WORKING PAPER NO.
E.P.A.-910-8-76-095

EFFECTS OF INDUSTRIAL WASTEWATER EFFLUENTS ON WATER QUALITY IN GIBSON COVE AND KODIAK HARBOR, KODIAK, ALASKA

AUGUST 26 - 29, 1974

U.S. ENVIRONMENTAL
PROTECTION
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OPERATIONS OFFICE
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SURVEILLANCE AND
ANALYSIS DIVISION
SEATTLE, WASHINGTON
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CONTENTS

List of Tables

INTRODUCTION

Study Area Background

The seafood industry in Alaska is one of the largest and oldest industries in the state and processes hundreds of millions of pounds of fish and shellfish each year. Of the many locations in the state that have one or more seafood processing plants, Kodiak Island has the greatest concentration of such facilities, at the city of Kodiak where 15 seafood processing establishments discharge wastes to the marine waters of Gibson Cove and Kodiak Harbor (Figure 1).

Kodiak industries in general have always been oriented toward the sea beginning with the sea otter and associated fur trade almost 200 years ago. Subsequent to the decline in the sea otter and fur trade, Kodiak industries primarily were those dealing with whaling until about 1885. With the development of petroleum resources elsewhere, the whaling industry followed the course of the sea otter based fur trade, but by then the waters of the Kodiak area had become recognized as an important source of salmon. In 1890 the worlds largest cannery was built at Karluk, a village about 80 miles west southwest of Kodiak, and it was only one of many in the area. The seafood industry on Kodiak Island, beginning with the harvest of salmon, thus has been in operation for about 84 years.

The salmon processing season on Kodiak Island has been and continues to be comparatively short and sometimes unpredictable because

of availability of the resource and demand for the product. The average processing season lasts about two months. In recent years however, fishing and processing of King and tanner crabs has contributed materially to longer operation of the seafood processing plants. Since 1948 the crab processing aspect of the Kodiak seafood harvest has boomed remarkably. In the early 1960's, the area's crab production alone averaged more than 5 million dollars annually.

Fishing grounds for King crabs consist of nearly 22,000 square miles of the continental shelf to a depth of 900 feet (150 fathoms) in the Kodiak area. About half of these fishing grounds are considered to be breeding area. Historical data for the Kodiak Island King Crab catch reveals a peak harvest of 90 million pounds in 1966 with a decline to 12 million pounds in 1969 and 1970. The estimated maximum sustained yield, however, is 15-20 million pounds (1).

Tanner and dungeness crab are also a significant part of the total harvest of crabs in the Kodiak area. The first significant commercial harvest of tanner crab occurred in 1967. In 1970 almost eight million pounds were harvested and this fishery has shown strong growth over the years with potential for further growth. When King crab availability is decreased, fishing effort usually is increased for tanner crabs. Thus the tanner crab fishery is important in supplementing the overall crab fishery, especially during times when King crab yield is low.

Dungeness crab also contribute to the total crab harvest, and, like tanner crab, supplement crab fishing when King crab production

is low. The dungeness crab fishery has developed rather steadily since 1962. The 1970 harvest amounted to 5.7 million pounds per year.

The Kodiak shellfishery also includes pink and sidestripe shrimp, but the market for the latter has not fully developed. The pink shrimp catch contributes significantly to the total shellfish harvest. It has increased from 3.4 million pounds in 1960 to 62.3 million pounds in 1970. The maximum sustained yield for this species is calculated to be 58 million pounds.

The seafood processors in Gibson Cove and Kodiak Harbor do not accommodate the total harvest of shellfish from the Kodiak area waters. Typically they process only about 80 percent of the total yield; the remainder are processed at other canneries elsewhere on the island or adjacent Afognak Island. Thus, about 70.5 million pounds of shellfish were processed at these facilities in 1970 from a total harvest of 88.2 million pounds. None of the shellfish wastewater from these canneries were given any form of treatment at this time, and it was inevitable with shellfish processing of this magnitude that the waters of Kodiak Harbor became polluted and contained sludge deposits adjacent to the canneries.

Other seafoods also harvested in the Kodiak Island area have included all five North American species of Pacific salmon and herring, halibut, scallops and razor clams. Commercial fishing for scallops has been discontinued in the Kodiak area, however, and fishing for razor clams has not been vigorous because of market conditions. Only about

0.13 million pounds of razor clams were harvested in the Kodiak area in 1970. In the same year about 8.6 million pounds of halibut were harvested.

Commercial fishing for herring began in 1912, was well developed in 1916, became a large scale operation by the early 1930's and continued in decreasing intensity to 1960 when it ceased because of poor markets. Then in 1964 it began again with Japanese interest in herring eggs (1). In 1970 about 1.3 million pounds of herring were harvested, primarily for the herring roe market in Japan; only a small amount of these fish were used for other purposes, such as bait or food, most being discarded.

Of the total Kodiak Island area salmon catch, pink, chum, and sockeye salmon provide the bulk of the harvest. Pinks constitute about 85 percent of the yield, chums and sockeye about seven percent, and Kings and silvers the remainder, but the contribution by species can be quite variable. The total harvest of salmon in 1970 was about 55.5 million pounds, and in the preceding 10-year period averaged 13.5 million pounds with considerable variation during the period. Although only about 15 percent of the salmon harvest is processed at the Kodiak Harbor area canneries, while the remainder is accommodated at other localities on the island (2), wastes from these processing activities also were not treated at these times; such wastes significantly contributed to the degradation of the waters of Kodiak Harbor.

Fifteen seafood processors have been operating adjacent to these waters since 1971, one in Gibson Cove and 14 in Kodiak Harbor. The 14 seafood processing plants operating in the Kodiak Harbor area,

located on the waterfront of the city of Kodiak, processed 110 million pounds of fishery products consisting of salmon, crab, shrimp, clams, scallops, halibut and herring in 1971. Based on the records of these 14 plants, an estimated 72 million pounds of wastes from these facilities were discharged without treatment to Kodiak Harbor. From 33-35 percent of the whole weight of salmon, 75-85 percent of crabs, and about 80 percent of shrimp are waste. The wastes consisted of discarded seafood animal parts such as heads, entrails, slimes, crab bodies without legs, shells, other carcass remains, and whole dead animals unfit for processing.

As recently as early 1973 none of the 15 processors now located in the Gibson Cove-Kodiak Harbor area were providing any treatment of their wastewaters for removal of any pollutants, and only a few occasionally ground the wasted animal parts prior to discharge even though state regulations required at least grinding and discharge at a depth not less than seven fathoms, or 42 feet. Wastes from shrimp and sometimes other seafood processing operations routinely were discharged without grinding, often to the surface of the water directly under the processing facility. On some occasions whole dead crab unsuitable for processing have been discarded to the watercourse from the areas of offloading facilities at some processing plants. Crab carcasses were often seen floating on the waters of Kodiak Harbor during the most active time of the crab processing season. Because of the indiscriminate practice of frequently by-passing grinders and not discharging wastes at the depth required by state regulations, it

was not uncommon to observe other discarded animal remains floating on the water too.

During the height of the processing season the waters of Gibson Cove and Kodiak Harbor adjacent to the seafood processing plant were typically highly discolored with body fluids and small pieces of animals, such as shrimp bodies and antennae, that were part of the wastewater discharges. At the same time, bubbles of hydrogen sulfide gas could be found bursting on the surface waters near most of the processing plants. During warm periods, strong foul-smelling odors were readily apparent near the processing facilities, and complaints of these odors were frequently registered in the community. The state waste discharge permitting agency has not issued a permit to any one of the Kodiak seafood processors. In 1973 the U.S. Environmental Protection Agency issued permits to each of these processors; these permits have required screening of processing wastewaters with the option of meeting an effluent limitation of 2 milligrams of solids per liter of sample. The processors have elected to meet the screening requirement of the permits which expire May 31, 1975.

Purpose of Study

The waters of Kodiak Harbor and Gibson Cove had not been sampled by a water quality regulatory agency since August 1971. The brief survey reported herein was undertaken to determine the present quality of the waste receiving waters and to determine the improvements, if any, that have occurred in water quality as a result of installation

of screening systems for removal of large solids from the processing wastewater lines at the seafood processing plants.

The following questions were answered in whole or in part as a result of this survey:

1. What is the present water quality in Gibson Cove and Kodiak Harbor compared to previously collected data, and to the Alaska Water Quality Standards criteria for dissolved oxygen, residues, sludge deposits, and toxic substances?

2. What improvements in receiving water quality, if any, have occurred since installation and operation of screens for removal of solids in the seafood processing wastewaters at the cannery facilities?

Scope of Study

Of the 15 seafood processing plants in the Kodiak area, 14 had completed the installation of screening facilities by July 1974; one processing plant still had not installed screens, however, by the time of the August 1974 survey. Sanitary wastes either are discharged separately from each installation or are connected to the city sewage wastewater collection system, but no attempt was made during the August 1974 survey reported herein to determine the influence of sanitary waste discharges on water quality. Thus no bacteriological samples were taken. The contribution of these wastewaters on other water quality parameters, such as dissolved oxygen, also was not isolated; however their influence is considered to be relatively minor.

Chemical and physical data were collected from 13 stations in Gibson Cove and the nearby waters of Kodiak Harbor (Figure 2) concurrently with an in-plant compliance monitoring survey at the 15 seafood processing plants at Kodiak. Both the in-plant and the

receiving water surveys were accomplished during the week of August 26, 1974. No attempt is made herein to correlate the findings of the in-plant survey with those of the receiving water survey. In the receiving waters, primary efforts were made to collect temperature, salinity, dissolved oxygen, Secchi disk, conductivity, and transmissivity data.

Bottom samples at 14 sites in the study area were collected to visually determine the presence of settleable solids in the form of wasted portions of seafood animals such as antennae, shell, entrails, ect., if any; to determine chemical composition to further characterize sludge formations known to be present during previous sampling surveys; for qualitative determinations of the occurrence of hydrogen sulfide; and for general biological information pertaining to macroscopic (readily visible) plants or animals that might inhabit the bottom deposits. No samples were obtained to evaluate floating or suspended microscopic plant or animal populations.

SUMMARY AND CONCLUSIONS

A brief water quality survey was conducted at Gibson Cove and Kodiak Harbor, Kodiak, Alaska, during the week of August 26, 1974 to determine the water quality influences of waste discharges from 15 seafood processing plants following installation and operation of screening equipment for solid removal from processing wastewater effluents, and to assay any improvements in the waste receiving waters as a consequence of installation of these screens.

Data obtained from three water column stations and one bottom station in Gibson Cove, and 10 water column stations plus 11 bottom stations in Kodiak Harbor consisted primarily of measurements for dissolved oxygen, temperature, pH, conductivity and transparency, and selected chemical and visual analyses of bottom deposits.

The Alaska Water Quality Standards criterion for dissolved oxygen in these marine waters, Class D and E is that it shall be "greater than 6.0 mg/l". Data from 100 dissolved oxygen measurements in 1974 and comparison with similar data obtained in 1971 reveal that:

1. in 1971 dissolved oxygen was always greater than 6.0 mg/l at Gibson Cove, but during the August 1974 survey it was less than 6.0 mg/l in 4 of 22 measurements or about 18 percent of the time, with less than 6.0 mg/l occurring in both the near surface and bottom water layers; thus, it is concluded there has been a decline in water quality rather than any improvement in Gibson Cove even with the installation of screening equipment.[1/]

[1/] Since 1971, the New England Fish Company has greatly increased its production and processing of seafoods, and an outfall from Bio-Dry, Incorporated has been installed near the mouth of Gibson Cove.

2. of 48 dissolved oxygen determinations in the Kodiak Harbor reach from the small boat basin westerly to the Alaska Pacific Seafoods dock, about 15 percent (7 determinations) were less than the 6.0 mg/l standards criterion during the August 1974 survey; during the August 1971 survey 22 percent of the samples (10 of 46) had less than 6.0 mg/l (values less than 6.0 mg/l occurred in both the near surface and bottom layers during both survey periods).

3. in 1974 in the Kodiak Harbor reach westerly of the small boat harbor, the lowest dissolved oxygen value (4.5 mg/l) was higher than that measured in 1971 (1.3 mg/l); additionally the average of the dissolved oxygen values less than 6.0 mg/l in the same reach in 1974 was higher than those for 1971 (5.2 and 4.1 mg/l respectively); thus it is concluded that there has been a perceptible improvement in the dissolved oxygen in this reach of Kodiak Harbor, but the improvement has been incomplete because dissolved oxygen values less than 6.0 mg/l still are to be found.

4. dissolved oxygen in the Kodiak Harbor reach easterly of the small boat harbor was found in concentrations greater than 6.0 mg/l at all times during the August 1971 and August 1974 surveys, but the average dissolved oxygen in this reach was lower during the August 1974 survey (7.7 mg/l) than during the August 1971 survey (10.7).

5. additional treatment, or the establishment of "no discharge zones" for process wastewaters, one for the discharges in the Gibson Cove area and another for those in the Kodiak Harbor reach west of the small boat basin, would provide compliance with the Alaska Water Quality Standards criterion for dissolved oxygen and assure a high quality of water for use by both the canneries and the crab boats which employ these waters to sustain crabs in holding facilities prior to processing thus reducing crab mortality.

The same standards criterion for pH in Gibson Cove and Kodiak Harbor is that it shall be within the range of 7.5 - 8.5. Data from the August 1974 survey show that 27 percent of the pH determinations were not within this range. Specifically, pH values as low as 6.9 and as high as 8.9 were found in the study area.

Transmissivity and transparency data obtained in 1974 show that some of the wastes passing through the screens at the Gibson Cove and

Kodiak Harbor seafood processing facilities are located in the upper rather than near-bottom reaches of the receiving waters in the study area. The average of 16 transmissivity determinations at Stations 1 through 6, the area west of the small boat harbor, was 74 percent at the 1 meter depth and 84 percent near the bottom. East of the small boat harbor there was no major difference in transmissivity at the 1 meter and near-bottom depths. Similar data from the August 1971 survey revealed the same pattern and there did not appear to be any significant difference in this parameter during the two study periods.

The Alaska Water Quality Standards criterion for transparency in Class D and E waters such as Gibson Cove and Kodiak Harbor is that Secchi disc measurements shall not be less than 1 meter. No Secchi disc measurements were made in 1971 because this criterion was not part of the standards at that time, but those for 1974 were all greater than 1 meter. Many were close to this value and show greatly reduced transparency below an expected value of 8 meters.

The standards criteria for residues and settleable and suspended solids were not met as indicated by chemical, biological and observational data collected in 1974. Comparison of these data from the August 1971 and August 1974 surveys showed no significant improvement in the chemical characteristics for organic matter and sulfides in the bottom deposits in Kodiak Harbor west of the small boat basin and the beginning of sludge accumulation in Gibson Cove. Some improvements were noted however in both the surface waters and bottom deposits in the Kodiak Harbor area. During the August 1971 survey the surface waters of the Kodiak Harbor area west of the small boat basin were

highly discolored, had many mats of bulked sludge and pieces of wasted seafood animal parts such as shrimp antennae, dead crabs etc., and had many bubbles of hydrogen sulfide. The bottom deposits along the piers and docks in this reach were covered almost continuously with decomposing recently-discharged fresh seafood animal remains that emitted extremely foul odors, and did not support any macroscopic live animals such as pollution tolerant, ooze dwelling polychaete worms.

During the August 1974 survey the waters in this reach were only moderately discolored; bulked sludge with shrimp antennae or other whole parts of other dead animals were not apparent; and hydrogen sulfide bubbles were not found. Except for one station the bottom deposits were not covered with recently deposited dead seafood animal parts and some of the bottom deposits supported ooze dwelling polychaete worms. Foul hydrogen sulfide odors in these deposits were still apparent, but were less noticeable than in 1971. The lack of a balanced bottom-associated community of aquatic life, the lack of significant improvement in the chemical characteristics of the bottom deposits, and the continued presence of hydrogen sulfide in the bottom reaches of Kodiak Harbor west of the small boat basin revealed that the improvements in this reach are not complete.

Additional treatment, or the establishment of no dumping zones in both Gibson Cove and the Kodiak Harbor reach west of the small boat basin would provide for compliance with the standards criteria for residues and settleable and suspended solids and assure improvement

in the chemical characteristics of these bottom deposits. The establishment of such zones for process wastewaters would effect dissipation of small waste solid particles and soluble wastes that pass through the screens.

STUDY AREA

General Description

Other than the wastewater discharges from a few municipal sewers and the 15 seafood processors, there are no major sources of non-saline water in the Gibson Cove-Kodiak Harbor area. Thus, the waters of this area are decidedly marine rather than estuarine. Gibson Cove is a small bean-shaped embayment protruding inland from St. Paul Harbor which provides ready access to the open ocean waters of Chiniak Bay (Figure 2). The cove is only about 600 yards long and 225 yards wide with a 90 yard wide connection to St. Paul Harbor, and with a maximum depth of only 5 fathoms. At the time of the August 1974 survey, only one seafood processing facility was located in this cove, but plans are being made to locate two more here. Gibson Cove also is the location of the Bio-Dry, Inc. facility which processes the screened waste solids from the canneries at Gibson Cove and Kodiak Harbor.

Kodiak Harbor, located northeasterly of Gibson Cove about 1/2 mile, is a relatively narrow channel formed by Gull, Uski, and Near Islands which lay just off Kodiak Island. Gull, Uski, and Near Islands provide protection from winds and waves. The harbor is about 3100 yards (1.76 miles) long and varies in width from 600 yards on its westerly end to about 110 yards near its easterly end; it has a maximum depth approximating 13 fathoms. Fourteen seafood processing facilities are located on the north shore of Kodiak Harbor, and more

than half of the 14 are concentrated along a 2100 yard length of the waterfront area westerly of the small boat basin.

Climatic Conditions

The Kodiak Harbor-Gibson Cove area is in the cold maritime region of Southcentral Alaska and is on the edge of one of the northernmost reaches of the Pacific Ocean. The area is situated adjacent to the Japanese Current which has significant influence on both air and water temperatures, and on climate. This influence is shown by mildly cool temperatures, small temperature variations, high precipitation, high humidity, fog, and frequent severe storms.

Except during approaching storms, the daily temperature varies only about 10 degrees. The average temperature of 55° during August, the warmest month, is only about 25 degrees higher than the average January temeprature of 29°F, the coldest month. Ice only rarely forms on Gibson Cove or Kodiak Harbor, and then only on the shoreline. The average annual precipitation amounts to about 58 inches per year, with few months having less than four inches any year. Snow is most common during the winter months of December, January, February and March, which each average near 10" of snow. Average precipitation, either as snow or rain, exceeds 3.5 inches per month. Despite an average of 58 inches of precipitation, residents in the town of Kodiak annually experience a severe water shortage, but these shortages are primarily the consequence of tremendous water consumption by the seafood processing industry and the lack of an adequate reservoir to provide sufficent storage to accommodate all water demands.

Prevailing winds are from the northwest and west at about 10 miles per hour, but during storms sustained velocities often are 30 miles per hour, particularly during the winter. Strong wind gusts not uncommonly exceed 70 miles per hour. The passage of storm frontal systems or their approach causes a change in the direction of wind. Some winds blow from the south and these produce fairly choppy waters or waves up to two feet high at the mouth of Gibson Cove and along much of the northern waterfront reach of Kodiak Harbor. In past years these winds have caused floating seafood wastes and associated foam on the water to accumulate on the shoreline adjacent to business establishments and residences.

Oceanography

Except for the industrial wastewater discharges from the seafood canneries and municipal sewers, there is no major in-put of non-brackish water to Gibson Cove and Kodiak Harbor. Thus these watercourse reaches are decidedly marine rather than estuarine with salinities that range from 28 to 31 parts per thousand.[1/] These salinities are near the lower limit tolerated by adult tanner crabs. During offloading operations to the canneries, the crabs are held alive with this low salinity water that is pumped into the holding tanks. At times of high temperatures (near or above 50°C) this water in Kodiak Harbor has contributed to crab mortality on board the fishing vessels while tied to docks for offloading.

[1/] Offshore seawater near the surface has a salinity of 32.5 parts per thousand.

The discharges of non-brackish water in Gibson Cove and Kodiak Harbor mildly dilute the seawater in these reaches, and the less-than-full-strength salinities in the area probably are also the result of stream runoff somewhat far removed from the area. Vertical and horizontal salinity gradients undoubtedly occur, but their intensity and duration have not been studied. The waters of Gibson Cove and Kodiak Harbor at the one meter depth and deeper seem to be only weakly stratified with regard to salinity. This probably is a consequence of their shallowness and the effect of adjacent islands and reefs that form a barrier between Chiniak Bay and Kodiak Island preventing full circulation of deeper and more saline oceanic water into Gibson Cove and Kodiak Harbor.

Oceanographic studies in the Kodiak Harbor and Gibson Cove areas are wanting, but it is evident that the industrial and municipal waste discharges to these waters have had a significant affect on water quality. Thus, discoloration of these waters, sludge deposits, and gross bacterial contamination has been apparent. The discharge of municipal wastes to Kodiak Harbor for many years has caused gross bacterial degradation and probably has contributed to the formation of sludge deposits, while industrial discharges, those from the processing of seafoods, were the principle source of sludge deposits and intense discoloration of the harbor waters.

Tides in the area have an amplitude of 17 feet, but the mean tidal range, i.e. mean high water to mean low water, is about 6 1/2 feet, the mean diurnal range, mean high high water to mean low low

water, is about 8 1/2 feet. Unpublished data obtained on January 25-27, 1968 show a mean velocity of 0.0154 knots (0.0285 km/hr) at a depth about five feet from the bottom in the Kodiak Harbor reach near the light marker, a narrow portion of the harbor at north latitude of 57° 47' 20". The net flow over 3 1/2 tidal cycles was computed to be about 317 cubic meters per second (11,196 cubic feet per second), and the direction of net flow was from southwest to northeast.

Water Uses

Uses of the waters of Gibson Cove and Kodiak Harbor, as stipulated in the Alaska Water Quality Standards (3), consist of water contact recreation, growth and propagation of fish and other aquatic life (including waterfowl and furbearers), shellfish growth and propagation (including natural and commercial growing areas), and industrial water supply other than food processing. Additionally other factual uses are navigation and discharge of wastewaters.

Of prime importance from a water quality viewpoint is the use of these waters by vessels and canneries that have holding tanks for live crab, because this water must be of sufficient quality to support these animals for periods up to five days. Live crab in the holding tanks of fishing vessels sometimes are contained therein while in port for one or more days prior to offloading during peak crabbing periods. After being offloaded from the fishing boats, the live crabs are transferred to holding tanks at the canneries which draw water at a depth about 6-10 feet above the bottom of Gibson Cove and Kodiak Harbor.

The waters in the Kodiak area constitute nursing and feeding grounds for young and adult crab. Trident Basin, just south of Near Island, for example, is a prime nursery, feeding, and breeding area for King crab and other shellfish. This basin contributes substantially to the regional fishery, up to five percent of the total commercial King crab and shrimp annual harvest in the Chiniak-Marmot Bays Statistical Area (2). These shellfish have an annual value to fishermen of $176,000, based on 1971 markets (3).

Previous Studies

In 1969 the canneries adjacent to Kodiak Harbor discarded about 63 million pounds of untreated seafood wastes according to a report by the National Marine Fisheries Service (4) which maintained records on harvest of these seafoods. Data from an unpublished report by the U.S. Environmental Protection Agency (5) show that in 1970 the 14 canneries adjacent to Kodiak Harbor processed an estimated 110 million pounds of seafood, excluding scallops, razor clams and herring, and discarded 72 million pounds of associated wastes.[1/] According to data obtained from the in-plant aspect of this study, these wastes had a 22 million pound chemical oxygen demand and contained about 23 million pounds of total solids. Shrimp processing operations constituted about 85 percent of the waste loading, crab 10 percent and salmon about five percent. Halibut, scallops, and herring did not contribute significantly to the total discharged wastes in the calculations of

[1/] The cannery at Gibson Cove was not operating in 1970.

the waste loadings. The in-plant study also showed that shrimp processing produces the strongest wastes as is evident in the following table:

Strength of Seafood Processing Wastes at Kodiak, Alaska as Based on Chemical Oxygen Demand and Total Solids Per Pound of Harvested Finfish or Shellfish

Seafood Item	Chemical Oxygen Demand	Total Solids
King Crab	0.10	0.14
Tanner Crab (est.)	0.10	0.14
Dungeness	0.12	0.20
Shrimp	0.31	0.30
Salmon	0.41	0.07

Because the seafood industry is highly variable from year to year due to product demand, marketability, and success of harvest of the seafood crop, it is difficult to assume that the same quantity and quality of seafood wastewaters would be discharged from year to year. There has been a strong tendency, for example, to shift major production at some of the canneries to shrimp in the past few years as evidenced by a notable increase in the number of shrimp processing units in 1971. Because of the various harvest regulations, and market conditions, though, the average quantity of wastes discharged to these waters was believed to be about 72 million pounds per year up until the time of installation of solids waste removal facilities at most of the canneries.

The same unpublished report (5) also included data on the receiving waters of Gibson Cove and Kodiak Harbor. In general, grossly polluted water was not perceptible in Gibson Cove, and it did not have sludge deposits. At that time Gibson Cove had only one seafood

processing facility, but two more are now contemplated. Kodiak Harbor though was grossly degraded in reaches adjacent to the canneries between the city dock and the west side of the small boat harbor.

This reach also contained sludge deposits overlaid with freshly discharged seafood wastes, and produced hydrogen sulfide gas apparent by odor of the sludge samples and by bubbles rising to the surface of the water along with bulked sludge and associated small mats of seafood wastes.

Surface dissolved oxygen in 1966 at three stations in Kodiak Harbor, specifically the City Dock, King Crab, Inc. Dock, and the State Ferry Dock, was less than six milligrams per liter (mg/l), the minimum allowed by the Alaska Quality Standards (6), in 24 (53%) of the samples collected between March 24, 1966 and January 1967, according to the unpublished data from the Alaska Department of Fish and Game that are in EPA's files. During May 11-14, 1971 the U.S. Environmental Protection Agency found dissolved oxygen in excess of 6.0 mg/l at all Kodiak Harbor sampling sites. During August 10 and 12 of the same year, dissolved oxygen as low as 1.3 mg/l was found in the surface waters adjacent to one of the canneries in the same study area. Five of 18 surface samples from this area and only two of 30 taken at greater depths on August 10 and 12 had less than the required 6.0 mg/l criterion.

WATER QUALITY STANDARDS

The present Alaska Water Quality Standards (6) designate the marine waters of the state, including Gibson Cove and Kodiak Harbor as Class C, D, E, and G. Beneficial uses of marine waters include water contact recreation, industrial water supply, growth and propagation of aquatic life and waterfowl, fur-bearers and other water-associated life. The standards criteria associated with marine waters that are of particular interest in this report are those for dissolved oxygen, residues in the form of floating solids and sludge deposits, and toxic substances. Of the various classifications, Class D and E have the most stringent criteria:

Dissolved Oxygen

Class D - greater than 6 mg/l in salt water

Class E - greater than 6 mg/l in the larvae stage. Greater than 5 mg/l in the adult stage.

Residues

Class D - residues may not make the receiving water unfit or unsafe for the uses of this classification; nor cause a film or sheen upon, or discoloration of, the surface of the water or adjoining shoreline; nor cause a sludge or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom or upon adjoining shorelines. Residues shall be less than those levels which cause tainting problems as determined by bioassay.

Class E - same as Class D.

Toxic Substances

Class D - Concentrations shall be less than those levels which cause tainting of fish, less than acute or chronic problem levels as revealed by bioassay or other appropriate methods and below concentrations affecting the ecological balance.

Class E - same as Class D.

SAMPLING PROGRAM

As indicated earlier, the sampling of the waters of Kodiak Harbor and Gibson Cove was done while routine compliance monitoring surveys in the canneries were being conducted. The receiving water sampling was conducted to determine the improvements, if any, in water quality since the installation and operation of screening equipment for removal of solids in processing wastewaters. Sufficient data were available from previous studies to compare with the 1974 findings reported herein to assay the magnitude of any significant improvements in water quality as related to the Alaska Water Quality Standards.

Although previous studies revealed that degradation of water quality occurred primarily in the top 1 meter of water, it was believed that any gross improvements in water quality could occur in both the surface or near bottom water reaches. Thus the 1974 sampling program for dissolved oxygen, pH, temperature, conductivity and transmissivity was restricted to the one meter and near the bottom zones of water in Gibson Cove and Kodiak Harbor. Chemical tests for sulfides, percent volatile solids, total organic carbon, and total organic nitrogren, and visual inspections for macroscopic animal components were conducted on selected samples from the bottom deposits. Their general composition also was noted.

Sampling Stations

A total of 11 stations were previously established in the study area during a 1971 sampling program. During the 1974 sampling period,

the sampling area with few exceptions remained the same (Figure 2), and the stations in this area were more intensively sampled than during 1971. The intensively sampled stations are those more closely associated with the cannery discharges. Additional stations, as in 1971, were sampled for bottom deposit data. The same station numbers used in the 1968-1970 study were retained for easier reference with the present survey.

Sampling Periods

Although seasonal variation in water quality of the study area had been evaluated in the 1971 report, such determinations were beyond the scope of the 1974 survey. Additionally, it was believed that any major improvements in water quality would be apparent during the fall of the year when cannery activity is intense and temperatures are highest. Thus, only one survey was made, but the intensity of sampling during the 1974 survey was increased to offset anomalous situations that might occur because of tidal variations.

Sampling for the selected chemical and physical parameters in the water column was begun about two hours or less before the beginning of a new tidal change, i.e. flood or ebb, in an attempt to sample during the worst time, i.e., slack tide, when waste discharges would be likely to have the greatest effect on water quality. Stations immediately adjacent to the canneries include the reaches of Gibson Cove and Kodiak Harbor most affected by wastewater discharges. These stations plus Station 9 were sampled shortly before or during two flooding tides and shortly before and during two ebbing tides.

Other stations, those not immediately adjacent to the canneries, were sampled without regard to tidal stage to collect tidal independent chemical, biological, and physical data from the bottom deposits. The tidal data and the beginning and end of sampling in the water column adjacent to the canneries on August 27-29 are as follows:

August 27, 1974

Time of High Tide	1103	Time of Beginning of Sampling	1030
Time of Next Low Tide	1556	Time of Ending of Sampling	1355

August 28, 1974

Time of High Tide	1149	Time of Beginning of Sampling	0950
Time of Next Low Tide	1700	Time of Ending of Sampling	1240
Time of Low Tide	1700	Time of Beginning of Sampling	1540
Time of Next High Tide	2310	Time of Ending of Sampling	1735

August 29, 1974

Time of Low Tide	1747	Time of Beginning of Sampling	1600
Time of Next High Tide	2358	Time of Ending of Sampling	1750

The sampling route was always along the shortest route in the numerical sequence of station numbers (i.e. from Station 1 through Station 9) during each sampling segment.

Methods

Dissolved oxygen, temperature, conductivity, and pH were determined with a Hydrolab Model 6D Surveyor Portable Water Monitor[1/] instrument that frequently was calibrated each sampling period, for example, the beginning and end of each sampling cycle. Additionally,

[1/] Use of product and company names is for identification only and does not constitute endorsement by the U.S. Environmental Protection Agency.

the dissolved oxygen probe of this instrument was calibrated to the standard Winkler method each time a suspected erratic value for this parameter was obtained. Thus, most low dissolved oxygen values were verified by standard, wet-method chemical techniques.

Salinity determinations were calculated from the conductivity and temperature data obtained with the Hydrolab instrument. Samples requiring laboratory analyses were collected in cubitainers, and shipped via air freight in ice-packed containers either to the U.S. Environmental Protection Agency laboratory in Seattle, Washington or the EPA laboratory at Fairbanks, Alaska.

The pH probe of the Hydrolab instrument did not function properly throughout the course of the 1974 survey, so only a very limited amount of pH determinations were made.

One set of determinations was made for transparency and for transmissivity. Transparency measurements were determined by use of a 20 centimeter Secchi disk, and transmissivity measurements were made with a Model 410-BR Hydro Products transmissometer that gives a direct reading of percentage of light absorbed when traversing a one meter path.

Chemical analyses of the bottom deposit samples were made at the Seattle, Washington laboratory facility. As with the other samples, the bottom deposit samples were packed in ice for preservation prior to air shipment. Bottom deposit samples were obtained by use of a small Peterson dredge. A small portion of each of these samples was collected for chemical analyses and the remainder was inspected

for animal life subsequent to screening through a 30 mesh U.S. Standard Sieve. Visual inspections of these samples were made to determine the presence or absence of living animals, recently deposited dead animal parts from the seafood processing facilities, and sludge.

RESULTS AND DISCUSSION

Temperature and Salinity

The waters of the Gibson Cove and Kodiak Harbor area are decidedly marine rather than estuarine. It has been found that they were slightly less saline than normal seawater (32.5 parts per thousand) by about 2-3 parts per thousand (0/00) because of the influence of wastewater discharges from the seafood processing facilities and those from the community of Kodiak as well as precipitation and perhaps freshwater discharge from somewhat distant streams. As is quite typical of northern marine environments where seawater is perceptibly diluted with fresh or less saline water, during the fall of the year, the waters of Gibson Cove and Kodiak Harbor were found to be stratified with a lense of less dense and poorly mixed brackish water that overlays deeper, more saline and more dense waters. The density stratification in Gibson Cove and Kodiak Harbor is not strong though. Even so, stratification is sufficient to inhibit good vertical mixing, and this has an important bearing in the distribution of soluble and suspended solids discharged to these waters, that is, they are located primarily in the surface and near surface waters rather than throughout the entire water column. Heavy solids such as crab shells settle to the bottom of the watercourse.

Calculations based on temperature and salinity for water density at Stations 1A and 4, in Gibson Cove and Kodiak Harbor, respectively, show a fairly consistent pattern of density with more saline, cooler,

and therefore denser water located beneath a less saline, warmer, and lighter layer (Table 1). This pattern is so predominant throughout the study area that it can be readily observed with few anomalous exceptions by noting only temperature data during the course of this survey (Appendix Table 1A).

Dissolved Oxygen

The importance of the above pattern of density and the associated stratification in the fall of the year is that most of the soluble and settleable solids in the process wastewaters from the canneries are much less saline, often warmer, and less dense than the receiving waters of Gibson Cove and Kodiak Harbor; thus, these wastewaters soon after discharge either rise to the surface if discharged near the bottom of the adjacent watercourse or are discharged directly to the surface where most oxygen consumption occurs.

Data from an August 1971 survey of these waters indicate most of the decrease in dissolved oxygen occurred in the surface and near-surface water layer (Appendix Table 2A). Dissolved oxygen concentrations as low as 1.3 mg/l were found in the surface waters at Stations 4 and 5 in Kodiak Harbor, but dissolved oxygen at concentrations less than 6.0 mg/l were not apparent except at one time at Station 4 in the bottom associated waters. None of the dissolved oxygen values were below 6.0 mg/l at Station 1 at the mouth of Gibson Cove, but 7 of 24 surface water samples (29%) from Kodiak Harbor had less than the 6.0 mg/l criterion for dissolved oxygen. Examination of the distribution of the stations in the study area (Figure 2) shows that the

TABLE 1

TEMPERATURE (°CENTRIGRADE), SALINITY (o/oo) AND DENSITY ($6t$) AT 1 METER AND BOTTOM AT STATIONS 1A IN GIBSON COVE AND 4 IN KODIAK HARBOR, KODIAK, ALASKA, AUGUST 27-29, 1974.

DEPTH	T°C	o/oo	$6t$	T°C	o/oo	$6t$	T°C	o/oo	$6t$	T°C	o/oo	$6t$
	AUGUST 27, 1974 1030 HOURS			AUGUST 28, 1974 0930 HOURS			AUGUST 28, 1974 1540 HOURS			AUGUST 29, 1974 1600 HOURS		
						STATION 1A						
1 METER	11.5	15.6	11.69	11.6	29.7	15.83	11.8	29.4	22.31	12.0	29.0	21.96
BOTTOM	11.0	30.1	22.9	11.2	30.1	22.96	11.5	30.1	22.89	11.3	30.1	22.94
	AUGUST 27, 1974 1240 HOURS			AUGUST 28, 1974 1140 HOURS			AUGUST 28, 1974 1640 HOURS			AUGUST 29, 1974 1645 HOURS		
						STATION 4						
1 METER	11.5	29.0	22.07	11.3	30.4	23.17	11.5	29.7	22.61	11.5	29.7	22.61
BOTTOM	11.0	30.1	23.22	10.8	30.4	23.25	11.2	30.1	22.96	11.2	30.1	22.96

dissolved oxygen values less than 6.0 mg/l occurred only in the reach between the front of Alaska Pacific Seafoods Cannery and the small boat harbor. This reach of Kodiak Harbor has the greatest concentration of canneries in the entire study area, and experienced the largest reduction in dissolved oxygen during the 1971 survey.

During the August 1974 survey a total of 100 dissolved oxygen determinations were made through the study area. As in the August 1971 survey, all determinations for dissolved oxygen at the mouth of Gibson Cove, Station 1, were above the 6.0 mg/l standard criterion (Table 2). Additional sites established in Gibson Cove during the August 1974 survey, however, revealed that at times the dissolved oxygen concentration was less than 6.0 mg/l at Stations 1A and 1B. Station 1A, sampled in 1971 for biological data but not for water column data, was sampled during the 1974 survey to obtain supplemental water column information from the interior reach of the cove,[1/] and is located about 46 meters (50 yards) offshore from the New England Fish Company cannery. Station 1B was established on August 28, 1974 when a highly discolored plume of water was noted near the east side of Gibson Cove adjacent to the Bio-Dry Incorporated facility which processes screened wastes from the canneries. This plume was the result of a break in the effluent line which was installed to extend the discharge from the Bio-Dry facility to the mouth of Gibson Cove.

[1/] The discharge line from this cannery was via an outfall line to a position just seaward of the mouth of Gibson Cove, but for various reasons it had been broken on separate occasions several times and was discharging processing wastewaters inside of the cove.

TABLE 2

DISSOLVED OXYGEN CONCENTRATIONS (MG/L) AT 1 METER AND NEAR BOTTOM* IN GIBSON COVE AND KODIAK HARBOR, KODIAK, ALASKA

AUGUST 27-29, 1974

	STATION NUMBERS												
Depth	1	1A	1B	2A	2	3	4	5	6	7	7A	8	9
	AUGUST 27, 1974 1030-1355 HOURS												
1 METER	8.5	8.0	-	8.6	8.6	6.7	5.4	6.2	6.8	6.7	-	8.8	9.2
BOTTOM	8.3	7.1	-	7.8	7.8	6.6	6.6	6.9	7.6	7.8	-	8.6	8.5
	AUGUST 28, 1974 0930-1240 HOURS												
1 METER	6.6	6.0	7.3	8.8	7.7	5.6	6.4	6.3	6.1	7.6	7.6	7.7	8.1
BOTTOM	8.7	8.7	8.0	7.5	8.1	6.2	6.7	7.0	7.3	7.9	7.9	8.0	8.2
	AUGUST 28, 1974 1540-1735 HOURS												
1 METER	6.3	5.9	6.3	7.1	6.8	6.3	4.5	6.2	6.7	7.5	7.7	7.4	8.3
BOTTOM	8.8	8.0	5.8	7.0	8.3	6.5	7.5	7.9	7.9	7.9	7.8	7.8	8.2
	AUGUST 29, 1974 1600-1750 HOURS												
1 METER	7.4	5.7	7.1	5.5	4.7	6.6	6.8	7.2	7.1	7.5	7.6	6.9	8.0
BOTTOM	6.9	6.5	7.0	5.7	5.3	7.1	7.3	7.2	7.5	7.6	7.9	7.5	8.1

*Bottom depths vary from 9 meters at Station 1 in Gibson Cove to 21 meters at Station 2A in Kodiak Harbor.

The data from the interior Gibson Cove Stations, Stations 1A and 1B show that about 21 percent of the samples (14) had less than 6.0 mg/l dissolved oxygen. Dissolved oxygen values less than the 6.0 mg/l standard were also apparent in the bottom waters at these stations. Thus the waste discharges from both the New England Fish Company facility and the one from the Bio-Dry facility have significantly degraded water quality inside the cove even though their discharge lines are extended to the mouth of Gibson Cove.[1/] This degradation would have occurred even if there had not been any breakage of the discharge lines from the two facilities because winds blowing from the south force the surface waters at the mouth of the cove and their load of discharged waste particles into the cove where the solids eventually mix with interior cove waters and ultimately settle to the bottom.

The wastewaters discharged to the mouth of Gibson Cove in 1971 were those from only the New England Fish Company. At the time of the 1971 surveys significantly reduced dissolved oxygen concentrations were not perceptible at Station 1 at the mouth of Gibson Cove. Since then, however, the New England Fish Company has expanded its facilities and substantially increased its production at Gibson Cove, and the Bio-Dry Facility has been installed with a waste discharge line extended to the mouth of the cove also. The discharges from both facilities produce two readily apparent plumes at the mouth of the cove and these have been observed moving to the interior reaches of the cove during southerly wind conditions.

[1/] The breaks in the discharge line from the New England Fish Company had been repaired prior to the August 1974 survey.

Even though the dissolved oxygen concentrations were more than the 6.0 mg/l criterion at Station 1 during both the August 1971 and August 1974 surveys, the dissolved oxygen was decidedly lower in 1974 than in 1971. A minimum dissolved oxygen concentration of 8.0 mg/l would be expected in this reach of the study area at all times and depths (particularly during choppy water conditions resulting from southerly winds) if not adversely affected by wastewater discharges. Thus, the wastewater discharges presently located at the mouth of the cove need to be extended into the deeper and farther offshore waters of St. Paul Harbor to assure compliance with the standards criterion for dissolved oxygen. The extensions of these two lines in this manner is especially important because of impending construction of additional seafood processing facilities along the northern shore of Gibson Cove. Such extensions have the added benefit of assuring an adequately oxygenated saltwater source of high salinity for usage by any crab processing facility that may be constructed in Gibson Cove and for the attendant crab boat fishermen which may be obliged to keep their catch alive for relatively long periods until the crab are offloaded to the future crab processing facility.

Of 48 dissolved oxygen determinations in the Kodiak Harbor reach between the front of the Alaska Pacific Seafoods dock and the small boat harbor, about 15 percent (7 determinations) were less than the 6.0 mg/l standards criterion. Such low values were found in both the surface and bottom layers in this reach (Stations 2A through 6, Table 2), but were more common in the surface than in the bottom waters which had only two values less than 6.0 mg/l. Comparison with

the August 1971 data for the same area show that of 46 samples about 22 percent (10 values) had less than 6.0 mg/l of dissolved oxygen, and that low values were also more common in the surface than in the bottom waters which also had only two values less than 6.0 mg/l (Stations 2 through 6A, Appendix Table 2A).

Further inspection of these two sets of data show that the lowest dissolved oxygen concentrations found during the August 1974 survey (4.5 mg/l) are higher than those measured during the August 1971 survey (1.3 mg/l). Additionally, comparison of the average dissolved oxygen values less than 6.0 mg/l for the August 1974 survey with those for the August 1971 data reveal that the former values are higher than the latter 5.2 and 4.1 mg/l, respectively. Thus it is concluded that the installation and operation of screening equipment for solids removal at the canneries in this reach of Kodiak Harbor has resulted in a perceptible improvement in the dissolved oxygen concentrations in the associated watercourse. However, the improvement is incomplete in terms of the Alaska Water Quality Standards criterion for this parameter because dissolved oxygen concentrations less than 6.0 mg/l were still readily apparent during the August 1974 survey.

In the Kodiak Harbor reaches located east of the small boat harbor, dissolved oxygen concentrations less than 6.0 mg/l were not found during either the August 1974 or August 1971 surveys even though wastes are discharged to this area from four seafood processing facilities. A decrease in the dissolved oxygen in the waters near these facilities is apparent, however, from inspection of the data gathered during the two surveys (Stations 7 through 8, Table 2 and Appendix Table 2A).

Specifically, Stations 9 and 9A were established as reference stations during 1974 and 1971, respectively, because they are relatively remote from the influence of cannery process-water waste discharges; these stations had higher dissolved oxygen concentrations than did Station 7 through 8. For example, the average concentration of dissolved oxygen at Station 9 for the August 1974 survey was 8.4 mg/l but at Stations 7, 7A and 8 it was 7.8, 7.6, and 7.9 mg/l, respectively; for the August 1971 data the average concentration at Station 9A was 11.8 mg/l, and at Stations 7, 7A and 8 it was respectively 10.9, 10.8 and 10.5 mg/l.

It is to be noted that the net flow of water in Kodiak Harbor is towards the northeast and that the waters associated with the reaches at Stations 7, 7A and 8 flow through a constricted channel. Most of the oxygen demand by the wastes that pass through the screens at the canneries, and subsequently discharged to Kodiak Harbor in the reach west of the small boat harbor, may be accommodated in terms of the dissolved oxygen criteria by the time these waters pass by Stations 7 through 8, but the addition of similar wastes to these waters as they pass through the constricted segment of Kodiak Harbor Stations 7 through 8 causes an increased oxygen demand. Thus, it is not surprising to find decreased concentrations of dissolved oxygen at the latter stations.

The finding that dissolved oxygen does not decrease to values less than the 6.0 mg/l standard in this narrow reach of the harbor may be attributed to the great amount of dilution there, and rapid dissipation and mixing of wastewaters because of the strong currents.

Conversely, there appears to be less dilution, discharge of more wastes, and definitely less current in the reach west of the small boat harbor, and the dissolved oxygen concentrations there, therefore, are much lower than elsewhere in Kodiak Harbor. Extension of process wastewater lines to deeper waters with stronger currents, i.e. towards Near Island, would more rapidly dissipate the oxygen demanding wastes that pass through the screens at the facilities in this area. In addition to achieving compliance with the water quality standards criterion for dissolved oxygen, as in the case for Gibson Cove, extension of these lines would have a similar benefit to both the processing facilities and boats that utilize these waters to hold live crabs before processing.

pH

As stated earlier in this report, the pH probe of the Hydralab instrument did not function properly during the course of the August 1974 survey and only a few pH measurements were made. These were obtained during the late afternoon sampling period on September 28 and show that about 27 percent were not within the standard criterion range of 7.5 to 8.5. Four of these values were above and three were below this standard criterion range (Table 3). The pH values below this range occurred at Stations 1A near the New England Fish Company cannery in Gibson Cove and Station 2A in front of the Alaska Pacific Seafoods Company dock. The pH values above this range were found at Station 5 and 6 near the company docks, respectively.

TABLE 3

pH AT GIBSON COVE AND KODIAK HARBOR
AUGUST 28, 1974

STATION NUMBER	ONE METER pH	BOTTOM
1A	6.9	7.4
1B	8.3	8.3
2A-1	7.3	7.8
2	8.1	8.3
3	8.2	8.4
4	8.4	8.4
5	8.7	8.9
6	8.6	8.9
7	8.2	8.2
7-A	8.0	8.0
8	8.0	8.3
9	8.2	8.1
Bio Dry	7.8	8.2

Transparency

Both transmissivity and transparency data were collected during the 1974 survey but only transmissivity information was collected during the 1971 survey. During the August 11, 1971 survey transmissivity determinations were made at many depths at only Stations 2 and 4 rather than at one meter and near the bottom at all significant stations along the waterfront as was done during the August 1974 survey. At Stations 2 and 4 in 1971, the transmissivity readings at the surface amounted to 86 and 40 percent, respectively, and near the bottom the respective values were 90 and 88 percent (5).

During the August 1974 survey transmissivity values at 1 meter for Stations 2 and 4 were both 74 percent and near the bottom they were 79 and 85 percents, respectively. There is no apparent relationship between these two sets of values for the two study years except

that examination of the 1971 values for all depths at these two stations show lower percentages of light transmittance in surface associated water than near the bottom, as was evident during the August 1974 survey (Table 4).

The average of 16 transmissivity measurements at Stations 1 through 6 was 74 percent at the 1 meter depth and 84 percent near the bottom. These stations are the ones most affected by waste discharges from the canneries which apparently cause a light transmittance reduction averaging about 10 percent in the near surface water layer. Elsewhere in the survey area, i.e. Stations 7A, 8 and 9 waste discharges from the canneries had a less perceptible effect as evidenced by only a very slight difference if any in light transmittance between the 1 meter and near bottom depths. This finding is quite compatible with those for dissolved oxygen, temperature and salinity in the general sense: the warmer, less saline, and less dense waters of Gibson Cove and Kodiak Harbor were near the surface, which contains the screened effluents from the canneries, where dissolved oxygen reduction is the greatest. The fact that light transmittance is reduced near the surface and is associated with a similar reduction in dissolved oxygen indicates that the reduction in light transmittance is not caused principally by phytoplankton, but is caused by waste discharges instead. It is to be noted that the reduction in light transmittance extends seaward (southerly) well beyond the immediate vicinity of the canneries in the Kodiak Harbor reach west of the small boat basin and is also apparent at both Stations 1 and 1A in Gibson Cove (transmissivity

TABLE 4

SECCHI DISK READINGS (METERS) AND TRANSMISSIVITY
(% TRANSMITTANCE AT 1 METER AND NEAR BOTTOM)
AT GIBSON COVE AND KODIAK HARBOR, AUGUST 26, 1974

STATION NUMBER	SECCHI DISK DEPTH (METERS)	TRANSMISSIVITY ONE METER	(% TRANSMITTANCE) BOTTOM (METERS)
1	1.6	76	83(9.1)
1A	1.2	72	83(9.1)
2A-1	1.1	66	84(18.3)
2A-2	1.0	72	82(21.3)
2A	1.4	74	79(6.1)
2B	1.2	74	82(18.3)
2C	1.3	74	81(18.3)
2D	1.1	69	83(16.8)
4A	1.3	74	85(-)
4B	1.2	76	87(-)
4C	1.3	79	87(-)
4D	2.2	82	87(-)
6A	1.1	75	83(-)
6B	1.6	76	84(-)
6C	1.2	72	84(-)
6D	2.1	78	85(-)
7A	3.3	82	84(-)
8	2.7	82	82(-)
9	3.7	83	83(-)

measurements were not made at Station 1B). Briefly then, there does not appear to be any significant change in the transmissivity of these waters during the two study periods as based on comparison of trends during the 1971 and 1974 surveys.

Transparency measurements as determined by Secchi disk readings were not less than the 1-meter standard criterion in either Gibson Cove or Kodiak Harbor during August 26, 1974, but they were very close to this value at many of the stations sampled in Gibson Cove and the Kodiak Harbor reach west of the small boat basin. Reduced

Secchi disk readings were apparent at all stations however, because it is not unreasonable to expect values of 8 meters and often as high as 10 meters in such near shore waters if not influenced by waste discharges.[1/]

Chemical and Physical Aspects of Bottom Deposits

Marine deposits not influenced by wastewater discharges that contain settleable organic solids are commonly characterized as consisting, on a dry weight basis, of less than 5 percent organic matter and volatile solids, less than 0.10 gram/kilogram of organic nitrogen and sulfides and less than 5 grams/kilogram of chemical oxygen demand. These values were exceeded in almost all of the samples collected during the August 1974 survey (Table 5 and Figures 3 and 4).

It is to be noted that the values reported for chemical oxygen demand, organic nitrogen and sulfides at all stations greatly exceed the values of 5, 0.10, and 0.10 for these parameters, respectively. Only 2 of the values for percent organic matter did not exceed the 5 percent criterion (Stations 3C and 3D), and only one, Station 3D, did not exceed the 5 percent volatile solids criterion. Even so, the criterion for sulfides, organic nitrogen, and chemical oxygen demand were exceeded at each of these stations.

[1/] It should be pointed out that the Secchi disk criterion of 1-meter was not one of the criteria for water quality during the 1971 study. Rather, this criterion was added in the 1973 Water Quality Standards revisions in 1973.

Similar findings were also apparent during the May and August surveys in 1971 (Appendix Table 3A for percent volatile solids, and concentrations of organic carbon and organic nitrogen. All but four of the samples of bottom deposits collected in 1971 had five percent or more volatile solids, and 66% of the samples had less than five grams/kilogram of organic carbon while all samples had organic nitrogen exceeding 0.10 gram/kilogram.[1/] No bottom deposit samples were collected at Stations 1, 8 and 9 in 1971 for chemical analyses. At this time there was only one seafood-associated processing facility in Gibson Cove and there was no evidence of bottom deposit degradation (the outfall was at the mouth of the cove). Bottom deposit samples could not be secured at Station 8 because of wreckages and debris from the 1964 earthquake which littered the bottom, and Station 9 deposits consisted of rocks and pebbles which were not analyzed. The only samples collected for chemical analyses in 1974 were those in Kodiak Harbor that were suspect of poor quality chemically, plus Station 1A, to determine whether there were any major changes in these deposits. Thus, bottom samples were not obtained at 2C-D, 3A, 4A-D, and 6A-B, and 6D in 1974; the samples collected were believed to be representative of the study areas, however. Inspection of the chemical data for the two different years, then, reveals that no major changes have occurred in the chemical characteristics of the bottom deposits in Kodiak Harbor. Although no 1971 data are

[1/] Bottom deposit samples from 1971 at Stations 2D, 3D, 4D and 6D were not perceptibly contaminated with sludge, and were not analyzed for chemical characteristics.

TABLE 5

CHEMICAL AND PHYSICAL CHARACTERISTICS OF BOTTOM DEPOSITS IN GIBSON COVE AND KODIAK HARBOR AUGUST 1974*

STATION NUMBER	PARAMETER					
	% SOLIDS (1)	% VOLATILE SOLIDS (2)	% ORGANIC CARBON (2)	SULFIDES (3) (g/kg)	ORGANIC NITROGEN (3) (g/kg)	CHEMICAL OXYGEN DEMAND (2) (g/kg)
1A	47.4	6.5	5.3	1.5	2.7	62
2A	40.0	14.8	10.2	1.4	8.8	122
2B	28.3	8.3	7.1	1.7	4.2	81
3B	37.5	7.5	6.4	1.9	4.3	76
3C	51.2	7.2	3.9	1.0	1.8	45
3D	52.6	4.8	2.7	0.9	1.5	31
5A	29.4	31.8	13.9	1.7	1.6	164
5B	16.9	15.1	14.2	3.9	9.5	169
5C	35.4	7.6	6.8	1.7	2.5	79
5D	20.1	8.7	7.0	1.9	4.5	84
6C	33.4	10.5	13.4	1.5	4.5	104
7	18.7	18.2	8.7	3.0	8.6	155

*All values are on a dry weight basis.
(1)Values after water has been evaporated.
(2)A value of 5 or greater is considered excessive.
(3)A value of 0.10 or greater is considered excessive.

available for the bottom deposits in Gibson Cove, it is apparent that those in the reach adjacent to the New England Fish Company Facility have become sufficiently contaminated to be of significant concern.

The cause of this contamination in Gibson Cove is the discharge of wastewaters from broken discharge lines inside the cove and the discharge of wastes near the mouth of the Cove that are transported by wind and wave action to the interior of the cove. Additionally, since 1971 the Bio-Dry Company facility, with its discharge near the mouth of the cove, has been installed on the cove shore easterly of the existing cannery. Like the waste discharge line from the cannery, there have been breaks in the outfall line from the Bio-Dry facility, and these wastes have added similarly to the discharges that degrade water quality in the cove and ultimately become a part of its bottom deposits also. Because of these problems, and the tentative plans to construct additional cannery facilities in Gibson Cove, it is very important to assure that no process wastewaters are discharged either into Gibson Cove or near its mouth. The establishment of a "no discharge zone" for process wastewaters throughout Gibson Cove and extending beyond its mouth to waters at least 8 fathoms deep (48 feet) should prevent further degradation of water quality and the additional accumulation of settleable solids that have formed sludge in the interior of the cove. The data for Gibson Cove are suggestive that perimeter for such a "no discharge zone" for process wastewaters should approximate the dashed line shown in Figure 3.

A similar "no discharge zone" should be established in the Kodiak Harbor reach west of the small boat basin because significant amounts of the settleable solids not removed by the screens in the canneries in this reach are settling in the associated watercourse rather than being carried away by the currents. In addition to improving water quality and probably preventing violations of the standards criterion for dissolved oxygen, and providing higher quality water for use in sustaining crabs in holding tanks on boats and at canneries, there should be a significant improvement in the chemical character of the bottom deposits if such a zone were established. The data from the bottom reaches in Kodiak Harbor are suggestive that the perimeter for such a "no discharge zone" for process wastewaters should approximate the dashed line shown in Figure 4.

Visual and Biological Aspects of Bottom Deposits

None of the samples obtained in the study area during the 1971 surveys contained readily-apparent, attached marine plants, and most consisted of soft deposits and sludge that emitted strong hydrogen sulfide odors.[1/] The unpublished report for the 1971 survey (5) indicates living macroscopic animals were not found at stations immediately adjacent to the canneries in Kodiak Harbor in the reach between the small boat harbor and the Northern Pacific Processors facility. Rather,

[1/] Bottom deposits at Station 2D, 3D, 4D and 6D were not perceptibly contaminated with sludge and were not analyzed for chemical characteristics. Also they supported a moderate variety of organisms such as amphipods, snails, several kinds of worms and brittle stars.

only sludge and accumulations of discarded animal parts were found at these locations, and hydrogen sulfide bubbles were profuse near the surface as were floating seafood animal parts and bulked sludge. Hydrogen sulfide bubbles, floating processing wastes, bulked sludge, and extensive discoloration were grossly apparent throughout most of the Kodiak Harbor area in 1971, but bottom sampling sites most distant from the canneries, i.e. closest to Uski Island, had rocks, pebbles and silt or sand in lieu of sludge, and supported a moderate variety of organisms such as tube dwelling polychaete worms, amphipods, snails and clams. Hydrogen sulfide odors were not noted in these deposits.

As was found during the 1971 surveys, none of the samples collected during the 1974 survey had readily-apparent attached marine plants. Unlike the 1971 survey, though, a general improvement in the bottom reaches of Kodiak Harbor was perceptible. Specifically, two stations ((2A-1 and 2A) one westerly of and the other in front of the Alaska Pacific Seafood facility, respectively) did not have copious quantities of recently wasted seafood animal parts such as crab bodies, shrimp antennae and skeletons, and other rotting wastes in 1974. Rather these two sites had actively decomposing sludge that supported pollution-tolerant, tube dwelling polychaete worms. At other stations immediately adjacent to cannery facilities in the reach west of the small boat harbor, there were no major accumulations of recently deposited seafood wastes, but the sludges there did not support polychaete worms. Hydrogen sulfide odors, however,

were quite prevalent in the sludges at all stations adjacent to the canneries in this reach of the harbor, and at several stations more distant from the canneries. Hydrogen sulfide bubbles, floating discarded seafood animal parts, and bulked sludge, which were readily apparent during the August 1971 survey, were not noted during the August 1974 survey. Milky discoloration of the surface waters was similarly apparent during the 1971 survey but was only slightly perceptible in a few localized patches during the 1974 survey in the Kodiak Harbor area.

These differences, specifically a slight increase in the occurrence and abundance of polychaete worms, the great reduction in quantities of recently settled, fresh, seafood-animal remains, the lack of floating sludge mats and hydrogen sulfide bubbles on the surface waters, and the decrease in intensity of water discoloration, is evidence that installation of screens in process wastewater lines since 1971 has resulted in a perceptible improvement in the bottom reaches of Kodiak Harbor reach west of the small boat basin. At the same time, though, the continued but slight discoloration of the water in this reach, the lack of a greater variety of bottom-associated clean water organisms such as starfish, urchins, shrimp, crabs, snails and clams, and the presence of sludge with foul odors of hydrogen sulfide is evidence that the improvements are nowhere near complete and that some steps should be taken either to provide additional treatment of wastewaters to reduce the quantity of solids discharged to this reach of Kodiak Harbor or to designate a "no

discharge zone" for process wastewaters, as discussed in a previous section of this report, to effect dissipation of small waste solid particles and soluble wastes that pass through the screens.

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1. Alaska Department of Fish and Game, Juneau, Alaska, "Kodiak Management Area, Commercial Fisheries Report", 1968.

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3. State of Alaska, Department of Health and Welfare, "Alaska State Plan, Water Quality Standards for Interstate Waters Within the State of Alaska", June 20, 1967, Revised November 10, 1967 and May 24, 1970.

4. Statement by M.L. Hayes, "Pollution Problems at Kodiak", National Marine Fisheries Service, November 17, 1970, Kodiak, Alaska.

5. U.S. Environmental Protection Agency, Region X, Alaska Operations Office, "Studies on Industrial Effluent and its Effect on Water Quality in St. Paul and Kodiak Harbors, and Gibson Cove, Kodiak, Alaska", May and August 1971. Unpublished.

6. State of Alaska, Department of Environmental Conservation, "Water Quality Standards", as revised, October 1973.

APPENDIX

APPENDIX TABLE 1A

TEMPERATURE (CENTRIGRADE) AND SALINITY (PARTS PER THOUSAND) AT 1 METER AND NEAR BOTTOM IN GIBSON COVE AND KODIAK, HARBOR, ALASKA, AUGUST 1974

	STATION NUMBERS												
Depth	1	1A	1B	2A	2	3	4	5	6	7	7A	8	9
						Temperature August 27, 1974	1030 - 1400 Hours						
1 Meter	11.5	11.7	--	10.9	11.5	11.5	11.5	12.0	11.7	11.7	--	11.3	11.2
Bottom	11.0	11.5	--	10.5	11.0	11.0	11.0	11.0	11.0	11.0	--	11.0	10.8
						Temperature August 28, 1974	0930 - 1240 Hours						
1 Meter	11.6	11.7	--	11.5	11.5	11.5	11.3	11.5	11.5	11.5	11.5	--	--
Bottom	11.2	10.7	--	10.5	10.7	10.7	10.8	10.6	11.0	10.9	11.0	--	--
						Temperature August 28, 1974	1540 - 1735 Hours						
1 Meter	11.8	11.5	11.7	11.2	11.5	11.5	11.5	11.5	11.3	11.5	11.0	10.5	10.6
Bottom	11.5	11.0	11.5	10.8	11.2	11.2	11.2	11.2	11.0	10.9	10.9	18.6	10.5
						Temperature August 29, 1974	1600 - 1800 Hours						
1 Meter	12.0	11.8	11.8	11.3	11.4	11.5	11.3	11.5	11.5	11.0	10.8	10.8	10.8
Bottom	11.3	11.0	11.7	11.0	11.0	11.0	11.2	11.0	11.3	10.8	10.6	10.5	10.4

APPENDIX TABLE 1A (CONTINUED)

TEMPERATURE (CENTIGRADE) AND SALINITY (PARTS PER THOUSAND) AT 1 METER AND NEAR BOTTOM IN GIBSON COVE AND KODIAK HARBOR, ALASKA, AUGUST 1974

	STATION NUMBERS												
Depth	1	1A	1B	2A	2	3	4	5	6	7	7A	8	9
					SALINITY AUGUST 27, 1974		1030 - 1400 HOURS						
1 Meter	15.6	30.8	--	30.8	30.8	30.1	29.0	30.1	30.1	30.4	--	30.1	30.4
Bottom	30.0	30.8	--	30.1	29.7	29.4	30.1	30.1	30.1	29.7	--	29.7	30.4
					SALINITY AUGUST 28, 1974		0930 - 1240 HOURS						
1 Meter	29.7	30.8	31.5	31.0	30.4	30.4	30.4	30.1	29.7	30.4	31.1	30.4	31.5
Bottom	30.1	30.4	31.3	30.4	30.1	31.1	30.4	30.1	30.1	30.1	30.4	30.4	30.4
					SALINITY AUGUST 28, 1974		1540 - 1735 HOURS						
1 Meter	29.4	30.4	30.4	29.4	30.1	30.8	29.7	30.1	30.1	30.4	30.1	30.1	30.9
Bottom	30.1	30.8	30.8	30.1	30.1	30.4	30.1	30.4	30.4	31.5	31.1	30.1	30.8
					SALINITY AUGUST 29, 1974		1600 - 1800 HOURS						
1 Meter	29.0	29.7	29.7	29.4	29.7	30.8	30.8	30.4	30.1	29.1	30.8	30.1	31.0
Bottom	30.1	30.3	30.1	30.3	29.7	30.1	30.1	30.1	30.6	30.1	30.8	30.4	30.4

APPENDIX TABLE 2A

DISSOLVED OXYGEN CONCENTRATIONS (MG/L) AT 1 METER, MID-DEPTH, AND NEAR BOTTOM*
IN GIBSON COVE AND KODIAK HARBOR, KODIAK ALASKA

AUGUST 10, 12, AND 13, 1974

	STATION NUMBERS															
DEPTH	1	2	2A	2B	3	3A	4	4A	5	5A	6	6A	7	7A	8	9A**
							AUGUST 10, 1971									
SURFACE	10.7	10.5			6.0		6.2		8.3		6.8		11.0	12.3	10.6	12.0
MID-DEPTH	9.9	10.5			9.5		5.8		8.3		-		-	10.2	10.6	11.3
BOTTOM	10.0	10.5			9.1		5.6		7.3		8.9		10.9	9.9	10.3	11.0
							AUGUST 12, 1974									
SURFACE		8.7	10.7		4.6		4.7		1.3	5.8					10.5	13.0
MID-DEPTH		10.1	10.1		10.1		10.1		9.8	-					-	11.8
BOTTOM		9.5	9.6		9.6		8.6		7.7	-					-	11.6
							AUGUST 13, 1974									
SURFACE		5.7		9.7	5.0	8.0	1.3	7.3			6.6	6.0				
5 METERS		8.6		-	6.6	-	4.1	-			7.5	-				
10 METERS		9.6		-	8.6	-	5.2	-			7.7	-				

* Bottom depths vary from 9 meters at Station 1 in Gibson Cove to 21 meters at Station 2A in Kodiak Harbor.

**Station 9A is located adjacent to the Quick Flasher Bell Buoy off Shahafka Cove, about one half mile northeast of Station 9 in Figure 2.

APPENDIX TABLE 3A

CHEMICAL AND PHYSICAL CHARACTERISTICS OF BOTTOM DEPOSITS IN KODIAK HARBOR, MAY AND AUGUST, 1971

STATION NUMBERS	% TOTAL SOLIDS (1)	% VOLATILE SOLIDS (2)	% ORGANIC CARBON (2)	% ORGANIC NITROGEN (3) (6/KG)
		MAY 13, 1971		
2A-1	56	5	2.1	0.48
2A	84	25	13.0	2.0
2B	58	6	2.5	0.33
2C	56	4	1.7	0.23
3A	67	22	14.9	3.7
3B	60	7	3.6	0.53
3C	56	5	2.3	0.33
4A	85	29	16.7	2.0
4B	59	6	2.7	0.40
4C	55	5	2.4	0.33
5A	76	19	16.4	2.36
5B	59	6	3.1	0.50
5C	60	6	2.7	0.43
5D	53	4	2.0	0.28
6A	66	9	4.3	0.42
6B	63	7	3.3	0.48
6C	52	5	2.2	0.31
7	65	11	6.1	0.94
		AUGUST 11, 1971		
2A	87	44	23.1	3.1
2B	84	41	3.9	2.4
2C	46	3	1.4	0.2
2D	51	12	1.4	0.2
4A	75	29	15.6	1.5
4B	60	7	3.2	0.5
4C	49	4	5.4	0.2

* All values are on a dry weight basis.
(1)Values after water has been evaporated.
(2)A value of 5 or greater is considered excessive.
(3)A value of 0.10 or greater is considered excessive.