percent of the samples.

Results showed that only one sediment sample collected north of the Manahawkin Causeway (RT. 72) had any detectable traces of DDT. The rest of the bay system along with Lagoon System D (Beach Haven West) did not show any pesticide level. All of the tributaries and Beach Haven West complex did show slight traces of DDT. Heptachlor expoxide, when detected, was also found with traces of DDT. The highest levels of DDT were observed at the farthest upstream station of Tuckerton Creek (receiving waters for Tuckerton Lake) and in Parker Run with 69 and 68 ppb, respectively.

The Bureau of Commercial Fisheries, at the Milford, Connecticut laboratory reported that DDT, toxaphine, and aldrin were found to be the most toxic to oyster and clam larvae. Lindane, on the other hand, was almost nontoxic to these larvae, but it inhibited the growth of plankton organisms in their food chain when present in low concentrations.

Smith (1972) reported DDT concentrations ranging from 1.15 to 3.70 ppm resulted in 55 to 98% mortality of winter flounder embryos and vertical deformaties were observed in 2-44% of the hatched larvae. Concentrations of heptachlor, endrin and lindane (0.3-0.4 ppb) killed or immobilized half of the adult commercial brown and pink shrimp (crustaceans) exposed in 48 hour laboratory tests. DDT and dieldrin showed similar effects at 1-6 ppb (Butler & Springer, 1963). In mollusks such as the oyster, Calabrese (1972) reported that DDT at 0.05 ppm caused over 90 percent mortality of oyster larvae and almost completely prevented growth in the survivors.

During Studies of the Upper Barnegat system (1972), DDT and its metabolites were detected in concentrations ranging up to 300 ppb in fish and 2,234 ppb in sediment. Such pesticide levels

detected in the fish samples for both estuarine (Upper Barnegat Bay and Little Egg Harbor-Manahawkin Bay) did not exceed FDA's established maximum level in fish for human consumption. However, it would appear that DDT concentrations recorded during this study are in sufficient quantities to have sublethal effects on estuarine organisms.

Heavy Metals

Analysis of the fish, shellfish and sediment samples showed that all five elements were present. Only slight traces (<0.01 ppm) of chromium were detected in the fish and shellfish meat. This was also evident for cadmium with the exception of two readings: .50 ppm and .75 ppm (detected in the hard clam and ribbed mussel, respectively). The concentrations of lead, zinc and mercury detected in the fish samples were comparable to the levels found in the shellfish samples. (see Table 18B).

Results also showed the hard clam to have slightly higher concentrations of zinc and mercury in the meat than the mussel. In fact, the highest levels observed in the edible tissue of both the fish and shellfish was zinc. Such levels were detected in white perch netted in Mill Creek and the Atlantic menhaden collected in the Beach Haven West Lagoon Complex. Hard clams collected in the bottom waters near Main Point, Manahawkin Bay had 20 ppm and the ribbed mussels taken from Parker Run was 17 ppm.

The heavy metal concentrations in the sediment were found to be much higher than the other samples. Chromium and zinc were detected in all thirty of the mud samples. Out of the five elements lead was found in the highest concentrations. Such concentrations were observed in the subaqueous samples collected at channel light

Flashing Green "21" and Meyer's Pond (197.5 ppb), Tuckerton and West Creek's (265 ppb), and channel light Flashing Green "53" and Cedar Run (237.5 ppb).

Results also showed that the upstream stations in most of the tributaries had higher levels of cadmium than the downstream sites (mouths).

The highest levels of mercury were detected in the bottom samples collected in Dinner Point Creek (2.75 ppb), Meyer's Pond and channel light Flashing Green "53" (2.07 ppb), Mill Creek (2.03 ppb), and Cedar Run (2.01 ppb). None of the fish nor shellfish analysis detected any high levels (<.4 ppb). In Studies of the Upper Barnegat system (1972), it was reported levels >1 ppm were detected in the bottom waters of Toms River near Pelican Island and in Forked River. Abnormally high levels of mercury are considered to be those exceeding the FDA established maximum of 0.5 ppm for food and 0.005 ppm for water. According to Julian (unpublished paper), hard clams taken from Barnegat Bay were found to have mercury levels ranging from 0.0 to 0.275 mg/kg in edible tissue and 0.0 to 0.3 mg/kg in the shell. Levels detected in the fish, and shellfish ~~and mud~~ are within the limits established by the FDA, however sediments limits had specified limits (FDA).

Metals reach the marine environment by many ways, including natural weathering as well as municipal and industrial discharges. These metals are, in varying degree, poisonous to humans and marine life, although some of them are essential in trace amounts to humans, as well as other animal life.

Dow and Hurst (1972) have summarized from the literature effects of heavy metals on marine resources:

Cadmium - Extremely toxic to oysters, less toxic to hard clams, and moderately to all other animals. Pringle (1968) reported a 15 week LC50 of 0.1 mg/l and inhibition of shell growth for Crassostrea virginica.

Damage to intestinal tract, kidney and gills of marine fish. It increases the toxicity of other metals.

Lead - Toxic to oyster gonads; also adversely affects hard and soft clam reproduction. Toxic to most enzyme systems. One hundred percent mortality to lobsters in tank. Inhibits one cell algal growth within .5 ppm in water 100 percent lethal in seven days. Oyster larvae killed by 3 ppm levels. Extremely toxic to soft clams above .02 ppm in water.

Zinc - Damage to gills of fish. Toxic to oysters in very small amounts.

Chromium - Not toxic except in large concentrations. This would also vary with valence state, form, pH, synergistic or antagonistic effects from other constituents and the species of organisms involved.

It would appear that some of the heavy metal concentrations recorded in this system are in sufficient quantities to have sub-lethal effects on estuarine organisms.

24 Hour Tidal Survey:

The objective of this study was to seasonably compare temperatures, salinity and dissolved oxygen distribution on an hourly basis for a period of twenty-four hours in a natural verses artificial system. Dinner Point Creek, selected as the natural area, was found to be very shallow (chart depths indicating 1/2 to 4 feet

at M.L.W.). However, just below the confluence of the first branch, water depths measured with a fathometer indicated about five feet at low water.

As was previously mentioned, the lagoon within the Beach Haven West complex does not receive any fresh water intrusion other than storm drains or effluent pipes associated with the lagoon type dwellings. The mouth of lagoon #08, situated in System A, was chosen as a station because of its close proximity to the bay area and easily accessible.

Results from this survey can be found in Figures 18 to 29.

In the natural drainage system where shallow depths are evident, it was found that air temperatures directly influence water temperatures. As one would expect, surface and bottom temperatures were similar. In the lagoon complex, this relationship was not evident. Surface and bottom readings varied throughout the survey. Water temperatures were stratified three out of the four periods. The spring survey revealed the greatest stratification; bottom waters remaining consistently colder with a 3.4 to 5.0°C difference over the 24 hour period. On the other hand, the fall survey showed little stratification (0.2°C difference). Water temperatures during the extreme periods (winter and summer) were found to be less stratified, generally evident from early morning till late evening. During the winter extreme, bottom waters were warmer than the surface (0.0 to 2.4°C difference); the summer was just the reverse. Vertical temperature difference ranged from .5 to 2.5°C.

The results indicated that the salinity distribution within the natural area is regulated by tidal flow and seasonal patterns.

During the summer survey, low stream flows produce salinity levels ranging from 22.6 to 27.3 0/00. But during the spring, (high flow period), salinity levels recorded ranged from 19.1 to 27.3 0/00. There was little variation between surface and bottom during the seasonal sampling.

Unlike the cyclic salinity patterns observed in the tidal creek, the salinity distribution in the lagoon area was found generally to be uniform; with little variation. It would appear concentrations are dependent on wind agitation and seasonal dilution. Salinity levels, during the summer survey, ranged from 24.5 to 25.8 0/00; whereas, the spring survey showed concentrations ranging from 24.1 to 24.6 0/00.

On the other hand, dissolved oxygen profiles within the natural area appeared to be regulated according to seasonal conditions. During the summer survey, dissolved oxygen levels were cyclic ranging from 2.0 to 7.5 mg/l. Oxygen levels are normally regulated by tidal flows and periods of photosynthetic activity. It would appear during this period though, that peak levels exist during flood tides; regardless of illumination (see Figure 28). Concentrations below 4.0 mg/l were recorded only during the early morning hours. There was little variation over a twenty-four hour period. Concentrations ranged from 8.0 to 10.1 mg/l with the decline in levels recorded during the early morning.

In the artificial area, oxygen levels were found to be extremely stratified during both the summer and spring surveys. Bottom concentrations during these periods were found to be variable as compared to the surface (0.0 to 8.0 mg/l). This condition was

not evident during the other periods. Surface levels during the survey appeared to be regulated by wind agitation and seasonal patterns. Concentrations did not fall below 5.0 mg/l.

The distribution of temperature, salinity, and dissolved oxygen recorded in the artificial system seem to indicate circulation within the area to be very poor at times. The water quality of such an area would be dependent on climatic conditions. Bottom waters were found during the spring and summer surveys to be at times completely void of oxygen. Such anaerobic conditions cannot continuously support a good benthic population. Thermal stratification was evident during three out of the four periods. Such conditions observed in some dredge holes (borrow pits) have been reported to attract over wintering finfish such as the white perch (see Mullica River Report, 1969). More research would be needed to completely evaluate the benefits of stratification within areas for over wintering populations. However, it has been observed that the white perch is one of the more common species found in the artificial systems (see Fish Studies for more details). The fluctuation of anoxic conditions observed during the spring and summer periods within the area would not be considered good water quality criteria for most of your living organisms. Only your more tolerant species could exist (e.g. eels and blue claw crabs).

Isohaline and Isotherm Distribution

Figures 30 to 33 present isohaline and isotherm distribution patterns mapped both on an incoming and falling tide during the summer season.

Discussion

Water temperatures recorded during the two survey periods (July 1973 - February 1974; and June 1974 - May 1975) ranged from -2.7 to 30.5°C. As one would expect, the lowest extremes were observed during the months of January and February; with the latter being the coldest month. The minimum temperature of -2.7°C was recorded in Dinner Point Creek. It is interesting to point out that this was the only system where water temperatures fell below 0.0°C for five consecutive months (December 1974 through April 1975). This tributary is very shallow and found with water depths ranging from 1/2 to four feet at M.L.W. (mean low water). As was reported during the 24 hour tidal survey, water temperatures are greatly affected by air temperatures.

Temperatures below 0.0°C were also recorded at stations WC-0, MC-0 and T-8 (-.5°C); MB-9 and T-8 (-1.0°C); and thermograph station located near Long Point (ranging from -2.2 to -1.7°C). Water temperatures at or above 29.5°C (85°F) were observed at the following stations: MB-8, MB-0, MC-0, PP-0, BHW-6 and -10 (29.5°C); DPC-3 and BHW-5 (30.0°C); and MC-6A (30.5°C). The maximum temperature of 30.5°C was recorded in Lagoon #91 (MC-6A), Mill Creek during the month of August.

Temperatures monitored at Beach Haven Inlet (Flashing Light "92") were considered representative of ocean temperatures. The inshore bays, characteristically shallow, are greatly influenced by climatic temperatures. The data shows that seasonal trends were consistent within this system as observed during previous studies conducted within the coastal waters of New Jersey. During the summer, ocean waters are found to be cooler than inshore regions.

However, in September average water temperatures were found to be similar with the exception of Dinner Point Creek (see Figure 34). Temperatures observed in this tributary were somewhat cooler as compared to the other areas. This trend was observed during the periods October to March (1973-74) and September to April (1974-75). Generally, water temperatures gradually decreased at the end of September through to December. Whereas in January and February, severe cold conditions caused abrupt changes in water temperatures. Mean temperatures in March steadily increased into the warmer months.

Water temperatures along the western portion of the bay are greatly influenced from the tributary drainages (see Figure 34).

The bay area showed very little vertical temperature difference; generally not differing more than .6°C. The only exception was a difference of 1.3°C recorded during September 1973. Typically, during the warmer months, water temperatures tended to increase from Beach Haven Inlet to the Manahawkin Causeway. During the winter period, water temperatures in the bay area were less stratified.

Thermal stratification was evident during both the summer and winter periods in some of the artificial systems. Late spring and summer temperatures were found to be much more stratified with bottom temperatures showing more variability than the surfce e.g. station BBW-2, -3, -6, -8 and MC-5. The bottom waters of station BBW-6 was observed with highest vertical temperature difference of 16.7°C. Stations BBW-3, -6 and -8 showed that stratification was not limited to the distal end of a lagoon.

Not all stations within the artificial complex were found to be thermally stratified. Only station BBW-6, the farthest

upstream in System B, was consistenly stratified throughout the study. This was also evident in the channel of Mill Creek, but to a lesser degree.

Salinity patterns were similar to water temperature stratification observed in Mill Creek insofar as the effects of fresh water intrusion in this system. It is interesting to point out, that the bottom waters of lagoon stations MC-4 and MC-5 were found to have salinity levels greater than the downstream channel station MC-3.

In the lagoon complex, vertical stratification was less pronounced but nevertheless evident. Bottom levels measured in some lagoons were also found to be higher than the downstream station, e.g. station BBW-2, -3, -6 and -8.

In the bay, salinity levels recorded for the surface and bottom waters were found to be similar; vertical differences never exceeding 2.1 0/00. Maximum salinity levels were recorded at Beach Haven Inlet (32.0 0/00). This station had a range of 27.5 to 32.0 0/00. The salinity differences from Beach Haven Inlet to the Manahawkin Causeway (Rt. 72) was never more than 8.9 0/00. Except for one reading of 19.8 0/00 levels never fell below 20.0 0/00.

Generally, average levels between tidal stages within the artificial areas were similar (see Figure 35). Overall averages from June through to December ranged from 24 to 25.5 0/00 with the exception in September, levels were around 23.0 0/00. From mid-winter through spring, when climatic conditions influence tidal dilution, average levels fell between 21.0 to 22.0 0/00.

Average salinity levels were higher in Dinner Point Creek as compared to Mill Creek. However, average levels were somewhat higher in the artificial areas than the natural system. Station DPC-3, the farthest upstream in Dinner Point Creek was found to have the greatest salinity fluctuation (3.3 to 26.2 0/00). Station MC-6, the farthest upstream station in Mill Creek was observed to have a range of .3 to 14.7 0/00.

Oxygen levels recorded in the artificial systems were found at times, as the water temperatures, to be extremely stratified and variable. This condition was not evident at those stations situated at the mouths of the lagoon complex (e.g. stations BHW-1 and -9).

All of the submerged waters within the artificial system (excluding stations BHW-1, -5 and -9) were found at some period of the survey to have oxygen levels less than 3.0 mg/l. Such concentrations are critical for many living organisms. This also was true for stations MC-4 and -5 located in Mill Creek.

Anoxic conditions (<1.0 mg/l within the lagoon complex) were found at depths ranging from seven to 26 feet. Almost 50% of these readings were observed at water depths over 15 feet (depths usually observed in the channel). Depths less than 15 feet were found at the distal end of the lagoons. Station BHW-6, in System B was found only during the months of October and November with oxygen levels above 4.0 mg/l. The rest of the months, bottom waters were void of oxygen.

In the bay, some stratification was evident but to a lesser degree. Surface oxygen levels were found to vary. Levels recorded in the lower bay area were generally lower than concentrations observed in the upper regions. This was probably attributed to

seasonal trends and/or climatic conditions. Concentrations were never detected below 5.4 mg/l.

In the natural area, oxygen levels below 5.0 mg/l were measured during the studies. This was very evident during the summer months and to a lesser degree in the fall. It is interesting to note that levels as low as 2.8 mg/l were observed during the fall sampling of the first study period. Normally, oxygen levels during this time of the year are found to be around 9.0 mg/l. The data shows that the farthest upstream station (DPC-3) was observed with reduced levels throughout the year. The second study again showed reduced oxygen levels in this system. Except for stations DPC-3 (farthest upstream) the data suggests reduced levels to be consistent with ebbing tides or low water conditions. It would appear from the reduced levels observed at this station, the area during certain periods of the season to be stressed.

Mill Creek, being deeper, only once was the bottom waters within the main channel found with levels below 3.0 mg/l. However, stations MC-4 (undeveloped) and MC-5 (developed lagoons), both located within Mill Creek system, were found with oxygen levels greatly stratified. Bottom waters were generally found greatly reduced or void of oxygen. Surface levels during the summer period were found to be extremely high (15.0 mg/l). Such conditions would suggest algae problems.

High surface dissolved oxygen levels were also observed in Tuckerton Creek and Parker Run. Oxygen levels of 15.0 mg/l or more were observed in Tuckerton Creek at stations TC-2 (16.2), -4 (16.8) and -5 (17.1) during October. In Parker Run, at station PR-4, high levels were observed in February (15.9) and April (16.8). There were other stations exhibiting unusual high surface oxygen levels

as compared to the time of the season; however, such concentrations did not exceed 15.0 mg/l. Such concentrations were observed at stations TC-4 (14.4), -5 (10.3), -6 (13.3) during July and in Parker Run at stations PR-3 (12.6 & 13.1), -4 (14.5) and -5 (14.9 & 12.2) during April. Anoxic conditions were also observed in some of the bottom waters of these two tributaries during the summer period (e.g. stations TC-2, -6, PR-4 and -5).

The waters of Westecunk Creek and Cedar Run were also found to be stratified. Reduced oxygen levels, evident primarily during the warmer months, were limited to the upstream stations of both tributaries (e.g. stations WC-3, -4, -5 and CR-2 and -3).

All pH levels measured in the bay were near or basic. There was little difference between surface and bottom readings. Maximum levels recorded in the bay were found in the waters at stations MB-1 (8.65) during August, MB-5 (8.5) and T-2 (10.0) during October and MB-9 (8.5) during October and May.

In the natural area, pH readings ranged from slightly acid to basic with the exception of station DPC-3, where levels were found to vary from acid to near basic.

In the artificial system (lagoons), pH levels ranged from slightly acid to basic. Readings above 8.5 were only recorded in Mill Creek at stations MC-3 (8.7), -4 (8.5, 8.8 and 8.9) and -5 (8.5 & 8.9). Except for station MC-4 with a reading of 8.8 recorded in July, all the other values were measured during August. Mill Creek was also found with the lowest pH of 5.7, recorded at station T-18.

Readings above 8.5 were also observed in Tuckerton Creek and Parker Run. The highest recordings measured in the tributaries during the two study periods were at station TC-6 (9.0 and 9.15)

during the month of July. Other readings taken during this period were measured at station TC-2 (8.55) and TC-5 (8.65). In Parker Run, during April, pH values of 8.72 and 8.5 were taken at station PR-4 and -5 respectfully.

Average surface carbon dioxide concentrations were lowest in the bay area as compared to the other systems (see Figure 37). Both Mill Creek and Beach Haven West were found to be similar, insofar as levels were lowest during the summer months followed by a slight increase going into the winter months. A gradual decrease in February was followed by an abrupt increase in April but quickly decreased going into May. In Dinner Point Creek average levels were found to the reverse. During the summer, carbon dioxide gradually increased up until August and gradually decreased going into the winter period. From February through June, levels remain very similar. The highest concentration was detected at station DPC-2A (36.3 mg/l).

Average secchi disk depths were found to higher in the artificial system as compared to the natural areas. Except for maximum depths recorded at stations BHW-2 (8'6"), -7 (11') and -8 (10') during the first survey, depths never exceeded 6'6" during the second period. Dinner Point Creek being shallower with a soft mud bottom, was found at times to be extremely turbid. Light penetration never exceeded 4'6". Average readings ranged from 1 to 2 feet.

Transparency values generally were high in the bay. Maximum depths or areas of greatest light penetration were observed in Beach Haven Inlet at ten feet (MB-1) and Sandy Island at 9'6" (MB-11A).

Biochemical Oxygen Demand (B.O.D.) values recorded during the two study periods were found to be good. Generallly, average B.O.D. levels were high during the summer period but gradually dropped going into the fall (see Figure 38). However, during November, high readings caused an abrupt increase followed by a decrease going into the spring. It has been suggested that a clear stream or harbor should not have a B.O.D. of greater than 4.0 ppm, (Lackey, 1958). Only during the second study period did concentrations exceed 4 mg/l.

In the artificial systems, B.O.D. values generally were found to be higher than the natural area. The drainages (main stem) of Mill Creek and Dinner Point Creek had similar average levels. However, station MC-6A (lagoon #91) located in Mill Creek, was found during November to have a B.O.D. value >12.0 mg/l. On the other hand neither Dinner Point Creek nor the bay area were found with concentrations exceeding 6.0 mg/l.

Nitrite nitrogen was analyzed only two months during the two studies. Concentrations detected were negligible (.036 mg/l was the highest level detected).

The nitrate values recorded during the first survey period (July '73 to February, 1974) were found to be extremely high. Such unusually high readings were considered unrealistic and were omitted from the data. Data collected during the second survey showed Dinner Point Creek to have higher nitrate levels than the artificial systems. Peak levels (.97-3.98 mg/l) were observed at the farthest upstream station, DPC-3. Concentrations were found to be consistently higher at this station. The data

also showed average levels recorded in Mill Creek to be slightly lower than the bay. The highest level observed in the Bay was .94 mg/l recorded at station MB-9.

Ammonia levels, when detected, were found to be very slight (0.0 to .4 mg/l). During the first survey period, traces were found to be similar. The only exception was during the month of January (0.0 - .28 mg/l). Concentrations were found to be lower during the second period as compared to the initial survey (0.0 - 0.16 mg/l). It was during the second study that no traces of ammonia were detected in the bay area. The only levels observed in Dinner Point Creek were detected at station DPC-3. With the exception of one reading (<.01), the artificial systems did not show any traces during the second period. In Mill Creek, only the stations MC-3, -4 and -5 located above the sewerage treatment facility did show traces.

Small amounts of the soluble form of phosphate were detected (0.0 - .17 mg/l). During the first survey period, average levels were highest in September. The second period showed maximum levels were during the month of November. It was also during this month that the highest level of .17 mg/l was recorded at station MB-7.

Detergent (MBAS) levels detected during the 1973-74 survey were all <.2 mg/l. Because of such low levels it was decided during 1974-75 period to only survey a few selected stations. During this second survey period, concentrations were found to range from 0.0 to .34 mg/l. The effect of detergent concentrations of .5 ppm of fish life is believed to be minimal (Eisler, 1965).

Detergent values recorded were highest during the months of September, October and November. It was during the month of

October that the highest reading of .34 mg/l was recorded at station DPC-3.

As was reported in the Shellfisheries Section, the waters of the Manahawkin Bay-Little Egg Harbor system were found to be very productive for both the commercial and recreational clammer (also see Use Study). The State of New Jersey Health Department, Bureau of Shellfish Control, located at Leeds Point, Absecon, routinely inspects and analyzes the water quality of New Jersey's coastal bays and waters. Contamination is determined by the number of coliform bacterial counts. The total coliform median MPN (most probable number) of the water does not exceed 70 per 100 ml, and not more than 10% of the samples ordinarily exceeds MPN of 230 per 100 ml for a five-tube decimal dilution test. However, there are other factors that also must be taken into consideration before a particular area is classified. It is equally important to conduct a hydrographic study of an area and if necessary to also include shoreline investigations. Even if the bacterial counts may be considered good, an area could be closed if other factors prove to be a danger to public health (Eisle, phone communication).

Naturally, overlying waters of shellfish areas are classified by standards developed by the U.S. Public Health Service and member States of the Cooperative Program, for Certification of Interstate Shellfish Shippers. The accepted standards are:

0-70 Coliform bacteria per 100 ml of water - Clean

71-700 Coliform per 100 ml of water - Moderately Contaminated

Over 700 Coliform per 100 ml of water - Grossly Contaminated

Tables 174 to 179 lists coliform density in MPN/100 ml (most probable Number per 100 milliliters). Results indicate that coli-

form counts did exceed 700 in the Manahawkin Bay-Little Egg Harbor System (see Tables 188A & 188B).

In the bay areas both total and fecal coliform counts were low except for one total coliform count reading (750) observed at station MB-5 during August. However, in the natural area (Dinner Point Creek drainage) several high total coliform readings were observed during the two survey periods (930 to 4,600). Readings were consistently high at station DPC-3 during the summer and fall period. An attempt was made to try to determine what was the contributing source of pollution. Unfortunately only one successful run was made to establish a fecal coliform-streptococcus ratio. No conclusive interruption could be made at this point. This particular test was conducted during a period of low readings (total coliform counts). However, the results have suggested that there are traces of human influence. This area is also reported to support a good wildlife population. The low dissolved oxygen concentrations that have been monitored throughout the survey at this station may further indicate stress conditions. Before any conclusions on whether present upland development could be a source would necessitate further research.

In Mill Creek, high tidal coliform counts were observed during September (930 - 4,600) and once during November (1,100). The maximum value of 4,600 was recorded at station MC-5 (lagoon 98). As was previously mentioned, this system is the receiving waters for the treated effluent (secondary) of the Beach Haven West Sewage Treatment Facility and drainage from Manahawkin Lake. During September, high readings were observed both below and above treatment plant and as well from upland drainage.

High fecal coliform counts were also recorded periodically in this drainage (91-2,400). The frequency of readings were greater as compared to total coliform counts. The fecal streptococcus tests, although limited, did suggest both human and animal influence.

Several high total coliform counts were measured in the artificial complex (930-4,600). Readings were found to be very sporadic. It is most probable, as suggested by fecal streptococcus tests, that the dock population utilizing these lagoons were the major factor.

Summary

The Manahawkin Bay-Little Egg Harbor System study was conducted within the following boundary lines: the farthest point of Manahawkin Bay indicated by a line from the mouth of Gunning River across the Intracoastal Waterway to Harvey Cedars; the southern portion indicated by a line across Beach Haven Inlet from Shooting Thorofare to the southern tip of Long Beach Island.

The survey concentrated on Little Egg Harbor Bay, Manahawkin Bay, drainages of Dinner Point Creek, Meyer's Pond, Popular Point, Mill Creek and Beach Haven West Lagoon Complex. Also included were tributaries such as Tuckerton Creek, Parker Run, Westecunk (West) Creek and Cedar Run. Water acreage for these areas surveyed were a total of 26,247.

The bay volume consisted of 28,889,370,202 gallons with a mean depth of 3.5 feet and a shoreline length of 75.8 statute miles.

It was estimated that a total of 15,922 acres of wetlands are located within the study area. Portions of this acreage that are State owned are the Great Bay Boulevard Wildlife Management Area (3,789 acres) and Manahawkin Wildlife Management Area (965 acres). Also included are Federally owned and/or managed property such as the wetlands extending south of Mill Creek (3,800 acres) and the Gunning River Refuge (3,506 acres) which is adjacent to the Manahawkin Tract.

According to the Wetlands Inventory by the New Jersey Department of Environmental Protection, twelve plant species have been identified in the study area: Spartina alterniflora (tall and short salt marsh cordgrass), Spartina patens (salt meadow cordgrass), Iva

Frutescens (hightide bush), Baccharis halimifolia (sea myrtle), Distichlis spicata (spike grass), Juncus gerardi (black grass), Parricum virgatum (switch grass), Scirpus olveyi (olvey's bulrush), Phragmites communis (common reed), Typha spp. (cattail), and Spartina cynosuroides (salt reed grass).

There has been very little development in the study area as compared to the remainder of Ocean County. Major development (2,139 acres) has been restricted primarily to the Manahawkin and Tuckerton area.

A total of sixteen lagoon systems have been identified. This would account for 2,061.6 acres of development resulting in 48,000 feet of developed shoreline.

This water systems is one of the cleanest and most productive estuaries along the New Jersey coast. Of the 34,789 acres between Beach Haven Inlet and Barnegat Inlet, only 2,480 acres are condemned. Commercially important shellfish found within the system include the hard clams, Mercenaria mercenaria; bay scallop, Argopectin irradians; and blue mussel, Mytilus edulis. Of these, the hard clams is the most important. Because of its abundance, the hard clam supports more shellfishermen than any other shellfish within this system. The soft clam, Mya arenaria and eastern oyster, Crossoptrea virginica are also found within this system but are not of commercial importance.

Water temperatures ranged from -2.7 to 30.5°C. The data shows that seasonal trends were consistent within this system as observed during previous studies conducted within the coastal waters of New Jersey. The lowest extremes were recorded during the months of January and February and the highest extremes during

August. The bay area showed very little vertical temperature difference; generally not differing more than .6°C. Thermal stratification was evident during both the summer and winter periods in some of the artificial systems. Some bottom waters had a temperature difference of 16.7°C.

Salinity ranged from .3 to 32.0 0/00 with the highest averages observed during the fall months. In the bay, salinity levels recorded for the surface and bottom water were similar; vertical differences never exceeding 2.1 0/00. The salinity difference from Beach Haven Inlet to the Manahawkin Causeway was never more than 8.9 0/00. Except for one reading of 19.8 0/00, levels never fell below 20.0 0/00.

In the lagoon complex, vertical stratification was less pronounced but nevertheless evident. Bottom levels measured in some lagoons were also found to be higher than the downstream station.

The maximum salinity fluctuation recorded in the surface waters at any one station was station DPC-3, the farthest upstream sampling location in Dinner Point (3.3 to 26.2 0/00).

Dissolved oxygen levels ranged from 0.0 to 17.1 mg/l. In the bay, some stratification was evident but to a lesser degree. Concentrations were never detected below 5.4 mg/l. However, in Dinner Point, levels below 5.0 mg/l were measured during the summer month and to a lesser degree in the fall. Reduced oxygen levels were consistently observed at station DPC-3 (farthest upstream) during a falling tide.

All of the submerged waters within the artificial systems (excluding BHW-1, -5 and -9) were found at some period of the survey to have oxygen levels less than 3.0 mg/l. Anoxic conditions (<1 mg/l) were found at depths ranging from seven to 26 feet.

Nearly 50% of these readings were observed at water depths over 15 feet (depths usually observed in the channel). The bottom waters of station BHW-6 in System B was found only during the months of October and November to show oxygen levels above 4.0 mg/l.

Mill Creek, on the other hand, only once was the bottom waters within the main channel found with levels below 3.0 mg/l. Lagoon stations MC-4 and MC-5, both located in this tributary, were generally observed with bottom waters greatly reduced or void of oxygen. During the summer period, surface levels were found to be extremely high (15.0 mg/l).

High surface levels (15.0 mg/l or more) were also observed in Tucckerton Creek and Parker Run during various portion of the survey.

pH readings throughout the Manahawkin Bay-Little Egg Harbor system ranged from 5.7 to 10.0. Normally readings did not go over 8.5 except during the months of July and August.

"Free" carbon dioxide levels measured, ranged from 0.0 to 36.3 mg/l. Generally average levels for the system were highest during the warmer months and minimal during the winter.

Secchi disk depths ranged from three inches to eleven feet. Transparency values were generally high in the bay. Average readings were found to be higher in the artificial system as compared to the natural area (Dinner Point Creek). Dinner Point Creek being shallower with a soft mud bottom, was found at times to be extremely turbid. Light penetration never exceeded 4'6".

Biochemical Oxygen Demand (B.O.D.) values measured during the two study periods were found to be good. Generally, average levels were high during the summer period but gradually dropped going into the fall. Levels ranged from 0.0 to 12.0 mg/l.

Nitrite nitrogen (.036 mg/l maximum) and ammonia levels (0.0 to .4 mg/l) were found to be very slight.

Nitrate levels recorded during the second survey, ranged from 0.0 to 3.98 mg/l. High concentrations (.97 to 3.98 mg/l) were consistently measured in Dinner Point Creek (station DPC-3). Generally, levels in the system were found to be higher during the fall rather than the winter season.

Small concentrations of orthophosphate were detected (0.0 - .17 mg/l). The highest level being recorded in the bay at station MB-7.

Slight traces of detergent were detected within this system ranging from .0 to .34 mg/l.

Bacterial monitoring program showed that total coliforms counts ranged from <3 to 4,600 MPN/100 ml and fecal coliform from <3 to 2,400 MPN. In the bay areas both total and fecal coliform were generally low. However, high coliform counts of 4,600 were observed in Dinner Point Creek, Mill Creek and in the Lagoon Complex. Before any conclusion can be made to determine whether animal or human influence may be a contributing factor; would necessitate further research.

Results of residue analysis for the chlorinated hydrocarbon showed slight traces of DDT and its metabolites were detected in 34.6% of the fish samples with values ranging up to 17 ppb. Only 20% of the shellfish meat showed any traces. None of the other insecticides was detected in either fish or shellfish meat.

DDT and its metabolites were detected in 76.6% of the sediment samples. Concentrations ranged up 69 ppb. The only other insecticide observed was heptachlor epoxide; detected in 33.3% of the samples.

Analysis of fish, shellfish and sediment samples showed that all five element were present. Only slight traces (<0.01 ppm) of chromium and cadmium were detected in the fish meat. Lead ranged from 0.0 to 6.1 ppm, zinc from 5.65 to 16.85 ppm and mercury from 0.0 to 0.4 ppm. Only slight traces of chromium (<0.01 ppm) were as well detected in the shellfish samples. Cadmium ranged from <0.01 to 0.75 ppm; lead ranged from 0.0 to 5.7 ppm; zinc ranged 2.5 to 20.0 ppm and mercury from 0.0 to 0.29 ppm.

In the sediment samples; cadmium ranged from 0.0 to 3.0 ppm; chromium from 3.0 to 50.0 ppm; lead from 0.0 to 297.5 ppm; zinc from 2.0 to 66.6 ppm and mercury from 0.0 to 2.75 ppm.

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Phase III, Use Study

by

Peter J. Himchak

ABSTRACT

The Use Study of the Manahawkin Bay - Little Egg Harbor System was designed to determine the ways in which the estuarine system is used, the estimated total man-days of activity for each major type of user-group, expenditure estimates for various user-groups, and an estimated resource harvest for the entire system.

Aerial surveys, bag and creel surveys, and expenditure surveys were the three integrated survey methods utilized to obtain data for the above determinations.

For the eight month study period, July 1973 to February 1974, resultant tabulations show that an estimated 158,269 man-days of activity had occurred within the study area and an estimated 446,754 fish (including crabs), 14,365,902 shellfish and 306 waterfowl were harvested at an estimated cost to those involved of $835,222.55.

During a second sampling period from June 1974 to May 1975, excluding November and December 1974, an estimated 230,326 man-days of activity occurred within the study area with an estimated total harvest of over 450,000 fish (including crabs) and over 19 million hard clams. An estimated $2,206,033.04 were spent by those persons using the study area during this time period.

INTRODUCTION

The Use Study of the Manahawkin Bay - Little Egg Harbor System is an attempt to estimate the extent and types of all major estuarine activities. Under the continuing Estuarine Evaluation Project, the Bureau of Fisheries conducts an intensive survey and inventory of all major New Jersey estuaries, usually allocating an entire year for each system. Manahawkin Bay - Little Egg Harbor represents the fifth major estuarine system to be studied under this continuing project.

The study area covers tidal waters and associated marshlands with the upland treeline serving as an easily recognizable boundary line. It is within these areas that most activities effecting estuarine resources are conducted. Covering the entire watershed was prohibitive due to insufficient manpower. The northern boundary of this study area was drawn at Sandy Island in Barnegat Bay midway between the Barnegat National Wildlife Refuge on its West and Harvey Cedars on its East. Little Egg Harbor Inlet and the North side of Great Bay Boulevard were the southern limits to the survey area. Activities performed on the bay side of Long Beach Island such as bank fishing were included whereas those activities such as surf fishing on the ocean side of the Island were not considered. (see Figure 39 for above specified locations).

The survey attempted to determine how the estuary is used by man, both commercially and recreationally, the different types of user-groups*, an estimated total man-days* for each activity, total resource harvest, and total expenditures by the different user-groups.

*Consult Definitions Section for an explanation of these terms.

There is also presented a comparison between the total use picture of the lagoon community of Beach Haven West and the adjacent natural marshland.

Initially, an eight month study of the Manahawkin Bay - Little Egg Harbor System was conducted from July 1, 1973 to February 28, 1974. This was followed by a similar, twelve month study of the same area from June 1, 1974 to May 31, 1975. The three month interim was due to administrative scheduling for report writing. This report presents the results of twenty months of field work covering both study periods.

ACKNOWLEDGEMENTS

The Use Study of Manahawkin Bay - Little Egg Harbor was initiated by Assistant Fisheries Biologist Bruce A. Halgren. The study continued under his supervision throughout the eight month period (July 1973 to February 1974) and also during seven months of the twelve month period (June 1974 to January 1975). Upon his transfer to a different project, I assumed leadership of this phase of the Estuarine Evaluation Project.

Fisheries Worker Russell Tilton performed the greatest part of the field work throughout the twenty months of sampling. His enthusiasm and dedication to the Use Study field sampling is most appreciated.

Principal Fisheries Biologist Paul E. Harner is also acknowledged for his supervisory assistance and recommendations.

The assistance with field work from other lab personnel is also greatly appreciated. Those of assistance include: Senior Fisheries

Workers Jeffrey Carlson and Keith Lockwood, Fisheries Workers Barry Preim and William Andrews, and Summer Worker Frederick Bubeck.

East Little Egg Harbor - See Figure 39: Section 3. That portion of the study area bordered on the south by Little Egg Inlet, on the west by a line from Tucker Island sand bar to Goosebar Sedge to East Sedge Island to Shelter Island, on the north by a line from Long Point to Marshelder Islands and on the east by Long Beach Island.

East Lower Manahawkin Bay - See Figure 39: Section 4. That portion of the study area bordered on the south by a line from Long Point to the Marshelder Islands, on the north by State Highway 72, on the east by Long Beach Island and on the west by a line from Shelter Island to Cedar Bonnet Island.

East Upper Manahawkin Bay - See Figure 39: Section 5. That portion of the study area bordered on the south by State Highway 72, on the north by a line from Dipper Point to Maiden Land in the Borough of Harvey Cedars, on the west by a line from Cedar Bonnet Island to Sandy Island and on the east by Long Beach Island.

Hours per Angler - The average number of hours spent per fishing trip.

Man-day - An indeterminant length of time an individual spends on the study area during any day.

section 1 of the study area that is bordered by Mill Creek on the north, Meyers Pond Creek on the south and the upland tree line to the west. Boats involved in activities in very close proximity, (within 10 to 20 feet) to the shoreline of the marsh were also included in this section.

Others - Any activity that was either unknown or which did not fit in the listed categories of major user-groups. This would inlcude, but is not limited to, sightseers, bird watchers, hikers, or other naturalists, picnickers and non-fishermen with groups of bank fishermen.

Shell Fishing - Any individual harvesting clams, oysters, scallops or mussels.

User-Group - A major activity category and its participants, such as bank fishermen, boat fishermen, etc.

West Little Egg Harbor - See Figure 39: Section 2. That portion of the study area bordered on the north by a line from Long Point to the Marshelder Islands, on the south by Great Bay Boulevard, on the west by the upland tree line and on the east by East Little Egg Harbor as defined above.

West Lower Manahawkin Bay - See Figure 39: Section 1. That portion of the study area bordered on the north by State Highway 72, on the south by a line from Long Point to the Marshelder Islands, on the west by the upland tree line and on the east by East Lower Manahawkin Bay as defined above.

West Upper Manahawkin Bay - See Figure 39: Section 6. That portion of the study area bordered on the south by State Highway 72, on the north by a line from Dipper Point to Maiden Lane in the Borough of Harvey Cedars, on the west by the upland tree line and on the east by East Upper Manahawkin Bay as defined above.

The following sub-section of this definition list also appears in the above mentioned Miscellaneous Report No. 14M and includes those species of fish and shellfish harvested by sport and commercial fishermen interviewed in the study area.

Common Name	Scientific Name
Bay Scallop	Argopecten irradians
Blackfish (Tautog)	Tautoga onitis
Blowfish (Northern puffer)	Sphaeroides maculatus
Blue crab (Blue claws)	Callinectes sapidus
Bluefish	Pomatomus saltatrix
Eel (American eel)	Anguilla rostrata
Flounder (Winter flounder)	Pseudopleuronectes americanus
Fluke (Summer flounder)	Paralichthys dentatus
Hard clam	Mercenaria mercenaria
Kingfish (Northern kingfish)	Menticirrhus saxatilis
Northern searobin	Prionotus carolinus
Oyster toadfish	Opsanus tau
Porgy (Scup)	Stenotomus chrysops
Sea bass (Black sea bass)	Centropristes striatus
Sandbar shark	Carcharhinus milberti

Common Name	Scientific Name
Smooth dogfish	Mustelus canis
Spot	Leiostomus xanthurus
Striped bass	Morone saxatilis
Weakfish	Cynoscion regalis
White perch	Morone americana

METHODS

Three integrated methods were employed to accomplish the objectives of the Use Study. Aerial surveys provided the data for monthly estimates of total man-days of activity within the study area. Bag and Creel surveys yielded total harvest estimates for the study area. Expenditure surveys enabled the calculation of per-trip expenditures and total expenditures for the different user-groups. In addition, a survey was initiated in June 1974, to determine the geographical origin of the different user-groups in the study area. A detailed presentation of the methods employed is given below.

I. AERIAL SURVEY

Three aerial surveys were scheduled weekly, two on weekdays and one on a weekend day or holiday. The days for scheduling of flights were randomly chosen. Due to the greater recreational pressure on weekend days, these data were completed separately from weekdays. Holiday flight data were treated as weekend days due to similar recreational pressure.

During the months of January and February of both study periods, sampling frequency was reduced to one weekday flight and one weekend flight per week to economize during minimal activity periods. This practice went into effect after the last day of duck hunting season in January. Also, there were no aerial surveys conducted during November 1974 and December 1974 when monies allocated to this study were temporarily exhausted.

All flights were randomly scheduled between the hours of 10:00 A.M. and 3:00 P.M., considered the greatest activity period of the day (Briggs, 1962). It should be realized that the estimated total man-days of activity will be a low estimate since no count is taken of user-groups utilizing the study area only during the early morning and late afternoon hours. No adjustments were made to monthly estimates for this fraction.

The survey area was divided into eight sections: East and West Little Egg Harbor, East and West Lower Manahawkin Bay, East and West Upper Manahawkin Bay, Beach Haven West, and the Natural Marsh Area. The divisions within the survey area facilitated counting and provided better understanding of areas of activity. These areas are described in the previous Definitions section and are shown on the Use Study map, Figure 39. Nine major activities were tallied for each section of the survey area to better understand where the different activities were being performed. These activities include: Bank Fishing, Boat Fishing, Boating, Shellfishing, Bathing, Sailboating, Water Skiing, Hunting and Trapping, with all other activities listed under an Others column.

All survey flights followed the shoreline within the survey area at an average altitude of 500 feet. A single pass through the survey area was generally the rule. Deviations from the

flight plan sometimes became necessary to more accurately count large numbers of boats or persons, to clarify the type of activity being performed, or to located waterfowl hunters. Altitude, ranging from 200 to 700 feet, was influenced by visibility and areas of high population density.

Attempts were made to reschedule those flights cancelled because of adverse weather conditions. Counts on foul weather days, if possible, would understandably lower the man-days estimates. Corrections for these cancelled flights on bad weathers were not made. Some cancelled flights could not be rescheduled and were lost for the month.

Boat counts were recorded on the field data sheets for the following activities: boat fishing, boating, shellfishing and sail boating. Actual head counts of people were taken for bank fishing, bathing, water skiing, hunting and trapping. The average number of persons per boat was determined by month through the bag and creel survey data.

Weekday means and weekend-holiday means of man-days of activity were computed by area and activity. These means were expanded according to the number of weekdays and weekend days/holidays in that particular month to determine a monthly estimate. Monthly estimates were computed for each activity in each of the eight sectors of the study area.

II. BAG AND CREEL SURVEY

To estimate the resource harvest per user-group, bag and creel surveys were conducted. Bank and boat fishermen, shell-

fishermen, hunters, and trappers were personally interviewed to determine the average catch per unit effort for each user-group.

Three bag and creel surveys were scheduled weekly coinciding with the three aerial survey days. One of the two weekday survey, was allocated to bank fishermen, the other to boat fishermen. The weekend survey was alternately scheduled for bank and boat fishermen. During hunting season, one survey day each week was reserved for hunters. The type of survey for each day was randomly chosen. During periods of minimal activity within the study area, such as the winter months, a bag and creel survey would include all user-groups as well as expenditures of those user-groups.

In conducting a bag and creel survey, the field worker visited the known access sites throughout the entire area during the day long survey. Transportation was by automobile. During the summer months, two interviewers were sometimes utilized, each covering half of the survey area.

In addition, one Boat by Boat Survey was scheduled weekly to obtain incomplete trip data from boat fishermen, clammers and hunters who might otherwise be missed during surveys by automobile. The number of Boat by Boat Surveys was determined by weather conditions and boat availability at the Laboratory.

For each Bag and Creel Survey, the field worker interviewed as many people as possible during the course of the day. Only those persons engaged in their activity for a minimum of one hour were counted. This time of one hour was arbitrarily considered the minimum angler or hunter trip to represent a true catch per effort ratio.

The following data were obtained during a bag and creel survey: number of persons in the party, hours engaged in the activity per person, how many hours each individual planned to remain participating in that activity, and catch or harvest by number of each species. Bank fishermen were usually recorded singularly, while boat fishermen at access areas at the end of their trip were interviewed as a group. The number of anglers per boat was recorded and averaged monthly. These data were used to expand the boat counts taken during aerial surveys to arrive at estimates of total persons engaged in boat fishing, boating, and sailboating. The average number of clammers per boat was determined from data taken on Boat by Boat Surveys.

Data derived from Bag and Creel Surveys were summarized monthly. Harvest per effort for hunters and clammers and catch per effort for fishermen were determined from the above described data. Total harvest and catch estimates were calculated by integrating data from aerial surveys and bag and creel survey.

III. EXPENDITURE SURVEY

Expenditure survey data were used to estimate average expenditures of the major user-groups both on a per trip basis and for the year. Originally, expenditure data were collected during bag and creel surveys from one out of every four persons interviewed by the field worker. During the summer months, one survey day per week was randomly chosen for collecting expenditure data only. For the twelve month study period, an expenditure survey was scheduled weekly throughout most of the year.

Data were collected on the following expenditures: bait, boat gas and oil, equipment rental, food, lodging, equipment cost and age, number of trips annually, miles traveled, and any miscellaneous fees. Food and lodging costs were taken for the day only. For example, if a bank fisherman were paying for lodging by the week, one-seventh of this dollar figure was entered on the field data sheets for that day. To estimate the daily value of equipment, the person interviewed was asked to estimate the original cost of his equipment present, the average age of the equipment, and the number of times a year he uses the equipment present for the activity in which he was engaged. The original equipment cost was divided by the product of equipment age and number of trips annually to estimate equipment cost for that day's usage. The round trip mileage for using the estuary was multiplied by the appropriate number of cents per mile for the time period in which the activity took place. During the eight month survey from July 1973 to February 1974, five cents per mile was multiplied by the round trip mileage to estimate car traveling expenses (1970 National Survey of Fishing and Hunting, Bureau of Sport Fisheries and Wildlife, Department of the Interior). For the twelve month survey, June 1974 to May 1975, a figure of twelve cents per mile was used (Federal Government allowance for employees' traveling expenses).

Expenditures data were summarized monthly to give expenditure means for expense categories, value of equipment, and miles traveled. These means were subsequently multiplied by user-group estimates from the aerial surveys to estimate total expenditures for the different user-groups.

IV. RESIDENCE SURVEY

An additional segment was added to the Use Study for the twelve month period, June 1974 to May 1975. This new survey was to determine the County or State of residence of those persons utilizing the survey area.

If the person were from out of State, that particular State was recorded. The yearly percentages of persons residing in Pennsylvania, New York and the individual Counties of New Jersey who traveled to the Manahawkin Bay - Little Egg Harbor Survey area either for recreational or commercial reasons were computed. People were interviewed for County or State residence during both the bag and creel survey and the expenditure survey.

RESULTS

I. AERIAL SURVEY

Seventy-two percent (72%) of all flights scheduled during the twenty months of sampling were completed. Fifty-three flights were cancelled due to inclement weather conditions. If it had been possible to obtain a count of persons using the study area on bad weather days, monthly estimates would understandably be lowered. As stated in the methods section, monthly estimates, as reported, of total man-days of activity are expected to be lower than the actual number since those persons using the study area during early morning and late day or night hours are missed altogether.

Below are listed the numbers of flights scheduled and completed during the twenty months of field sampling.

Date	Flights Scheduled	Flights Completed Weekend/Holiday + Weekday	Totals
July '73	14	4 + 6	10
Aug. '73	14	3 + 6	9
Sept. '73	13	5 + 8	13
Oct. '73	13	4 + 8	12
Nov. '73	12	4 + 5	9
Dec. '73	13	2 + 7	9
Jan. '74	9	3 + 3	6
Feb. '74	8	3 + 1	4
Totals	96		72

Seventy-five per cent (75%) of ninety-six scheduled flights were completed during the eight month study of the Manahawkin Bay - Little Egg Harbor System.

Date	Flights Scheduled	Flights Completed Weekend/Holiday + Weekday	Totals
June '74	9	1 + 5	6
July '74	14	2 + 9	11
Aug. '74	12	2 + 6	8
Sept. '74	13	3 + 4	7
Oct. '74	5 (1/2 month sched.)	2 + 1	3
Jan. '75	6	1 + 3	4
Feb. '75	8	2 + 5	7
Mar. '75	8	4 + 3	7
Apr. '75	9	2 + 5	7
May '75	10	1 + 4	5
Totals	94		65

Sixty-nine percent (69%) of ninety-four scheduled flights were completed during the twelve month study of the Manahawkin Bay - Little Egg Harbor System.

In summation, the two time periods combined yield the following data:

	Flights Scheduled	Flights Completed	Percentage
	96	72	75
	94	65	69
Totals	190	137	72%

Use Estimates

Results of the two study periods will first be presented separately. A comparison of the findings will then be made attempting to combine the twenty months of data into yearly estimates of total man-days of activity.

Ia. Eight Month Study -- July 1973 to February 1974

The following use estimates for Manahawkin Bay - Little Egg Harbor are taken from Nacote Creek Research Station, Miscellaneous Report No. 14M, and are reproduced in their entirety.

During the eight month study period, a total of 158,269 man-days of activity were spent on the study area (Table 189). Boat fishing was the most heavily engaged in activity in the study area and represented 42.25% of all activity in the study area.

Even this figure, however, is considered minimal since a substantial portion of boaters, the second largest single category, were actually fishermen under way from one fishing ground to another, or between fishing grounds and a landing.

Following boat fishing in popularity were boating (22.51%), shell fishing (11.75%), sailboating (10.90%), bathing (5.56%), bank fishing (4.91%), others (1.11%), water skiing (0.68%) and hunting (0.34%) in that order.

The warm summer months proved to put the greatest activity demands upon the study area. July (36.44%) and August (39.00%) combined to account for over 75% of all activity during the eight month study period. After the summer months, user activity declined steadily for the remainder of the study period. Tables 190 through 197 give estimated man-days of activity figures by area and activity for each month of the survey, while Table 198 gives the total estimated man-days of activity for the entire study period, also broken down by area and activity. These tables also present figures for that percent of user-group activity that occurs in each area section (this figure appears as the upper percentage figure on the charts and is totalled across) and for that percent of total sector activity that each user-group represents (this figure appears as the lower percentage figure and is totalled down).

East Little Egg Harbor accommodated the greatest activity demands of the study are (27.55%). This is due mainly to the fact that it contained the greatest percentage of boat fishermen and boaters, the two most popular user-groups. This section of the study area also accounted for the greatest amount of user activity in the category of others. The majority of the fishing

done in this portion of the bay was by private boats with fluke being the most sought after and successfully caught species; weakfish, striped bass and bluefish were also taken.

West Little Egg Harbor ranked second in overall activity and accounted for the greatest percentage of shell fishermen (42.77%) and bank fishermen (25.42%) and the second greatest percentage of boat fishermen and boaters.

East Lower Manahawkin Bay ranked third in overall activity and accounted for the greatest percentage of sailboaters (32.28%) and bathers (43.89%) and the second greatest percentage of bank fishermen.

West Upper Manahawkin Bay had the lowest percentage of overall activity, but had the second highest percentage of hunter activity. It also probably had the greatest number of boat rentals for fishing and crabbing, and undoubtedly produced the best crabbing in the study area.

West Lower Manahawkin Bay accounted for only 14.03% of all activity in the study area but it contained the sub-sections of Beach Haven West and the Natural Marsh, and therefore deserves some special comment in this portion of the report. The following table shows the total man-days of activity estimates for the Beach Haven West and Natural Marsh sub-sections.

	Bank Fishing	Boat Fishing	Boating	Sail Boating	Bathing	Hunting	Others	Total
Beach Haven West	89	17	1537	32	554	--	27	2256
Natural Marsh	32	76	21	--	--	71	3	203
Totals	121	93	1558	32	554	71	30	2459

It is noticed from the above chart that Beach Haven West accommodated over ten times the total amount of activity of the Natural Marsh. This figure may, however, be very misleading. Over 68% of the activity occurring in Beach Haven West was boating. It does not matter whether these boaters were on their way to go pleasure boating, boat fishing, or water skiing, it seems obvious that they were on their way somewhere else to enjoy their end activity. In this regard, the lagoon community was acting only as a docking facility. It is also probable that the sailboats encountered within the lagoon community were also in transit to the bay to fully realize the enjoyment of sailing, although moving under sail within the lagoon complex must test their skills to the utmost.

The Natural Marsh sub-section has a higher percentage of activity for only two activity categories. These are boat fishing, which makes up 0.70% of the total boat fishing of West Lower Manahawkin Bay, and hunters which make up 27.20% of all area 1 hunters and 13.20% of all hunters within the study area.

Tables 199, 200 and 201 show the distribution of bank fishing, boat fishing, and boating, respectively, for the eight month study period by sector and month.

Ib. Twelve Month Study - June 1974 to May 1975

It is estimated that 230,326 man-days of activity were spent in the study area during ten months of aerial surveys. Since no aerial surveys were conducted during November 1974 and December 1974, a yearly estimate of total man-days of activity is not presented in this section for the twelve month study period.

Table 202 presents the estimated total man-days of activity by activity category and month.

Tables 203 through 212 present the monthly estimates of man-days of activity for those ten months in which aerial surveys were conducted.

Boat fishing again accounted for the greatest percentage of activity, 46.56%. The remaining activity categories and their percentages are reported as follows: boating (22.00%), shellfishing (16.75%), bank fishing (6.91%), sail boating (3.68%), bathing (3.34%), others (0.54%), water skiing (0.17%), and hunting (0.05%).

The estimated total man-days of hunting activity, 117 man-days, appears to be a gross underestimate for the study period due to having data for only the month of October.

By month, the summer months of July and August understandably accounted for over sixty percent of the total activity within the study area.

The months sampled and their corresponding percentage of total estimated activity are as follows: January (1.10%), February (0.85%), March (2.42%), April (3.36%), May (4.54%), June (12.60%), July (28.26%), August (31.94%), September (10.13%), and October (4.80%).

East Little Egg Harbor Bay, with the great recreational pressures of boat fishing and boating, accommodated the most activity, 28.90%.

West Little Egg Harbor Bay accommodated 27.35% of the activity during the study period, again, boat fishing (45.61%) predominating the activity. The greatest percentage of shellfishing (49.89%) occurred within this area.

West Lower Manahawkin Bay, including Beach Haven West and the Natural Marsh Area, accounted for 15.41% of all activity, dominated by boat fishing and shellfishing.

The greatest percentage of bank fishermen, 28.32%, was located in West Upper Manahawkin Bay.

East Upper Manahawkin Bay contained the most bathers, 33.65%, within the survey area.

Refer to Table 213 for a complete breakdown of activity by area and activity category. Tables 214 through 216 present the distribution of bank fishing, boat fishing, and boating by area and month for the study period.

A comparison of Beach Haven West and the Natural Marsh Area is given in the following chart:

	Bank Fishing	Boat Fishing	Boating	Sail Boating	Bathing	Hunting	Others	Totals
Beach Haven West	155	187	4051	40	383	--	84	4900
Natural Marsh	151	330	592	4	--	9	69	1155
Totals	306	517	4643	44	383	9	153	6055

Again, the boating estimate of 4,051 for Beach Haven West may be misleading in estimating total activity for that area. It is very likely that many of these boats were in transit from the lagoon community to participate in boat fishing, pleasure boating, or some other activity elsewhere.

Ic. Comparison of Use Estimates for the Two Sampling Periods

Aerial surveys were conducted each month of the eight month study period. During the twelve month study of the same area, aerial surveys were conducted during only ten of the twelve months due to temporary expiration of project funds. Consequently, only six months of the year were sampled twice as shown below:

Month	Estimated Man Days of Activity	Month	Estimated Man Days of Activity	Percent Increase
July '73	57,678	July '74	65,100	+ 12.87
Aug. '73	61,726	Aug. '74	73,559	+ 19.17
Sept. '73	22,029	Sept. '74	23,324	+ 5.88
Oct. '73	7,948	Oct. '74	11,061	+ 39.17
Jan. '74	2,000	Jan. '75	2,532	+ 26.60
Feb. '74	1,308	Feb. '75	1,960	+ 49.85
Totals	152,689		177,536	+ 16.27

For those months which were sampled twice, the twelve month study shows an average percent increase of 16.27% over the eight month study in total man-days of activity.

This percent increase of 16.27% from the first study period to the second was used to estimate those months when no aerial surveys were conducted or the study was not in progress. This was done to provide two twelve-month periods of total man-days of activity, thus giving yearly estimates of total man-days of activity for the two study periods. Yearly estimates were not previously given when each study period was analyzed separately.

Below are listed the data for two estimated yearly totals of man-days of activity.

Month	June 1973 to May 1974 Total Man Days of Activity	June 1974 to May 1975 Total Man Days of Activity
January	2,000	2,532
February	1,308	1,960
March	4,785*	5,564
April	6,656*	7,739
May	8,994*	10,457
June	24,968*	29,030
July	57,678	65,100
August	61,726	73,559
September	22,029	23,324
October	7,948	11,061
November	3,274	3,807*
December	2,306	2,681*
Total	203,672	236,814
Average Month	16,973	19,734

*Estimated using the 16.27% average increase between the two study periods.

Below is a comparison by activity category of estimated man-days of activity for the two study periods showing the totals for those six months which were sampled twice.

	1973-1974* Man-Days of Activity	1974-1975* Man-Days of Activity	Difference in Man-Days
Bank Fishing	7,503	11,997	+ 4,494
Boat Fishing	65,033	81,908	+16,875
Boating	34,319	42,746	+ 8,427
Shellfishing	16,913	25,721	+ 8,808
Sailboating	17,194	7,476	- 9,718
Water Skiing	1,071	357	- 714
Bathing	8,795	6,393	- 2,402
Hunting	114	117	+ 3
Others	1,747	821	- 926
Total	152,689	177,536	+24,847

*Totals for the months of July, August, September, October, January and February only.

The four major activity categories of bank fishing, boat fishing, boating, and shellfishing showed increases in man-days of activity of 60%, 26%, 24% and 52% respectively. These increases account for an additional 38,604 man-days of activity. Major decreases in use estimates occurred in the sailboating and bathing categories, 12,120 man-days of activity. The overall difference in use estimates for the two six month sampling periods shows a net increase of 24,847 man-days of activity when all activity categories are considered.

II. BAG AND CREEL SURVEY

Harvest Estimates

IIa. Eight Month Study - July 1973 to February 1974

The following harvest estimates are taken from Nacote Creek Research Station, Miscellaneous Report No. 14M, and are reproduced below. A total of 1,878 persons were interviewed during the bag and creel surveys for this study period (see Table 217).

Bag and creel interviews, expanded to the extent of the use estimates indicate that over four hundred thousand fish (including crabs), 9.5 million clams, 4.5 million bay scallops and three hundred waterfowl were harvested from the study area during the eight month study period. Estimated total catch, catch composition, and catch per effort statistics on the above mentioned renewable resources are given in Tables 218 through 224.

The boat fisherman accounted for 94.86% of the total estimated fish catch. The highest estimated boat catch occurred in July and decreased every month after that throughout the survey period. Boat fishing catch per effort hit a peak of over four fish per hour in October, but averaged only slightly above 1 fish per hour for the survey period. The blue crab constituted the most readily caught species and comprised 68.21% of the total catch. The fluke was undoubtedly the most sought after fish and was the second most plentiful representative in the fisherman's creel at 13.12% of the catch. Bluefish (9.67%), blowfish (1.48%) and spot (1.37%) comprised the bulk of the remaining catch.

Blue crabs accounted for the majority (79.36%) of the bank fisherman's catch. Bluefish (6.43%), fluke (4.66%), spot (3.30%), eels (0.97%) and weakfish (0.97%) were also taken with fair success by the bank angler. The highest estimated bank catch occurred in July, and like the boat catch, decreased every month after that throughout the survey period. The best catch per effort occurred in November for the bank fisherman with 1.38 fish per hour. The survey long average was 1.02 fish per hour, slightly lower than that of the boat fisherman. The "others" category of fish taken represented 1.82% of the total combined estimated catch and was mainly comprised of the oyster toadfish, northern searobin, sandbar shark, and smooth dogfish.

The bank fisherman had his highest estimated catch in July, which stands to reason since he also had more man-days of participation in July than any other month. The boat fisherman, on the other hand, had over three thousand more man-days of participation in his sport in August than in July, but recorded a greater catch in July. This was due basically to better fishing (a better catch per effort ratio) and more hours spent on the water in July (a longer average man-day).

The waterfowl harvest estimates given in this report are probably low. The aerial survey flights are scheduled randomly between 10:00 A.M. and 2:00 P.M. so that they occur during the peak activity period (Briggs, 1962). There is no doubt that hunters frequently entered and left the study area before and after the peak activity period, or to be more precise, before and after the aerial survey flight. Waterfowl hunters increase their success by being inconspicuous and staying out of sight of their prey. Thus, the

skillful hunter may also have escaped observation by aerial survey, and further lowered the estimated hunter activity and harvest figures. Hunter interviews were also found difficullt to obtain and low numbers of interviews could also cause inaccuracies in the survey.

An estimated total waterfowl harvest of 306 birds was recorded on the survey area during the 1973 hunting season with a hunter success ratio of 0.11 birds per hour. The black duck (38.56%) and bufflehead (29.74%) comprised the bulk of the hunter's bag (Table 223).

Shellfishing was the third most heavily engaged in activity within the study area during the eight month survey, and during the winter months of December, January, and February, the most heavily engaged in activity. Sport and commercial shellfishermen harvested over 14.3 million shellfish during that period. Shellfishing is the only year-round, heavily engaged in activity in the study area, has high recreational and commercial interests, produces a highly valuable commodity, and costs the shellfishermen an estimated ninety-six thousand dollars to engage in their activity for eight months. This must be ranked as being among the top two or three more important human activities within the study area.

Clams are harvested on a year-round basis. The highest harvest levels occur in the summer months when recreational and part-time commercial clammers swell the ranks. The highest catch per effort levels occur during the winter months when only the full time experienced commercial clammers are plying their trade. Scallops are harvested only during the open season which extends into the three cold weather months of November, December, and January.

During this period, an estimated 4,658,326 bay scallops were harvested at an outstanding estimated catch per effort rate of over 776 scallops per hour.

IIb. Twelve Month Study - June 1974 to May 1975

Data from over twenty-five hundred interviews (see Table 225) during bag and creel surveys were expanded to estimate total harvest for the Manahawkin Bay - Little Egg Harbor System. Total estimated bank fishing, boat fishing, shellfishing, and hunter harvest are presented in Tables 226 through 232 for those ten months in which aerial surveys were conducted. It is estimated that over 450,000 fish (including crabs), and over 19 million clams, were harvested within the survey area during a ten month period. Hunter harvest figures are suspect due to the small amount of data taken only during the month of October 1974. This will be elaborated upon later in the report.

Bank fishermen caught an estimated 46,594 fish (see Table 226), 89.60% of which were blue claw crabs. Of the finfish species caught by bank fishermen, bluefish 3.90%, winter flounder 2.97%, and eels 0.82%, comprised the bulk of the catch. Less than 3.00% of the estimated total catch of bank fishermen was composed of species other than those mentioned above. The summer months of July and August accounted for over sixty percent of the ten month total catch, again comprised mostly of blue claw crabs.

Catch per effort figures for bank fishermen given in Table 230 show the greatest success in August and September, 1.79 and 1.77 fish (including crabs) per hour. The yearly catch per effort

for bank fishermen was 1.32 fish per hour, greatly influenced by the crabbing success of the summer months.

Boat fishermen caught an estimated 412,287 fish, including 242,651 blue claw crabs for the ten months sampled (Table 227). The blue crab represents 58.85% of the total estimated catch. Following crabs were: fluke, 79,450 for 19.27%; bluefish, 31,112 for 7.55%; black sea bass, 21,590 for 5.24%; winter flounder, 15,222 for 3.69%; and weakfish, 11,390 for 2.76%. The total catch is based on the total estimated man-days for boat fishermen. It has been mentioned that a good percentage of those counted in the user-group, boating, were actually boat fishermen in transit. Boat fishing man-days of activity for the ten month period are estimated at 107,239 man-days. Total estimated catch is based on this figure. The boating category accounts for an estimated 50,682 man-days of activity. What percentage of these boaters were actually boat fishermen is not known. Therefore, the total estimated boat fishing catch is a low estimate. Catch per effort figures for boat fishermen (see Table 229) are highest for September, 1.66, and October, 1.93, when bluefish, black sea bass, fluke, and weakfish dominated the catch. The ten month catch per effort average for boat fishermen was 1.19 fish (including crabs) per hour.

Table 228 shows the total estimated combined fishing catch composition for bank and boat fishermen for the ten month period. Of the total estimated catch, 458,881 fish and crabs, boat fishermen accounted for 89.85% of the catch, compared to 10.15% for bank fishermen. Of the combined man-days of activity for bank and boat fishermen, 123,159 man-days, bank fishermen accounted for only 12.93% of the activity, boat fishermen, 87.07%. Catch per effort

comparisons show bank fishermen having slightly better success than boat fishermen, 1.32 to 1.19. Species listed in the "others" include: sharks, sea robins, and oyster crackers.

Only thirty-two hunters were interviewed during the survey period, hunter activity being estimated at 117 man-days during the month of October 1974. Since no aerial surveys were conducted during November 1974 and December 1974, no estimate of total man-days of hunting activity is given. Table 230 represents the actual and estimated data for hunter harvest based on hunter interviews. Species harvested include the green winged teal, mallard, black duck, and blue winged teal (see Table 231).

Division owned land in the Great Bay Boulevard Area was surveyed by Game Biologists for waterfowl harvest during the 1974-1975 waterfowl hunting season (see Wetlands Ecology, Waterfowl Harvest, Project No. W-53-R-3, Job No. I-D). Only about half of the Great Bay Boulevard Area surveyed under the above project is included in the Manahawkin Bay-Little Egg Harbor survey area, the marshland north of the boulevard. For the entire Great Bay Boulevard Area, hunters spent 2,129 days harvesting 854 ducks and 46 geese. Rail hunters harvested 524 clapper rails and 7 sora rails during an additional 221 days of hunter activity in that same area.

Clamming total harvest estimates based on the ten months of field data project a total of 19,177,104 hard clams taken from the Manahawkin Bay-Little Egg Harbor System (see Table 232). Clamming harvest was estimated for the day for each clammer interviewed and expanded based on the estimated man-days of clamming activity for each month. Catch per effort figures show the number of clams harvested per hour based on interview data. Clamming

activity was highest during the month of July, 9,878 man-days of activity, but showed the lowest catch per effort, 44.43 clams per hour. Both the commercial and recreational clamming data are combined in estimating catch per effort and total harvest. Over three million clams were harvested during the months of August and September, reflecting good catch per effort and man-days of activity figures. The best catch per effort occurred in the month of October when 205.67 clams were harvested per hour.

IIc. Comparison of Harvest Estimates for the Two Sampling Periods

For the six months of the year which were sampled twice and have total harvest estimates, comparisons are given in Tables 233 through 235. Bank fishing, boat fishing, and clamming harvest estimates are presented, as well as catch per effort figures. Hunter harvests were not compared due to insufficient data. Catch per man-day, as opposed to catch per man-hour, estimates are used throughout this section of comparisons of total harvest estimates.

Table 233 compares the estimated bank fishing catch by species for the two time periods: July, August, September, October 1973, January, February 1974 against July, August, September, October 1974, January, February 1975. Total estimated catch of Manahawkin Bay-Little Egg Harbor shows an increase of 79% from the first sample to the second a year later. However, total man-days of bank fishing activity increased 60% for the same time periods, from 7,503 to 11,997 man-days. When total catches are compared for an equal number of man-days of activity, the estimated bank fishing catches show an increase of 12%. The catch per man-day for the second time period shows an increase from 3.00 to 3.35 fish (including crabs) per man-day.

Boat fishing harvest comparisons show a decrease of 24% from the first sampling period to the second. Adjusting total harvest estimates for equal numbers of man-days of boat fishing activity, a comparison shows an even larger decrease in number of fish and crabs of 40%. Table 234 shows the comparison of harvest estimates by species. The bulk of the estimated harvest decrease is due to a substantial reduction in the blue claw crab catch from 289,052 to 187,193 crabs. Comparing estimated boat fishing catches for the two sampling periods excluding the crab catch figures reduces the percent difference in half from -40% to -20%. The closing or significnt reduction in business of a large boat livery could drastically reduce the catch of blue claw crabs. Also, reduced sampling at such boat liveries would also produce such a decrease in catch estimates. Catch per effort figures for the two sampling periods also shows a decrease in numbers of fish (including crabs) per man-day of boat fishing activity (see Table 234). Comparing catch per effort for total harvest estimates, there was a decrase from 6.47 fish per man-day for the first sampling period 1973-1974 to 3.90 fish per man-day for the second sampling period 1974-1975. Catch per effort figures for finfish species only show a decrease from 2.02 to 1.62 fish per man-day.

Hard clam harvest comparisons are presented in Table 235. For an equal number of man-days for each sampling period, there occurred a 9% decrease in the total number of clams harvested. Total man-days of clamming activity increased 63% from the first sampling period, 1973-1974, to the second sampling period, 1974-1975. Total catch estimates increased only 49%. Adjusting either total catch for an equal number of man-days of activity shows the 9% decrease in total number of hard clams harvested.

III. EXPENDITURE SURVEY

Expenditure Estimates

IIIa. Eight Month Study - July 1973 to February 1974

Over sixteen hundred persons were interviewed for expenditure data during this sampling period (see Table 236). Tables 237 through 240 present the estimated expenditures of bank fishermen, boat fishermen, shellfishermen, hunters, bathers, and sailboaters. The following text analyzes these data and is taken from Nacote Creek Research Station. Miscellaneous Report 14M.

An estimated total of 74,632 angler days were spent on the study area with an accompanying estimated $738,921.27 expenditure on the part of the anglers involved. This works out to be an expenditure of $9.90 per angler trip, including equipment costs. The estimated 446,754 fish (including crabs) taken by anglers over the survey period cost an average of $1.65 per fish.

Boat fishermen spent an estimated $697,987.66 on an estimated 66,861 angler-trips for an average of $10.44 per trip or $1.65 per fish. Bank fishermen spent an estimated $40,933.61 on an estimated 7,771 angler-trips for an average of $5.27 per trip or $1.78 per fish.

Shellfishermen spent an estimated 18,603 man-days on the bay at an estimated cost to the shellfishermen of $96,301.28 or approximately $5.18 per trip. An estimated 538 hunter-days were spent in the study area at an estimated hunter cost of $8,676.35 or $16.13 per trip. Bather man-days were estimated at 8,795 with an

accompanying expenditure of $29,204.15 for an estimated $3.32 expenditure per trip. Sail boaters enjoyed an estimated 17,250 man-days engaged at their sport at an estimated ccost of $300,787.97 or $17.44 per trip.

Per trip expenses ranged from a high for sailboaters of $17.44 in order through hunters ($16.13), boat fishermen ($10.44), bank fishermen ($5.27) and shellfishermen ($5.18) to a low of $3.32 fo bathers.

Total estimated expenditure for all categories surveyed for expenditures for the eight month survey period were $1,173,891.02.

IIIb. Twelve Month Study - June 1974 to May 1975

Over twenty-four hundred persons were interviewed for expenditure data during this sampling period (see Table 241). Tables 242 through 245 present expenditure breakdowns for the major activity groups.

Bank fishermen spent an estimated $116,464.95 for the ten month period, June 1974 to May 1975, excluding November and December 1974 (see Table 242). The average per trip expenditure of $7.33 is broken down in the following manner: $0.59 for bait, $0.62 for food, $0.48 for lodging, $0.40 for equipment, and $5.21 for traveling expenses. Other expenses include equipment rental and miscellaneous fees, a total of $0.04 per trip. The estimated total harvest for bank fishermen for this sampling period was 46,594 fish (including crabs). The cost per fish estimate is $2.50.

Boat fishermen during this same time period spent an estimated $1,630,680.52 to harvest an estimated 412,287 fish (including

crabs). This comes to $3.96 per fish. Per trip expenditures for a boat fisherman are estimated at $15.21: $0.66 for bait, $0.54 for boat gas and oil, $2.05 for equipment rentals, $0.29 for food, $0.82 for lodging, $6.65 for equipment, $4.18 for traveling expenses and $0.02 for miscellaneous fees. Estimated total expenditures for boat fishermen are presented by month in Table 243.

Estimated total expenditures for shellfishermen, Table 244, are $209,924.95 for the above sampling period. The estimated per trip expenditure of $6.23 is comprised of: $1.21 for boat gas and oil, $0.29 for food, $0.40 for related fees, $1.81 for equipment, and $2.53 for traveling expenses. Clamming expenditure data includes both the year long commercial clammer and the seasonal recreational clammer. It would be a fair assumption that the per trip expenditure for a commercial clammer would be less than the estimate of $6.23 due to reduced traveling expenses and equipment value, whereas the per trip expenditure of a recreational clammer would be more.

Sailboating expenditures are estimated at $23.24 per man-day of activity based on eight-five interviews (see Table 245). Of this estimated daily expense, $0.95 was for equipment rental, $2.39 for food, $3.27 for lodging, $0.44 for related fees, $5.98 for equipment, and $10.21 for traveling expenses. Total estimated expenditures for sailboaters for the four months of June, July, August, and September 1974 are $186,962.39.

One hundred and eighty-six bathers were interviewed for expenditure data. The bathing expenditure estimate of $8.15 per man-day of activity is broken down into the following categories: $3.41 for traveling expenses, $3.00 for lodging, $1.69 for food, and $0.04 for miscellaneous fees.

Total expenditures for the activity groups interviewed within the survey area for a ten month period are estimated at $2,206,033.04. Expenditure data were not tabulated for those persons in the activity categories of boating, water skiing, and the "others" category. Hunter expenditure estimates are not given due to insufficient data.

IIIc. Comparison of Cost Estimates for the Two Sampling Periods

There is an increase in per trip expenditure estimates for all the major activity categories sampled during the two study periods.

	8 month study July '73 - Feb. '74	12 month study June '74 - May '75
Bank fishermen	$ 5.27	$ 7.33
Boat fishermen	$10.44	$15.21
Shellfishermen	$ 5.18	$ 6.23
Sailboaters	$17.44	$23.24
Bathers	$ 3.32	$ 8.15

The per trip expenditure estimates for the above activity categories are broken down below into separate per trip expenses to better understand where expenditure estimates have increased. The most obvious increase is in traveling expenses where the per mile cost estimate has gone from $.05 for the first sampling period to $.12 for the second sampling period. Bait, equipment, and food expenses may have increased from one year to the next.

Bank fishing per trip expenditures increased from $5.27 to $7.33 due largely to increased travel costs:

	July '73 to Feb. '74	June '74 to May '75
Bait	$0.41	$0.59
Equipment rental	0.01	0.02
Food	0.76	0.62
Lodging	1.26	0.48
Fees	0.02	0.01
Equipment	0.67	0.40
Mileage	2.14 (40 miles)	5.21 (44 miles)
	$5.27	$7.33

Boat fishermen's per trip expenditure estimates went from $10.44 to $15.21, again due largely to travel expenses and also due somewhat to equipment cost estimates:

	July '73 to Feb. '74	June '74 to May '75
Bait	$ 0.45	$ 0.66
Boat gas and oil	0.46	0.54
Equipment rental	1.82	2.05
Food	0.22	0.29
Lodging	0.41	0.82
Fees	0.05	0.02
Equipment	5.74	6.65
Mileage	1.29 (30 miles)	4.18 (35 miles)
	$10.44	$15.21

Clammers' per trip expenditures increased from $5.18 to $6.23, travel cost estimates increasing substantially while equipment costs decreased somewhat:

	July '73 to Feb. '74	June '74 to May '75
Boat gas & oil	$1.69	$1.21
Food	0.31	0.29
Fees	0.05	0.40
Equipment	2.53	1.80
Mileage	0.60 (12 miles)	2.53 (21 miles)
	$5.18	$6.23

Sailboating again proved to be the most expensive activity with per trip expenditure estimates increasing from $17.44 to $23.24, even though equipment cost estimates were nearly half as much:

	July '73 to Feb. '74	June '74 to May '75
Equipment rental	$ 1.31	$ 0.95
Food	0.54	2.39
Lodging	1.22	3.27
Fees	0.04	0.44
Equipment	11.52	5.98
Mileage	2.81 (56 miles)	$10.21 (85 miles)
	$17.44	$23.24

Bathers' per trip expenditures increased in every major expense category. The per trip expenditure estimates of $3.32 and $8.15 are explained below:

	July '73 to Feb. '74	June '74 to May '75
Food	$0.39	$1.69
Lodging	1.86	3.00
Miscellaneous	0.17	0.05
Mileage	0.90 (18 miles)	3.41 (28 miles)
	$3.32	$8.15

Hunters' per trip expenditure estimates are not compared due to insufficient data for the second sampling period, June 1974 to May 1975.

IV. RESIDENCE SURVEY

Over twenty-five hundred persons during the survey year, June 1974 to May 1975, were asked their County and/or State of residence, during either the bag and creel or expenditure surveys. The yearly summarization of these data appears in Table 246. New Jersey residents accounted for 70.75% of sportsmen using the Manahawkin Bay-Little Egg Harbor System, engaging in either bank fishing, boat fishing, or clamming throughout the year. Pennsylvania residents accounted for 24.19% of the total; New York, 4.62%; and other States, 0.44%. Over half the total number of persons interviewed were bank fishermen.

Tables 247 through 250 give a seasonal breakdown of the residence of persons using the survey area during. Four three-month intervals.

The percentages of those persons residing in the separate counties within the state of New Jersey on interview data are:

County	Percentage
Ocean	39.86
Burlington	19.91
Camden	13.72
Mercer	5.29
Essex	3.32
Bergen	3.21
Hunterdon	1.97
Union	1.86
Somerset	1.69
Gloucester	1.63
Middlesex	1.57
Morris	1.52
Hudson	1.41
Monmouth	0.73
Cumberland	0.56
Atlantic	0.28
Others	2.47
Total	100.00%

SUMMARY

The Use Study of the Manahawkin Bay-Little Egg Harbor System is an attempt to estimate the total man-days of the major estuarine activities, thee total resource harvest of fishermen, shellfishermen, and hunters, and the total expenditures of the major activities occurring within the study area.

Aerial surveys were designed to determine the numbers of persons engaged in the major activities of: bank fishing, boat fishing, shellfishing, boating, sailboating, water skiing, bathing, and hunting. These separate activities were also tabulated by eight geographical areas to better develop a total use picture of the study area.

During bag and creel surveys, data were obtained through personnel interviews to estimate the total resource harvest, as well as catch per effort figures, for the major activity categories of bank fishing, boat fishing, shellfishing, and hunting.

Expenditure data were also obtained through personal interviews to estimate the total expense and per trip expense of the major activity categories.

A residence survey was conducted to determine the county and/or state of residence of those persons participating in the estuarine related activities.

This report presents the above estimates for two separate sampling periods. Initially, the Use Study of Manahawkin Bay-Little Egg Harbor was conducted from July 1973 to February 1974 (hereafter referred to as the first sampling period). The study was resumed in June 1974 and continued to May 1975 (the second sampling period). Estimates of total activity, resource harvest,

and expenditures are presented for each sampling period. Activity estimates, catch per effort estimates, and per trip expenditure estimates were then compared for the two sampling periods.

Aerial survey data show an increase of 16.27% in estimated man-days of activity from the first sampling period to the second. Yearly estimates of total man days of activity are 203,672 man-days for June 1973 to May 1974 and 236,814 man-days for the time period, June 1974 to May 1975. The four major activity categories of bank fishing, boat fishing, boating, and shellfishing showed increases in man-days of activity of 60%, 26%, 24% and 52% respectively, whereas, major decreases in use estimates occurred in the sailboating and bathing categories.

Bank fishing resource harvest estimates show an increase of 79% from the first sampling period to the second. The catch per effort increased from 3.00 to 3.35 fish (including crabs) per man-day, and the total bank fishing activity increased 60%. Boat fishing harvest comparisons show a decrease of 24% from the first sampling period to the second, due mostly to a reduction in the blue claw crab catch. Catch per effort estimates decreased from 6.47 to 3.90 fish (including crabs) per man-day. Hard clam harvest estimates decreased 9% when comparing an equal number of man-days of activity. Over nineteen million clams were harvested for the ten month period, June 1974 to May 1975, excluding November and December 1974. An estimated total waterfowl harvest of 306 birdds was recorded on the survey area during the 1973 hunting season with a hunter success ratio of 0.11 birds per hour.

Bank fishermen's per trip expenditures increased from $5.27 to $7.33, boat fishermen from $10.44 to $15.21, shellfishermen from $5.18 to $6.23, sailboaters from $17.44 to $23.24, and bathers from $3.32 to $8.15, all due mostly to increased traveling costs.

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