Division of Water
Anchorage
MAY 18 2007
RECEIVED

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
**REGION 10**
1200 Sixth Avenue
Seattle, WA 98101

MAY 15 2007

Reply To
Attn Of: OWW-134

Lynn J. Tomich Kent, Director
Division of Water
Department of Environmental Conservation
555 Cordova St.
Anchorage, AK 99501-2617

RE: Approval of the Ward Cove Residues and Dissolved Oxygen TMDLs

Dear ~~Ms. Kent~~: Lynn

The U.S. Environmental Protection Agency (EPA) Region 10 is pleased to approve the Ward Cove residues and dissolved oxygen (DO) revised total maximum daily loads (TMDLs) submitted to EPA by the Alaska Department of Environmental Conservation (ADEC) on March 29, 2007. The enclosure describes EPA's basis for its decision.

Our review indicates that these allocations have been established at a level that, when fully implemented, will lead to the attainment of the water quality criteria addressed by these TMDLs. Therefore, the State does not need to include Ward Cove on the next 303(d) list for the pollutants covered by these TMDLs.

This DO TMDL supersedes the DO TMDL approved by EPA in 1994 that addressed the top one meter of the water column because this TMDL addresses the entire water column. By EPA approval, these TMDLs are now incorporated into the State's Water Quality Management Plan under Section 303(e) of the Clean Water Act.

We greatly appreciate the opportunity to work with your staff throughout the development of these complex TMDLs. In particular, we commend Dave Sturdevant, Chris Foley and Kent Patrick-Riley of your staff for their close collaboration with the City and Borough of Ketchikan, other state, and federal agencies, members of the public and native organizations to develop these TMDLs.

We look forward to continuing to work collaboratively on water quality issues in Ward Cove. Please feel free to call me at (206) 553-7151 if you have any concerns or questions regarding this approval, or you may contact Martha Turvey of my staff at (206) 553-1354.

Sincerely,

Michael F. Gearheard, Director
Office of Water and Watersheds

cc: Jim Rypkema, ADEC, Manager, Nonpoint Source Water Pollution Control Program
Kent Patrick-Riley, ADEC, Manager, Restoration and Protection Section
Chris Foley, ADEC, Manager, Forestry Section
Dave Sturdevant, ADEC, Forestry Section

# Total Maximum Daily Loads (TMDLs) for Residues and Dissolved Oxygen in the Waters of Ward Cove near Ketchikan, Alaska

## REVISED FINAL

March 2007

Alaska Department of Environmental Conservation
555 Cordova Street
Anchorage, AK  99501

# ACKNOWLEDGEMENT

The Ward Cove TMDLs were prepared by the Alaska Department of Environmental Conservation (ADEC) in coordination with the U.S. Environmental Protection Agency (EPA) Region 10.

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# Draft Total Maximum Daily Loads for Residues and Dissolved Oxygen in the Waters of Ward Cove near Ketchikan, Alaska

## TMDLs AT A GLANCE:

| | |
|---|---|
| **Residues:** | |
| *Water Quality-limited?* | Yes |
| *Hydrologic Unit Code:* | 19010102 |
| *Standard of Concern:* | Residues |
| *Designated Uses Affected:* | Water supply; water recreation; growth and propagation of fish, shellfish, other aquatic life, and wildlife; harvesting for consumption of raw mollusks or other raw aquatic life |
| *Environmental Indicators:* | Wood residues (pulp residues, logs, bark, wood debris) on the bottom of Ward Cove |
| *Major Sources:* | Historical pulp mill, log storage facility, and log transfer facility discharges |
| *Loading Capacities:* | Log storage area (incl. ship loading and unloading areas), 1.2 $m^3$/day over 46 acres<br>Log transfer area, 0.22 $m^3$/day over 1 acre |
| *Wasteload Allocations:* | Log storage area (incl. ship loading and unloading areas), 0.023 $m^3$/acre/day<br>Log transfer area, 0.20 $m^3$/acre/day |
| *Load Allocation:* | Zero (0) $m^3$/acre/day |
| *Margin of Safety:* | 10% of loading capacity<br>Log storage area (incl. ship loading and unloading areas), 0.12 $m^3$/acre/day<br>Log transfer area, 0.022 $m^3$/acre/day |
| **Dissolved Oxygen:** | |
| *Water Quality-limited?* | Yes |
| *Applicable Season:* | June through September |
| *Hydrologic Unit Code:* | 19010102 |
| *Standard of Concern:* | Dissolved gas (dissolved oxygen) |
| *Designated Uses Affected:* | Water supply; water recreation; growth and propagation of fish, shellfish, other aquatic life, and wildlife; harvesting for consumption of raw mollusks or other raw aquatic life |
| *Environmental Indicators:* | Oxygen-demanding material (wood residues, fish residues) |
| *Major Sources:* | Historical pulp mill and log storage and transfer facility discharges; historical fish processing facility discharges |
| *Loading Capacity:* | 5 mg/L |
| *Wasteload Allocation:* | No point source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L |
| *Load Allocation:* | No nonpoint source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L |
| *Margin of Safety:* | Implicit |

# Executive Summary

Section 303(d)(1)(C) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 Code of Federal Regulations [CFR] Part 130) require that a Total Maximum Daily Load (TMDL) be established to achieve state water quality standards (WQS) when a waterbody is water quality-limited and will not meet standards with the implementation of technology-based effluent limits and other pollution control requirements. A TMDL determines the Loading Capacity (LC)--the amount of a pollutant that a waterbody can receive while still meeting WQS--and establishes discharge limits for existing and future discharge sources of the pollutant, including an appropriate margin of safety (MOS). Discharge limits for point sources are called Wasteload Allocations (WLAs); discharge limits for nonpoint sources are called Load Allocations (LAs).

The Alaska Department of Environmental Conservation (ADEC) initially included Ward Cove on its 1990 303(d) list of water quality-limited waters for low dissolved oxygen and the presence of residues due to the discharge from Ketchikan Pulp Company's (KPC) dissolving sulfite pulp mill. On the 1994 and subsequent 303(d) lists through 2004, the most recent list, Ward Cove was listed as water quality-limited for three pollutant parameters: residues (wood residues), dissolved gas (dissolved oxygen), and toxic and other deleterious substances (sediment toxicity) (ADEC 2003a). Sediment toxicity was removed from the 2004 303(d) list and placed in category 4b ("Other Pollution Controls") because the Record of Decision for the Superfund sediment remediation project (USEPA 2000) for Ward Cove is accepted as a pollution control requirement that will achieve WQS for sediment toxicity (ADEC 2006). This TMDL report includes TMDLs to address the impairments associated with residues and dissolved oxygen; no TMDL will be developed for sediment toxicity. With completion of these TMDLs, the classification of Ward Cove for residues and dissolved oxygen on the next revised Alaska section 303(d) list will be changed to Category 4a—"TMDL has been completed."

The sources of impairments to Ward Cove are primarily historical industrial point source discharges. The KPC pulp mill discharged large amounts of chemicals and pulp residues to Ward Cove during its years of operation, 1954 to 1997, particularly in the years prior to 1971, when an EPA discharge permit was first issued to the pulp mill. In addition, high volumes of log storage (approximately 7 billion board feet) caused accumulation of bark waste and sunken logs on the bottom of the cove. Although the discharge ceased with the mill's closure, log storage activities continued until 2001 under the operation of a sawmill and veneer mill by Gateway Forest Products, Inc., contributing additional wood residues to the cove. Wards Cove Packing Company, a seafood processing facility, discharged fish-processing waste to the cove from 1912 until its closure in 2002. The seafood waste discharge was the most influential source causing depletion of dissolved oxygen in the deeper waters of Ward Cove in the summer months; based on computer modeling, a small component was due to decomposing wood waste. Minor continuing permitted discharges to Ward Cove include two small sewage treatment plants, stormwater runoff at the former pulp mill site, and a discharge of leachate from the KPC landfill.

The continuing residues impairment in Ward Cove is caused by the historical accumulation of wood waste on the bottom of the cove. The waste includes an estimated 16,000 sunken logs over at least 75 percent of the bottom and decomposing pulp, wood, and bark waste in sediments in thicknesses up to 10 feet over at least 50 percent of the bottom (Exponent 1999). Wood waste residues can displace and smother organisms, alter habitat, release leachates, create anoxic conditions, and produce toxic substances, all of which may adversely affect organisms that live both on top of sediments and within sediments.

As a result of detailed studies in the 1990s, the Superfund sediment remediation project in 2000 (unrelated to the TMDLs) defined an 80-acre Area of Concern for sediment toxicity on the bottom of the cove (Exponent 1999). In 2000–2001 Superfund dredged approximately 3 acres and placed sand capping over approximately 30 acres of the bottom. In 2004, KPC (with EPA oversight) conducted chemical and biological monitoring of the bottom to determine progress toward the objective of biological recovery. Results showed that three sand-capped areas and one shallow natural recovery area (not sand-capped) have achieved biological recovery; three other natural recovery areas tested have not achieved biological recovery but are making significant progress. In two reference areas tested in Ward Cove outside the Superfund Area of Concern, like the other three natural recovery areas, benthic communities were dominated by species commonly found in organically-enriched environments. (Exponent 2005). The TMDL for residues has a goal for biological recovery that is similar to that of the Superfund project.

The residues TMDL establishes loading capacities and WLAs that provide allowable quantities of wood waste accumulation (primarily bark) in log storage areas and log transfer areas. Log storage and transfer areas are limited to a maximum of 47 acres, 25 percent of the area of the bottom of Ward Cove with documented accumulation of wood wastes. Log storage areas (including ship loading and unloading areas) are a maximum of 46 acres; the WLA is 0.023 $m^3$/acre/day. Log transfer areas are limited to one acre total; the WLA is 0.20 $m^3$/acre/day, with a requirement for removal of wood waste in log transfer areas if a volume of 365 $m^3$ or a thickness of 30 cm (12 inches) is exceeded. The Margin of Safety is 10 percent. The LA for residues for nonpoint sources is zero $m^3$/acre/day.

The dissolved oxygen impairment was due largely to the fish-processing waste discharge from the seafood processing facility until 2002, and it was limited to the summer months in deeper waters of the cove (below the picnocline, or stratification layer, approximately 10 meters deep). With that discharge removed, limited monitoring in August and September 2003 indicated that dissolved oxygen impairment might remain near the bottom in waters at depths of 30 meters and greater at certain times and locations due to low natural levels of dissolved oxygen and the continuing decomposition of wood waste. Above 30 meters depth, the waters of the cove appeared to meet the standard for dissolved oxygen. However, there may be limited capacity for waters at 30 meters and deeper to receive additional loading of oxygen-demanding materials and still meet the standard in summer months.

Because there are no current discharge sources measurably impacting dissolved oxygen and dissolved oxygen is assumed to be recovering, the dissolved oxygen TMDL establishes the loading capacity at the WQS level of 5 mg/L. The WLA is set as no point source loading of oxygen-demanding substances that will cause a measurable decrease (0.2 mg/L) in dissolved oxygen level below 5.0 mg/L from June through September. The LA is set as no nonpoint source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L from June through September.

# 1. Overview

Section 303(d)(1)(C) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 Code of Federal Regulations [CFR] Part 130) require that a Total Maximum Daily Load (TMDL) be established to achieve state water quality standards (WQS) when a waterbody is water quality-limited. A TMDL identifies the amount of a pollutant that a waterbody can receive and still meet WQS, and it establishes allocations of the pollutant load to sources that discharge the pollutant. The mechanisms used to implement TMDL allocations can include effluent limits and monitoring requirements for point sources established in National Pollutant Discharge Elimination System (NPDES) discharge permits, and voluntary or required best management practices for nonpoint sources.

Alaska initially included Ward Cove on its 1990 303(d) list of water quality-limited (impaired) waters for low dissolved oxygen and the presence of residues due to the discharge from Ketchikan Pulp Company's (KPC) dissolving sulfite pulp mill. On subsequent 303(d) lists through 2004, Ward Cove was listed as impaired due to residues; dissolved gas (dissolved oxygen); and toxic and other deleterious substances (sediment toxicity) (ADEC 2003a). In the 2004 listing, sediment toxicity was removed from the 303(d) list and placed in category 4b (other pollutant controls) because the Record of Decision of the Superfund sediment remediation project (USEPA 2000) for Ward Cove is accepted as a pollution control requirement that will achieve WQS for sediment toxicity (ADEC 2006). This TMDL report includes TMDLs to evaluate impairments and establish future discharge limits (load allocations and wasteload allocations) for residues and dissolved oxygen. While Ward Cove remains "impaired" for sediment toxicity, no TMDL will be developed for sediment toxicity.

A TMDL was developed in 1994 to address dissolved oxygen in the 1-meter surface layer of Ward Cove. Since the pulp mill closure in 1997, surface water dissolved oxygen has met WQS. However, severe depletion of dissolved oxygen, often violating the limit of the Alaska WQS, occurred regularly in deeper water below the picnocline (stratification layer) during the summer months through 2002. The largest source of oxygen-demanding material was fish-processing waste discharged from the Wards Cove Packing Company (WCPC) fish processing facility in the summer months from 1912 until the facility's closure at the end of 2002. The problem is set up by stratification of the water during the summer and by water that is naturally low in oxygen entering Ward Cove from Tongass Narrows during summer months. A recent study by ADEC has demonstrated that low oxygen levels are a widespread occurrence in the deep waters of bays and coves of Southeast Alaska in July and August and can occur up to the surface. Oxygen levels can naturally fall below the state minimum standard for dissolved oxygen (4.0 mg/L) and even below 2 mg/L (Gendron, 2005). Importantly, monitoring in Ward Cove in 2003 in the absence of the discharge of fish-processing waste indicated that minimum summer oxygen levels in deep water were not below the state standard of 4.0 mg/L, and most values were above 5.0 mg/L.

Studies associated with the Superfund sediment remediation project in 1996 and 1997 documented that pulp residues, bark waste, and logs cover roughly 75 percent of the bottom of

Ward Cove in varying degrees (Exponent 1999). These wood waste residues constitute exceedance of the WQS for residues and are the basis for listing Ward Cove as impaired. Wood waste residues also may contribute in small degree to seasonal depletion of dissolved oxygen in the deeper water of Ward Cove. Biological and chemical monitoring of wood waste sediments in 2004 by the Superfund sediment remediation project demonstrated that considerable progress is being made in the development of biological communities on the bottom of Ward Cove. Certain areas were determined fully recovered.

The dissolved oxygen TMDL is presented in terms of loading of oxygen-demanding substances. The residues TMDL is expressed in terms of wood waste residues. The following sections provide overviews of the impairments in Ward Cove.

## 1.1 Residues

Past and current 303(d) lists identify wood waste as the cause of the residues impairment. The accumulated wood waste residues in Ward Cove have altered the physical and chemical nature of the cove's sediments, affecting the type and health of the benthic community. The presence of residues on the bottom can displace and smother organisms, alter habitat, release leachates, create anoxic conditions, and produce toxic substances, all of which can adversely affect organisms that live on top of sediments and within sediments. At the same time, wood residues, both small and large, also provide habitat and food resources for some organisms. Wood residues in sediments up to 50 percent by volume typically maintain diverse and abundant communities of infaunal organisms (see Appendix A).

KPC operated the pulp mill from 1954 to 1997 and operated a sawmill from 1989 to 1997, processing raw logs into pulp, lumber, and hog fuel. Gateway Forest Products operated the sawmill in 1999-2000, and constructed and operated a veneer mill in 2000-2001. The wood waste residues are attributed to two activities—pulp residues discharged to the cove in the pulp mill waste stream and logs stored and transferred in the cove for use in the pulp mill and sawmill. Logs were brought into Ward Cove bundled into rafts and were held in the water in three main areas until taken into the mills for processing. Over time, an estimated 16,000 logs sank to the bottom, particularly in the upper center portion of the cove. It is presumed that logs in storage also discharged a large volume of bark over time. Log storage and transfer continued in Ward Cove at reduced volume until late in 200l, when all operations ceased.

A separate facility to transfer logs to water, the East LTF, was constructed at the northeast end of the cove about 1/4 mile south of Ward Creek in 1977 and operated from time to time until 2000. A continuous-chain let-down ramp at the LTF was constructed in 1998 and remains in place. The property recently was sold by the Ketchikan Gateway Borough to a private interest. A dive survey in 2004 found 1.2 acres of continuous cover and 0.6 acre of discontinuous cover by bark debris on the bottom at this location.

It is believed that most of the logs on the bottom of Ward Cove sank in the early years of pulp mill operation. The logs in rafts were contained in bundles of 10 to 20 logs. Until about 1971, the bundles were broken apart in the water in preparation for processing. Waterlogged logs sank to the bottom, particularly to the pile existing in the upper center of the cove. Single logs were carried by a conveyor chute from the water into the pulp mill. In 1971 a bundle crane was constructed on the north end of the pulp mill facility to remove whole bundles from the water, followed in 1989 by the log bundle lift that is still present at the head of the cove. Continuation of log storage will require that logs be contained in bundles and removed from the water in bundles so that sinking of logs should not be an issue.

Similarly, much of the pulp residues might have been discharged before 1980. KPC discharged untreated effluent from the pulp mill into Ward Cove until 1971. After 1971 effluent was required to receive primary treatment in a wastewater treatment plant before discharge (USEPA 2000). In 1980 secondary treatment was required, greatly reducing the discharge of pulp residues. Over time, improvements to waste management and effluent treatment resulted in substantial reduction in the discharge of sulfite liquor, suspended and settleable solids, and oxygen-demanding materials. Studies under Superfund in 1996 and 1997, however, documented the presence of a black, organic-rich layer of sediment that is distinctly different from underlying native sediments (Exponent 1999). This organic sediment layer lies offshore from the former pulp mill and along the northwest shoreline toward the mouth of the cove. It generally ranges in thickness from 2 to 10 feet, but some areas are more than 10 feet thick. The Superfund sediment remediation project accomplished dredging of 3 acres and capping over roughly 30 acres of these residues in 2000–2001.

The seafood processing plant operated by WCPC discharged fish-processing waste to Ward Cove until closure in 2002. In later years the fish-processing waste was ground to 1/2 inch or less and was discharged through an outfall pipe at a depth of approximately 90 feet. The waste contained both solid material that sank and accumulated as residues on the bottom of the cove, and a liquid and fine-particulate portion that was suspended and carried off by currents. The accumulated solid fish residues were authorized, at least in later years, in an EPA discharge permit through a zone of deposit issued by ADEC. While the amount of fish-processing waste remaining on the bottom four years after closure is unknown, fish waste piles typically diminish in size fairly rapidly.

## 1.2 Dissolved Oxygen

Historical discharges from the KPC pulp mill and the WCPC seafood processing facility contributed organic and nutrient loads that exerted an oxygen demand in the waters of Ward Cove, resulting in severely depressed dissolved oxygen levels at certain times and locations. With those sources removed, it is believed, based on limited monitoring conducted in 2003, that dissolved oxygen has returned to close to natural levels, particularly since closure of the fish processor in 2002. The only remaining source that might cause a slight depression of oxygen levels in summer months near the bottom is decomposing wood waste in bottom sediments. While the amount of seafood waste remaining on the bottom is not known, any remaining seafood waste is expected to have only a de minimus effect on dissolved oxygen.

The WCPC fish processor continued to discharge fish-processing waste until fall 2002. Detailed computer modeling has shown that fish-processing waste was the main cause of oxygen depletion in water below the picnocline (Tetra Tech, Inc. 2001). The picnocline is a zone of high density gradient that is present in summer months at a depth of 10 to 30 meters due to stratification of the water caused by warming of surface waters. The picnocline constitutes a barrier that impedes the passage of dissolved oxygen from the surface to deeper waters by current mixing or diffusion. While this stratification is highly variable in depth and strength, it can create distinct surface and deep-water layers, with differing oxygen environments.

The WCPC facility discharged waste from an outfall pipe at a depth of roughly 90 feet at Mean Lower Low Water (zero tide level). The waste contained a solid portion that settled to the bottom, which was monitored occasionally by dive surveys. The waste also contained a liquid and fine particulate portion that was suspended in the water. The suspended waste was carried up into the cove by prevailing counterclockwise currents, allowing decomposition and the accompanying depletion of oxygen. The solid waste on the bottom exerted an oxygen demand of unknown extent. The quantity of fish-processing waste discharged varied greatly from day to day in the summer, as did the oxygen demand. However, monitoring over a number of years from 1997 through 2002 showed severe and persistent depletion of oxygen during August and September at certain locations in water near the bottom.

While in operation, the pulp mill discharged 35 to 45 million gallons of wastewater per day. Because the discharge was fresh water and elevated in temperature, the discharge tended to rise to the surface and was evident as a reddish discoloration of the water. Earlier monitoring found depression of oxygen levels in the near-surface water, and in 1994 EPA issued a TMDL for dissolved oxygen in the 1-meter surface layer for the months of June through October, establishing a WLA of 20,000 lb/day of biological oxygen demand. However, monitoring of oxygen levels since closure of the pulp mill in 1997 shows that there has been no violation of the dissolved oxygen standard in near-surface water since that time.

The Alaska standard for dissolved oxygen in marine water is a minimum of 6 mg/L in the 1-meter surface layer in coastal water, except where natural conditions cause this value to be depressed; a minimum of 5 mg/L in estuaries, except where natural conditions cause this value to be depressed; and a minimum of 4.0 mg/L at any point in both coastal water and estuaries. Ward Cove is considered both a coastal water and an estuary. Prior to 2003, the lowest dissolved oxygen readings near the bottom in certain locations in Ward Cove in August and September regularly were less than 5 mg/L, occasionally were 2 to 3 mg/L, and at times were 1 mg/L or less. In late summer, the depression of oxygen levels attributed to fish-processing waste was up to 2 mg/L, and the depression of oxygen levels attributed to wood wastes was up to 0.5 mg/L (Tetra Tech, Inc. 2001). In June and July, less depletion of oxygen was observed. In fall, winter, and spring months, stratification is absent and storm action facilitates mixing of waters and replenishment of oxygen in deep water.

ADEC monitored oxygen levels in Ward Cove on five dates in August and September 2003, the annual period of lowest oxygen levels (Tetra Tech Inc. 2003b; see Appendix E). Monitoring was done at nine stations, measuring oxygen levels every 5 meters from surface to bottom. This was the first year in which the fish-processing waste discharge was absent. Five stations in the cove showed minimum oxygen levels between 4 and 5 mg/L on one or more dates at the bottom in depths of 30 meters and greater, a substantial improvement over earlier years when fish-processing waste was present. With the exception of one data point at the bottom at one station, all oxygen values above a depth of 30 meters were greater than 5 mg/L.

It should be noted that monitoring over the years has found that deep water coming into the cove from Tongass Narrows in the summer carries oxygen minimums below the standard, with lows at 4.5 to 5 mg/L. In 2003 the measured minimum from late August to early September in Tongass Narrows was 4.5 mg/L. By the end of September, the oxygen level had risen to just above 5 mg/l. In 2003 only one station in Ward Cove showed oxygen levels less than the levels in Tongass Narrows, on two dates. That depression varied from 0.5 to 0.7 mg/L. The station was near the WCPC cannery and not in wood waste areas. From this limited information, it appears that the continuing depression of oxygen levels in Ward Cove below the state standard is very slight, is limited to certain locations, and may be caused naturally.

However, any future discharge of oxygen-demanding materials into deeper waters of Ward Cove in the summer months, depending on amount, location, and timing, could cause depression of oxygen levels below the state standards. Because of this situation, the loading capacity for dissolved oxygen is set at 5 mg/L, and the wasteload allocation is set as no point source loading of oxygen-demanding substances that will cause a measurable decrease (0.2 mg/L) in dissolved oxygen level below 5.0 mg/L from June through September.

# 2. General Background

This section provides background on the characteristics of Ward Cove and its watershed.

## 2.1 Characteristics of Ward Cove

Ward Cove is an estuary on the west side of Revillagigedo Island approximately 5 miles (8 kilometers, km) north of the city of Ketchikan in southeastern Alaska (Figure 2-1). The area surrounding the cove is mountainous and largely forested. From the north, the terrain slopes steeply down from Slide Ridge, which peaks at approximately 2,100 feet (640 meters, m) about 1 mile (1.6 km) from the shoreline. Ward Mountain, at 2,670 feet, forms a boundary 2 miles to the southeast. The mouth of the cove opens onto Tongass Narrows, a 14-mile-long waterway between Revillagigedo Island and Gravina Island. The predominant orientation of the cove is from northeast at the head to southwest at the mouth.

The cove itself is approximately 1 mile (1.6 km) long and 0.5 mile (0.8 km) wide at its widest point. The water depth is 200 feet (about 61 m) at the mouth of the cove, decreasing gradually up to the head of the cove. The shoreline is mostly rocky basalt and is relatively steep. Portions of the north shoreline are especially steep; the slope of some areas exceeds 25 percent.

Ward Creek drops quickly from the nearby mountains to enter the cove at its head. Ward Creek is the cove's primary source of fresh water, and it has an extensive tideflat and tidal basin at its mouth. Walsh Creek, a much smaller stream, enters Ward Cove along its southeast shoreline; an unnamed intermittent stream originates on Dawson Point. Runoff from precipitation also enters Ward Cove along the shoreline from its immediate watershed.

The tides at Ward Cove are semidiurnal (a tidal period of 12.4 hours). The mean tidal range is 13.3 feet (4.05 m), and spring tides reach 15.7 feet (4.78 m). Field measurements of currents within Ward Cove identified a counterclockwise residual circulation pattern with flows into the cove along the southeastern shoreline and flows out of the cove along the northwestern shore. Superimposed on this horizontal residual circulation pattern is a standard estuarine flow condition caused by the mixing of saline waters from the narrows with fresh water coming out of Ward Creek. The pattern superimposed shows residual flows into the cove along the bottom and flow out at the surface (Exponent 1999).

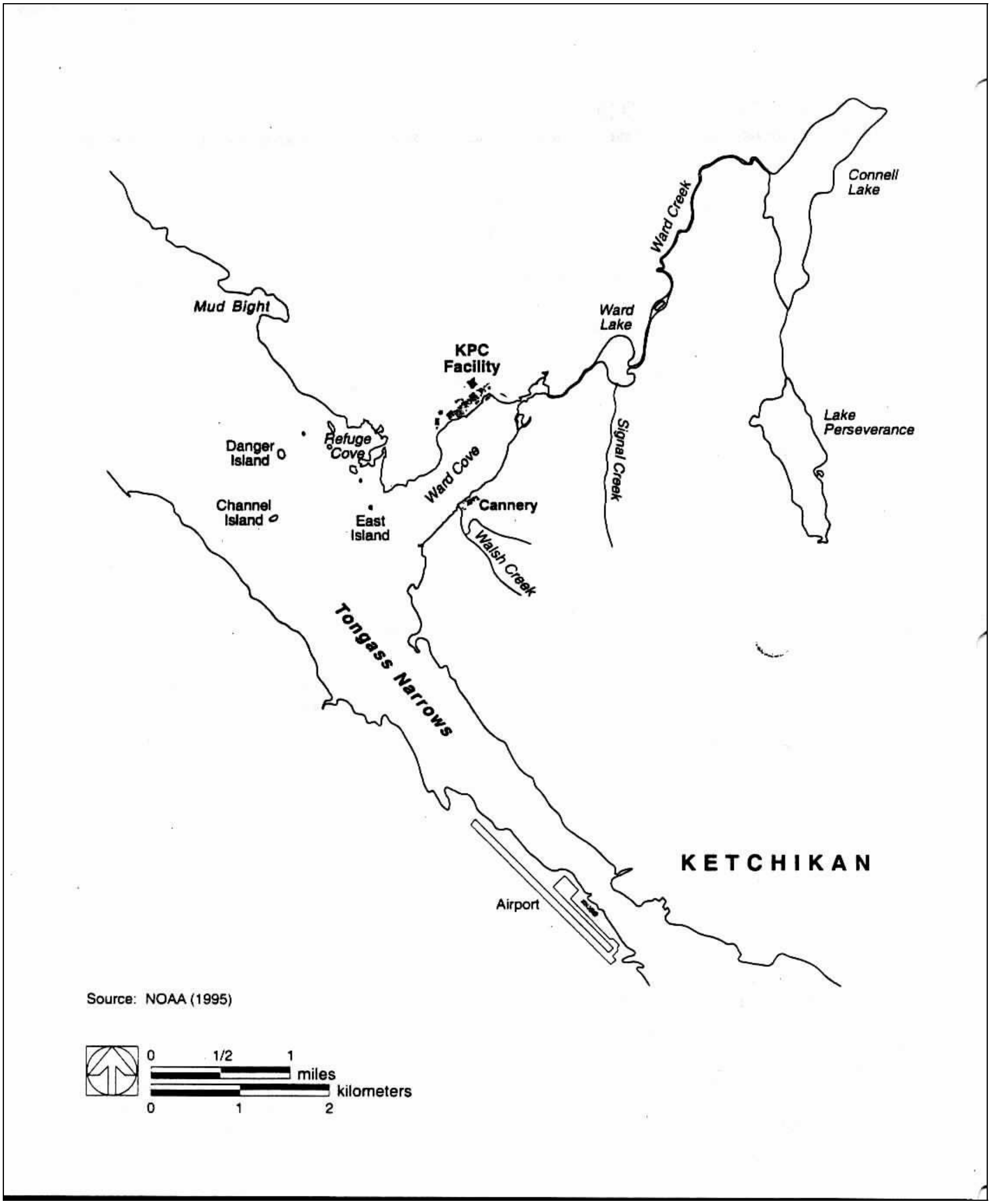


**Figure 2-1. Location of Ward Cove (Exponent 1999).**

As an embayment of Tongass Narrows, Ward Cove exhibits estuarine circulation with saline waters at depth and less saline waters near the surface. A salinity density gradient, or picnocline, separates surface water from deeper water in the summer months, with corresponding gradients in temperature and dissolved oxygen. Because it is less dense than salt water, fresh water remains on top when there is no strong mixing impetus and flows outward, while the deeper salt water migrates inward to maintain a mass balance of water. Near the entrance to Ward Cove, there is no bilayer flow or other dominant pattern. This is likely caused by influences of the swifter currents and eddies in Tongass Narrows. Because Ward Cove's tidal range is large, its currents are largely tidally driven.

Average flow velocities in Ward Cove vary with depth. In the main section, average velocities decrease slightly with depth (2.4 cm/s near the surface to 1.2 cm/s near the bottom). Near the mouth, average velocities increase slightly with depth (3.0 cm/s near the surface to 3.4 cm/s near the bottom). The rapid currents in Tongass Narrows might cause the higher velocities at depth.

There appears to be no area of stagnation within Ward Cove. In combination with the bilayer flow, this indicates that dissolved or suspended material introduced to the surface water layer is likely to be transported to the mouth of the cove and then mixed into the flow of Tongass Narrows. Dissolved or suspended material introduced to deeper waters likely would be subject to circulation below the picnocline. However, material that has settled on the floor of the cove is not expected to travel.

## 2.2 Characteristics of the Cove's Bottom and Its Sediments

The only surficial features of the cove bottom, other than sunken logs and decomposing wood residues, are occasional exposed bedrock and remains of a mound of seafood waste offshore from the former WCPC seafood processing facility on the southern shore (Exponent 1999). Sunken logs and bark residues are present in varying amounts over at least 75 percent of the bottom of the cove. The concentration of logs on the seafloor varies from more than 500 per 10,000 square meters ($m^2$; approximately 2.47 acres) in the upper center of the cove to fewer than 100 per 10,000 $m^2$ near the mouth of the cove (Exponent 1999). Underwater video and side-scan sonar data have indicated that there are multiple layers of logs in the area of highest concentration in the upper center of the cove, as well as numerous partially buried logs. The pile of fish processing waste is located directly offshore from the WCPC facility at a depth greater than 90 feet. Under the NPDES general permit for seafood processors, the area was limited to 1 acre. Monitoring in 1999 found that the debris pile formed hills, valleys, and stair steps that progressed rapidly down at approximately a 45-degree grade from the discharge point (Wards Cove Packing 1999). No discharge of fish-processing waste has occurred since 2002; the present pile size is unknown but likely has diminished.

An extensive area of nonnative sediments that is primarily the result of pulping effluent discharges from the former KPC mill occurs on the seafloor along the northwest shore from the former mill site out toward the cove entrance. These organic sediments might contain bark, wood chips, and other wood waste. The pulp residues range from undetectable to greater than 10 feet (3 m), with a typical thickness of about 4 feet (1.2 m).

Throughout the cove, the upper sediment material is generally a watery, black, flocculent material that has a strong sulfide odor and contains varying amounts of fine wood debris (e.g., wood chips, bark). In three assessments--the 1989 *Ward Cove Water Quality Assessment* (Jones & Stokes and Kinnetic 1989); the Superfund sediment remediation project (Exponent 1999); and the Superfund monitoring report (Exponent 2005)-- it is indicated that surface sediments throughout the cove contained bark or other wood debris, with a higher percentage of wood present in cores collected near the pulp mill docks. Wood debris in these sediments exists not as large pieces, but as very small fragments. In non-capped areas, the Superfund monitoring report describes sediment samples as "fine grain sediment" or "very fine grain sediment."

The underlying native sediments are olive-green to gray silty clays and clayey silts with imbedded roots, shells, and schist fragments. The combined thickness of the organic-rich sediments and native clay sediments ranges from 66 to 98 feet (20 to 30 m). The Water Quality Analysis section of this report (section 4) contains more information on the surface and subsurface sediments in Ward Cove.

As mentioned, the East LTF log transfer facility operated from 1977 to 2000 on the east side of the cove about 1/4 mile south of Ward Creek. A dive survey in 2004 found 1.2 acres of continuous cover by bark debris on the bottom at this location.

The Superfund sediment remediation project investigated the rate of natural sediment accumulation in Ward Cove using two forms of radioisotope analysis on sediment core samples at two locations. Only one sample location yielded useful data. It was determined that the rate of natural sediment accumulation was 0.35 cm/year, and that rate appeared essentially constant for the past 100 years or more. It was concluded that this rate of sediment accumulation is likely representative of most of Ward Cove following shutdown of the KPC mill. Current speeds and distances from Ward Creek, the principal continuing source of sediment, might affect spatial variation in the deposition rate (Exponent 1999).

## 2.3 Land Use

Land use in the area surrounding Ward Cove is a mix of industry, commerce, residences, and recreation.

### *Industry and Commerce*

The KPC pulp mill was the dominant man-made feature around Ward Cove until it closed in 1997. The mill site covered approximately 70 acres (28.3 hectares, ha) on the north shoreline. KPC operated an associated sawmill until late 1999, when the entire pulp mill facility was sold to Gateway Forest Products. Gateway continued to operate the sawmill through 2000 and also constructed a veneer mill, which operated from November 2000 until late 2001. At the end of

2001, Gateway filed for bankruptcy protection and all operations ceased. In mid 2002 the Ketchikan Gateway Borough acquired most of the pulp mill site, including the sawmill and veneer mill, through a combination of leases and purchases. Dismantling of pulp mill facilities has taken place since 1997. The sawmill, along with other remaining equipment, was sold at auction and removed in 2002. In the spring of 2006, the Ketchikan Gateway Borough sold to a private interest, the Renaissance Ketchikan Group, most of the former pulp mill site and lands, including the veneer mill, the entire water frontage on the north side of the cove from the head out to the mouth, and the patented bottom of the cove on the north side of the cove's approximate centerline. The Borough also sold to private parties shore lands on the south side of the cove from the head about halfway out to the mouth. As mentioned, the continuous-chain let-down ramp at the East LTF remains in place, and could be restored to use. A small sewage treatment plant that formerly served the pulp mill complex is located near the head of the cove on the former pulp mill site.

The North Tongass Highway runs along the shoreline of Ward Cove on the south side and around the head of the cove to the north and west. There is no road along the shoreline southwest from the former pulp mill site. Approximately 12 small businesses, including a tire store, construction company (yard and office), refuse hauler, self-service mini-storage facility, auto body shop, and auto wrecking yard, are located immediately across from the pulp mill's water filtration plant north of the North Tongass Highway. There are other small commercial properties on the northwest and northeast shorelines, near the mouth of Ward Cove and adjacent to Refuge Cove.

On Ward Cove's southern shore, Wards Cove Packing Company (WCPC) operated a seafood processing facility from 1912 to 2002. The plant was sold in 2004 to Boyer Towing, and the fish processing equipment was pulled out. Current uses include an industrial bunkhouse and galley for transient workers and a commercial dive shop. However, other small seafood processors have expressed interest in locating operations at the facility (Sturdevant 2005). There also are residential and commercial properties outside the mouth of Ward Cove to the south and adjacent at Refuge Cove to the north.

The Ketchikan Gateway Borough is promoting industrial development in the Ward Cove area and is in the process of selling most of the land it owns around the cove to prospective developers. Possible development under consideration includes reopening the existing veneer mill, developing a marina, loading ships with logs for export, constructing an ethanol plant, constructing a ship take-down facility, and porting or wintering ships. The Borough has constructed a sewage sludge separation facility on the grounds of the former pulp mill, and is discharging sludge liquids through the existing sewage treatment plant.

#### ***Residentia*l**

There are approximately six residences immediately north of the pulp mill site across the North Tongass Highway. One is across the highway from the main plant entrance (north of the heliport); several others are near businesses north of the mill's water filtration plant. Steep terrain limits the number of suitable building sites near Ward Cove. However, several residences are situated near the mouth of the cove on the south side. Approximately 1 mile west of the entrance to the pulp mill area, there are additional residences on both sides of the North Tongass Highway.

The 2000 census placed the population of Ketchikan Borough at 14,070, slightly greater than the 1990 population (Alaska Department of Labor 2004).

#### ***Recreation***

The area near the mouth of Ward Creek (where the Tongass Highway crosses the creek) is a popular sport fishing location during salmon season, including commercially-guided fishing. Some sport fishing and personal-use crab pot fishing has taken place in the past, and may continue, in the waters of the cove. Commercial scenic boat tour operations have been based at the former Wards Cove Packing cannery on the south side near the mouth of the cove. Because of the industrial nature of the shoreline and the inaccessibility of portions, little recreational use occurs from the shoreline.

## 2.4 Wildlife Resources

A survey of wildlife habitats was conducted as part of the Superfund sediment remediation project in Ward Cove. No sensitive habitats were observed in the areas surveyed, including the pulp mill area, the wood waste and ash disposal landfill, and adjacent forestland. The pulp mill site is a highly industrialized landscape. Adjacent to the pulp mill site along the highway is a collection of mixed commercial businesses and residences within the heavy forest that dominates the undeveloped areas. Wildlife habitat is not present in the pulp mill area; only a few scattered, disjunct areas of vegetation (e.g., grasses, forbs) are present near storage tanks or along portions of the steeply sloped shorelines of Ward Cove (Exponent 1999).

Incidental observations during a February 1997 reconnaissance indicate the presence of a relatively diverse winter fauna. In addition to the bird species commonly observed in Ward Cove, species observed during the reconnaissance of the upland areas included black-billed magpies (*Pica pica*) and black-capped chickadees (*Ardea herodias*) along Ward Creek and its tributaries. According to mill employees, deer are relatively common in the area. Although none were observed during the reconnaissance, deer tracks were present (Exponent 1999).

## 2.5 Climate

The Ketchikan area's maritime climate is characterized as relatively mild and very wet. Average seasonal temperatures range from 29 to 39 °F (-2 to 4 °C) in winter, 45 to 55 °F (7 to 13 °C) in the spring and fall, and 51 to 65 °F (11 to 18 °C) in the summer. Winds are from the southeast and the northwest due to the funneling effect of the Tongass Narrows. The predominant winds are from the southeast as a result of the presence of low-pressure cells to the northwest, which draw air from the Gulf of Alaska to the Ketchikan area. The annual average wind speed is 6 mph (9.7 km/h). The average annual rainfall at Ketchikan is 151 inches (3,850 mm), making it one of the wettest locations in the United States. The annual rainfall is usually spread over the year, with a dryer period during July and August. Evapotranspiration is approximately 24 inches (61 cm) per year (Exponent 1999).

Site-specific data from a local meteorological station at the Gateway facility indicate that depending on the season, local winds come from the west, south, east, or northeast at an average wind speed of approximately 6 mph (9.7 km/h) per hour (Exponent 1999).

# 3. Applicable Water Quality Standards

The Alaska Water Quality Standards (WQS) regulation (18 AAC 70), for both fresh and marine waters, establishes 13 pollutant parameters, establishes designated uses of waters, and sets water quality criteria to protect the designated uses. The water quality criteria, which may be numeric or narrative expressions, serve as "pollution limits" that may not be exceeded in waters by human actions. The WQS contain an antidegradation provision requiring that "existing water uses and the level of water quality necessary to protect existing uses must be maintained and protected." The WQS also contain various narrative provisions that govern the implementation of standards, including several limited exceptions to the statewide standards, notably the Zone of Deposit provision pertaining to the residues parameter.

TMDLs are developed to meet applicable WQS. This section identifies the applicable water quality standards for residues and dissolved oxygen in Ward Cove.

## 3.1. Designated Uses

Designated uses for both fresh and marine waters are established by regulation in the Alaska Water Quality Standards (18 AAC 70) along with water quality criteria to protect the uses. For marine waters of the state, these designated uses include (1) water supply for aquaculture, seafood processing and industrial uses; (2) contact recreation and secondary recreation; (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife; and (4) harvesting for consumption of raw mollusks or other raw aquatic life (18 AAC 70.020).

Exceedance of the residues standard in Ward Cove most directly affects the designated use of growth and propagation of fish, shellfish, other aquatic life, and wildlife. The most stringent standards generally apply to this designated use; therefore, this designated use is the focus of these TMDLs. The accumulation and decomposition of residues can adversely affect benthic organisms through burial, displacement, alteration of habitat, reduction of dissolved oxygen, and production of leachates and toxic by-products. Changes in benthic populations may be reflected in other changes throughout the food chain. Effects also might occur on recreational uses such as boating and sport fishing and on the harvest for consumption of raw aquatic life.

Depressed dissolved oxygen levels also can adversely affect growth and propagation of fish and aquatic life, and can have secondary effects on recreational uses and harvest of raw aquatic life. The effects of low oxygen levels depend on temperature and duration of exposure. Even a moderate reduction in oxygen can affect behavior such as growth and feeding. Extremely low dissolved oxygen can result in fish kills and severe damage to the benthic community. At the same time, however, low oxygen levels regularly occur naturally in the deeper waters of estuaries during the summer throughout Southeast Alaska.

Aquatic resources at risk in Ward Cove include the subadult or adult stages of eight anadromous salmonids, approximately 75 non-salmonid estuarine and marine fish species, and benthic invertebrate fauna. Adult salmonids will usually avoid hypoxic conditions, except when staging to enter freshwater during their annual spawning migrations. Salmonids encountering prolonged low-oxygen conditions in Ward Cove may sustain sublethal effects like reduced reproductive success. More severe hypoxic exposures in combination with low flows and high water temperatures in Ward Creek may result in adult mortality. Juvenile salmonids out-migrating from Ward Creek appear to move through the cove prior to the onset of depressed dissolved oxygen conditions (Karna 2003).

Non-salmonid estuarine and marine fish are considerably less sensitive than salmonids to depressed oxygen levels and also can avoid hypoxic conditions. However, some species and life stages of fish with low mobility residing in Ward Cove may be adversely affected by depressed oxygen. Non-mobile benthic invertebrates are similarly affected. Lethal exposures are believed to have occurred for some of these organisms as hypoxic conditions persisted for at least 14 days during 1998 and 1999. Sublethal stress more commonly occurred as dissolved oxygen levels less than 4 mg/L persisted within the cove from early August to mid to late September during 1998, 1999, and 2002 (Karna 2003).

## 3.2. Parameters of Concern

Ward Cove initially was included by the State of Alaska on its 1990 303(d) list of water quality-limited waters for low dissolved oxygen and the presence of residues due to the discharge from Ketchikan Pulp Company's (KPC) dissolving sulfite pulp mill. On the 1994 and subsequent 303(d) lists through 2004 (the most recent list), Ward Cove was listed as water quality-limited for three pollutant parameters: residues; dissolved gas (dissolved oxygen); and toxic and other deleterious substances (sediment toxicity) (ADEC, 2006). This report includes TMDLs to address impairments associated with wood residues and dissolved oxygen. No TMDL will be developed for sediment toxicity.

For residues, the pollutant parameter of concern identified on the 303(d) list is wood waste residues. For dissolved gas, the pollutant parameter of concern is dissolved oxygen. Wood residues on the seafloor also create oxygen demand as they decompose. However, based on the modeling study described in Appendix B, their effect was estimated to be roughly 4 times less than the effect of the fish wastes during times of operation for the processing facility.

With completion of these TMDLs, the classification of Ward Cove for residues and dissolved oxygen on the next revised Alaska Section 303(d) list will be changed to Category 4a--"TMDL has been completed." For sediment toxicity, Ward Cove was placed in Category 4b--"Other Pollution Controls" in the 2004 303(d) report, issued in April 2006 (ADEC, 2006). The Record of Decision of the Superfund sediment remediation project (USEPA 2000) for Ward Cove is accepted as a pollution control requirement that will achieve water quality standards for sediment toxicity.

## 3.3. Applicable Water Quality Criteria

Water quality criteria are the actual numeric or narrative limits on pollutant parameters established in the Alaska Water Quality Standards (18 AAC 70.020). This section identifies applicable criteria for residues and dissolved oxygen in Ward Cove.

### *Residues*

For the designated use, “Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife,” the Alaska water quality criteria state that residues “May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use, or cause acute or chronic problem levels as determined by bioassay or other appropriate methods. May not, alone or in combination with other substances, cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid, or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines.” (18 AAC 70.020 (b)(2)) Table 3-1 contains the full water quality criteria for residues.

Under the Zones of Deposit provision of the WQS (18 AAC 70.210), ADEC may issue a permit that allows the deposit of substances on the bottom of marine waters within limits set by ADEC. It is important to note that the water quality criteria of 18 AAC 70.020 and the antidegradation requirement of 18 AAC 70.015 may be exceeded in a zone of deposit, but must be met at every point outside the zone of deposit and in the water column. In allowing a zone of deposit ADEC must consider several factors, including impacts on human health, impacts on aquatic life, impacts on other uses of the waterbody, alternatives to reduce adverse effects, and duration and transport of pollutants. The Zones of Deposit provision is presented in Table 3-2.

**Table 3-1. Alaska's water quality criteria for residues in marine waters (18 AAC 70.020)**

| Pollutant & Water Use | Criteria |
|---|---|
| (**20) RESIDUES, FOR MARINE WATER USES: Floating solids, debris, sludge, deposits, foam, scum, or other residues** | |
| (A) Water Supply<br>(i) aquaculture | May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use. May not cause detrimental effects on established water supply treatment levels. |
| (A) Water Supply<br>(ii) seafood processing | May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use; cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid, or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines. |
| (A) Water Supply<br>(iii) industrial | May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use. |
| (B) Water Recreation<br>(i) contact recreation | Same as (20)(A)(ii). |
| (B) Water Recreation<br>(ii) secondary recreation | Same as (20)(A)(ii). |
| (C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife | May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use, or cause acute or chronic problem levels as determined by bioassay or other appropriate methods. May not, alone or in combination with other substances, cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid, or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines. |
| (D) Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life | May not make the water unfit or unsafe for the use; cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid, or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines. |

**Table 3-2. Alaska's WQS Zones of Deposit provision (18 AAC 70.210)**

| |
|---|
| **18 AAC 70.210. Zones of deposit.** (a) The department will, in its discretion, issue or certify a permit that allows deposit of substances on the bottom of marine waters within limits set by the department. The water quality criteria of 18 AAC 70.020(b) and the antidegradation requirement of 18 AAC 70.015 may be exceeded in a zone of deposit. However, the standards must be met at every point outside the zone of deposit. In no case may the water quality standards be violated in the water column outside the zone of deposit by any action, including leaching from, or suspension of, deposited materials. Limits of deposit will be defined in a short-term variance issued under 18 AAC 70.200 or a permit issued or certified under 18 AAC 15.<br><br>(b) In deciding whether to allow a zone of deposit, the department will consider, to the extent the department determines to be appropriate,<br><br>(1) alternatives that would eliminate, or reduce, any adverse effects of the deposit;<br><br>(2) the potential direct and indirect impacts on human health;<br><br>(3) the potential impacts on aquatic life and other wildlife, including the potential for bioaccumulation and persistence;<br><br>(4) the potential impacts on other uses of the waterbody;<br><br>(5) the expected duration of the deposit and any adverse effects; and<br><br>(6) the potential transport of pollutants by biological, physical, and chemical processes.<br><br>(c) The department will, in its discretion, require an applicant to provide information that the department considers necessary to adequately assess (b)(1)-(6) of this section. In all cases, the burden of proof for providing the required information is on the person seeking to establish a zone of deposit. (Eff. 11/1/97, Register 143) |

Because the residues water quality criteria are narratives and are use-based, ADEC applies the residues criteria on a case-by-case basis. A Zone of Deposit (ZOD) may be used to implement the TMDL through a permit. ADEC's application of the narrative criteria is discussed in Appendix G of the 303(d) listing report, *Alaska's Final 2004 Integrated Water Quality Monitoring and Assessment Report*, as follows (ADEC 2006).

> The water quality criteria for residues are narrative criteria with several provisions that are subject to interpretation. As such, it is overly simplistic to characterize the residues standard as "zero discharge." The first sentence of the criteria for most uses provides that residues "[m]ay not, alone or in combination with other substances or wastes, make the water unfit or unsafe, **for the use**..." [emphasis added] This is a "use-based" criterion – meaning, a use impairment determination must be made to trigger a water quality violation or a significant non-compliance situation.
>
> The second sentence within the narrative criteria for some uses states that residues "may not cause a sludge, solid, or emulsion to be deposited" on the surface, bottom, or shoreline. This prohibition against deposits is the most restrictive provision of the residue criteria. But it is not treated as a zero discharge standard in all instances. For example, DEC permits zones of deposit under 18 AAC 70.210; mixing zones under 18 AAC 70.240-.270; and variances under 18 AAC 70.200.

ADEC has developed a residues target for the Ward Cove TMDL as a level of residues that will support the achievement of stable benthic biological communities with balanced species composition in more than 75 percent of the area with documented coverage by wood residues on the bottom of Ward Cove, within 40 years. This target is based on scientific findings that natural benthic communities, because of dynamic conditions, generally have no more than 75 percent of area exhibiting such mature biological communities (EVS 2001). The acceptable amount of residues loading will vary depending on the type of activity occurring, as discussed in the loading capacity section. This target also reflects the WQS residues criteria that state that residues may not make the water unfit or unsafe for biological use. Also based on scientific studies, ADEC has determined that a wood waste content of 40 percent in total sediment volume will allow development and maintenance of stable and balanced benthic biological communities (see Appendix A). Section 6.1 provides additional explanation on the TMDL target and loading capacity for residues as a reflection of this interpretation.

***Dissolved Oxygen***

Table 3-3 presents the Alaska water quality criteria for marine waters for dissolved gas as dissolved oxygen. Ward Cove is considered to be both coastal water and an estuary. The applicable criteria for minimum levels of dissolved oxygen in Ward Cove are not less than 6.0 mg/L for a depth of one meter except where natural conditions cause this value to be depressed (coastal water); not less than 5.0 mg/L below one meter except where natural conditions cause this value to be depressed (estuaries); and not less than 4.0 mg/l at any point beneath the surface (all water).

The natural conditions clause attached to the 6.0 mg/L criterion for a depth of one meter for coastal waters means that where the natural level of dissolved oxygen is between 4.0 and 6.0 mg/L at any time and location in the surface one meter, the natural level is the applicable criterion. The natural conditions clause attached to the 5.0 mg/L criterion for estuaries means that where the natural level of dissolved oxygen is between 4.0 and 5.0 mg/L at any time and location below one meter, the natural level is the applicable criterion. Where natural conditions are the criteria, no measurable decrease in dissolved oxygen level may occur due to introduced pollutants. Both criteria apply in Ward Cove, and the TMDL applies throughout the waterbody.

**Table 3-3. Alaska's water quality criteria for Dissolved Gas in marine waters (18 AAC 70.020)**

| Pollutant & Water Use | Criteria |
|---|---|
| **(15) DISSOLVED GAS, FOR MARINE WATER USES** | |
| (A) Water Supply<br>(i) aquaculture | Surface dissolved oxygen (D.O.) concentration in coastal water may not be less than 6.0 mg/l for a depth of one meter except when natural conditions cause this value to be depressed. D.O. may not be reduced below 4 mg/l at any point beneath the surface. D.O. concentrations in estuaries and tidal tributaries may not be less than 5.0 mg/l except where natural conditions cause this value to be depressed. In no case may D.O. levels exceed 17 mg/l. The concentration of total dissolved gas may not exceed 110% of saturation at any point of sample collection. |
| (A) Water Supply<br>(ii) seafood processing | Not applicable. |
| (A) Water Supply<br>(iii) industrial | Not applicable. |
| (B) Water Recreation<br>(i) contact recreation | Same as (15)(A)(i). |
| (B) Water Recreation<br>(ii) secondary recreation | Same as (15)(A)(i). |
| (C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife | Same as (15)(A)(i). |
| (D) Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life | Same as (15)(A)(i). |

## 3.4. Seasonal Variation and Critical Conditions

TMDLs must be developed with consideration of seasonal variation and critical environmental conditions. Developing a TMDL that identifies the allowable loading to meet water quality standards under seasonal and critical conditions ensures that the waterbody will maintain water quality standards under all expected conditions.

### *Residues*

The existing wood residues in Ward Cove and the impaired status are not associated with a particular season or environmental condition. The impairment is a result of the cumulative impact of years of accumulation and decomposition of wood residues occurring year-round under prevailing environmental conditions. Therefore, development of the TMDL for specific conditions is not necessary; the TMDL is established to be protective under all conditions.

### *Dissolved Oxygen*

For dissolved oxygen, critical conditions occur within the bottom waters during summer months when the water column is stratified, with a warmer surface layer separated from deeper water by a picnocline, or density gradient, at a depth of 10 to 30 meters. Generally, the lowest measured values of dissolved oxygen have occurred during the months of August and September. When the density gradient within the picnocline is high, transport of oxygen from the aerated surface waters to the lower waters by mixing is significantly reduced. In this situation, the uptake of oxygen through respiration by living organisms and decomposition of organic matter in the water column and sediments is greater than the replenishment of oxygen through transport from Tongass Narrows and from the surface waters of Ward Cove. This results in depleted levels of dissolved oxygen in the system.

Another critical factor affecting dissolved oxygen in the bottom waters of Ward Cove is the levels of dissolved oxygen in Tongass Narrows. Tongass Narrows is the source of water entering Ward Cove through tidal action. Water quality measurements show that the lowest dissolved oxygen levels in Tongass Narrows also occur in the months of August and September. At times the oxygen levels in deep water are between 4.0 and 5.0 mg/L. Where the natural condition is in this range (in Tongass Narrows or in Ward Cove), the natural level of dissolved oxygen is the standard. This means there will be no ability for that component of the water to receive input of organic substances that will cause measurable decrease in oxygen levels (see Wasteload Allocation, Section 6.2). More detailed analyses of the historic water quality data are presented in Section 4.

# 4. Water Quality Analysis

This section assesses the water quality conditions in Ward Cove for residues and dissolved oxygen in sections 4.1 and 4.2. Table 4-1 presents a summary of environmental studies of Ward Cove.

**Table 4-1. Summary of Studies of Ward Cove**

| Study | Summary | Reference |
|---|---|---|
| **Uplands Investigation** | | |
| Scoping Document for the Remedial Investigation and Feasibility Study | Summarizes relevant historical information, provides a preliminary conceptual site model, presents a preliminary list of applicable and relevant or appropriate requirements, and establishes a decision-making framework for agency and KPC project managers. | PTI 1997b |
| Compilation of Existing Data, Ketchikan Pulp Company Site | Summarizes data gathered during upland investigations prior to July 1997, including data from routine monitoring events. It was prepared to supplement the scoping document for the Remedial Investigation/Feasibility Study (RI/FS). | PTI 1997a |
| Work Plan for the RI/FS | Reviews relevant information, including analytical results of source material samples, and identifies samples and analyses to be conducted during upland sampling. Also identifies procedures for transport and fate analyses and risk assessments to be conducted using site data. | PTI 1997e |
| Technical Memoranda | Documents the results of aerial deposition modeling and identifies soil sampling locations to evaluate aerial deposition. | PTI 1997c, d |
| Preliminary Site Characterization | Summarizes upland sites data and identifies chemicals of potential concern in upland sites. | PTI 1997f |
| **Tissue Chemistry Studies** | | |
| Remedial Investigation for the APC Mill | As part of a remedial investigation for the APC mill, 26 sediment samples, 4 mussel samples, and 1 rockfish sample were collected from West Sawmill Cove and analyzed for polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofurans (PCDDs/PCDFs). Results are considered comparable with PCDD/PCDF sediment sampling results in Ward Cove because of similar ranges in toxic equivalent concentrations in sediments. Provides evidence that bioaccumulation of PCDDs/PCDFs is limited. | Foster and Wheeler 1997 |
| Ward Cove Data | Ongoing studies to identify how chemicals of concern may be affecting aquatic fauna. | 1990 - 1996 |
| **Sediment Chemistry and Toxicity Studies** | | |
| 2004 Monitoring Report for Sediment Remediation in Ward Cove, Alaska | Results of 2004 monitoring of sediment chemistry, sediment toxicity, and benthic macroinvertebrate communities in Ward Cove to evaluate progress made in achieving Remedial Action Objectives for reducing toxicity and enhancing recolonization by healthy biological communities. | Exponent 2005 |
| Ward Cove Sediment Remediation Project, Detailed Technical Studies Report | Provides a detailed account of activities conducted to identify, evaluate, and remediate toxic sediments throughout a large portion of Ward Cove. | Exponent 1999 |

| Study | Summary | Reference |
|---|---|---|
| 1988 Sediment Study | Results of sediment sampling throughout Ward Cove (26 stations) in August/September 1988. Analyses included total organic carbon, total sulfide, biochemical oxygen demand, oil and grease, nine metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc), toxicity of whole sediments (at five stations) using a 10-day amphipod test, and toxicity of sediment elutriates (at three stations) using a 96-hour test with a mycid. | Jones & Stokes and Kinnetic 1989 |
| 1992 Sediment Study | Results of sediment sampling at five stations in the inner part of Ward Cove in January 1992. Analyses included total organic carbon (TOC), grain size, pH, alkalinity, chloride, sulfate, four leachable metals (calcium, magnesium, potassium, and sodium), toxicity of whole sediments using a 10-day amphipod test, and benthic macroinvertebrate assemblages. This is the most detailed and quantitative characterization of benthic macroinvertebrate assemblages in the cove. | EVS 1992 |
| **Water Quality Studies** | | |
| Ward Cove Baseline Characterization | Characterizes baseline conditions in Ward Cove (water column, plankton, and benthic macroinvertebrate assemblages) prior to KPC facility's opening. | AWPCB 1953 |
| Ward Cove Baseline Follow-up | Characterizes conditions in Ward Cove after the KPC facility was in operation for over 1 year. | AWPCB 1957 |
| Water Quality Investigation | Evaluates Ward Cove water quality. | FWPCA 1965 |
| Ward Cove Characterization | Evaluates water quality and benthic invertebrate assemblages and intertidal blue mussel populations in Ward Cove and in Tongass Narrows near the mouth of the cove. | FWQA 1970 |
| Ward Cove Characterization | Evaluation of Ward Cove and Tongass Narrows that indicates that conditions had not improved since the 1968–1969 study conducted by Federal Water Quality Administration (FWQA). | USEPA 1975 |
| Evaluation of Dissolved Oxygen and Chemical Constituents in Ward Cove Alaska and Tongass Narrows | Evaluation of dissolved oxygen and chemical constituents in Ward Cove and Tongass Narrows through construction of a detailed computer model. | Tetra Tech, Inc. 2002 |
| Ward Cove and Tongass Narrows Dissolved Oxygen Study | Evaluation of dissolved oxygen in Tongass Narrows and Ward Cove and currents in Tongass Narrows. | Tetra Tech, Inc. 2003a |
| Ward Cove Dissolved Oxygen Evaluation | Evaluation of dissolved oxygen in Ward Cove in the absence of summer discharge of fish-processing waste. | Tetra Tech, Inc. 2003b |
| **Miscellaneous Studies** | | |
| Bathymetric Survey | Maps water depth distributions and bottom topography throughout Ward Cove. | David Evans and Assoc, Inc. 1997 |
| Geophysical Survey | Describes physical characteristics of surface sediments using side-scan sonar and characteristics of subsurface sediments using subbottom profiling and seismic reflections. Video ground-truthing verified side-scan sonar and subbottom profiling data. | Golder and Associates, Inc. 1997 |

| Study | Summary | Reference |
|---|---|---|
| Hydrodynamic Survey | Characterizes current patterns, tidal elevations, and salinity/temperature profiles within Ward Cove. Data were used to assess the potential for sediment transport into Tongass Narrows, improve knowledge of water circulation within the Cove, and support assessment of the potential for natural recovery of sediment. | Exponent 1999 |
| Ward Cove LTF dive survey | Results of dive survey of benthic bark accumulation at former East LTF in Ward Cove conducted in November 2004: continuous bark cover, 1.2 acres; discontinuous bark cover, 0.6 acre. | Haggitt Consulting 2004 |

Source: Adapted from Exponent (1999)

## 4.1 Residues

There is no official mapped boundary to establish the limits of Ward Cove. The waterbody is taken to lie inside a line "point to point" across the mouth of the cove. The Superfund Detailed Technical Studies Report (DTSR) (Exponent 1999) provides two maps of wood residues distribution in Ward Cove. Figure 10-5 of the DTSR shows the density distribution of an estimated 16,000 logs over the cove bottom. It shows that logs are present over roughly 75 percent of the bottom (188 acres) in densities varying from fewer than 100 logs per 10,000 $m^2$ (1 hectare or 2.47 acres) to greater than 500 logs per 10,000 $m^2$. The area of highest log density covers an estimated 18 acres in the upper center of the cove in a "pile" up to 20 feet high. The map also shows the area in front of the former pulp mill, spanning about 0.5 mile, where sediments containing wood wastes, mainly pulp residues, are 5 to 10 feet thick.

Figure 10-6 of the DTSR shows the thickness of wood-waste-containing sediments measured at sample points over roughly half of the cove bottom. Those sediments vary from 0.3 foot to greater than 10 feet thick. The nonnative, organic-rich sediments are described as watery, black, and flocculent, with a strong sulfide odor, and containing varying amounts of wood debris. As indicated previously, the July 2004 Superfund monitoring assessment describes sediments as fine to very fine grain, containing wood debris (Exponent 2005).

A dive and video survey in July 2003 of portions of the bottom in areas where log storage occurred found, apart from the pile of logs in the upper center of the cove, a fine-grained, flocculent sediment surface with scattered small pieces of bark (ADEC, 2003b). It is important to understand that, according to best information, there is not an obvious accumulation of pulp residues or bark wastes on the bottom of the cove, but rather (apart from the logs) predominantly soft, fine-grained sediments containing decomposing fine wood waste material.

It is estimated from the two maps taken together that wood residues cover at least 75 percent of the bottom of Ward Cove. However, the entirety of Ward Cove (250 acres) remains on Alaska's 2004 303(d) list because there is no information to show that the remaining 25 percent of the bottom does not contain wood residues and is biologically healthy.

The DTSR found that the native substrate on the cove bottom underlying the wood residues is clay material on top of bedrock. The combined thickness of organic sediments and native clay sediments ranged from 66 to 98 feet. From this, it appears that the native bottom of Ward Cove exhibited a soft-bottom habitat formed by deposited sediments prior to the introduced accumulation of wood waste.

The areas of the cove that were sand-capped, certain areas with minimal deposits of wood waste, and certain areas that might contain little or no wood waste, might presently be recovered to meet the TMDL target specified in Section 6.1. However, information is not currently available to characterize these areas sufficiently, ensure that the target is achieved, and remove them from impaired designation.

In summer 2004 the Superfund sediment remediation project conducted the first biological monitoring exercise following the sand capping in 2001. Monitoring results indicate that substantial progress has been made in the recovery of biological communities on the bottom of Ward Cove. Biological assessment was conducted in nine areas on the bottom of the cove, with 4 to 7 sample sites in each area. Three sampled sand-capped areas were determined to be recovered. One shallow natural recovery (uncapped) area with thin wood waste deposits also was recovered. These areas exhibited communities with multiple taxonomic groups with species commonly found in areas where organic enrichment is low or declining. In three other natural recovery areas, benthic communities have not progressed as far toward recovery but are making significant progress. These areas exhibit communities characterized primarily by species commonly found in organically enriched areas, and they are dominated by two polychaete species (Exponent 2005). In two references areas tested in Ward Cove outside the Superfund Area of Concern, benthic communities also were dominated by the two polychaete species commonly found in organically enriched areas.

A dive survey of benthic bark accumulation was conducted in November 2004 at the East LTF. The survey found 1.2 acres of continuous bark cover and 0.6 acre of discontinuous bark cover (Haggitt Consulting 2004). The area surveyed, on the east shoreline approximately 1/4 mile south of the mouth of Ward Creek, is outside of the wood waste area documented by the Superfund assessment.

A second dive survey in November 2004 was conducted at the existing log lift in front of the former sawmill at the head of the cove. This site could be used for log transfer to land in the future. The survey found no significant continuous bark cover and 0.4 acre of discontinuous bark cover. This area is within the wood waste area documented by the Superfund assessment. The dive report states that “large Halibut, Dungeness crab and a considerable number of shrimp and Bullheads were scurrying in all directions…thousands of torredo worms were visible on the silt and on the debris” (Haggitt Consulting 2005). Although limited in area covered, this dive survey indicates substantial complexity to the biological community, with the implied presence of small organisms that serve as food for the larger organisms observed.

The 2003 dive and video survey showed moderate colonization on the large pile of logs in the upper center of the cove and limited organisms such as fish and sea stars on the bottom sediment surface in the absence of logs. Almost no organisms were observed on the bottom surface in a limited area west of the pulp mill site. This survey covered a very small portion of the bottom of the cove and did not assess infauna (ADEC 2003b).

It is clear that despite the dominance of wood waste as both logs and decomposing sediments, substantial developing biological communities are present on the bottom of Ward Cove. The Superfund sand-capped areas (30 acres) and one shallow natural recovery area with thin organic deposits appear to be recovered to meet the target. Other natural recovery areas evaluated are in beginning to moderate recovery stages with substantial communities typical of organically enriched areas.

It must be presumed that recovery of complex benthic communities will continue to advance with (a) continued decomposition of wood waste at the sediment surface and (b) accumulation of natural sediment at the approximate rate of 1 centimeter every 3 years. The result, as typically experienced in recovering organically enriched marine substrates, should be the development of stable, balanced benthic communities through natural biological succession.

## 4.2 Dissolved Oxygen

The environment of Ward Cove can be divided into three periods with respect to assessment of impairment of dissolved oxygen. From 1954 to March 1997, both the pulp mill and the fish processing facility were in operation. From 1997 to September 2002, the fish processor alone continued operation. From 2002 forward, neither discharge source was present, and the only significant remaining sources of introduced organic material in deeper water are legacy wood residues and fish wastes on the bottom, along with secondary-treated sewage discharged at a depth of approximately 90 feet MLLW at the former fish-processing facility, which now is a commercial business facility.

In 1994, EPA completed a TMDL for dissolved oxygen in the surface one-meter layer of water in Ward Cove to address effects of the pulp mill discharge. The reason for the focus on the surface layer was that noncompliance was found with respect to the higher standard that applies at the surface, 6.0 mg/L, rather than the standard of 5.0 mg/L (or natural conditions down to 4.0 mg/l) that applies below one meter (it is not known why the TMDL did not address dissolved oxygen in deeper water). That TMDL established a loading capacity of 20,000 lbs/day of biological oxygen demand ($BOD_5$) in the surface layer. A wasteload allocation of 16,000 lbs/day was set for the pulp mill discharge. As described below, monitoring conducted from 1997 to 2003 showed that the surface layer has met the dissolved oxygen standard since closure of the pulp mill.

Monitoring of dissolved oxygen conditions in the cove, both longitudinally and vertically, along with salinity, temperature, and pH, was continued by Ketchikan Pulp Company and its successor, Gateway Forest Products, from 1997 through 2002, as a requirement of the NPDES discharge permit issued to the pulp mill, which was transferred to Gateway for its continuing operations. Monitoring data showed that severe exceedance of the dissolved oxygen standard occurred each summer in deeper waters of the cove.

With the continued 303(d) listing of Ward Cove for residues, dissolved oxygen, and sediment toxicity, EPA commenced preparation of additional TMDLs in 1999. An analysis of dissolved oxygen conditions and preparation of a detailed computer model were carried out to evaluate effects on dissolved oxygen from the decay of fish-processing waste discharged by the fish processing facility and from legacy wood residues on the bottom of the cove. Although dissolved oxygen data had been collected before cessation of the KPC discharge (March 1997), the analysis was performed only on data collected after the KPC closure.

For the 1997-2002 period, vertical profiles of salinity, temperature, and dissolved oxygen are available at 13 stations throughout Ward Cove and in Tongass Narrows (Figure 4-1). Nine water quality sampling stations are distributed throughout the cove from near the confluence of Ward Creek to the entrance channel. In addition, four stations in Tongass Narrows provide reference conditions of dissolved oxygen in water that may enter the cove from the Narrows. Monitoring generally was conducted twice per month in August and September and once per month in other months, although the dates were variable. Appendix C presents the vertical profiles of salinity, temperature, and dissolved oxygen for each station.

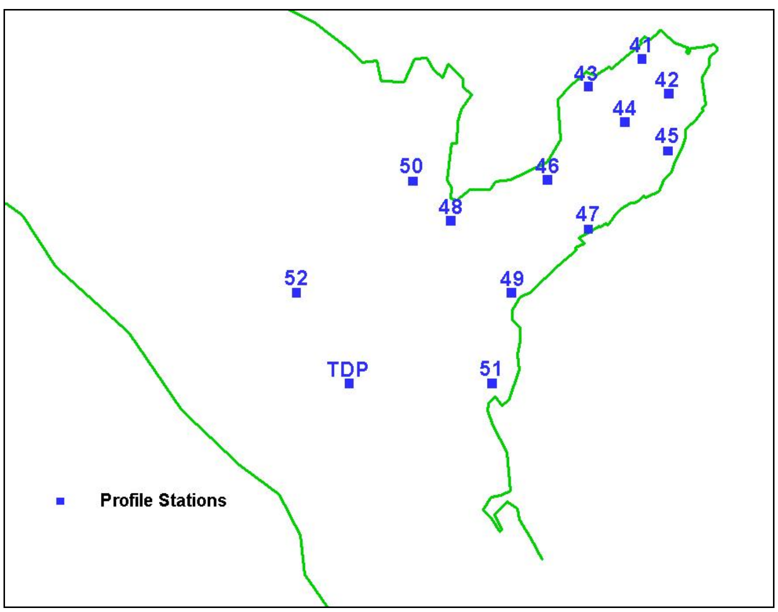


**Figure 4-1. Location of water quality sampling stations in Ward Cove.**

Analyses of the measured profile data were performed for the dissolved oxygen concentrations below the picnocline, estimated at a depth of 10 meters in Ward Cove. The analyses were performed on three primary stations—44, 46, and 52—to characterize the conditions longitudinally through the system from the center of Ward Cove, through the transition between Ward Cove and the Tongass Narrows, and within Tongass Narrows, respectively. In addition, these stations were sampled within the deepest areas and represent the worst-case conditions of dissolved oxygen deficit in the lower waters.

The analyses were done for the months of May, June, July, August, and September. The dissolved oxygen data were analyzed for monthly means, maximums, and minimums for the data measured below the picnocline. In addition, the data were analyzed to determine the number of readings below the WQS of 5.0 mg/L.

Figures 4-2 through 4-4 present the means, maximums, and minimums by month for stations 52, 46, and 44, respectively. The data show a general trend of decreasing dissolved oxygen from May through August; August and September generally show the lowest values. The data show average conditions at the two Ward Cove stations below 5.0 mg/L in August and September, with the lowest oxygen levels just above or below 1 mg/L in deeper waters in the upper center of the cove. In Tongass Narrows, average conditions were not below 5.0 mg/L, but minimum values occurred below 5.0 mg/L in July and August and below 4.0 in September. The data indicate that the additional dissolved oxygen deficit in the bottom waters of Ward Cove relative to Tongass Narrows was due to stratification, reduced circulation, and the effects of oxygen-demanding materials. This is consistent with the general findings of the *Ocean Discharge Criteria Evaluation for the NPDES General Permit for Alaskan Seafood Processors* (Tetra Tech, Inc., 1994), which found that impacts from seafood processors are greatest in embayments with reduced circulation and stratification. This additional deficit in Ward Cove was up to 3.0 mg/L lower than the level found in Tongass Narrows at similar time periods. Figure 4-5 presents a comparison of the vertical profiles of dissolved oxygen at the Tongass Narrows stations and the interior cove stations, showing the level of deficit that existed in the cove. The vertical profiles of salinity and temperature in Appendix C show that the degree of stratification in Ward Cove can be very high, reducing the reaeration of bottom waters from the surface waters.

Figure 4-6 presents the percentage of dissolved oxygen readings below 5.0 mg/L at stations 44, 46, and 52 during the summer. During August, over 80 percent of the dissolved oxygen readings in the bottom waters of Ward Cove at stations 44 and 46 were below 5.0 mg/L. In Tongass Narrows most exceedances of the WQS occurred during September, with nearly 40 percent of the readings in the bottom waters below 5.0 mg/L. This indicates that Tongass Narrows also experienced periods when dissolved oxygen levels were below the WQS. This is a critical factor in the development of the TMDL for Ward Cove because the waters in Tongass Narrows provide the background source water to Ward Cove through tidal action. With natural oxygen levels near or below 5 mg/L, the deeper waters of Ward Cove may have limited ability to assimilate oxygen-demanding materials and still meet the WQS in the period of lowest oxygen levels.

In addition, a complex hydrodynamic and water quality computer model was constructed to evaluate the relative effects on depression of dissolved oxygen from the fish processing waste discharge and the legacy wood residues. The model used data only from 1997, which proved to be a representative year. According to the model, under the worst conditions, in August 1997, the depression of dissolved oxygen due to fish-processing waste was approximately 2.0 mg/L, and the depression due to wood residues was approximately 0.5 mg/L (Tetra Tech, Inc. 2001; see Appendix B).

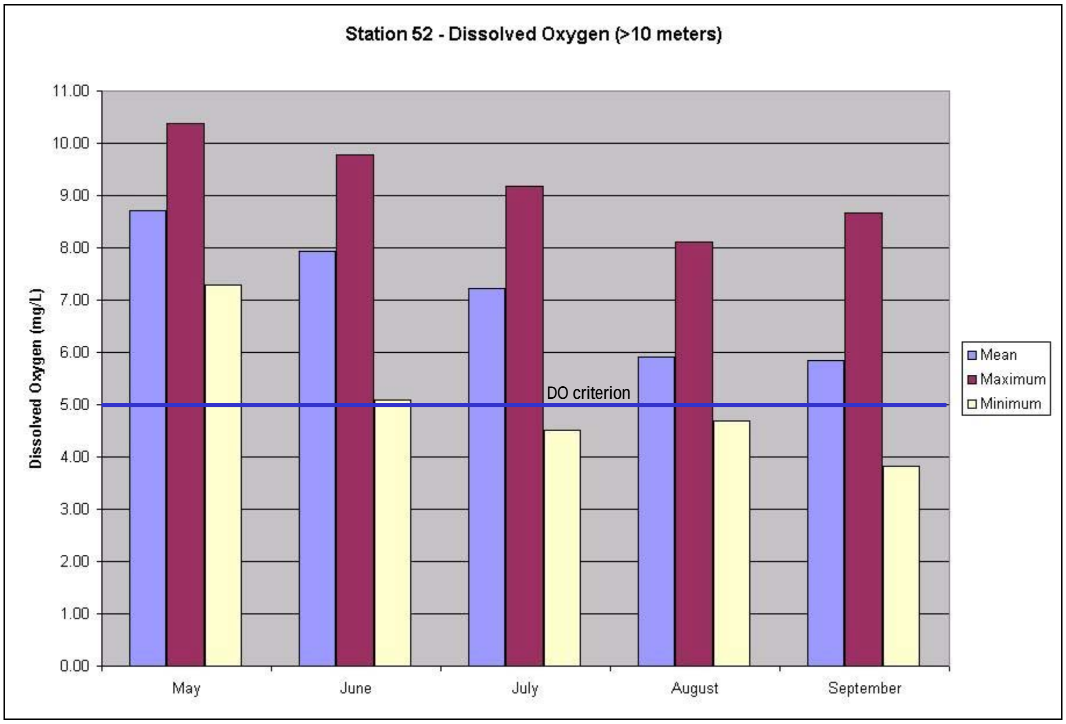


**Figure 4-2. Monthly mean, maximum, and minimum dissolved oxygen at station 52 (in Tongass Narrows).**

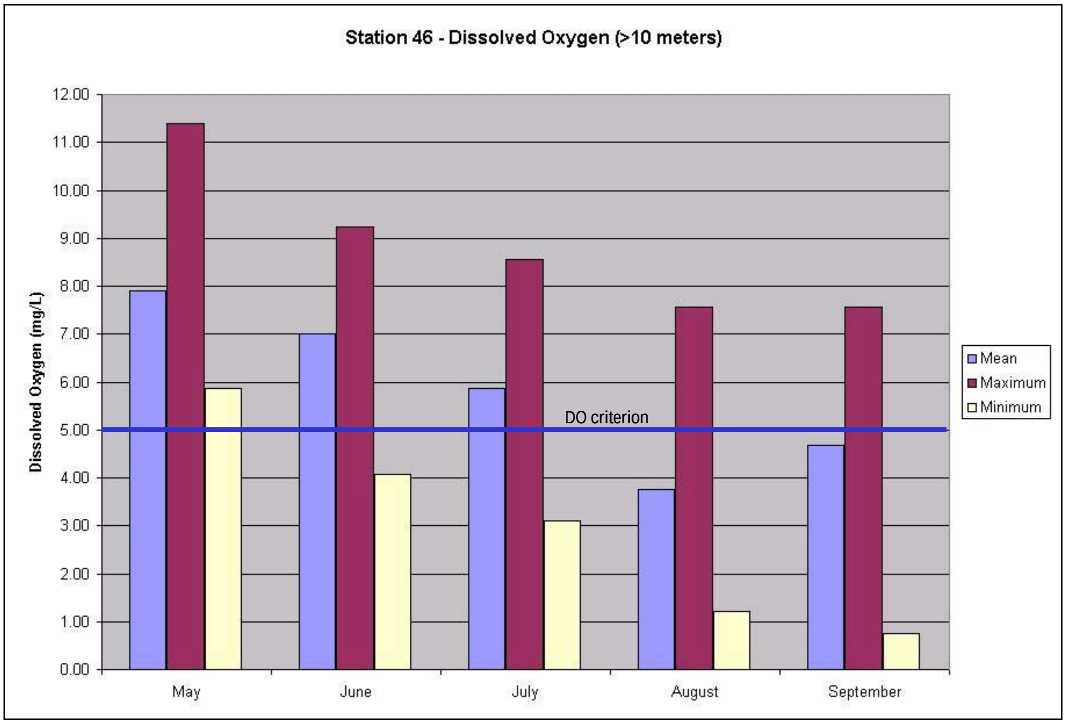


**Figure 4-3. Monthly mean, maximum, and minimum dissolved oxygen at station 46 (in Ward Cove).**

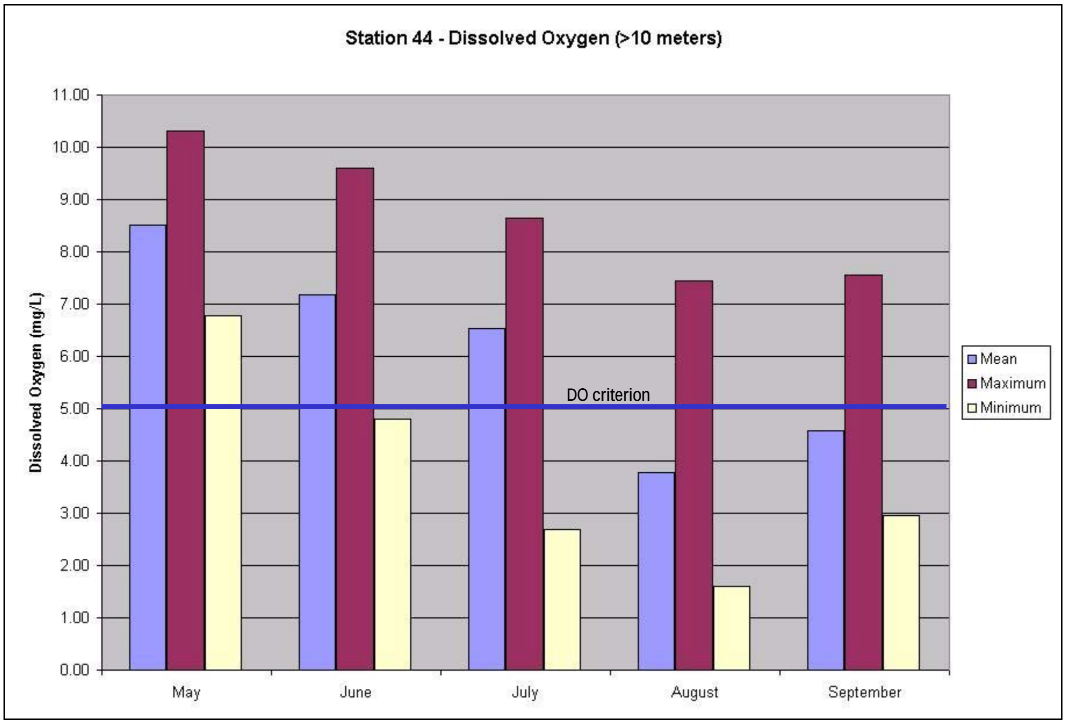


**Figure 4-4. Monthly mean, maximum, and minimum dissolved oxygen at station 44 (in Ward Cove).**

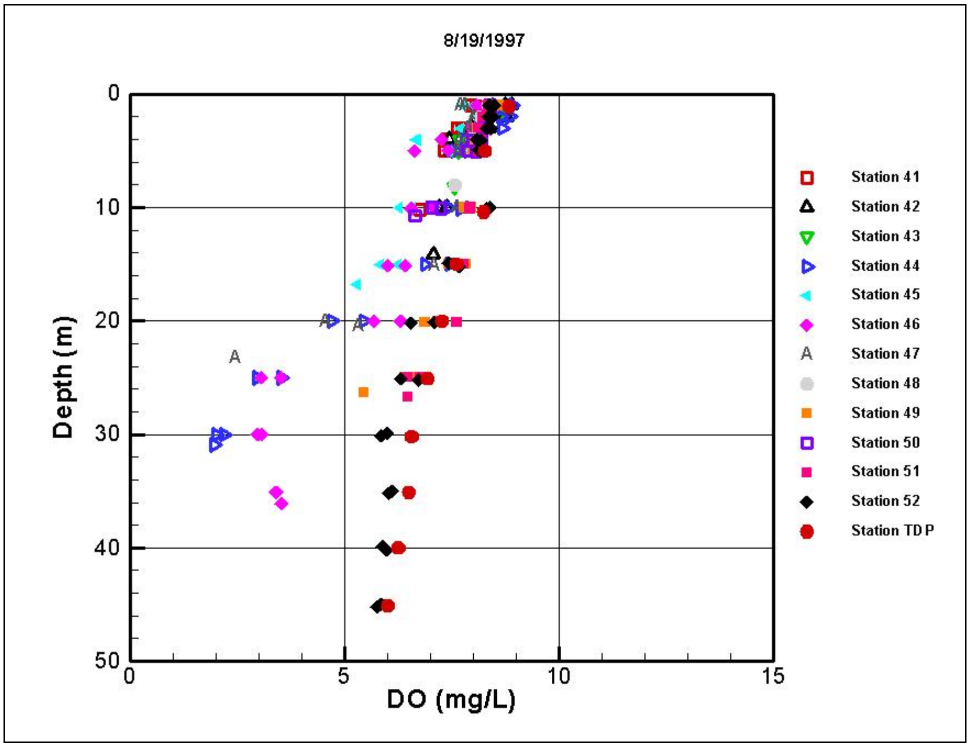


**Figure 4-5. Vertical profiles of dissolved oxygen.**

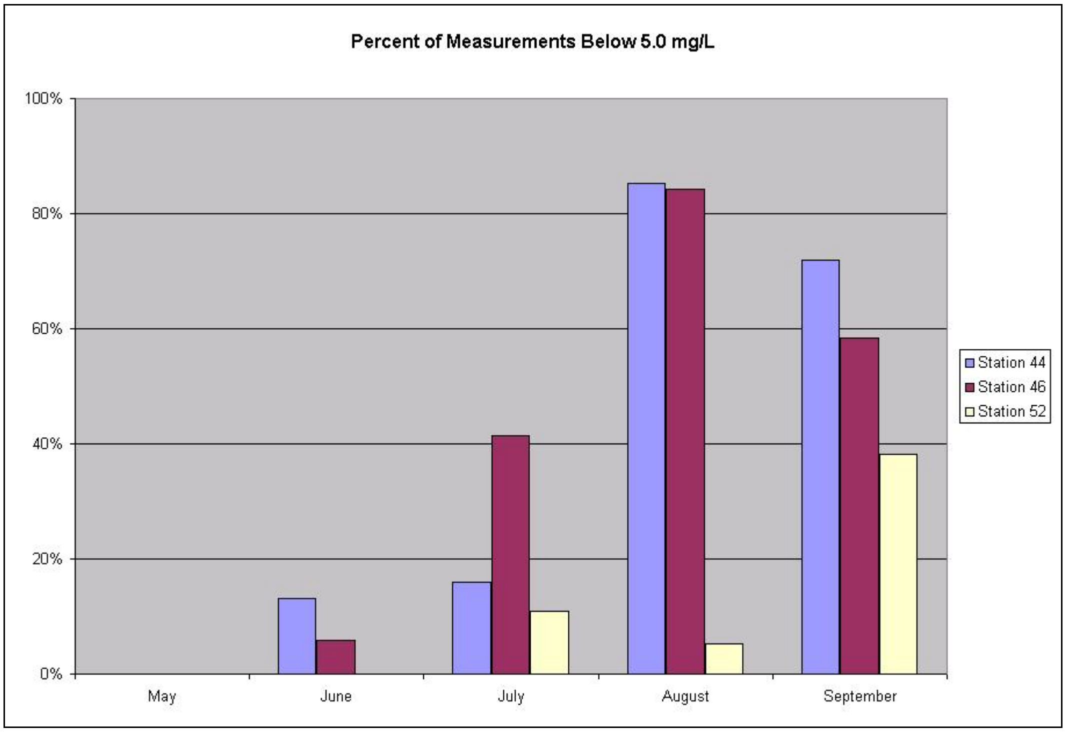


**Figure 4-6. Percentage of readings below 5.0 mg/L.**

The WCPC fish processing facility ceased operation in September 2002. Removal of this substantial annual oxygen-demanding load will avoid the severe depression of oxygen levels associated with the decomposition of suspended fish-processing waste in the cove. No monitoring has taken place to determine the amount of solid fish wastes remaining on the bottom of the cove in front of the former facility. While fish wastes are known generally to diminish rapidly, it is presumed that some remaining fish wastes are present and will continue to decompose with de minimus effects on dissolved oxygen levels.

In the summer of 2003, ADEC assessed dissolved oxygen levels in Ward Cove in the absence of fish-processing waste discharge using nine of the stations previously monitored by KPC, including Station 47 located adjacent to the former WCPC site (Tetra Tech, Inc., 2003b; see data in Appendix E). Five sampling events were carried out, two in August and three in September. The first sampling event in mid-August produced incomplete data. In late August within Ward Cove only station 47 exhibited dissolved oxygen values at the bottom below 5.0 mg/L, with a minimum of 4.07 mg/L; station 52 in Tongass Narrows showed minimum oxygen level at 4.76 mg/L at the bottom. The lowest oxygen values were found at a sampling event in early September, when five stations within Ward Cove exhibited minimum oxygen levels below 5.0 mg/L near the bottom, with the lowest reading at 4.42 mg/L, and all values at 10 meters depth and below were under 6 mg/l. At that time, Station 52 showed minimum oxygen level at 4.58 mg/l at the bottom. For a sampling event in late September, only station 47 again exhibited a dissolved oxygen value below 5.0 mg/L, with a single reading of 4.75 mg/L at the bottom; Station 52 showed 5.01 mg/L. <u>The lowest values in Ward Cove were well above the minimums of 1 to 3 mg/L found when fish-processing waste was discharged during the same summer months, and were slightly above levels observed in deeper water in Tongass Narrows</u>. For oxygen levels between 4.0 and 5.0 mg/L, the water quality criterion for dissolved oxygen is the natural condition. The WQS therefore do not allow introduced wastes to cause measurable decrease in dissolved oxygen levels below the natural level.

There was considerable variation in oxygen levels with depth and among the sample dates. Among sample stations on a given date, oxygen levels varied between 0.5 and 1 mg/l. In all cases, dissolved oxygen levels increased steadily in ascending the water column from bottom to surface. Water depths with oxygen readings below 5 mg/L were found at 30 meters and deeper (excepting a single reading of 4.85 mg/L at 20 meters depth at Station 43 in early September), with a maximum of 50 meters depth. Aside from the early September sampling event, mid water depths above 30 meters ranged generally from 5.5 to 7.5 mg/L; early September mid water values were 5 to 6 mg/L. In the upper 10 meters of the water column, oxygen levels generally ranged from 6.5 to 8 mg/L, except in early September when values ranged from 5.2 to 7.2.

The 2003 measurements were taken using a standard YSI recording instrument, which was lowered through the water column to take readings at 5-meter depth increments. Quality control checks were performed by taking grab samples at two selected stations (44 and 46) and measuring dissolved oxygen on-site using Winkler titration kits. For 16 samples on 4 sample dates, the Winkler titration results averaged 0.53 mg/L <u>higher</u> than the results from the recording instrument at the same stations and depths. The accuracy of both procedures is not known, but the Winkler titration usually is considered the more accurate method. If the Winkler values are correct, it would suggest that few of the oxygen levels measured actually were lower than 5.0 mg/L.

The historical monthly monitoring of dissolved oxygen and other parameters required by the NPDES permit held by Gateway Forest Products was continued in 2003. The monitoring method was similar to that described above: a recording instrument was lowered in the water column to take readings of dissolved oxygen at 5-meter increments. In July 2003 oxygen levels at all stations were well above the standard of 5.0 mg/L. In mid and late August, results showed minimum oxygen values of 3.46 and 4.41, respectively, at station 46, the only station below 5.0 mg/L. No report is available for September. In early October the minimum oxygen level was 6.87 mg/L; in late October it was 10.8 mg/L, indicating the end of stratification in the water. These results are generally consistent with the 2003 monitoring that ADEC conducted. Accuracy of these results is not known.

The dissolved oxygen data collected from 1997 through 2002 show that minimum dissolved oxygen levels varied considerably from year to year. The differing oxygen levels presumably were due to variation in natural oxygen levels and hydrodynamic conditions and to variation in discharge of fish-processing waste. It is not known whether 2003 was "high" or "low" for natural dissolved oxygen levels in Ward Cove. It appears that there was a dramatic recovery of dissolved oxygen levels in 2003 in the absence of fish-processing waste discharge. However, at the time of lowest seasonal oxygen levels (early September 2003), minimum levels in water at depths of 30 meters and greater remained near or below 5.0 mg/L.

The finding that oxygen levels were near or below 5 mg/L is the basis for establishing the TMDL for dissolved oxygen. Below 5 mg/L, the natural conditions water quality criterion for dissolved oxygen does not allow introduced wastes to cause measurable decrease in dissolved oxygen level below the natural level. Therefore, the loading capacity is set at 5 mg/L. The wasteload allocation is set as no point source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L from June through September. "Measurable decrease" means a decrease in dissolved oxygen level of 0.2 mg/L or greater.

# 5. Pollutant Sources

This section identifies historical pollutant sources that caused impairments by residues and low dissolved oxygen in Ward Cove, as well as potential future discharge sources. Historical records, the Superfund sediment remediation project, water quality monitoring, water quality assessments, discharge permits issued, and other information provide a clear record for describing impairments and future discharges.

## 5.1 Point Sources

This section describes the permitted sources of residues discharges to Ward Cove.

### *Ketchikan Pulp Company Pulp Mill (Historical)*

The KPC pulp mill operated from 1954 to 1997 and historically discharged 35 to 45 million gallons per day (mgd) through several outfalls to Ward Cove (Exponent 1999). Initially, KPC held a discharge permit issued by the Alaska Water Pollution Control Board. In 1971, with passage of the federal Clean Water Act and creation of EPA, the first NPDES discharge permit was issued, requiring primary treatment of effluent. A revised NPDES permit in 1980 brought secondary treatment; other controls were imposed in subsequent years. Fresh process water was supplied to the pulp mill through a wood-stave pipeline from Connell Lake, 2 miles above the mill site. In addition to wastewater from pulp mill processes, in later years discharges included leachate from the KPC landfill on the north point at the mouth of the cove and wastewater from a sewage treatment plant onsite, as well as stormwater runoff.

The pulp mill effluent contained highly processed pulp residues that had a high oxygen demand and could degrade in sediments to form ammonia, sulfides, and other potentially toxic substances. At high enough levels, ammonia and sulfides can contribute to the toxicity of sediments. The effluent also contained chemicals, including resin acids, phenols, and dioxins and furans; however, these chemicals have been determined not to be “chemicals of concern” in Ward Cove (USEPA 2000).

The following sections discuss the primary historical activities at the KPC facility that contributed to the residues impairment in Ward Cove—wastewater treatment discharges and in-water log storage. The pulp mill effluent discharge ceased when the pulp mill closed in 1997. Minor discharges associated with the KPC facility continued until 1999 when the pulp mill facilities were sold to Gateway. These discharges were small relative to historical contributions. Log storage continued under operations by Gateway Forest Products until the end of 2001, along with discharge from the landfill, discharge from the sewage treatment plant, and stormwater runoff. Much of the information in the following sections is contained in the Superfund Detailed Technical Studies Report (Exponent 1999).

### Wastewater Discharge

In addition to inputs from log storage activities, wastewater treatment discharges from the KPC facility included historical sources of chemicals and organic material to Ward Cove. The discharges from the pulp mill wastewater outfalls contributed high concentrations of fine-grained organic matter. Fine-grained organic matter, which has a higher surface-to-volume ratio than larger pieces of bark or wood, provides a more reactive surface for microbial activity.

Wastewater was discharged into Ward Cove near the pulp mill through four separate outfalls (001, 002, 003, 004) from 1954 until 1972. Untreated wastewater primarily from the acid plant, wash plant, bleach plant, and machine room was discharged through outfall 001 (Figure 5-1). Partially treated wastewater from the boiler house was discharged through outfall 002. Wastewater generated in the wood rooms passed through north rotary screens and was discharged, via the hog house, through outfall 003. Sediments and filter backwash from the water treatment plant were discharged through outfall 004. The outfalls were located progressively from west to east.

A primary treatment facility, which included a vacuum filter, a “V” press, and a grit chamber, was constructed in 1971 to reduce discharges of suspended solids. As a result, outfall 003 was eliminated in 1972 and routed to primary treatment. Wastewater from the primary treatment facility was discharged from a separate outfall. In 1972 outfall 002 was eliminated by rerouting to the main outfall. At that time, outfall numbers were redesignated; however, the main outfall (001) remained the same. The primary discharge was designated 002, and the water treatment plant became 003.

A secondary activated sludge treatment system was installed in 1980 to reduce biochemical oxygen demand (BOD) discharges. It included an aeration basin and a secondary clarifier. Primary and secondary effluents were combined and discharged through a newly constructed outfall separate from the main outfall. In 1993 an effluent neutralization system was installed to combine all process discharges and control the pH of the combined discharge. This discharge was designated outfall 001, and the water treatment plant outfall became 002.

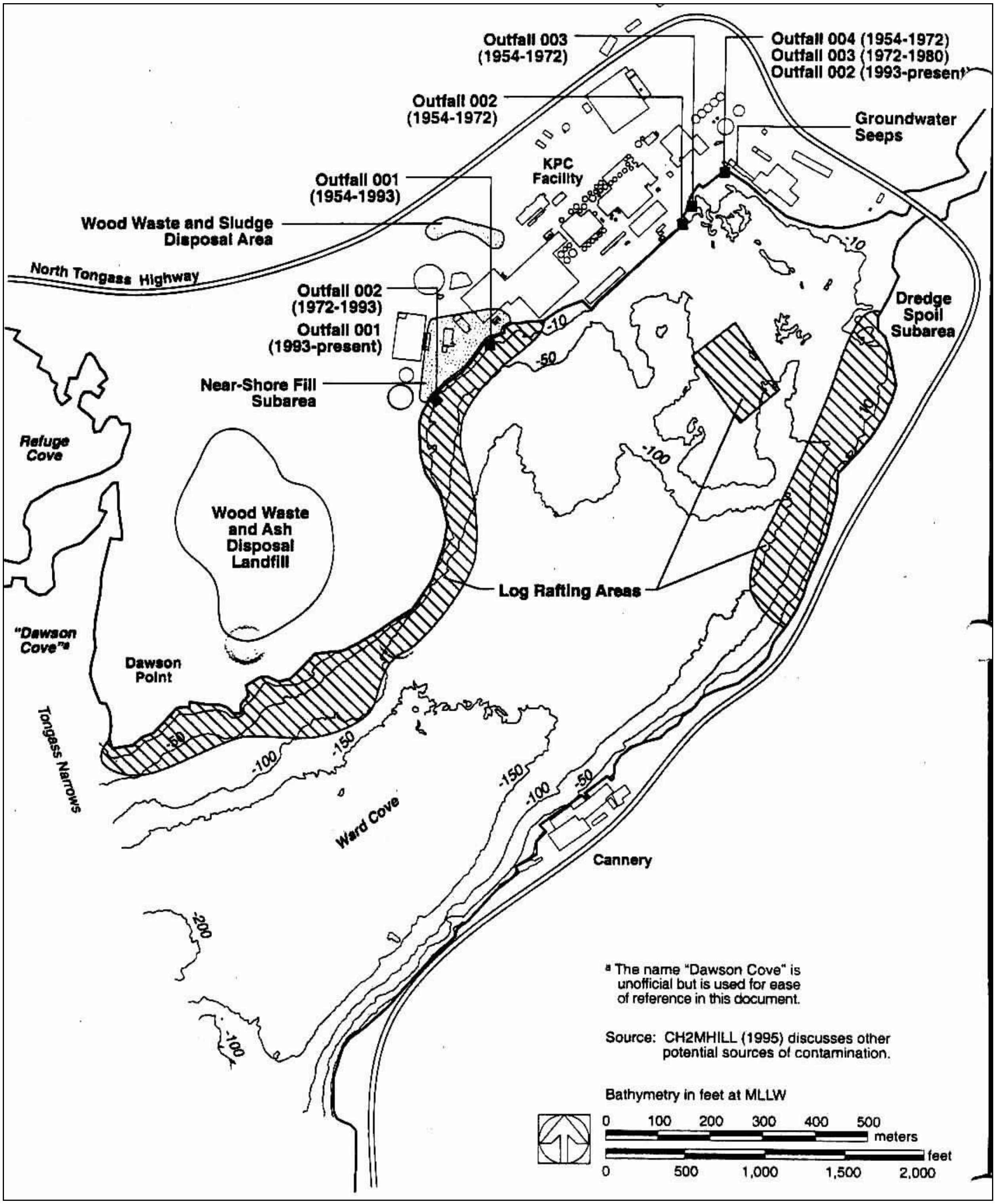


**Figure 5-1. Location of potential sources of residues and sediment toxicity in Ward Cove (Exponent 1999).**

Discharge of pulp waste ended when the pulp mill was shut down in 1997. The KPC NPDES discharge permit was transferred to Gateway Forest Products in 1999. Gateway continued to operate the sawmill and sewage treatment plant and constructed and operated a veneer plant until all operations ceased at the end of 2001. Continued discharge included the sewage discharge, landfill leachate, stormwater runoff, and approximately 2 to 3 mgd of Lake Connell water throughput to preserve the wood-stave pipeline. The discharge permit was inactivated when EPA issued a new NPDES discharge permit to the Ketchikan Borough in October 2004 to allow continued discharge from the sewage treatment plant along with stormwater and the Lake Connell throughput. Leachate from the KPC landfill now is discharged through a new outfall constructed by KPC near the north mouth of the cove, under an NPDES permit issued to KPC in October 2004. Residues associated with these discharges are negligible, and BOD discharges are relatively small. Both discharges are to nearshore waters at roughly 10 meters depth in Ward Cove and are not expected to affect the oxygen levels in deeper waters.

### Log Storage

During the years of pulp mill operation, logs were brought into Ward Cove bundled in rafts and stored in the water until they were taken into the pulp mill. No permit was required for log storage in the cove until development of the EPA and state general permits in 2000. For the life of the pulp mill, the discharge and accumulation of logs and bark from logs in storage was not regulated by permit. Logs were stored primarily at the locations shown in Figure 5-1. Logs were not stored north of Dawson Point. Pilings and anchors were used on the northern and southern shorelines of Ward Cove to hold log rafts.

Over the years log storage and transfer were the source of an estimated 16,000 sunken logs on the bottom of the cove. It is unknown how much bark waste was discharged from logs in storage. However, monitoring by the Superfund assessment in 1996-1997 and in 2004 found little intact bark on or in sediments. Reports from these assessments describe upper sediments as watery, black, and flocculent, and fine to very fine grain. The high organic content of non-capped sediments (7 to 24 percent Total Organic Carbon) is substantially elevated due to wood waste material. Excepting sunken logs, decomposition has reduced wood material in sediments to fine-grain condition. Moreover, Total Organic Carbon levels found in 2004 were significantly lower than the values found in 1996-1997.

### Log Transfer

As mentioned, a log transfer facility known as the East LTF was constructed to transfer logs to water in 1977 and was operated periodically until 2000, mostly by operators other than KPC. The location of the LTF, still in place, is about 1/4 mile south of Ward Creek on the opposite side of the cove from the former pulp mill. The Ketchikan Gateway Borough recently sold the property to a private interest. A dive survey in 2004 found 1.2 acres of continuous cover by bark debris on the bottom at this location.

### *Gateway Forest Products, Inc. (Historical)*

Gateway Forest Products acquired the entire KPC facility and sawmill in November 1999 and operated the sawmill until the end of 2000. Gateway constructed a veneer plant adjacent to the sawmill at the head of Ward Cove and operated it from late 2000 until late 2001, when all operations ceased and the company filed for bankruptcy. Gateway continued to store logs in Ward Cove throughout this period, though at volumes considerably reduced from the storage that had occurred while the pulp mill was operating. Other activities associated with operating the sawmill and veneer plant included dewatering log bundles; debarking logs; sawing and chipping logs; hogging bark; transferring sawn wood products, chips, and hog fuel to barges; and loading logs onto barges. Although these activities took place on land, they might have contributed incidental amounts of bark and wood waste to the cove.

As mentioned, after the KPC NPDES discharge permit was transferred to Gateway in 1999 discharges continued from the sewage treatment plant, the landfill leachate, and the freshwater pipeline through outfall 001, and stormwater runoff through a variety of small outfalls. KPC has constructed a new outfall for the landfill leachate near the north point at the mouth of Ward Cove and received an NPDES permit for this purpose in October 2004.

### *Ketchikan Gateway Borough*

The Ketchikan Gateway Borough acquired most KPC and Gateway facilities in 2002, including the pulp mill remains, sawmill, and veneer mill. The sawmill was subsequently dismantled and removed, along with much of the pulp mill equipment. In 2004 the Borough received a new NPDES permit for discharges from the sewage treatment plant, freshwater pipeline, and stormwater runoff, and also for treatment and discharge of up to 10,000 gallons per day of sewage sludge liquids from a sewage sludge separation facility being built on the KPC site. This permit requires meeting the Alaska standard for dissolved oxygen and all other water quality standards at the end of pipe. Thus, no significant effect on oxygen levels in waters of the cove is expected, and there is no significant discharge of residues from these facilities.

In May 2004 ADEC issued the Ketchikan Gateway Borough a state individual wastewater discharge permit to authorize the discharge of bark and wood residues into Ward Cove from log storage and transfer activities over a 5-year period to supply the veneer mill and also to load ships with logs for transport to markets (ADEC 2004). No log storage has occurred under this permit, and none may occur until an NPDES individual permit is obtained from EPA to authorize discharge from log storage and transfer. EPA will not consider issuing an NPDES permit until the TMDL for residues is completed. More information on the state permit can be found online at http://www.dec.state.ak.us/water/wnpspc/forestry/ipwardcoveip.htm.

In the spring of 2006, the Ketchikan Borough sold most of the former KPC pulp mill facility, the veneer mill, and KPC lands west to the north point at the mouth of Ward Cove to a developer, the Renaissance Ketchikan Group. The Renaissance Ketchikan Group has indicated it plans to reopen the veneer mill in late 2006, but has stated that logs will not be stored in the water of the cove, which will avoid the potential for bark discharge from that activity and from log transfer from water to land.

### *Wards Cove Packing Company (Historical)*

WCPC operated a seafood processing facility during the summer on the southern shore of Ward Cove. The facility closed in 2002, but during operation it discharged fish-processing waste, ground to a maximum ½-inch size, under EPA's NPDES general permit for seafood processors. This permit allowed a 1-acre zone of deposit for the accumulation of waste on the ocean bottom. The outfall depth was approximately 90 feet MLLW. Discharge of fish wastes occurred in peaks on an approximately weekly basis with varying quantity, depending on the timing of delivery of fish to the cannery by fishing boats. A pile of fish processing waste of undetermined size still may be present directly offshore from the WCPC facility, and elevated concentrations of several contaminants of concern were detected in a sediment sample collected near that site (Exponent 1999). The *Ward Cove Water Quality Assessment* (Jones & Stokes and Kinnetic 1989) also indicated elevated concentrations of pollutants (e.g., total sulfide, BOD) offshore of the cannery. Although elevated concentrations of chemical pollutants were measured at this monitoring station, there were not sufficient data to confirm that the concentrations were a result of the cannery discharge or that the pollutants were at toxic levels.

Although the present size of the fish-processing waste pile is undetermined, WCPC completed surveys of the waste pile as part of the compliance monitoring required under the NPDES general permit. A December 1999 survey included measuring thickness of the debris field at 15-foot intervals along 5 radial transects, with the outfall as the center point (Wards Cove Packing Company 1999). The survey indicated that the fish-processing waste pile extended at least 150 feet from the outfall and had a width of at least 240 feet. Of the 37 survey points, 20 found waste thickness of at least 4 feet, which is the maximum depth measured by the survey equipment.

The discharge from the former WCPC facility can be classified into solid and dissolved (or particulate and soluble) wastes. Solid waste consisted primarily of unused portions of processed raw fish, including heads, skin, scales, viscera, and fins discarded during cleaning and butchering operations. Dissolved waste included solubilized organic matter, blood, and nutrients leached from fish during processing (USEPA 1994). Most solid material likely sank to the bottom, creating and adding to the waste pile, while fine particulate and dissolved material remained suspended.

The dissolved and suspended waste material from the WCPC facility exerted a BOD within the water column and provided nutrients to the system. The quantification of the BOD for this TMDL was determined on the basis of a report prepared for EPA in 1994, *Ocean Discharge Criteria Evaluation for the NPDES General Permit for Alaskan Seafood Processors* (Tetra Tech, Inc., 1994). The daily pounds of production were used to determine the total BOD load to the system from the WCPC facility.

Computer modeling conducted for EPA indicated that the dissolved and suspended fish-processing waste was responsible for a highly variable depression of dissolved oxygen levels within Ward Cove, particularly in deeper waters, with a maximum depression of roughly 2 mg/L. Water circulation in Ward Cove tends to be counterclockwise, which pulled the suspended fish-processing waste from the outfall location up into the cove, where biological decomposition resulted in the oxygen depression observed (Tetra Tech, Inc., 2001, 2002). The amount of fish-processing waste discharged varied greatly day by day during the processing season, July through September. Measured oxygen levels also varied considerably by time and location in the cove.

Solid waste from the seafood processing facility consisted mainly of fish bone, fin material, skin, and other tissues. Soft tissues in fish-processing waste are expected to degrade relatively rapidly (contributing to oxygen demand), leaving bones and hard tissue to degrade more slowly. Fish-processing waste also serves as a food resource for bottom-dwelling fish, shellfish, and other organisms.

In summer 2004 the fish processing plant was sold to Boyer Towing. The fish processing equipment was pulled out of the plant. A secondary-treatment sewage plant with capacity for approximately 250 persons continues to operate and discharge at the facility. Current uses of the facility include an industrial bunkhouse and galley for transient workers and a commercial dive shop. Other light industrial or commercial uses with no particular discharge to water might occupy the facility. Other small seafood processors have expressed interest in locating their operations at the facility.

## 5.2 Nonpoint and Natural Sources

ADEC's 2004 303(d) list identifies the primary sources of impairment as industrial point sources. It is unlikely that nonpoint or natural sources contribute significantly to the wood residues and dissolved oxygen conditions in Ward Cove.

The nonpoint source load to Ward Cove considered in the evaluation of the dissolved oxygen TMDL is the flow that enters Ward Cove through Ward Creek. Ward Creek is the primary discharge-carrying flow from the watershed surrounding Ward Cove. The load is based on flows calculated from rainfall data and watershed drainage area, along with measured concentrations of the constituents of concern in Ward Creek. These loads are generally not significant relative to the former point source loads to the system. Because the loads are input with the freshwater inflow, they tend to remain within the surface waters, not influencing the conditions in the bottom waters of concern.

# 6. Analytical Approach and TMDLs

A TMDL requires a combination of technical analysis, practical understanding of important watershed and estuarine processes, and interpretation of pollutant loadings and receiving water responses to those loadings. In identifying the technical approach for developing dissolved oxygen and residues TMDLs for Ward Cove, the following core principles were identified and applied:

1. The TMDLs must be based on scientific analysis and reasonable assumptions.
2. The TMDLs must use the best available data and information.
3. Models should be applied where appropriate.
4. Methods should be clear and simple to facilitate explanation to stakeholders.

In this section, TMDLs are established for residues and dissolved oxygen. The TMDLs include discussions of the following individual TMDL elements:

- **Target.** The water quality target for a given pollutant in a TMDL is a numeric or narrative expression that serves as the goal for the TMDL, which equates to attainment of the WQS. The target also is the basis for establishing the loading capacity. Where appropriate, the target is simply the applicable numeric criterion for the pollutant. In some situations, including residues, a quantitative target might not be appropriate or available and therefore a narrative target is used to determine whether the WQS is attained.

- **Loading Capacity (LC).** The LC is the greatest amount of a pollutant that a waterbody can receive without violating the applicable WQS, as reflected by the target. The loading capacity is the pollutant quantity that is available to divide up to establish WLAs, LAs, and MOS.

- **Wasteload Allocation (WLA).** A WLA is the portion of the loading capacity allocated to an existing or future point source.

- **Load Allocation (LA).** An LA is the portion of the loading capacity allocated to an existing or future nonpoint source or background source.

- **Margin of Safety (MOS).** An MOS is the portion of the loading capacity that is set aside to account for any uncertainty or lack of knowledge concerning the relationship between LAs and WLAs and water quality. The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination.

- **Seasonal Variation.** A TMDL must consider seasonal variation in the analysis. Seasonal variation in pollutant loadings, waterbody response, or impairment conditions can affect the development and expression of the TMDL.

- **Future Sources**. A TMDL must establish allocations for both existing and future point sources and nonpoint sources of the listed pollutant.

## 6.1 Residues

This section presents target, loading capacity, LAs, WLAs, MOS, seasonal variation, and future sources for the TMDL for residues in Ward Cove.

### *Target*

The water quality target serves as the goal for the TMDL, which equates to attainment of the applicable WQS. The target also is the basis for establishing the loading capacity. Although specific targets and allocations are identified in the TMDL, the ultimate success of the TMDL is not whether these targets and allocations are met, but whether designated uses and the WQS are achieved.

Given that wood residues in Ward Cove will persist for a substantial but unknown period, it is not feasible to establish a TMDL target that is the absence of introduced wood residues or that achieves recovery to a "natural condition." The target must be directed to biological recovery that will support designated uses and achieve WQS in the waters of the cove.

The scientific studies reviewed and analysis conducted in developing this TMDL support an allowance in the TMDL for an amount of future wood waste accumulation that will not significantly impede the biological recovery process on the bottom of Ward Cove. Alaska's WQS allow the deposit of residues by establishing limits in a discharge permit.

It is important to recognize that benthic biological condition is highly variable in natural marine systems. Changes in benthic communities occur continually due to disturbances and varying natural conditions. Monitoring of the seafloor shows a patchwork of different stages of succession, often on a scale of tens of meters. In a recovering benthic situation, it is generally expected that not more than 75 percent of the affected bottom simultaneously will exhibit a mature (Stage 3) infaunal community (EVS 2001). "Stable, balanced communities" are viewed as "mature equilibrium communities of burrowing, deep-dwelling, head-down, deposit-feeding organisms, or other 'Stage 3' communities."

Because of the dynamic nature of the biological recovery process, the following TMDL target for residues is established for Ward Cove: Achievement of stable, balanced benthic communities through natural biological succession, in more than 75 percent of the area with documented accumulation of wood wastes, within 40 years. The loading capacity and WLA established below allow future bark accumulation in 25 percent of the area with documented accumulation of wood wastes at a level that will allow continued recovery of biological communities. The acceptable amount of residues loading will vary depending on the type of activity occurring, as discussed in the loading capacity section. This target also reflects the

WQS residues criteria that state that residues may not make the water unfit or unsafe for biological use.

This target parallels the Record of Decision for the Ward Cove Superfund project, which established the following remedial action objectives for surface sediments: "reduce toxicity of surface sediments" and "enhance recolonization of surface sediments to support a healthy benthic infauna community with multiple taxonomic groups" (USEPA 2000). Although the Superfund project carried out thin capping with sand over 30 acres of the 80-acre Area of Concern, the ROD specified "natural recovery" as the selected remedy where capping and mounding were not feasible.

***Loading Capacity***

The loading capacity is the greatest amount of a pollutant that a waterbody can receive without violating the applicable WQS, as reflected by the target. Most WQS apply to pollutants in the water column. If the target is a numeric criterion, the loading capacity can be calculated as the greatest pollutant load that will not cause the criterion to be exceeded, expressed as kilograms per day or another suitable daily limit. In the recovering wood waste environment of Ward Cove, the established target is largely a qualitative goal, though quantitative measures can be applied to characterize biological communities. The loading capacity is based on reasonable presumptions that should lead to attaining the target.

Because there are potential continuing and new sources of wood waste residues discharge in Ward Cove, a loading capacity that will allow future accumulation of a relatively small amount of wood waste residues on the bottom of the cove, while meeting the stated target, is established.

To ensure that recovery will proceed with no impediment in the waterbody as a whole, it is determined that future wood waste accumulation is limited to 25 percent of the area with documented present accumulation of wood waste. This area, based on log and wood waste maps developed by the Superfund sediment remediation project (Exponent 1999), is estimated at 188 acres; 25 percent of 188 acres is 47 acres available for potential future wood waste accumulation. Of the 47 acres, 46 acres are allocated to log storage areas (including ship loading and unloading areas) and 1 acre is allocated to log transfer areas (Table 6-1). As indicated, biological recovery is expected to proceed within log storage areas. The East LTF site also has documented accumulation of wood waste, measured at 1.2 acres in 2004.

The loading capacity must address two separate conditions. The first is wood waste that might accumulate on the bottom in log storage areas (including ship loading and unloading areas). The second is wood waste that might accumulate in log transfer areas , where logs might be moved from the water to land or from land to water.

**Table 6-1. Areas Included in the TMDL**

| Area | Source |
|---|---|
| 250 acres | The entire area of Ward Cove, listed as impaired on Alaska's 303(d) list |
| 188 acres | The area with documented coverage by wood residues, based on wood waste maps developed by the Superfund sediment remediation project (Exponent 1999) |
| 47 acres<br>• 46 acres for log storage areas (including ship loading and unloading areas)<br>• 1 acre for log transfer areas | 25 percent of the documented wood residues area (188 acres), used to calculate the loading capacity (LC), where future wood residues might accumulate |
| 203 acres | The area of Ward Cove with zero allocation for future wood waste accumulation |

### Loading Capacity for Log Storage Areas

Two questions are central to establishing a loading capacity for the log storage areas. First, what amount of future wood waste accumulation mixed with or on top of the sediment surface will allow establishment of stable, balanced benthic communities in the log storage areas? Second, over what portion of the impaired area of Ward Cove can this degree of wood waste accumulation occur and still allow the recovery of benthic communities to proceed?

The impacts of wood waste on marine benthic organisms and communities, as well as the process of recolonization of wood waste-containing sediments, received considerable research attention in the 1970s and 1980s. Several specific studies, both field and laboratory, were conducted, and a few reviews of the literature have been issued. The studies varied greatly as to purpose, location, method, and results, making it necessary to apply considerable interpretation to address the questions noted. Various studies are summarized in Appendix A.

A key factor in biological recovery is the accumulation of natural sediment. In Ward Cove, the Superfund assessment measured actual natural sediment accumulation at a single site as 7.8 cm in 22.3 years, or 0.35 cm per year, using isotope dating (Exponent 1999). Although sediment accumulation can be variable, depending on factors like bottom slope, currents, and distance from sediment source, the assessment indicated that this value probably is representative of the cove. The major source of settleable sediment likely is Ward Creek at the head of the cove. Ocean detritus presumably contributes to sediment accumulation, but it might decompose in varying degrees.

Accumulated sediment largely determines habitat type and biological communities where it forms benthic substrate in natural settings, and with time it should substantially influence habitat in recovering wood waste areas. Newly added wood waste will become mixed with the accumulating sediment, and will affect the nature of the habitat. Moderate amounts of wood waste in the sediment mixture do not adversely affect biological communities; excessive amounts of wood waste in the sediment mixture will alter communities to a predominance of "pollution tolerant" species.

The documented accumulation of sediment is an important part of the basis for establishing a loading capacity, and leads to a calculation of the amount of additional wood waste in the sediment mixture that will allow the target to be achieved.

Studies summarized in Appendix A indicate that sediment mixtures with wood residues content up to 50 percent by volume typically maintain diverse and abundant communities of infaunal organisms. This TMDL allows a sediment mixture that is 40 percent wood waste and 60 percent natural sediment by volume. The maximum sediment accumulation rate in this TMDL, including wood waste and natural sediment, is 0.58 cm per year. Sixty percent (60%) of the total sediment accumulation is due to natural sedimentation of 0.35 cm/year. Forty percent (40%) of the total sediment accumulation is future wood waste accumulation of 0.23 cm per year (40% of 0.58 cm per year = 0.23 cm per year). The wood waste accumulation rate at 0.23 cm per year is less than 0.1 inch per year, and amounts to 0.45 inch in 5 years.

The calculation of 40 percent wood waste actually must be based on the known value of the natural sediment rate, 0.35 cm per year, and can be done as follows, where "W" represents the wood waste rate.

$$\text{Wood waste} = 0.4\ (\text{Wood waste} + \text{natural sediment})$$

$$W = 0.4\ (W + 0.35\ \text{cm/yr})$$

$$W = 0.23\ \text{cm/yr}$$

The impact of this thickness of wood waste alone also can be considered. One study (McGreer et al. 1985) examined colonizing infauna in wood waste at thicknesses of 1, 5, and 15 cm and found that the greatest diversity and abundance of infauna occurred at 5 cm; the assemblage at 1 cm was similar to the assemblage in the reference sediment with no wood waste. On the basis of wood waste thickness, studies indicate that 1.15-cm wood waste accumulation in 5 years would not be expected to significantly alter the natural biological community or impede the development of stable, balanced benthic communities.

Furthermore, studies generally show that when wood waste (e.g., bark) establishes continuous (100 percent) coverage of the bottom, impacts become more pronounced (see Appendix A). Coverage of 100 percent means that at a given sample point the bottom is fully covered by bark, with little or no bottom visible through the bark pattern. Coverage of 50 percent at a sample point, for example, means that the pattern of bark is scattered or checkered, being approximately half bark and half visible bottom surface. Analysis of 2004 dive surveys at nine Sealaska Timber Corporation log transfer facilities in Alaska indicates that the thickness of bark that causes 100 percent coverage varies from less than 1 inch to 4 inches or more. At a 1-inch (2.5-cm) bark thickness, coverage of the bottom is 100 percent only 30 percent of the time. It appears that 1 centimeter of bark thickness represents approximately 50 percent coverage (Sturdevant 2006).

As above, this level of coverage should not significantly impede the development of benthic communities.

The loading capacity for the 46 acres of potential log storage areas (including ship loading and unloading areas) in Ward Cove is based on future wood waste accumulation at the rate of 0.23 cm per year, yielding a volume percentage of wood waste in the total sediment mixture of 40 percent. The loading capacity for log storage areas for this accumulation, expressed as a daily limit over 46 acres, is derived as follows.

$$46 \text{ acres x } 4047 \text{ m}^2\text{/acre x } 0.23 \text{ cm/year x } 0.01 \text{ m/cm / } 365 \text{ days/year} = 1.2 \text{ m}^3\text{/day}$$

The loading capacity for future wood waste accumulation in log storage areas (including ship loading and unloading areas) in Ward Cove is determined to be 1.2 $m^3$/day, over an area of 46 acres. Based on this loading capacity, the WLA for log storage areas (including ship loading and unloading areas) described below is established on a per-acre basis.

It is important to recognize that a loading capacity does not mean that bark discharge from log storage is expected to accumulate at a uniform level. The loading capacity is a volumetric load limit. Because no specific log storage area or activity has been established, the actual thickness and distribution of bark accumulation are not known. Because of uneven distribution, bark accumulation likely will be thinner in some portions of the area and thicker in other portions. The pattern of bark accumulation will reflect the volume of logs stored, the pattern of log storage, and currents that move bark in the water and on the bottom.

### Loading Capacity for Log Transfer Areas

Log transfer in Ward Cove might occur in the future to move logs from water to land or from land to water. Log transfer to land took place historically at various locations to feed the pulp mill, sawmill, and veneer mill, and could be revived to serve the veneer mill or another facility. The existing device for transfer of logs to land is the “log lift” at the head of the cove, a large mechanical tray on vertical rails that drops into the water and lifts a log bundle up out of the water and onto the deck at ground level. The log lift was constructed in the late 1980s and was used until the sawmill and veneer mill closed in 2001.

Log transfer to water took place at the East LTF south of Ward Creek periodically from 1977 to 2000. A small ramp with a continuous-chain let-down device, constructed in 1998, is still in place at the site. Logs transferred to water were both sent to the pulp mill and loaded onto ships for export; logs transferred in the future similarly could go to various destinations.

Log transfer in the future might use the existing transfer devices and locations or other transfer devices and locations. However, only one LTF should be established for transfer of logs from water to land, and only one LTF should be established for transfer of logs from land to water.

A transfer area is viewed as an "impact zone." Within a transfer area, attainment of the target is not expected while log transfer continues to take place. However, given the limited size of the transfer areas—less than 0.05 percent of Ward Cove—it is determined that biological recovery will proceed without significant impediment in the waterbody as a whole.

In this TMDL, the loading capacity sets the maximum total size of log transfer areas at 1.0 acre. The total one-acre area and the total loading capacity may be split in proportion between two LTFs as described. For the total log transfer area, the loading capacity is set to ensure that the volume of bark accumulation does not exceed an average of 10 cm thickness over 1 acre in a five year period and does not exceed 30 cm thickness at any point. Removal of wood wastes is required if these limits are exceeded; bark accumulation then may continue until the limits again are exceeded.

Ten centimeters of bark accumulation have been recognized as an allowable limit in zones of deposit authorized in NPDES permits for bark discharge at log transfer facilities since 1985, including the current Log Transfer Facility (LTF) General Permits. This thickness is based on the Alaska Timber Task Force's guidelines (Alaska Timber Task Force, 1985).

The loading capacity for future wood waste in the total of one acre of log transfer areas in Ward Cove, allowing an average of 10 cm thickness of bark to accumulate in one acre in a five-year period, expressed as a daily limit, is derived as follows.

$$1 \text{ acre} \times 4{,}047 \text{ m}^2/\text{acre} \times 10 \text{ cm}/5 \text{ years} \times 0.01 \text{ m/cm} = 405 \text{ m}^3/5 \text{ years}$$

$$405 \text{ m}^3/5 \text{ years} \div (5 \text{ years} \times 365 \text{ days/year})/5\text{years} = 0.22 \text{ m}^3/\text{day}$$

<u>The loading capacity for future wood waste accumulation in log transfer areas in Ward Cove is determined to be 0.22 $m^3$/day, over an area of one acre, which may be applied over a five-year permit period</u>.

### ***Margin of Safety***

The MOS is the portion of the loading capacity that is set aside to account for any uncertainty or lack of knowledge concerning the relationship between LAs and WLAs and water quality. The MOS can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination.

An explicit 10 percent MOS is established for this TMDL to account for uncertainty in the estimates and assumptions of the TMDL, including the following:

- Present area of wood waste accumulation
- Amount and pattern of future wood waste accumulation
- Accuracy of monitoring future wood waste discharge and accumulation
- Rate of accumulation of natural sediments

- Relationship between continued wood waste accumulation and biological recovery
- Potential transfer area impacts outside 1 acre

### Load Allocation

An LA is the portion of the loading capacity allocated to an existing or future nonpoint source or background source.

No discharge of substances contributing to the residues impairment in Ward Cove is expected from nonpoint sources, except incidental natural sources. In both log storage areas and log transfer areas, the LA for nonpoint source wood residues is zero $m^3$/acre/day.

### Wasteload Allocations

A WLA is the portion of the loading capacity allocated to an existing or future point source.

Possible future point source discharges of wood waste in Ward Cove are the reason for establishing WLAs for residues in this TMDL. As with loading capacity, two WLAs are established, one for log storage areas (including ship loading and unloading areas) and one for log transfer areas. It should be noted that the time of commencement and the duration of possible log storage and transfer activities in Ward Cove are not known. No log storage or transfer facilities may be sited over the capped areas addressed by the Superfund Record of Decision. No accumulation of solid seafood waste may be permitted in Ward Cove.

#### Wasteload Allocation for Log Storage Areas (including ship loading and unloading areas)

Because the LA is set at zero and a 10 percent MOS is included in this TMDL, 90 percent of the loading capacity (LC) for log storage areas is available to the WLA. The WLA for log storage is set on a per acre basis because the actual log storage areas that may be authorized in future discharge permits are not known and might be only a portion of the loading capacity's 46 acres. Based on the loading capacity of 1.2 $m^3$/day and a 10 percent MOS, the WLA for future wood waste accumulation in the log storage areas (including ship loading and unloading areas), expressed as a daily limit per acre, is derived as follows.

$$(LC – LA – 10\% \text{ MOS}) / 46 \text{ acres} = WLA$$

$$(1.2 \text{ m}^3\text{/day} – 0 – 0.12 \text{ m}^3\text{/day}) / 46 \text{ acres} = 0.023 \text{ m}^3\text{/acre/day}$$

The WLA for future wood waste accumulation in log storage areas (including ship loading and unloading areas) in Ward Cove is determined to be 0.023 $m^3$/acre/day, which may be applied over a maximum of 46 acres, over a five-year permit period.

### Wasteload Allocation for Log Transfer Areas

As indicated, the log transfer area is an impact zone in which attainment of the target is not expected while log transfer continues to take place; recovery will proceed in the waterbody as a whole. As with log storage areas, because the LA is set at zero and a 10 percent MOS is included in this TMDL, 90 percent of the loading capacity for the log transfer area is available to the WLA. Based on the loading capacity of 0.22 $m^3$/day and a 10 percent MOS, the WLA for future wood waste accumulation in the log transfer area, expressed as a daily limit over the one-acre log transfer area, is derived as follows.

(LC – LA – 10% MOS) / 1 acre = WLA

(0.22 $m^3$/day – 0 – 0.022 $m^3$/day) / 1 acre = 0.20 $m^3$/acre/day

The WLA for future wood waste accumulation in log transfer areas in Ward Cove is determined to be 0.20 $m^3$/acre/day, which may be applied over a five-year permit period. Additional wood waste thickness in a log transfer area may not exceed 30 cm at any point. If wood waste accumulation in a total of one-acre of log transfer areas exceeds, at any time, 365 $m^3$ (405 $m^3$ less 10 percent MOS; see LC for log transfer area) or 30 cm at any point, as determined by on-site monitoring, all continuous coverage by wood waste within that log transfer area must be removed. Wood waste accumulation in accordance with the WLA then may continue. Log transfer areas are limited to one area for log transfer from water to land and one area for log transfer from land to water. The total area of the two log transfer areas may not exceed 1 acre. The total area and the WLA may be split between the two log transfer areas in proportion. Storage of logs transferred to water should take place in a log storage area, not in a log transfer area, except for the time necessary to collect logs into bag booms for transport to a log storage area or ship-loading site.

### *TMDL Allocations Summary*

Table 6-2 summarizes the LCs, WLAs, LAs, and MOSs for the residues TMDL.

**Table 6-2. TMDL Allocation Summary for Residues**

| Area | LC | WLA | LA | MOS[a] |
|---|---|---|---|---|
| Log Storage Areas | 1.2 $m^3$/day/46 acres | 0.023 $m^3$/acre/day | 0 $m^3$/acre/day | 0.12 $m^3$/acre/day |
| Log Transfer Areas | 0.22 $m^3$/day/1 acre | 0.20 $m^3$/acre/day | 0 $m^3$/acre/day | 0.022 $m^3$/acre/day |

[a] The MOS is set at 10 percent of the total loading capacity, leaving the remainder of the capacity for the WLA.

It is important to note that the WLAs might need to be modified if benthic recovery is found to be significantly faster or slower than anticipated. Periodic monitoring of the benthic community is key to determining whether the TMDL is achieved. It is recommended that the TMDL be assessed after a period of 10 years as a basis to modify existing discharge permits or issue new discharge permits that are appropriate to achieve recovery of the benthic ecosystem in Ward Cove.

***Seasonal Variation and Critical Conditions***

The historical impairments to Ward Cove due to residues and the effects of future discharges of residues represented by the WLAs in this TMDL are not associated with a particular season or environmental condition. Therefore, no accommodation is made for seasonal variation or critical conditions.

***Future Sources***

Land use in the area surrounding Ward Cove is a mix of light industry, commerce, residences, and recreation along the shoreline and highway. Ketchikan Gateway Borough is working to promote the development of land surrounding Ward Cove for commercial and industrial purposes. The Borough in 2006 sold to private parties most of the land it owns around the cove to prospective developers. Possible development under consideration includes reopening the existing veneer mill, loading ships with logs for export, constructing an ethanol plant, developing a marina, constructing a ship take-down facility, constructing a ferry terminal, and porting ships. The Borough has constructed a sewage sludge separation facility on the grounds of the former pulp mill, which discharges sludge liquids through the existing sewage treatment plant.

The only apparent potentially significant sources of residues discharge to Ward Cove are log storage to supply the veneer mill or to load or unload ships, and transfer of logs to or from water. Logs could be transported to the mill by barge, with no in-water storage. Barges also could place logs in storage in water. Logs could be brought in by rafts, stored in the water in the cove, and transferred to land or ships. To store or transfer logs in water, an operator would need to obtain an NPDES individual permit for discharge of bark from EPA, certified by ADEC. The permit must be issued in conformance with the WLAs for residues contained in this TMDL.

Two discharges of wastewater to the cove presently are permitted by EPA NPDES individual permits: (1) a small sewage treatment plant with associated stormwater runoff and (2) leachate discharge from the former pulp mill landfill site. Neither source discharges wood residues. Both sources are permitted to discharge small amounts of suspended sediment, which is not considered relevant to the residues TMDL.

## 6.2 Dissolved Oxygen

This subsection presents target, loading capacity, WLA, LA, MOS, seasonal variation, and future sources for the TMDL for dissolved oxygen in Ward Cove.

***Target***

<u>The target for the dissolved oxygen TMDL is established as the WQS level of 5.0 mg/l</u>.

***Loading Capacity***

The LC for Ward Cove is established as 5.0 mg/L of dissolved oxygen; in addition, the TMDL allows no loading of oxygen-demanding substances that will cause "measurable decrease" in dissolved oxygen level below 5 mg/L from June through September. "Measurable decrease" means a decrease of 0.2 mg/L or greater. Section 4.2 presents an analysis of dissolved oxygen levels in Ward Cove.

Prior to October 2006, 5 mg/L was the applicable water quality criterion for dissolved oxygen in Ward Cove in water below the surface one-meter layer. In October 2006 modified criteria were approved by EPA. The applicable criterion below the surface one-meter layer now is 5.0 mg/L, except where natural conditions cause this value to be depressed, and a minimum of 4 mg/L. This means that natural conditions are the applicable criterion between 4.0 and 5.0 mg/L, and 4.0 mg/L is the applicable criterion if the natural condition is 4.0 mg/L or lower (see Section 3.2 concerning water quality standards). These criteria below 5.0 mg/L do not allow for measurable decrease in dissolved oxygen levels caused by introduced wastes.

Water quality monitoring conducted from 1997 through 2002 after closure of the KPC pulp mill when the Wards Cove Packing Company fish processing facility was in operation found that severe depletion of dissolved oxygen occurred in portions of the cove in deeper water in June through September. Minimum levels of dissolved oxygen regularly were found in late summer at 1.0 to 3.0 mg/L, well under 5.0 mg/L.

The WCPC facility ceased operation in 2002. Water quality monitoring in 2003 indicated dramatic recovery of oxygen levels in the summer months in the absence of the discharge of fish-processing waste. Oxygen levels in 2003 in water at depths of 30 meters and greater remained near or below the state standard of 5.0 mg/L, with a minimum of 4.07 mg/L. At mid-water depths below 10 meters, oxygen levels generally were in the range of 5.5 to 7.5 mg/L; in the upper 10 meters, oxygen levels generally were in the range of 6.5 to 8 mg/L. These findings from a single year of monitoring indicate that there is significant but limited capacity in Ward Cove in summer months above a depth of 30 meters to assimilate oxygen-demanding materials while maintaining the standard for dissolved oxygen, and that there is little or no capacity below a depth of 30 meters.

Natural oxygen levels in Ward Cove are limited by two conditions. First, water entering Ward Cove from Tongass Narrows in the summer has regularly exhibited oxygen levels in deep water below the state standard of 5 mg/L, with mean August and September values below 6.0 mg/L and minimum values around 4.0 mg/L. Second, stratification of the water in Ward Cove in the summer creates a picnocline at a depth of 10 to 30 meters. The picnocline reduces the ability to transport oxygen from surface waters to deeper waters to replace oxygen lost to respiration and decomposition.

A hydrodynamic and water quality model was constructed to evaluate the amount of oxygen depletion in the cove caused by the two discharge-related sources that were present. The technical development of the model is described in Appendix B. The model found that fish-processing waste discharged by the WCPC fish processing facility was responsible for a maximum of approximately 2.0 mg/L of oxygen depletion below the picnocline and that wood waste residues on the bottom of the cove were responsible for a maximum of 0.5 mg/L of oxygen depletion at the peak of summer stratification within approximately two meters of the bottom, diminishing to a maximum of roughly 0.25 mg/L of oxygen depletion in mid water and to negligible effect in the upper 10 meters of water.

With closure of the pulp mill and the fish processor, the only active discharge source in deeper water is the outfall from the sewage treatment facility at the former fish processor, which is located at a depth of approximately 90 feet MLLW, or 27 meters. It is assumed that current dissolved oxygen levels are largely the result of natural conditions, with a possible small influence due to historically accumulated wood residues and fish residues.

The Alaska WQS do not include the concept of "measurable decrease" for dissolved oxygen. However, the Washington Department of Ecology has established 0.2 mg/L as the "measurement quality objective" for dissolved oxygen in stream monitoring. (http://www.ecy.wa.gov/pubs/0303200.pdf). Additionally, 0.2 mg/l is the manufacturers' stated accuracy of typical field instruments used to measure dissolved oxygen in the ocean environment. Biological research studies used to establish water quality criteria are characterized by oxygen concentrations that commonly fluctuate by more than 1.0 mg/L. Even individual studies, therefore, cannot be used to infer precision greater than 0.2 mg/L as necessary or appropriate for applying the criteria (Washington Department of Ecology, 2005). The 0.2 mg/L limit for an allowable dissolved oxygen decrease is also a conservative number further supported by the *Quality Criteria for Water 1986* ("The Gold Book"; USEPA 1986). The Gold Book addresses what is a reasonable level of fluctuation. It states, "Where natural conditions alone create dissolved oxygen concentrations less than 110 percent or the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration." This provides a fluctuation level as high as 10 percent or 0.5 mg/L of the 5 mg/L standard. The 0.2 mg/L is well within what is considered a reasonable level of fluctuation. Thus, a decrease in dissolved oxygen level of 0.2 mg/L or greater is considered "measurable decrease" in this TMDL. Further, it potentially allows for a future point source discharge as long as that point source can demonstrate that its effluent would not result in a depression of dissolved oxygen level of 0.2 mg/L or greater below 5.0 mg/L.

### *Wasteload Allocation*

The WLA is established as no point source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L from June through September. "Measurable decrease" means a decrease in dissolved oxygen level of 0.2 mg/L or greater.

### *Load Allocation*

The LA is established as no nonpoint source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L from June through September. "Measurable decrease" means a decrease in dissolved oxygen level of 0.2 mg/L or greater.

Other than existing wood residues on the bottom of Ward Cove and incidental natural sources, there are no identified current or future nonpoint sources affecting dissolved oxygen levels in Ward Cove in summer months.

#### *Margin of Safety*

Because the loading capacity is set at 5 mg/L, and the WLA and LA are set not to cause measurable decrease in dissolved oxygen level below 5.0 mg/L, an MOS is implicit. The MOS traditionally accounts for the uncertainty concerning the relationship between TMDL limits and water quality. The MOS ensures that the WQS will be met regardless of uncertainties or errors in TMDL calculations and resulting wasteload and load allocations. Since loading capacity, WLA, and LA are direct measures of the waterbody response, an MOS is implicit in this TMDL.

#### *Seasonal Variation and Critical Conditions*

Seasonal variation and critical conditions for dissolved oxygen are discussed in sections 3.4 and 4.2. As indicated, summer is the critical time for low dissolved oxygen in Ward Cove because water that is low in oxygen enters the cove from Tongass Narrows and because stratification of the waterbody reduces the ability to transport oxygen from surface waters to deeper waters. The minimum dissolved oxygen levels monitored in summer 2003 below a depth of 30 meters remained near or below the state standard of 5.0 mg/L in June through September. This indicates that there may be limited capacity in the summer below 30 meters, depending on time and location, for the cove to assimilate oxygen-demanding materials while maintaining the standard for dissolved oxygen. In non-summer months, stratification is absent and levels of dissolved oxygen usually are well above the standard, as shown by monitoring from 1997 to 2002. The TMDL responds to these seasonal and critical conditions by establishing the loading capacity at the WQS level of 5.0 mg/L and by allowing no measurable decrease in dissolved oxygen below this level from June through September.

#### *Future Sources*

Land use in the area surrounding Ward Cove is a mix of light industry, commerce, residences, and recreation along the shoreline and highway. Ketchikan Gateway Borough is working to promote the development of land surrounding Ward Cove for commercial and industrial purposes. Possible development under consideration includes reopening the existing veneer mill, loading ships with logs for export, constructing an ethanol plant, developing a marina, constructing a ship takedown facility, constructing a ferry terminal, and porting ships.

It is possible that future activities might seek to discharge wastewater containing oxygen-demanding material. Certain fish processors have expressed interest in establishing operations at the former WCPC plant or elsewhere. These entities have proposed much smaller waste discharge volumes than the former cannery. Any future point source discharge of wastewater to the cove will require an NPDES individual permit issued by EPA and certified by ADEC. Any permit issued must conform with the TMDLs for residues and dissolved oxygen. Allowable discharge of oxygen-demanding material in deeper waters for June, July, August, and September likely will be considerably limited. In addition, the residues TMDL does not provide a WLA to allow the accumulation of fish-processing waste on the bottom of the cove.

Ketchikan Gateway Borough has constructed a sewage sludge separation facility on the former pulp mill site. Sludge liquids are treated and discharged through the existing sewage treatment plant. This plant discharges wastewater to Ward Cove under an NPDES individual permit issued by EPA and certified by ADEC. The permit requires that the standard for dissolved oxygen be met at the point of discharge. It is expected that the freshwater discharge will rise in the water and be contained above the picnocline in the summer. The discharge is not expected to affect levels of dissolved oxygen significantly above or below the picnocline in the summer months.

A second existing discharge is leachate from the former pulp mill landfill site, also under an NPDES individual permit issued by EPA and certified by ADEC. The recently-constructed outfall is near the mouth of the cove on the north shore. The freshwater discharge is not expected to affect levels of dissolved oxygen significantly above or below the picnocline in the summer months. A third existing discharge is the treated sewage outfall from the former fish processing facility, now a commercial site.

The existing log, pulp, and bark residues will remain on the bottom of the cove and are expected to decompose slowly over time. Computer modeling estimated that the oxygen demand from decomposing wood waste resulted in a maximum depression of the dissolved oxygen level of 0.5 mg/L near the bottom of the cove at peak stratification periods (August and September), but typically is much less. The degree of dissolved oxygen depression that will occur because of wood wastes as sediment deposition and biological recovery proceed is not known.

# 7. Monitoring

This section presents information on planned and recommended water quality monitoring associated with the TMDLs for residues and dissolved oxygen in Ward Cove. EPA encourages developing TMDLs using available information and data with the expectation that a commitment to additional monitoring will accompany the TMDL (USEPA 1991). Past monitoring activities in Ward Cove are outlined in the water quality analysis section of the TMDLs (and in Exponent 1999).

## 7.1 Residues

It is expected that monitoring of residues will be required under any NPDES discharge permit issued by EPA and DEC for log storage and transfer (except ship loading and unloading). Such a permit likely would require monitoring of bark discharge and accumulation in log storage and transfer areas, as well as limited biological observations.

The Superfund sediment remediation project will monitor sand-capped and natural-recovery areas every three years to track progress toward Superfund clean-up goals. The monitoring program will evaluate sediment chemistry, sediment toxicity, and benthic macroinvertebrate communities. The first monitoring exercise was conducted in July 2004. Results, discussed in subsection 4.1, indicate that sand-capped areas and one shallow natural-recovery area have achieved biological recovery, and that natural recovery (non-capped) areas are in varying degrees of biological recovery. This monitoring is important to the residues TMDL because it documents the degree of biological recovery in the sediments of Ward Cove.

EPA and ADEC support appropriate additional monitoring of wood residues to determine progress toward biological recovery in Ward Cove.

## 7.2 Dissolved Oxygen

No monitoring of dissolved oxygen in Ward Cove is taking place or currently planned. The NPDES permit held by the Ketchikan Pulp Company and Gateway Forest Products, which required monitoring of dissolved oxygen, expired in 2004. Current NPDES permits in Ward Cove do not require monitoring of oxygen in ambient waters.

Future NPDES permits authorizing discharge of significant amounts of oxygen-demanding materials below the picnocline in summer months likely will require monitoring of dissolved oxygen. ADEC supports such additional monitoring. If this monitoring shows that dissolved oxygen levels are meeting water quality standards, then DEC will pursue removing the impairment listing for dissolved oxygen.

# 8. Possible Future Actions

This section presents potential future actions to reduce the impairments to Ward Cove by residues and dissolved oxygen and achieve TMDL targets.

## 8.1 Controlling Accumulation of Residues

Any future operator desiring to store and transfer logs in Ward Cove will be required to obtain an NPDES individual permit from EPA, certified by ADEC, for the discharge of bark and wood waste. Any permit must be issued in conformance with the WLAs in the residues TMDL and would contain requirements for monitoring bark discharge and accumulation. No log storage or transfer facilities will be sited over the capped areas addressed by the Superfund Record of Decision. Also, no accumulation of solid seafood waste may be permitted in Ward Cove.

No actions to remove the wood waste in place on the bottom of Ward Cove are expected.

## 8.2 Superfund Clean Up Activities

The Ward Cove Sediment Remediation Project identified thin capping, dredging, and monitored natural recovery as the preferred remediation strategy for sediment toxicity (USEPA 2000). Thin capping can reduce surface sediment toxicity, enhance recolonization of surface sediments, and provide an abundant, functioning benthic community that serves as a food source for larger invertebrates and fish. This alternative is particularly suitable for the type of problem sediment in Ward Cove, which has limited toxicity and does not contain persistent, highly toxic chemicals that might bioaccumulate to levels of concern. Monitored natural recovery is a critical component of the remediation strategy for portions of the Area of Concern where thin-layer capping or other active remediation is not feasible (USEPA 2000).

Thin capping and dredging activities were completed in February 2001 (USEPA 2001). Nearly 25,000 tons of sand were placed at the Ward Cove site to cap about 27 acres of contaminated sediments and 3 other acres (USEPA 2001). In addition, about 3 acres of contaminated sediments were dredged in front of the main dock facility and 1 acre was dredged near the northeast corner of the cove. An additional 50 acres of contaminated sediments have been left to recover naturally (USEPA 2001).

Long-term monitoring of progress toward recovery from sediment toxicity will take place at 3-year intervals. The first monitoring exercise in July 2004 found that recovery had been achieved at three sand-capped sites sampled and at one natural recovery (non-capped) site (Exponent 2005). Three other natural recovery sites exhibited lesser stages of recovery.

## 8.3 Education and Outreach

Education about the Ward Cove TMDL will help the community of Ketchikan better understand requirements for water quality protection and will help foster support for stewardship of Alaska's waters.

ADEC and EPA jointly wrote and distributed TMDL project newsletters in 2002 and held a stakeholder information meeting and a public information meeting in May 2002. A project information Web site has been maintained since June 2002 (http://www.dec.state.ak.us/water/wnpspc/forestry/wardcove.htm). These activities are intended to establish an open communication process, promote community involvement and understanding of the TMDL, and obtain public input.

## 8.4 Management

The impairments to Ward Cove were caused by historical discharges of wood residues and seafood waste to the cove. In early years, these discharges were not regulated. The first EPA permit was issued to the KPC pulp mill in 1971. That permit and successive permits reduced the discharge of pulp residues but did not limit the volume of log storage or bark discharge. Log storage was not regulated until 2000, well after closure of the pulp mill, and then was not limited in volume. The WCPC fish processing facility first received an EPA discharge permit in 1974. Permits through 2002 allowed discharge of fish-processing waste to the cove. It appears that the role of fish-processing waste in causing depletion of dissolved oxygen was not recognized during the years of pulp mill operation and came to light only after 2000.

The Superfund investigations and development of the TMDLs have documented conditions in the cove for pollutants of concern and will form the basis for a new approach to management and regulation of activities that seek to discharge into Ward Cove. In particular, any discharge permits issued in the future must conform to the TMDLs. Discharge of pollutants other than the TMDL pollutants, however, is not limited by the TMDLs and will be subject to meeting the WQS under normal permitting rules. In addition, the Superfund and TMDL processes might increase awareness of nonpoint source pollutant concerns and thereby lead to better observance of management practices to reduce and avoid pollutant introduction as new development takes place in and around the cove.

## 8.5 Restoration

With the KPC pulp mill and the WCPC facility now closed, the associated pollutant discharges to Ward Cove have ceased. The waters and sediments of the cove are in a process of recovery to meet WQS. It is believed that the waters meet the standards for pollutants other than residues, sediment toxicity, and dissolved oxygen. On the basis of limited monitoring, it appears that dissolved oxygen in the waters of the cove has largely recovered to natural levels. Only a very small level of depletion possibly remains due to the continuing decomposition of wood residues and seafood residues. Despite the legacy wood waste on and in bottom sediments, recovery of healthy benthic biological communities appears well in progress and should continue to advance. It seems likely that most of Ward Cove will meet the residues TMDL target for biological recovery in the time frame specified, 40 years. Although buried wood waste likely will remain in place for a longer time, healthy biological communities in surface sediments will achieve biological recovery and support designated uses in the waters of Ward Cove.

# 9. Public Comments

The Ward Cove TMDLs for residues and dissolved oxygen were developed over a period of roughly seven years as a joint effort between EPA and ADEC. On May 30, 2002, EPA and ADEC held a public informational meeting in Ketchikan to present information on the TMDLs' process and content. On the same day, the agencies held an informational meeting with representatives of the Ketchikan Gateway Borough, the City of Ketchikan, and certain local industries. Also in 2002, the agencies distributed two newsletters with status reports on the TMDL project to a mailing list of approximately 200 persons in Ketchikan.

ADEC issued public notice of the availability of draft TMDLs for public review and comment beginning January 22, 2006 and ending March 8, 2006. The public notice appeared in the Ketchikan Daily News, on the State of Alaska public notice website, and on ADEC's website for the Ward Cove TMDLs. A copy of the public notice was mailed in January to approximately 150 persons in the Ketchikan area. A fact sheet concerning the draft TMDLs was available through the ADEC website or upon request.

ADEC held a public informational meeting concerning the draft TMDLs in Ketchikan on February 15, 2006, attended by approximately 12 persons. ADEC gave a PowerPoint presentation on the TMDL process and the content of the draft TMDLs, followed by a question-and-answer period. Copies of the draft TMDLs were sent to the Ketchikan Gateway Borough and to EPA.

Four entities submitted written public comments to ADEC. Public comments were wide ranging, varying from minor error corrections to detailed issues, and offered both support for the TMDLs and opposition to them. Appendix E contains a summary of public comments received and ADEC's responses to comments.

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# Acronyms

| | |
|---|---|
| AAC | Alaska Administrative Code |
| ADEC | Alaska Department of Environmental Conservation |
| AOC | Area of Concern |
| BOD | Biochemical oxygen demand |
| CFR | Code of Federal Regulations |
| CBOD | Carbonaceous biochemical oxygen demand |
| COD | Chemical oxygen demand |
| DO | Dissolved oxygen |
| EFDC | Environmental Fluid Dynamics Code |
| EPA | U.S. Environmental Protection Agency |
| EUTRO | Eutrophication submodel of WASP |
| gpd | Gallons per day |
| KPC | Ketchikan Pulp Company |
| LA | Load allocation |
| LTF | Log transfer facility |
| mgd | Million gallons per day |
| MLLW | Mean lower low water |
| MOS | Margin of safety |
| MSL | Mean sea level |
| NCDC | National Climatic Data Center |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |
| SOD | Sediment oxygen demand |
| STORET | Storage and Retrieval database (USEPA) |
| TMDL | Total maximum daily load |
| TOC | Total organic carbon |
| USGS | U.S. Geologic Survey |
| WASP | Water Quality Analysis Simulation Program |
| WCPC | Wards Cove Packing Company |
| WLA | Wasteload allocation |
| WQS | Water Quality Standards |
| ZOD | Zone of Deposit |

# Glossary

**Bathymetry.** Measurement of the depth of a waterbody.

**Benthic.** Refers to material, especially sediment, at the bottom of an aquatic ecosystem. It can be used to describe the organisms that live on, or in, the bottom of a waterbody.

**Biochemical oxygen demand (BOD).** The amount of oxygen per unit volume of water required to bacterially or chemically oxidize (stabilize) the oxidizable matter in water. Biochemical oxygen demand measurements are usually conducted over specific time intervals (5, 10, 20, 30 days). The term BOD generally refers to a standard 5-day BOD test. BOD = CBOD + NBOD.

**Carbonaceous biochemical oxygen demand (CBOD).** Refers to the oxygen demand associated with the first phase of the BOD reaction, the oxidation of organic carbon.

**Chemical oxygen demand (COD).** The amount of oxygen consumed by inorganic reactions that occur in sediment.

**Clean Water Act.** The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.

**Critical conditions.** The critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.

**Decomposition.** Metabolic breakdown of organic materials; the formation of by-products of decomposition releases energy and simple organic and inorganic compounds.

**Designated use.** Those uses specified in water quality standards for each waterbody or segment whether or not the uses are being attained.

**Dissolved oxygen.** The amount of oxygen dissolved in water. This term also refers to a measure of the amount of oxygen available for biochemical activity in a waterbody.

**Estuary.** Brackish-water area influenced by the tides where the mouth of a river meets the ocean.

**Evapotranspiration.** Water loss into the atmosphere by evaporation from both open water surface and soils.

**Hydrodynamic model.** Mathematical formulation used in describing fluid flow of circulation, transport, and deposition processes in receiving water.

**Load allocation.** The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished. (40 CFR 130.2(g))

**Loading capacity.** The greatest amount of loading a waterbody can receive without violating water quality standards.

**Margin of safety (MOS).** A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody (CWA §303(d)(1)(C)). The MOS can be incorporated implicitly through conservative assumptions used to develop TMDLs (generally within the calculations or models) or explicitly as a portion of the loading capacity (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).

**Mean lower low water (MLLW).** The tidal datum plane of the average of the lower of the two low waters of each day, as would be established by the National Geodetic Survey, at any place subject to tidal influence.

**National Pollutant Discharge Elimination System (NPDES).** The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.

**Nonpoint source.** Pollution that is not released through pipes but rather originates from multiple or diffuse sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.

**Oxygen demand.** Measure of the dissolved oxygen used by a system (microorganisms) in the oxidation of organic matter.

**Phytoplankton.** A group of generally unicellular microscopic plants characterized by passive drifting within the water column.

**Picnocline.** Zone of high density gradient that creates a stratification between the surface layer and deeper waters of a waterbody.

**Point source.** Discernible, confined, and discrete conveyance, including a pipe, ditch, channel, tunnel, conduit, well, container, rolling stock, or vessel or other floating craft, from which pollutants are or could be discharged.

**Residues.** Floating solids, debris, sludge, deposits, foam, scum, or any other material or substance remaining in a waterbody as a result of direct or nearby human activity, defined in the Alaska Water Quality Standards (18 AAC 70.990).

**Sediment oxygen demand (SOD).** Oxygen demand exerted by the decomposition of organic material in bottom sediments.

**Semidiurnal.** Occurring or relating to half a day; occurring approximately once every 12 hours.

**STORET.** U.S. EPA national water quality database for STOrage and RETrieval (STORET). Mainframe water quality database that includes physical, chemical, and biological data measured in waterbodies throughout the United States.

**Stratification.** Formation of water layers each with specific physical, chemical, and biological characteristics. As the density of water decreases, a stable situation develops with lighter water overlaying heavier and denser water.

**Superfund Program.** EPA program established by Congress in 1980 to locate, investigate, and clean up the worst uncontrolled or abandoned hazardous waste sites nationwide. The Superfund Program is administered by EPA in cooperation with individual states and tribal governments.

**Total maximum daily load (TMDL).** The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, and a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.

**Ultimate biochemical oxygen demand (BODu).** Long-term oxygen demand required to completely stabilize organic matter in wastewater or natural water.

**Ultimate carbonaceous oxygen demand (CODu).** Long-term oxygen demand required to completely stabilize organic carbon in wastewater or natural water.

**Viscera.** The soft internal organs of the body.

**Wasteload allocation.** The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation (40 CFR 130.2(h)).

**Water quality criteria.** Numeric or narrative criteria established in water quality standards to protect designated uses. Numeric criteria are scientifically-derived ambient concentrations developed by EPA or states for various pollutants of concern to protect uses such as human health and aquatic life. Narrative criteria are general statements that describe desired water quality goals for pollutants of concern.

**Water quality standards.** State or federal law or regulation required by the Clean Water Act consisting of a designated use for the waters of the United States, water quality criteria necessary to protect the uses of the waterbody, and an antidegradation policy and implementation procedures.

**Watershed.** A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

# APPENDICES

# Total Maximum Daily Loads (TMDLs) for Residues and Dissolved Oxygen in the Waters of Ward Cove near Ketchikan, Alaska

## REVISED FINAL

March 2006

Alaska Department of Environmental Conservation
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# Contents

## Tables



## Figures

# Appendix A: Summary of Science Studies and Management Experience Concerning Wood Waste in Sediments

## Summary of Available Literature [References at the end of this Appendix]

**Conlan and Ellis, 1979.** Infaunal communities were examined by taking grab samples on the bottom of a log-handling site on a straight, well-flushed, sand bed shoreline in British Columbia. At 16 stations, 4 to 11 m deep, 7 had no bark (sand bed) and 9 had a bark thickness from 0.8 cm to greater than 15.5 cm. The average number of species in the sand bed was 63 and in the debris areas, 45. Abundance in the debris was slightly less than that in the sand bed, but biomass was reduced by more than half. The sand bed and debris areas held many species in common, but the most abundant forms were different. The dominant sand bed organisms (suspension feeders and bivalves) were largely eliminated in bark deposits greater than 5 cm, and were greatly reduced even at 0.8 and 0.9 cm. Conversely, debris was dominated by species of low abundance in the sand bed. Diversity was reduced but remained relatively high. The sedimentation rate in the area had been estimated at 4 to 6 mm per year, but little accumulation of sediment over the bark debris was evident at an inactive log-handling site. It was observed that "the recolonization process may have started" but "a return of the infauna to the sand bed community type was not far advanced" and "cannot be expected until the debris blanket has virtually disappeared through siltation or decomposition or both." Other literature has noted that recovery in pulp mill fiber beds might occur in 5 years, while log booming grounds might take several decades to recover due to larger particulate debris.

**Ellis, 1973.** Scuba divers performed underwater studies to observe wood waste and numbers of large invertebrates at five sites in Southeast Alaska used for log dumping or raft storage, with two control sites. At four log dumps, the outstanding feature noted was the tremendous but localized accumulation of bark and wood debris. The debris eliminated plants and nearly eliminated animals from the areas. At one log-rafting area, conditions in the vicinity of the log rafts were similar to those of adjacent areas. Little or no abnormal appearance was found in the littoral plants and animals, except a marked decrease in the abundance of plants directly under rafts. Numerous epifaunal organisms were observed, including shrimp, horse crabs, sea cucumbers, hermit crabs, sea anemones, sand lance, blennies, cottids, and a few adult Dungeness crabs.

**Jackson, 1986.** At an LTF in Southeast Alaska, infauna were compared to an adjacent control area through 38 benthic samples taken using a suction dredging technique in two depth zones, 3 to 6 m and 7 to 10 m. Most of the site was covered by bark greater than 12 cm in thickness, up to 50 cm. Twenty-one samples were taken in a control area and 17 samples in the bark area. Only organisms greater than 12 mm were assessed. Bivalves and polychaetes dominated both sites but their numbers were diminished in the bark area. The results indicated that a complete covering of bark can have drastic effects on the structure of benthic communities. In extreme conditions, macroinfauna can be virtually eliminated; in less severe instances, deposit feeders replace suspension feeders. The results support other findings that low levels of pulp fiber frequently result in an increase of species numbers, but a complete fiber blanket has drastic effects on the structure and stability of benthic communities; and that molluscs and several polychaetes are virtually excluded by bark accumulations greater than 2.5 cm.  The study stated, “It should be noted that deep bark is not sterile.  Bacteria, protozoa and nematodes can thrive in sulphide-rich substrates; fungi, sea cucumbers, anemones, urchins and sea stars are often present on the surface of bark deposits.  Dominant organisms in bark areas are deposit feeders, which replace suspension feeders in bark-free areas.”

**Abundance and Biomass (Jackson 1986)**

| Average per Sample | Numbers | | Biomass (g) | |
|---|---|---|---|---|
| | **Control, shallow** | **LTF, shallow** | **Control, shallow** | **LTF, shallow** |
| Bivalves | 11.2 | 1.8 | 246.1 | 176.7 |
| Polychaetes | 17.8 | 19.9 | 10.3 | 8.8 |
| Bivalves + polychaetes | 26.6 | 21.7 | 256.4 | 185.5 |
| | **Control, deep** | **LTF, deep** | **Control, deep** | **LTF, deep** |
| Bivalves | 20.0 | 3.0 | 544.1 | 28.8 |
| Polychaetes | 48.8 | 7.4 | 28.3 | 2.2 |

**Kathman et al., 1984.**  Benthic invertebrate (infauna) colonization was observed in artificial <u>mixtures</u> of wood waste (not bark) and sediment in trays placed at an ocean depth of 75 feet for 11 weeks in August through October in British Columbia.  The wood waste content was 0, 20, 50, or 100 percent.  Compared to no wood waste, mean diversity was increased 60 percent with 20 percent wood waste and increased slightly with 50 percent wood waste.  Abundance was doubled at 20 percent, and similar at 50 percent.  The dominant taxa were bivalves and polychaetes in all three substrates; significant numbers of teredo worms were added at 20 percent and 50 percent.  Significant species shift became evident at 50 percent wood waste.  Diversity decreased markedly and abundance increased considerably at 100 percent wood waste, indicating dominance by fewer wood waste-adapted species, notably polychaetes and teredo worms.  The researchers concluded that wood waste up to 1 cm thickness does not adversely affect the recruitment of macrobenthos compared to natural sediments, and that the upper limit of beneficial mixtures of wood waste and sediment lies between 0 percent and 50 percent.

**Taxa and Abundance by Substrate Wood Percent (Kathman et al. 1984)**

| | **0%** | **20%** | **50%** | **100%** |
|---|---|---|---|---|
| # Taxa | 39 | 63 | 33 | 18 |
| Mean Abundance | 48 | 79 | 53 | 85 |

**McGreer et al., 1985.**  This study was a companion to Kathman et al. (1984) and used a similar method.  Sediment trays with surface wood waste <u>thicknesses</u> at 0, 1, 5, and 15 cm were placed at 25 meters for 9 weeks in June through August.  The biological community at 1 cm was found to be similar to the reference, and the conclusion was made that up to 1 cm of wood waste does not adversely affect recruitment of organisms.  (Wood waste thicknesses between 1 and 5 cm were not tested, and peaks and trends therefore are not known.)  However, peak abundance and diversity of organisms occurred at 5 cm wood waste. Numbers of taxa were slightly less than the reference in all wood waste treatments. Abundance was significantly increased in wood waste treatments. Although dominant taxa were the same in all treatments, distinct shifts in species took place in the wood waste treatments. Teredo worms were absent, perhaps due to season. The researchers concluded that there is increased impact with increased wood waste thickness.

**Taxa and Abundance by Substrate Wood Thickness (McGreer et al. 1984)**

| | Reference | 1 cm | 5 cm | 15 cm |
|---|---|---|---|---|
| Total Number of Taxa | 35 | 28 | 28 | 24 |
| Mean Abundance | 144 | 166 | 255 | 225 |

**Pease, 1974.** The impacts of log rafting and dumping on water quality and benthic ecology were investigated at five rafting sites, eight active and inactive log dump sites, and three control sites in Southeast Alaska during summer 1972. A layer of bark covered the bottom within a radius of 50–75 feet at most abandoned dumping sites and 200 feet at the two oldest active dumping sites. Leachate toxicity testing was conducted in the laboratory. The abundance of benthic epifauna was relatively unaffected by log rafting and dumping at most sites, except at the oldest site studied. Scattered bark increases the abundance of epifauna by providing a hard substrate for attached forms, such as tunicates and anemones. A decrease in epifauna was seen at the oldest and largest dumping site, Thorne Bay. The bark deposits at all dumping areas caused a decrease in infauna abundance, probably due to low dissolved oxygen, and possibly leachates. Species diversity was not affected. Benthic bark deposits had a higher BOD than surrounding sediments. BOD might lower the dissolved oxygen of overlying water slightly at sites with deep, recent bark layers; however, dissolved oxygen at all sites was above 6 ppm. Intertidal raft storage compacts bottom sediments, and the weight of log bundles crushes infauna; infauna can be nearly eliminated.

**Walker, 1974.** Wood debris at 12 to 40 percent by volume showed no decline in the diversity or density of macroinfauna.

## Additional Information to Support the TMDL Target and Loading Capacity (Section 6)

Studies have shown that small to moderate amounts of wood waste present on the sediment surface or mixed with sediments create beneficiation by providing additional habitat and food resources for biological communities. The studies are consistent in showing that <u>diversity</u> and <u>abundance</u> of infauna may decrease or increase somewhat, but both remain relatively high <u>at moderate bark levels</u>: 0.8- to10-cm bark thickness (Conlan and Ellis 1977); 12- to 50-cm bark thickness (Jackson 1986); 20 to 50 percent bark mixture by volume (Kathman 1984); and 1-to 5-cm bark thickness (McGreer et al. 1985; Pease 1974).

However, substantial shifts occur in species present with increasing bark levels. The suspension feeding organisms that dominate clean sediments are replaced by deposit feeding organisms as the level of wood waste increases, beginning at bark levels of less than 1-cm thickness and progressing to substantial replacement by 2.5 cm. At wood waste levels up to 50 percent by volume or 5-cm thick, diverse communities with multiple taxonomic groups tend to remain in place. At greater wood waste levels, diversity is reduced and deposit feeders become dominant; total abundance of organisms tends to be higher, but biomass might be decreased. Species composition inherently becomes adapted to the wood waste habitat. In summary, wood waste communities can maintain good diversity and abundance with wood waste content of 50 percent by volume or 5-cm thickness, albeit with altered species make-up. However, variability is found both within and among studies.

Management prescriptions have been developed in Washington State based on science studies and considerable experience with wood waste management. In a report prepared for the Hylebos Wood Debris Group, a group of wood-processing facilities on the Hylebos Waterway near Tacoma, the following levels of wood waste are identified, with corresponding cleanup actions (Floyd and Snider, Inc., et al. 2000):

- High-wood-accumulation areas contain 75 percent or greater surficial wood cover and a total volatile solids (TVS) of 40 percent or greater. A TVS of 40 percent corresponds to approximately 60 percent wood by volume.
- Little-to-no-wood accumulation areas are defined as having less than 25 percent surficial wood cover and a TVS of 20 percent or less. A TVS of 20 percent corresponds to approximately 25 percent wood by volume.
- Low- to moderate-wood-accumulation areas are defined as having intermediate values or having one, but not both, parameters elevated.

An associated report set out the following prescriptions for the management of wood debris in the Hylebos Waterway based on monitoring results (Shenk and Associates, L.L.C., et al. 2000):

- *One-acre log transfer area.* In the event that wood exceeds a depth of 1 foot over at least three-quarters of the area, the area will be dredged. The dredged area will extend beyond the area as needed to capture adjacent areas with greater than 75 percent cover.
- *In-water log storage and handling areas and log holding areas for ship loading.* If wood debris accumulations exceed 75 percent coverage over at least 1 contiguous acre, dredge management units that are at least 1 acre in size will be constructed and will be designed to capture all areas with greater than 75 percent wood debris coverage and as many areas with greater than 50 percent wood debris coverage as practicable.
- *Areas where no log storage or handling takes place.* If wood debris accumulations exceed 40 percent coverage over at least 1 contiguous acre, the Wood Debris Group will conduct an evaluation to assess the cause of the effect, its potential prevention, and whether cleanup would result in sufficient net environmental benefit to justify action.

A report prepared by the U.S. Army Corps of Engineers and the Washington Department of Ecology noted, “Wood waste is commonly encountered in the aquatic environment of the Pacific Northwest, due to the prevalence of lumber, pulp, and paper industries.” (Kendall and Michelsen 1997.) The paper in part sets out the following guidelines for the management of dredged wood waste material:

- Wood debris content at 25 percent dry weight is 50 percent by volume.
- Dredged material with organic content less than 25 percent dry weight will be considered suitable for unconfined open-water disposal without further testing.
- Dredged material with organic content greater than 25 percent dry weight will be required to undergo biological testing to assess the suitability of the material for unconfined open-water disposal.
- Because of its potential to cause adverse impacts on aquatic life, wood waste must be cleaned up when it is demonstrated to be harmful.
- If wood waste is present in sufficient quantities that it may be classified as a solid waste rather than sediments, deposits may be required to be removed from the aquatic environment and disposed of in a permitted solid waste facility, even when toxicity to aquatic life is low.

As noted, dredged material with less than 25 percent dry weight wood debris content (50 percent by volume) is considered suitable for unconfined open-water disposal.

Dive surveys at Alaskan LTFs measure bark thickness and coverage at 3-foot-square sample points set at intervals along transect lines. The diver estimates percent coverage and measures bark thickness to the nearest inch; less than 1 inch is difficult to measure accurately and is recorded as "< 1 inch." However, both coverage and thickness depend considerably on the size of the bark pieces, which is quite variable. Bark pieces tend to appear in size classes at a given sample point, which might vary considerably across a site. Bark classes often observed are small fragments a fraction of an inch long, linear shreds 1 to 3 inches long, and chunks 3 to 6 inches long. Fragments and shreds are on the order of 1 to 3 millimeters thick; bark chunks are roughly 1/4 to 1/2 inch thick. Larger pieces of bark occur occasionally but are not common (Sturdevant 2005).

The size of bark pieces greatly affects the pattern of bark accumulation. Within a 3-foot-square sample point, small fragments in a uniform 1-inch thick layer likely form continuous coverage. Scattered large chunks of bark alone might provide coverage of only 25 to 50 percent, but a thickness of 2 or 3 inches, depending on the largest piece or the highest pile. A few large chunks could raise the thickness of the first example to 2 or 3 inches. What typically is seen at sample points along a monitoring transect is considerable variability in the size of bark fragments, percent coverage, and thickness (Sturdevant 2005).

It is not uncommon at LTFs to find bark intermixed with sediment in varying degrees or to find a thin layer of sediment on top of accumulated bark. The amount of visible sediment varies from site to site.

At Alaskan LTFs that transfer logs to water, the average area of continuous bark accumulation is about 0.3 acre. There is little information concerning bark accumulation at log storage areas; few have been monitored because they usually are sited in deep water. The indication, however, is that very little bark accumulation at log storage areas associated with LTFs reaches the level of continuous cover (Sturdevant 2005). At one log-rafting area investigated earlier, conditions in the vicinity of log rafts were similar to adjacent areas; little or no abnormal appearance was found in littoral plants and animals with the exception of a marked decrease in abundance of plants directly under the rafts (possibly due to shading); numerous epifaunal organisms were present (Ellis 1973).

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# Appendix B. Supporting Modeling Analysis for the Dissolved Oxygen TMDL in Ward Cove

This appendix presents detailed information on the modeling analysis to evaluate dissolved oxygen conditions in Ward Cove. The following sections discuss the models used, the model parameters and input, comparison of model results to observed data, and evaluation of the relative impacts of the oxygen-demanding substances to Ward Cove.

Numerical modeling techniques were developed to simulate the loading of organic material and nutrients, and the resulting response of dissolved oxygen within Ward Cove. For this TMDL a system of models was developed to allow the determination of the circulation and transport within Ward Cove, and the response of critical water quality parameters. The system of models includes the following:

- Environmental Fluid Dynamics Code (EFDC) – to simulate the circulation and transport of material within Ward Cove.
- Water Quality Analysis and Simulation Program (WASP) – to simulate the response of critical water quality parameters to the loads.

The following presents general descriptions of each of the models along with descriptions of the model parameterization and application.

## B.1 General Model Descriptions

The following sections provide detailed information on the hydrodynamic and water quality models used in the evaluation of dissolved oxygen conditions in Ward Cove.

### *Hydrodynamic Model (EFDC)*

EFDC is a hydrodynamic modeling package for simulating three-dimensional flow and transport in surface water systems including: rivers, lakes, estuaries, reservoirs, wetlands and near shore to shelf scale coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications and is public domain software.

The physics of the EFDC model, and many aspects of the computational scheme, are equivalent to the widely used Blumberg-Mellor model (Blumberg and Mellor 1987) and the U. S. Army Corps of Engineers' CH3D or Chesapeake Bay model (Johnson, et al. 1993). The EFDC model solves the three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motions for a variable density fluid. Dynamically coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved. The two turbulence parameter transport equations implement the Mellor-Yamada level 2.5 turbulence closure scheme (Mellor and Yamada 1982; Galperin et al. 1988).

The EFDC model uses a stretched or sigma vertical coordinate and Cartesian or Curvilinear, orthogonal horizontal coordinates. The numerical scheme employed in EFDC to solve the equations of motion uses second order accurate spatial finite differencing on a staggered or C grid. The model's time integration employs a second order accurate three-time level, finite difference scheme with an internal-external mode splitting procedure to separate the internal shear or baroclinic mode from the external free surface gravity wave or barotropic mode.

The external mode solution is semi-implicit, and simultaneously computes the two-dimensional surface elevation field by a preconditioned conjugate gradient procedure. The external solution is completed by the calculation of the depth average barotropic velocities using the new surface elevation field. The model's semi-implicit external solution allows large time steps that are constrained only by the stability criteria of the explicit central difference or high order upwind advection scheme (Smolarkiewicz and Margolin, 1993) used for the nonlinear accelerations. Horizontal boundary conditions for the external mode solution include options for simultaneously specifying the surface elevation only, the characteristic of an incoming wave (Bennett & McIntosh, 1982), free radiation of an outgoing wave (Bennett, 1976; Blumberg & Kantha, 1985) or the normal volumetric flux on arbitrary portions of the boundary.

The EFDC model's internal momentum equation solution, at the same time step as the external, is implicit with respect to vertical diffusion. The internal solution of the momentum equations is in terms of the vertical profile of shear stress and velocity shear, which results in the simplest and most accurate form of the baroclinic pressure gradients and eliminates the over-determined character of alternate internal mode formulations. Time splitting inherent in the three time level scheme is controlled by periodic insertion of a second order accurate two time level trapezoidal step. The EFDC model is also readily configured as a two-dimensional model in either the horizontal or vertical planes.

The EFDC model implements a second order accurate in space and time, mass conservation fractional step solution scheme for the Eulerian transport equations for salinity, temperature, suspended sediment, water quality constituents and toxic contaminants. The transport equations are temporally integrated at the same time step or twice the time step of the momentum equation solution (Smolarkiewicz and Margolin 1993). The advective step of the transport solution uses either the central difference scheme used in the Blumberg-Mellor model or a hierarchy of positive definite upwind difference schemes. The highest accuracy upwind scheme, second order accurate in space and time, is based on a flux corrected transport version of Smolarkiewicz multidimensional positive definite advection transport algorithm (Smolarkiewicz and Clark (1986) and Smolarkiewicz and Grabowski (1990) which is monotonic and minimizes numerical diffusion. The horizontal diffusion step, if required, is explicit in time, while the vertical diffusion step is implicit. Horizontal boundary conditions include time variable material inflow concentrations, upwinded outflow, and a damping relaxation specification of climatological boundary concentration. For the temperature transport equation, the National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory's atmospheric heat exchange model (Rosati and Miyakoda 1988) is implemented.

***Water Quality Model (WASP 5.1)***

The Water Quality Analysis and Simulation Program (WASP) modeling system is a generalized modeling framework for contaminant fate and transport in surface waters. Based on flexible compartment modeling, WASP can be applied in one, two, or three dimensions. WASP is designed to permit easy substitution of user written routines into the program structure. Problems that have been studied using WASP include biochemical oxygen demand, dissolved oxygen dynamics, nutrients/eutrophication, bacterial contamination, and toxic chemical movement.

The Eutrophication Model (EUTRO) combines a kinetic structure adapted from the Potomac Eutrophication Model with the WASP transport structure. This model predicts dissolved oxygen, carbonaceous biochemical oxygen demand (CBOD), phytoplankton, chlorophyll a, ammonia, nitrate, organic nitrogen, and orthophosphate in bed and overlying waters. Figure B-1 presents a schematic of the water quality kinetic processes simulated with the WASP Eutrophication model.

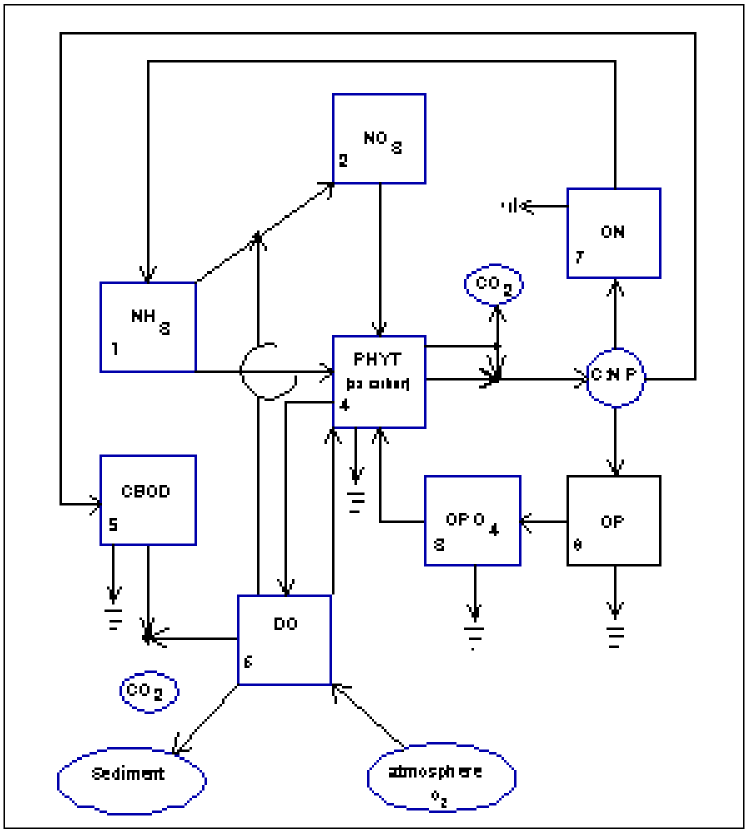


**Figure B-1. Schematic of WASP 5.1 eutrophication model.**

Several physical-chemical processes can affect the transport and interaction among the nutrients, phytoplankton, carbonaceous material, and dissolved oxygen in the aquatic environment. EUTRO can be operated by the user at various levels of complexity to simulate some or all of these variables and interactions. To simulate only BOD and dissolved oxygen, for example, the user may bypass calculations for the nitrogen, phosphorus, and phytoplankton variables. Six levels of complexity are available for application.

1. Streeter-Phelps
2. Modified Streeter-Phelps
3. Full linear dissolved oxygen balance
4. Simple eutrophication kinetics
5. Intermediate eutrophication kinetics
6. Intermediate eutrophication kinetics with benthos

EUTRO simulates the transport and transformation reactions of up to eight state variables. They can be considered as four interacting systems: phytoplankton kinetics, the phosphorus cycle, the nitrogen cycle and the dissolved oxygen balance. The general WASP mass balance equation is solved for each state variable. To this general equation, the EUTRO subroutines add specific transformation processes to customize the WASP transport equation for the eight state variables in the water column and benthos.

For the Ward Cove simulations, the WASP model was utilized in two levels of complexity. It was used in both the relatively simple full linear dissolved oxygen balance formulation to isolate the effects of BOD loadings and sediment oxygen demand (SOD) on the system, and in the full eutrophication mode with benthic interactions. Under the full eutrophication mode, the model simulated the potential for growth and respiration on the dissolved oxygen conditions in the system.

WASP is a compartment water quality model, and needs the transport and exchange between the model cells as an input; these come from the EFDC 3-dimensional simulations. The EFDC model can be externally linked to the WASP5 model. In the external linking mode, the EFDC model generates WASP5 input files describing cell geometries and connectivity as well and advective and diffusive transport fields. For estuary simulation, the transport fields may be intratidally time averaged or intertidally time averaged using the averaging procedure described by Hamrick (1994).

## B.2 Hydrodynamic Model Parameter Estimation

The EFDC hydrodynamic application for Ward Cove is a three-dimensional simulation with tidal forcing at the ocean boundary, and freshwater inflow at the upstream boundaries. The shoreline and bathymetry are represented through the use of a curvilinear grid whose boundaries are based on the digital NOAA shoreline data, and whose depths are interpolated from NOAA digital depth data.

The simulation period covers the summer of 1997 from May 1 (julian day 120) to August 30 (julian day 240). This period was chosen based upon the availability of data that was collected by Exponent for their study for Ketchikan Pulp Company (Exponent 1999). This study was mainly focused on sediment characterization, but a hydrodynamic and water quality survey on the water column was conducted as part of Phase 2 of the study in July and August 1997. The data collected were salinity, temperature and dissolved oxygen vertical profiles at thirteen stations throughout the system. Current meters with salinity and temperature ports were also placed at five locations in Ward Cove and at one location in Ward Creek.

The hydrodynamic model was forced based on astronomical tide projections for 1997 at Ward Cove. Wind and atmospheric pressure were not considered in the tidal forcing boundary conditions, but wind effects on local water currents were taken into account. The model results for water surface elevation at Ward Cove were compared to the astronomical tide at the projection site. Therefore, these data do not account for the effects of far field winds and atmospheric pressure on the water surface elevation in the Tongass Narrows. Given the dominance of the astronomical tides on water surface elevation, with tide ranges on the order of 4 m (13 feet), the components of the water surface elevation caused by meteorological forcing is assumed negligible. The model comparisons for currents used measured values at the five Ward Cove locations. In this case, the local meteorological effects were taken into account by the model because local wind forcing was input to the model. The meteorological effects on Tongass Narrows which influences the cove through the boundary conditions, was not considered within the water surface elevation forcing function.

The model accuracy in representing mass transport and stratification conditions within the system was also determined. This was done through comparison of salinity and temperature vertical simulated profiles with measured profiles, and by comparison of salinity and temperature simulated and measured time series.

The model parameterization was accomplished by adjustment of limited parameters (solely bottom friction and horizontal diffusion) within acceptable literature ranges to achieve the best fit between the model results and observed data. Based on the discussions presented above, the model parameters were determined through the following comparisons:

- Tidal wave phase and amplitude through comparison of water surface elevation inside the cove
- Time dependent tidally driven flow through comparison of interior currents
- Dispersion and stratification through comparison of interior salinity and temperature time series and vertical profiles.

### *Model Inputs*

Figure B-2 presents the model grid used to simulate the hydrodynamics in Ward Cove. The model grid covers part of Tongass Narrows in order to correctly simulate the hydrodynamics at the cove mouth. The tidal wave propagates along the Narrows from north to south generating strong currents, which in turn generate eddies at the cove mouth. Placing the model boundary at the mouth of the cove prevents the correct simulation of the hydrodynamic interaction between the Narrows and the cove by weakening these eddies which are the main flow pattern in the zone.

The grid resolution is fine to medium with an average cell length of 100 m (330 feet) in the cove, and 200 m (650 feet) in Tongass Narrows.

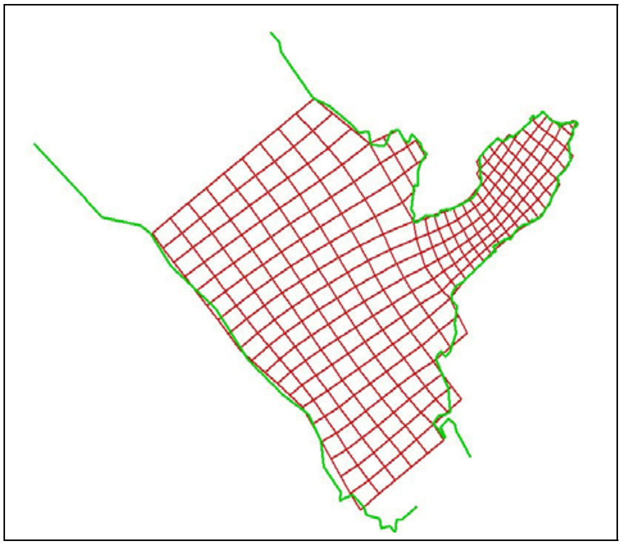

**Figure B-2. EFDC model grid of Ward Cove.**

Figure B-3 presents a graphical representation of the bathymetric conditions used in the model simulations. Based on this figure, the model is able to capture the variations in bathymetric conditions both in the cove and Tongass Narrows.

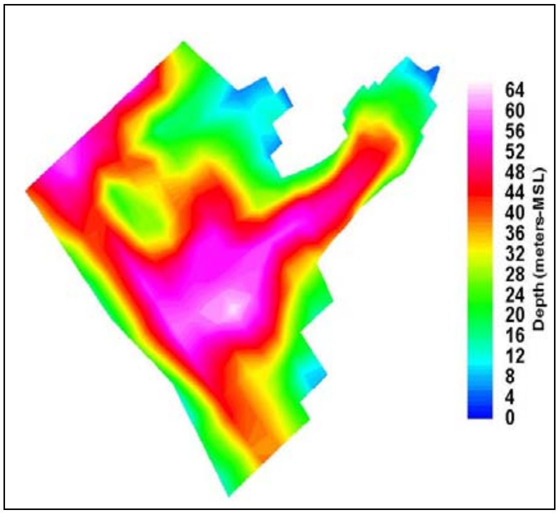


**Figure B-3. EFDC model bathymetry of Ward Cove.**

To determine the boundary conditions on the North and South boundaries of the model domain, the propagation of the tidal wave along Tongass Narrows was analyzed. Projected astronomical tides for Ketchikan, south of Ward Cove on Tongass Narrows, and Vallenar Point, north of the Cove at the confluence of Tongass Narrows and Behm Canal, were used to this effect. The tidal signals from these two locations show that the tidal wave propagates from north to south along the Narrows.

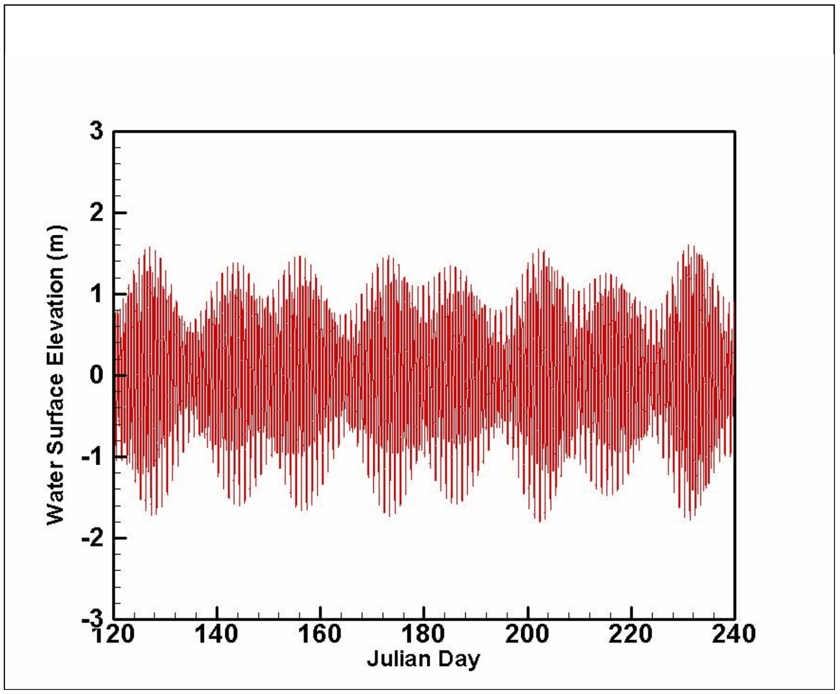


**Figure B-4. Projected astronomic tides at the north boundary with respect to mean sea level (Julian Day 120. to 240)**

To correctly simulate the tidal wave propagation and minimize boundary reflections, the Ward Cove Model was forced with a non-radiating water surface elevation boundary condition at the north boundary. On the south boundary a free-surface non-radiating boundary condition was set up. This type of boundary condition lets the tidal wave freely propagate through it. Figure B-4 presents the water surface elevation condition at the north boundary, based on projected astronomical tides at Ward Cove, used to drive the model. The water surface elevations were referenced to mean water level.

The storm freshwater inflow from Ward Creek at the head of the cove was determined using the rational method, based on the formula:

$Q = C\ i\ A$

Where:

| | | |
|---|---|---|
| C | = | runoff coefficient |
| i | = | rainfall in inches |
| A | = | drainage basin area |

The fresh water inflow for Ward Creek was computed by the rational method, using a runoff coefficient of C = 0.3, a watershed area A = 55 $km^2$, and the rain intensity measured at the National Climatic Data Center (NCDC) Ketchikan station (WBAN No. 25325) shown in Figure

B-5. The watershed area was graphically obtained from a topographic map of Revillagigedo Island.

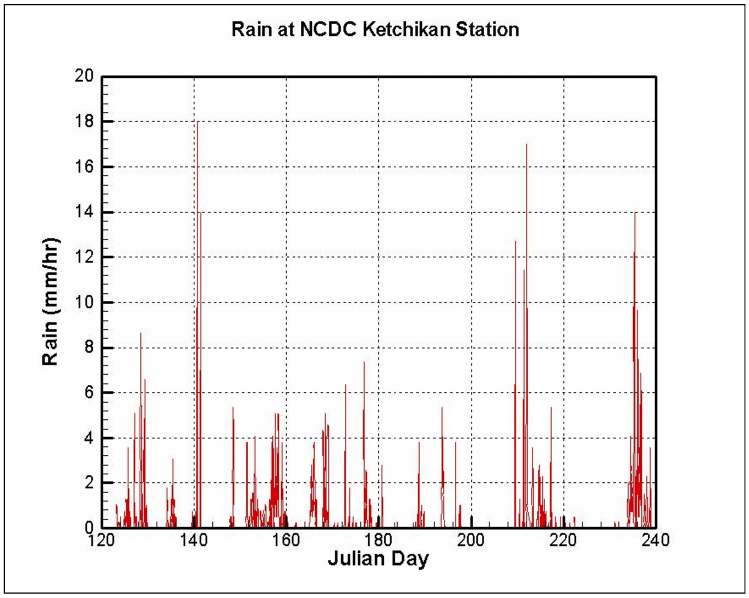


**Figure B-5. Rain registered at NCDC Ketchikan station.**

Historical flow data measured by the U.S. Geological Survey (USGS) at Perseverance was used to compute the base flow. The Perseverance gage was located at the outlet of Lake Perseverance and is within the Ward Creek watershed. The base flow obtained at Perseverance was multiplied by the ratio of the Lake Perseverance watershed to the overall watershed to define the base flow used in the model. The freshwater inflow to the model then is the summation of the base flow and the calculated rainfall driven flows. Where rainfall is zero, the flow is equivalent to the base flow. Figure B-6 presents the flow utilized in the model simulation.

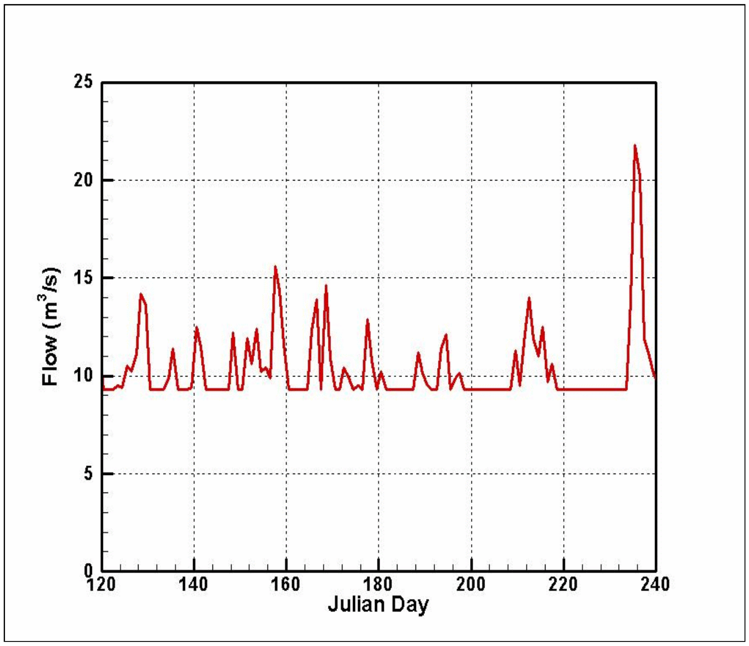


**Figure B-6. Computed freshwater inflow at Ward Creek (Julian Day 120 to 240).**

Additional meteorological data (beyond rainfall discussed above) used to force the hydrodynamic, and subsequently the water quality model, were taken from measurements made at the NCDC Ketchikan Station. These data included wind speed and direction, solar radiation, air temperature, barometric pressure and relative humidity. Appendix C presents plots and descriptions of the meteorological data.

For the hydrodynamic calibration only the wind speed and direction were utilized within the model to drive the flow and transport. Figure B-7 presents the measured wind speed and direction used in the model for the summer 1997 simulations.

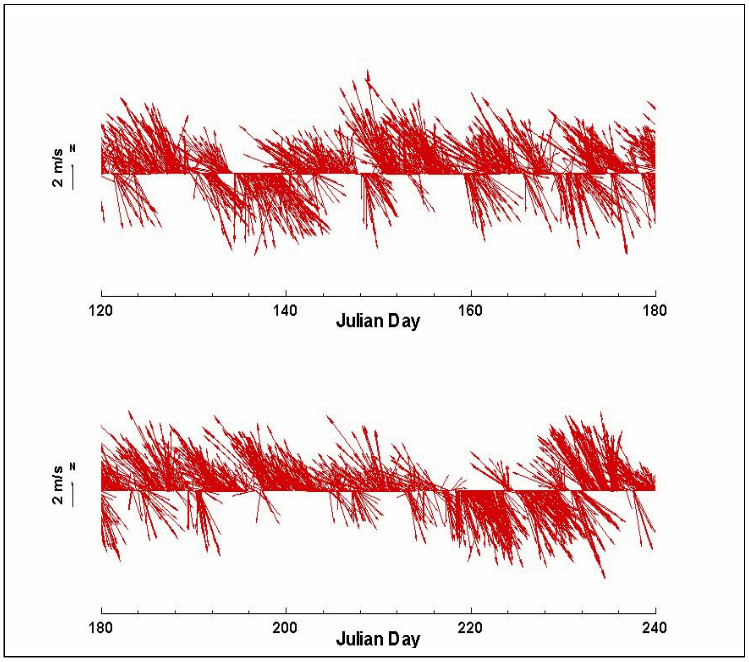


**Figure B-7. Measured wind speed and direction at Ketchikan (Julian Day 120 to 240).**

### *Model/Data Comparisons*

As described in Section B.2, the hydrodynamic model parameterization was accomplished through adjustment of the following primary mechanisms:

- Adjustment of the bottom friction to simulate velocities and advective transport.
- Adjustment of vertical and horizontal dispersion coefficients to simulate salinity and temperature transport and stratification and dispersive transport.

The following presents comparisons between the simulated and measured conditions during the summer of 1997 for the parameters discussed in Section B.2.  These simulations represent the best overall results achieved under the model parameterization discussed above, the limited available boundary and interior data, and the time frame available for model development.  The model parameterization goal was to capture the primary circulation and transport processes in the system.

The final values of the bottom roughness coefficient and the horizontal dispersion were 0.01 meters and 90 $m^2/s$ respectfully, and were uniform throughout the model.  The vertical dispersion was determined internally within the model using a turbulence closer scheme, which calculated the vertical dispersion based on local velocity shear.  A minimum vertical mixing coefficient of 0.01 $m^2/s$ was utilized to limit the allowable degree of stratification.

Figure B-8 presents the locations of the data collection stations.  The data included vertical profiles of salinity and temperature, continuous current measurements with associated salinity and temperature, and water surface elevation.  The water surface elevation station is located in the center part of the cove and was used as reference to calibrate the amplitude and phase of the boundary forcing. Current stations are concentrated inside the cove, with two stations at the cove mouth, two at the center zone and one at the head.

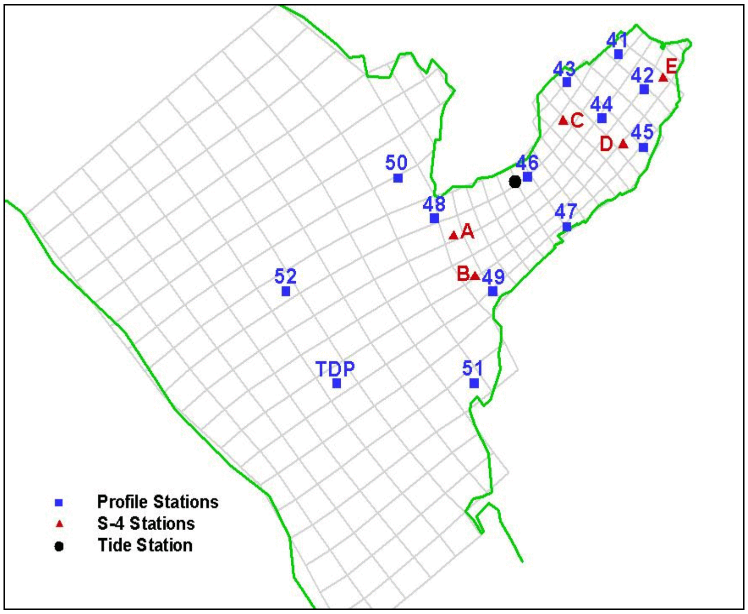


**Figure B-8. Data collection stations for 1997 in Ward Cove.**

Figure B-9 presents the comparison between the projected and simulated water surface elevations.  Due to the small area modeled, no appreciable differences in phase appear inside the domain.

Figure B-8 presents the locations of the stations where temperature and salinity profile measurements were taken periodically through the spring and summer of 1997.  In addition, the S-4 current meters had conductivity and temperature sensors, which allowed for collection of continuous salinity and temperature at stations A through E.

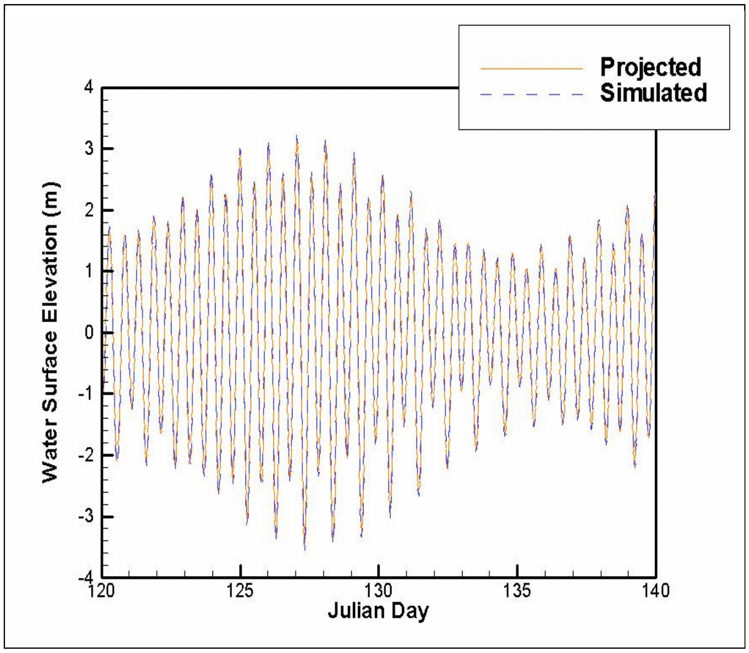


**Figure B-9. Projected and simulated water surface elevation in Ward Cove.**

Figure B-10 presents comparisons of the time series of measured salinity versus the simulations for the period from July 21 (julian day 203) to August 21 (julian day 234). This is the period of deployment of the current meters. For these simulations, the model was spun up through the simulation starting in May. This allowed the salinity conditions within the model to come to equilibrium prior to performing model comparisons. Figure B-11 presents comparisons of the time series of measured temperature over the same time frame.

Figures B-12, B-13, and B-14 present comparisons of the vertical profiles of salinity over the entire period of the model simulation (May through August, 1997) at Stations 44, 46 and 52 respectively. Figures B-15, B-16, and B-17 present comparisons of the vertical profiles of temperature for the same stations, respectively. The results show that the model does simulate the degree of stratification and the vertical distribution of salinity and temperature overall, although certain events are not captured well. Based upon the limited temporal data for the vertical distribution of salinity and temperature within the narrows, some of the errors may be a function of the limited boundary forcing data.

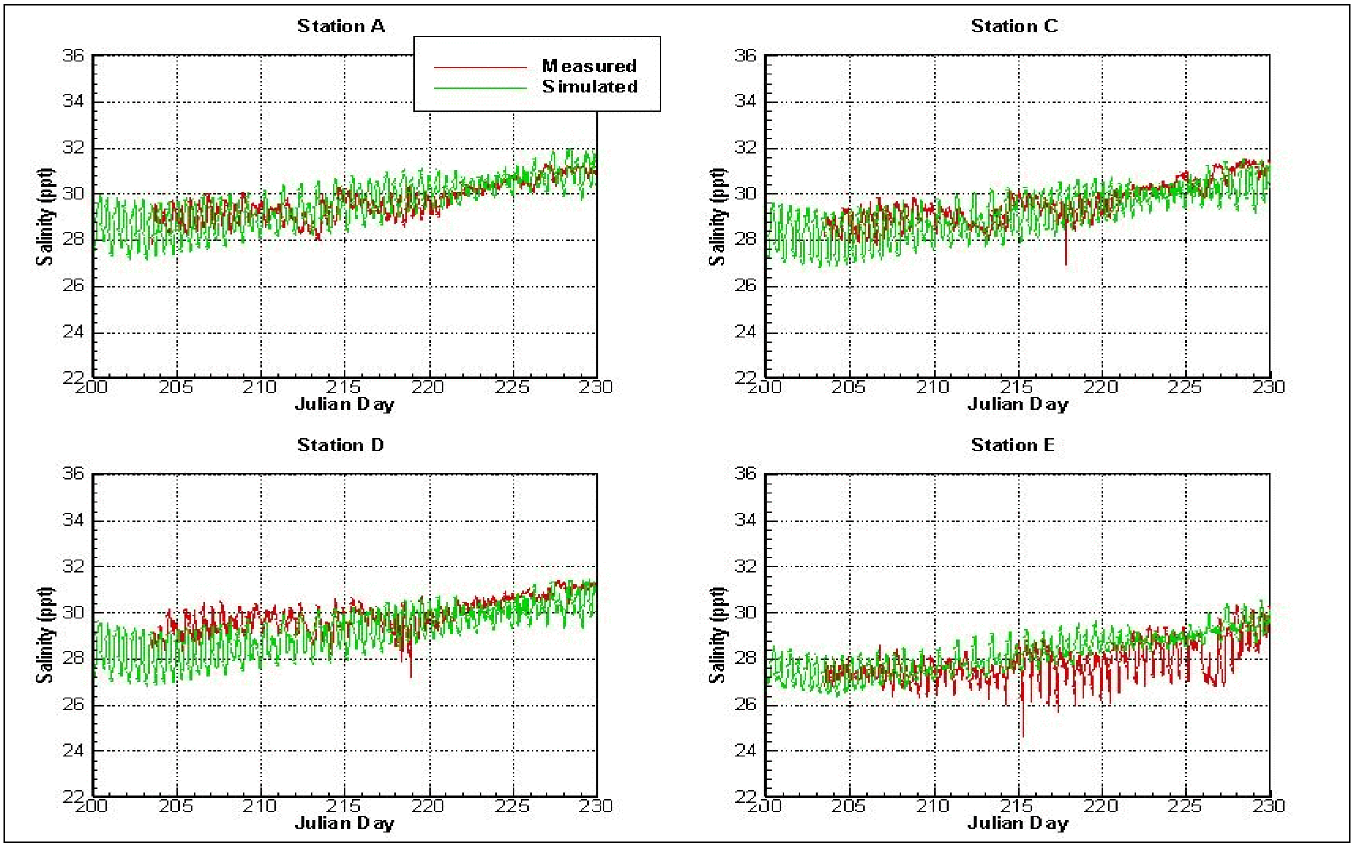


**Figure B-10. Comparisons of salinity time series at Stations A through E.**

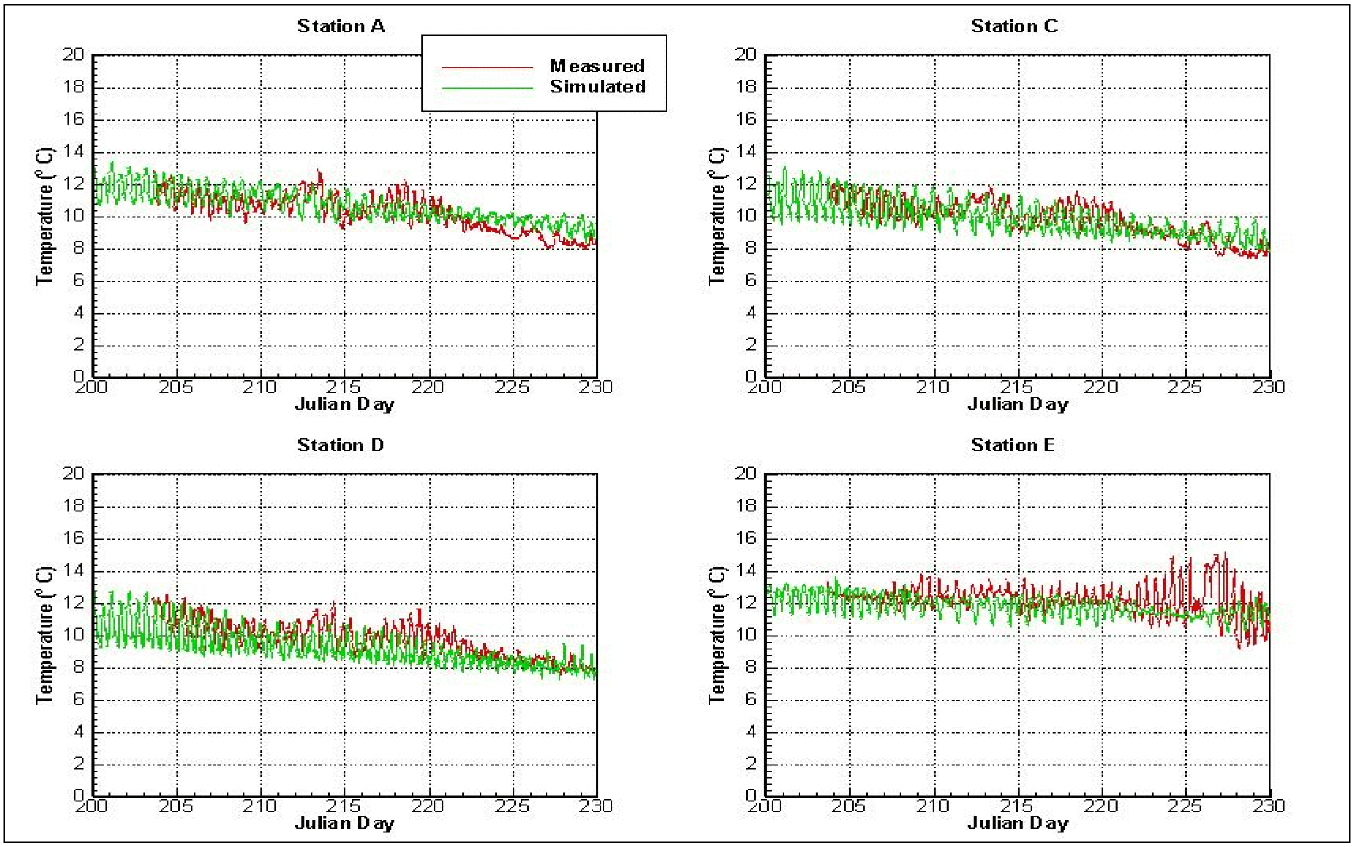


**Figure B-11. Comparisons of temperature time series at Stations A through E.**

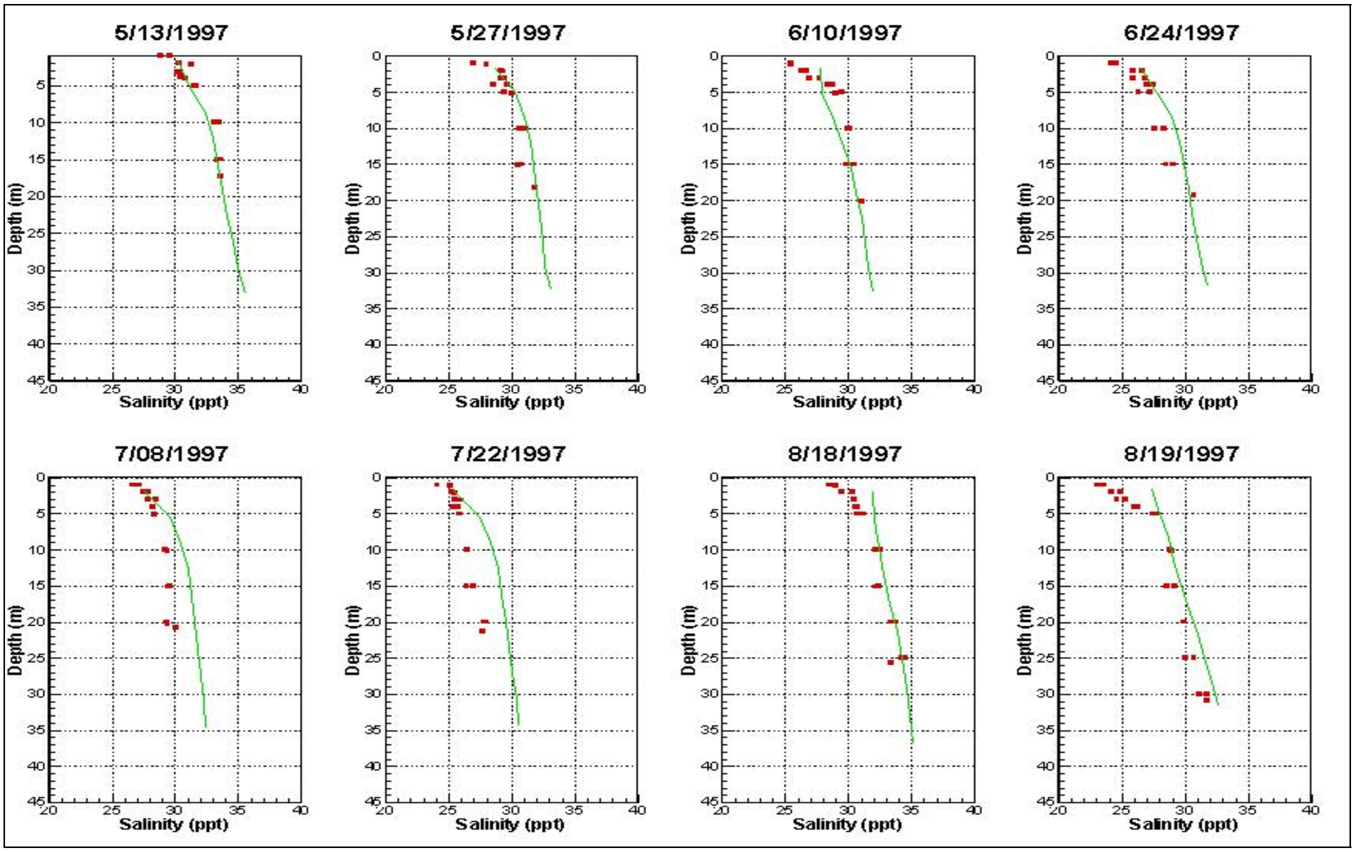


**Figure B-12. Comparisons of salinity profiles at Station 44.**

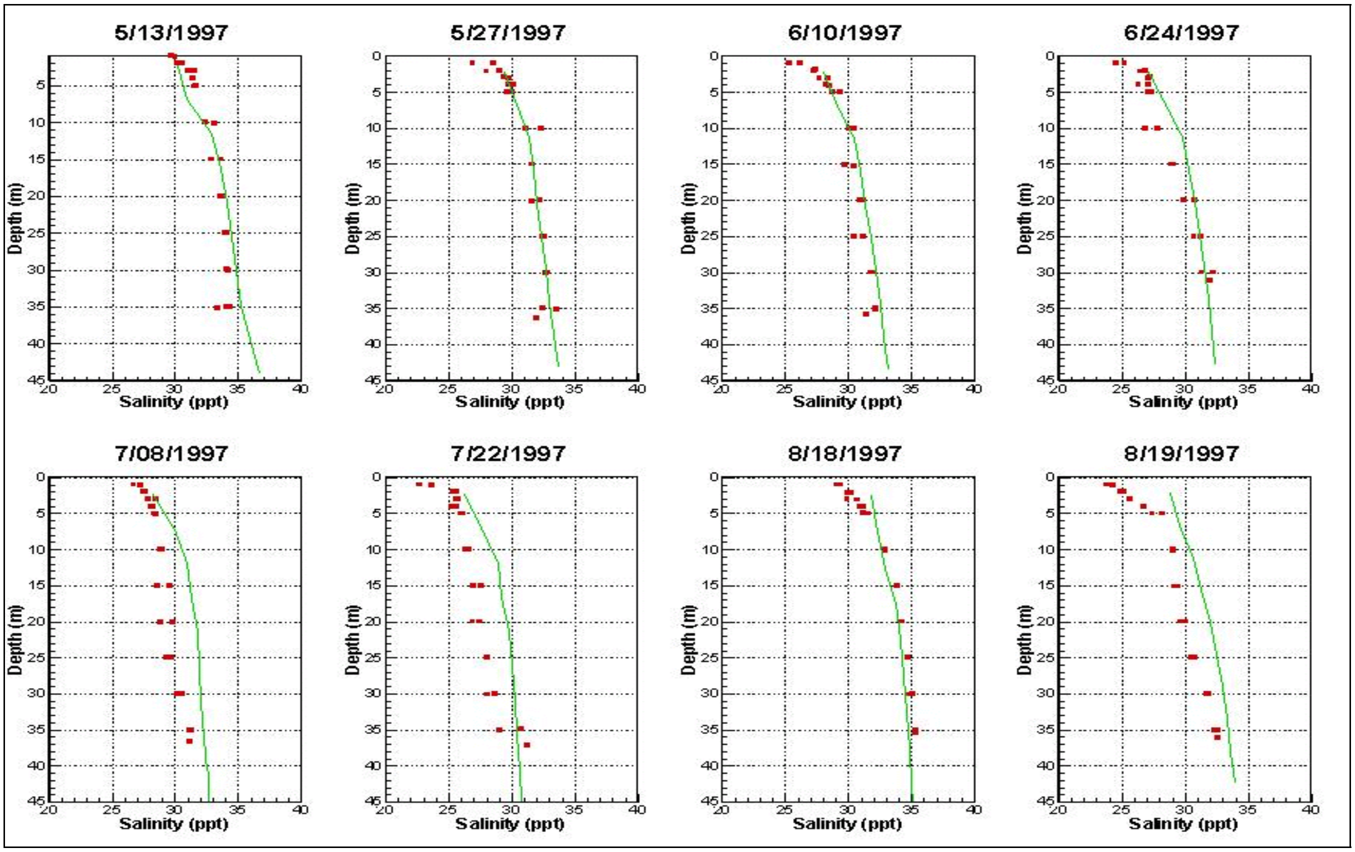


**Figure B-13. Comparisons of salinity profiles at Station 46.**

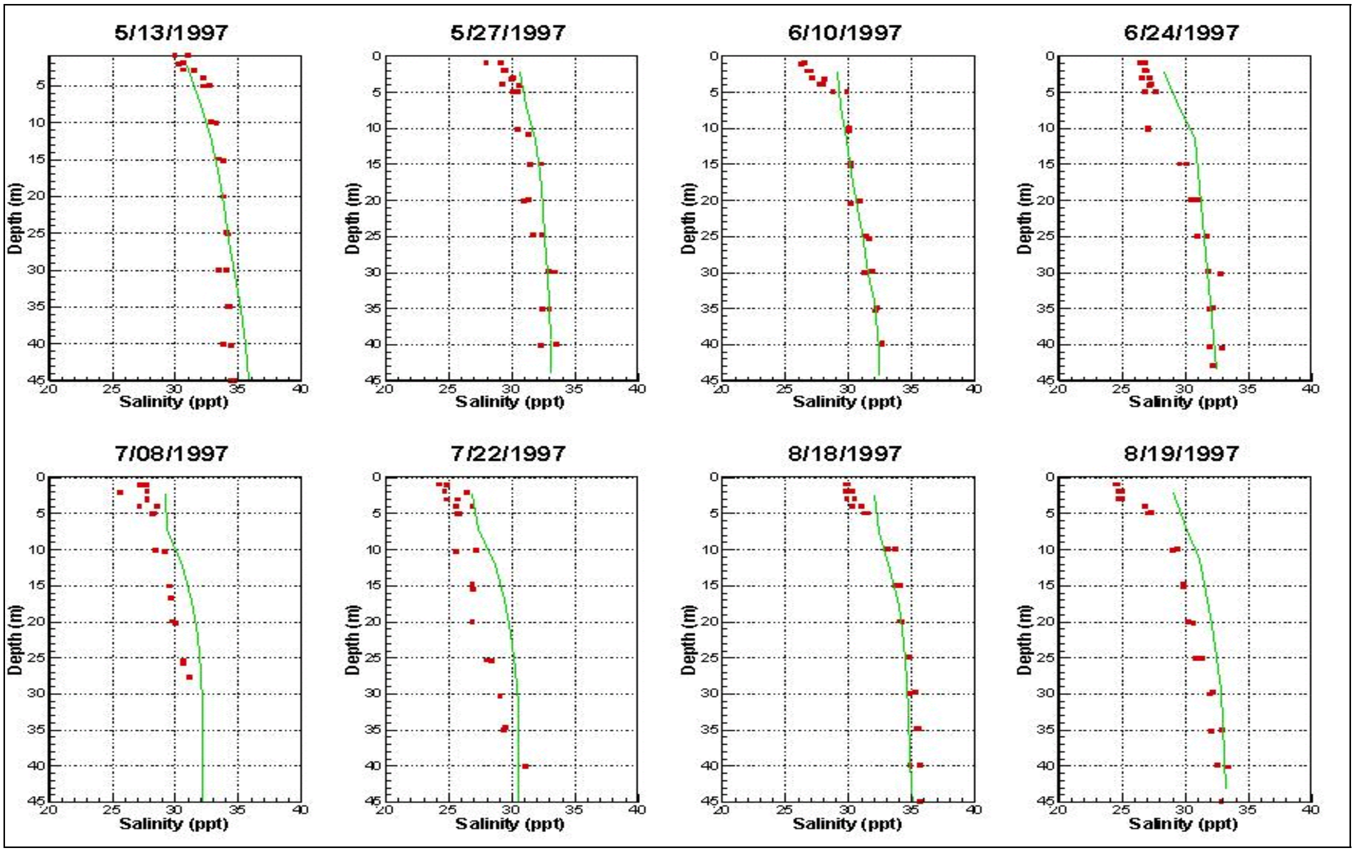


**Figure B-14. Comparisons of salinity profiles at Station 52.**

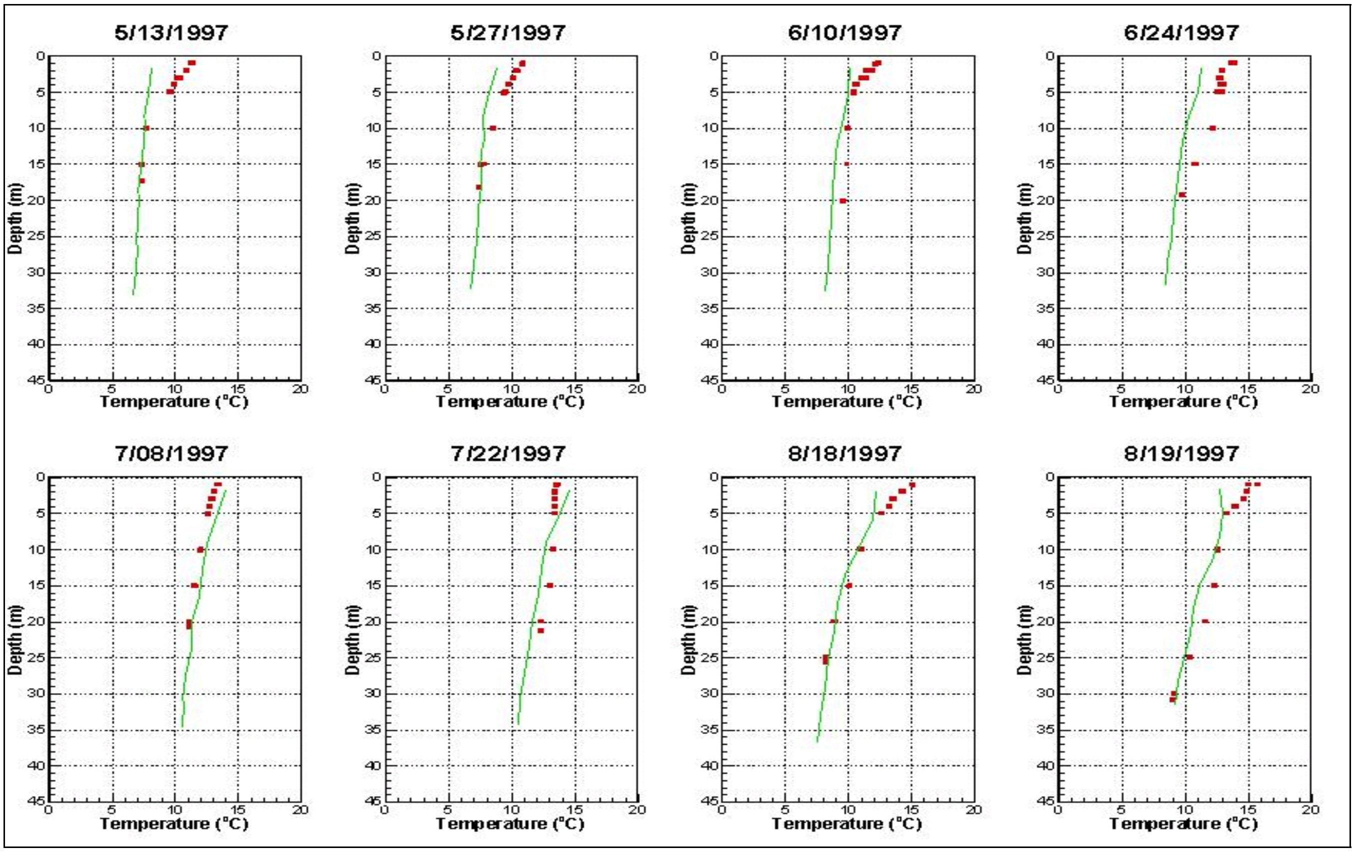


**Figure B-15. Comparisons of temperature profiles at Station 44.**

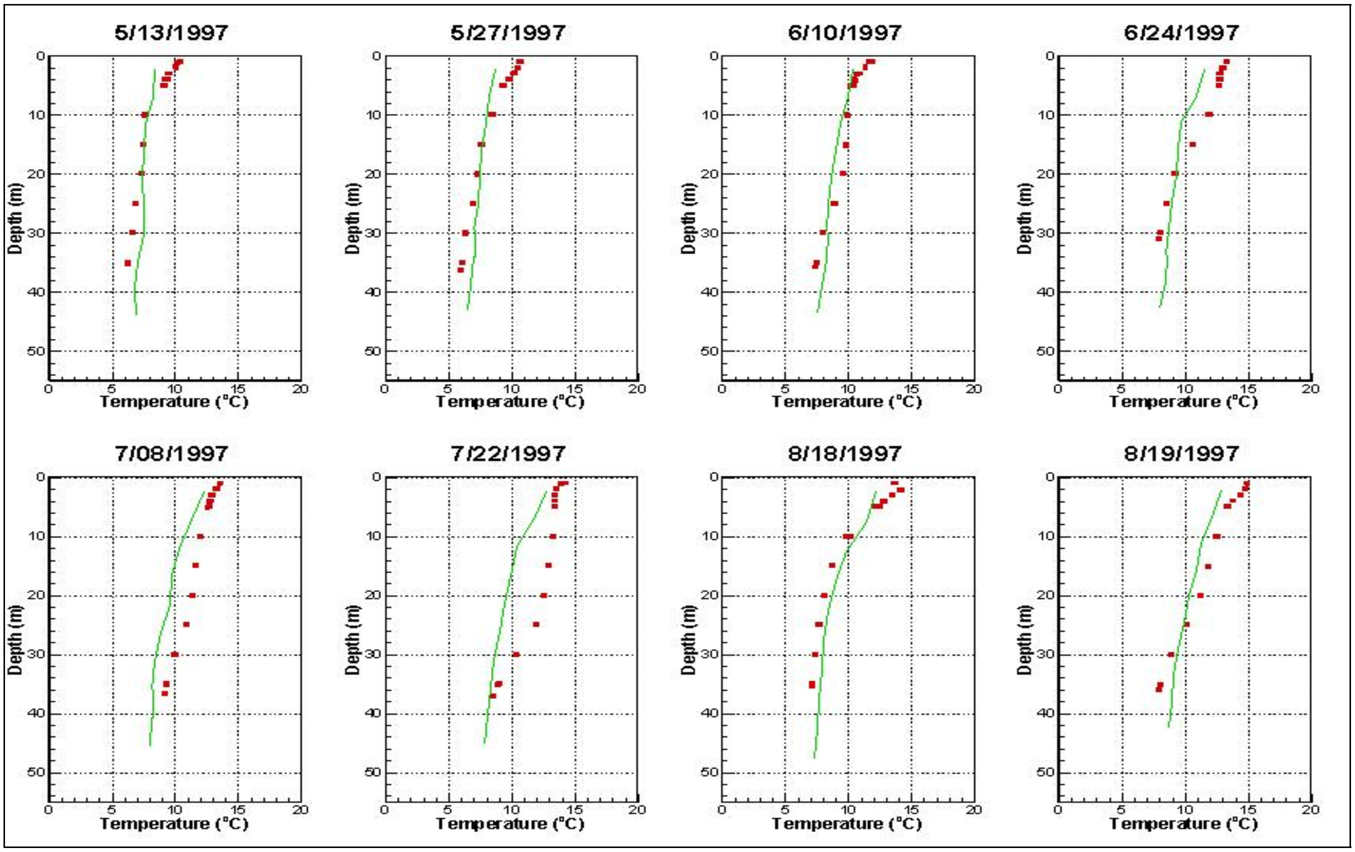


**Figure B-16. Comparisons of temperature profiles at Station 46.**

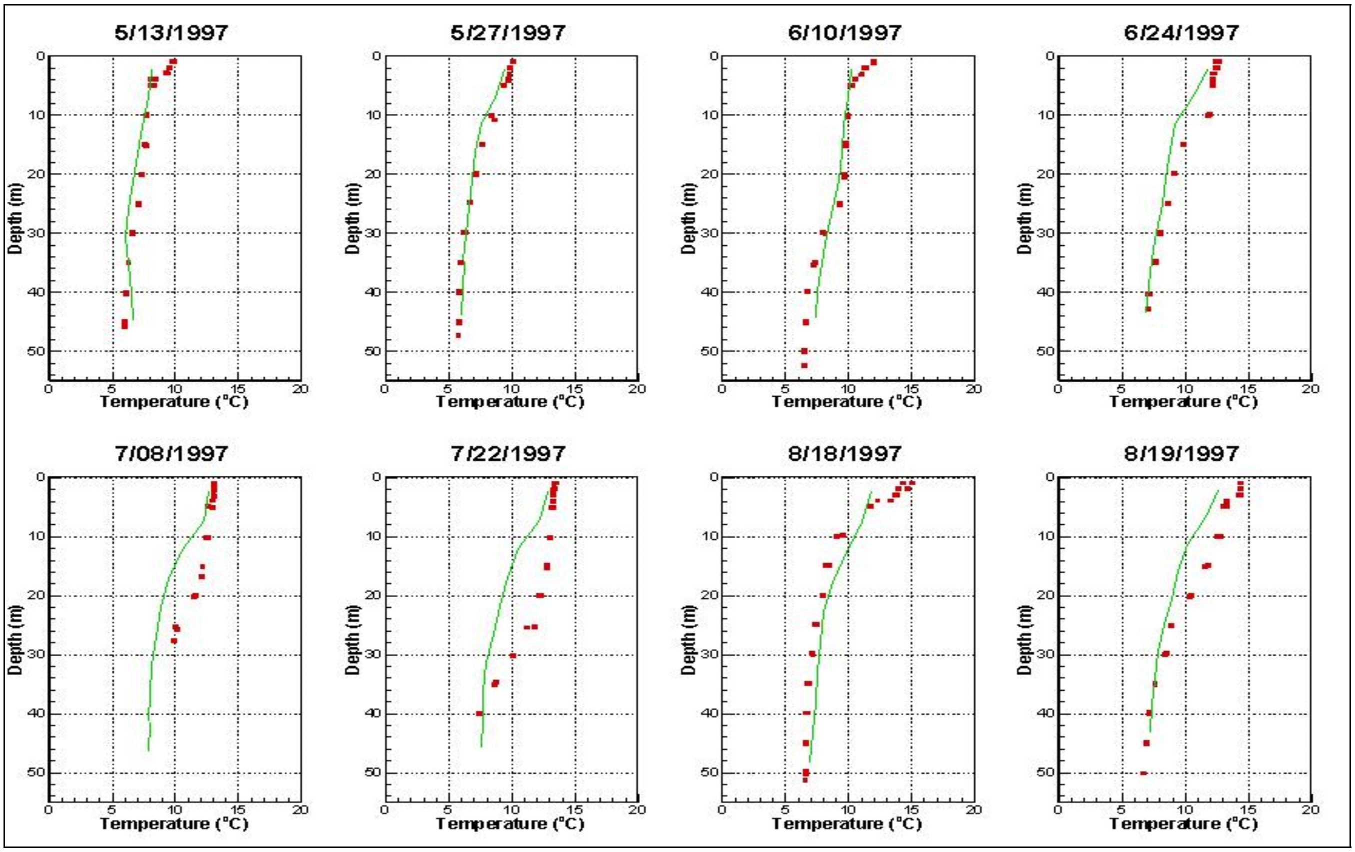


**Figure B-17. Comparisons of temperature profiles at Station 52.**

## B.3 Water Quality Model Parameter Estimation

The water quality application for Ward Cove utilized the WASP 5.1 component model in a dynamic three-dimensional simulation.  The hydrodynamic conditions, including the temporal and spatial variations in the cell volumes, depths, flows, and dispersion coefficients are imported as an external forcing file generated by the EFDC 3-D hydrodynamic model discussed in Section B.2.  The advective and dispersive transport solutions within the WASP simulation were performed on the identical model grid used to simulate the hydrodynamics (Figure B-2).

The full EUTRO4 simulation is performed within the WASP model for the simulations in Ward Cove.  The primary state variable of concern is dissolved oxygen, but the model also simulates the fate and transport of ammonia, nitrate/nitrite, organic nitrogen, total phosphorus, ortho-phosphorus, ultimate BOD ($BOD_u$), chlorophyll a.  The kinetic processes, sources, and sinks considered within the WASP simulations that impact the mass balance of dissolved oxygen were:

- $BOD_u$ decay (combined nitrogenous and carbonaceous)
- Reaeration
- SOD
- Headwater and offshore boundary fluxes of $BOD_u$ and nutrients
- Point source discharges of $BOD_u$ from the fish processing plan

- Phytoplankton respiration and death (as chlorophyll a)

Limited data were available for development of concentration boundary conditions, determination of the model kinetic rates and constants, and comparisons of model projections of nutrients and other parameters. The data available included:

- Vertical profiles of dissolved oxygen
- Historic measurements of nutrients and BOD at nearby stations
- Sediment chemistry studies from the DTSR study (Exponent 1999)

Based on the limited data sets, model parameterization was conducted by providing a baseline input set of boundary conditions, and model kinetic rates and constants taken from historic reports and literature values. The model was spun up above the inputs described below and the simulations of vertical profiles of dissolved oxygen were compared with the measured data to evaluate model performance. The following section describes the model inputs used for the parameterization and any adjustment of those parameters to improve model performance in comparison with observed vertical dissolved oxygen profiles.

***Model Inputs***

Table B-2 presents the concentrations values of the WASP state variables within the Tongass Narrows for the 1997 simulations. As no specific data for the time period of our study were available for water quality concentrations in the Tongass Narrows, typical values, taken from EPA's STORET were utilized.

Table B-1 also presents the concentrations of the WASP state variables in the freshwater inflow from Ward Creek. As with the boundary concentrations in the narrows, no data were available for the water quality concentrations entering from the creek for the period of simulation. Therefore, representative values for Ward Creek based on STORET measurements were utilized as input to the model.

**Table B-1. Water Quality Concentrations at Boundaries for Model Simulations**

| Parameter | Tongass Narrows Concentration | Ward Creek Concentration |
|---|---|---|
| CBOD (mg/L) | 2 | 2 |
| Ammonia (mg/L) | 0.03 | 0.01 |
| Nitrate-nitrite (mg/L) | 0.1 | 0.1 |
| Organic nitrogen (mg/L) | 0.3 | 0.2 |
| Orthophosphate (mg/L) | 0.03 | 0.02 |
| Organic phosphorus (mg/L) | 0.1 | 0.1 |
| Phytoplankton (Φg/L of chl. a) | 2 | 2 |

Appendix C presents plots of the meteorological forcings used in the WASP water quality model. For the WASP simulations the meteorological parameters utilized are as follows:

- Wind speed for calculation of reaeration.
- Short wave solar radiation for input to growth equations for chlorophyll a.

These inputs were taken directly from the NCDC Ketchikan Station and used to force the model. The values of the meteorological data are available at an hourly time step, but were input at 6-hour intervals.

A primary aspect of the Ward Cove model is the oxygen demand associated with the bottom sediments. Historic discharges from the KPC facility resulted in large areas of accumulated waste in the bottom of the cove. These wastes have been shown to produce fluxes of ammonia (NH3) and TOC, both of which can impact the oxygen demand in bottom waters of the cove. Additionally, there is a baseline sediment oxygen demand associated with the waste discharges due to organic decomposition and anaerobic conditions at the soil water interface.

Under the Superfund program, extensive testing and mapping of the bottom sediments within Ward Cove was conducted. This testing is summarized within a report entitled *Ward Cove Sediment Remediation Project, Detailed Technical Studies Report, Volume I, Remedial Investigation and Feasibility Study* (Exponent, 1999). This report presents maps of the distribution of ammonia, $CBOD_u$, and TOC concentrations within the sediments. Additionally, model simulations of the flux of ammonia and TOC from the sediments to the water column were conducted for Exponent (1999). These model simulations defined the rate of ammonia and TOC flux to the surface waters and the associated changes in sediment concentration over time.

For the 1997 model simulations, the assumption was made that a spatial distribution of the SOD existed that was proportional to the distribution of CBOD, ammonia, and TOC in the pore waters. This provided the basis for establishment of a spatial distribution of SOD multiplier in the system (Figure B-18). The next step was to establish a baseline sediment oxygen demand, or assumed average SOD on which to apply the SOD multipliers. Historically, under the conditions of full discharge from the KPC facility, SOD measurements were taken within Ward Cove. These measurements were presented in *Ward Cove Water Quality Assessment* (Jones & Stokes and Kinnetic 1989). Utilizing the measured SOD from this report, along with the spatial multiplier determined from Exponent (1999), a spatial distribution of SOD within the system was determined. The baseline or average SOD utilized with the spatial multipliers was 3.3 $g/m^2/d$ (Jones & Stokes and Kinnetic 1989). This condition represents the potential worst case condition immediately following the removal of the KPC discharge for SOD within Ward Cove.

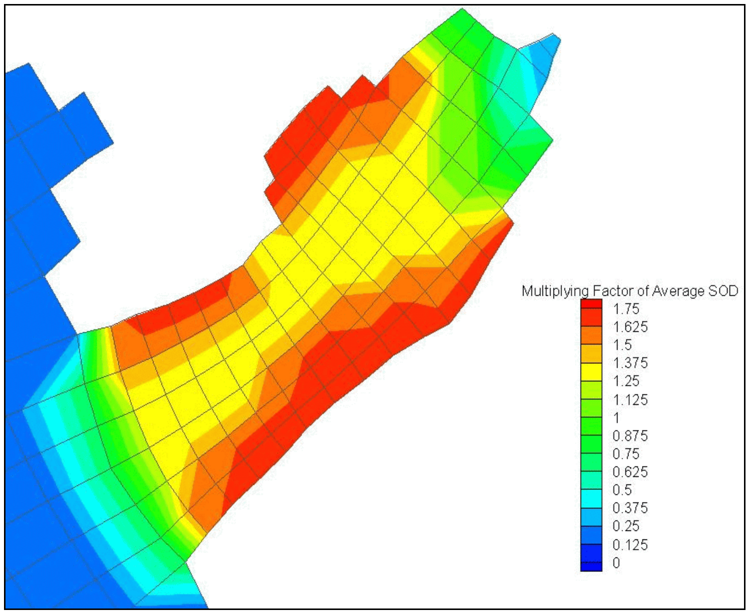


**Figure B-18. Spatial distribution of SOD multiplier.**

The calculations to determine the BODu associated with the WCPC fish processing plant located on the south side of Ward Cove were based on assumptions from *Ocean Discharge Criteria Evaluation for the NPDES General Permit for Alaskan Seafood Processors* (Tetra Tech 1994). Tetra Tech (1994) lists a typical seafood processor BOD5 concentration of 155 mg/L. To determine a $BOD_u$ concentration an f-ratio (the ratio of the $BOD_u$ to the 5-day BOD) of 3.0 was utilized to get the final concentration used in the calculations (465 mg/L). The $BOD_u$ discharged was calculated based on the Round Production assuming a discharge flow of 1 mgd for every 52,860 lbs of Round Fish processed with $BOD_u$ of 465 mg/L. The flow rate by Round Fish processed was based on typical flow rates associated with salmon processing plants. Figure B-19 presents WCPC's 1997 Round Production as reported to EPA on the Annual Certification of Compliance.

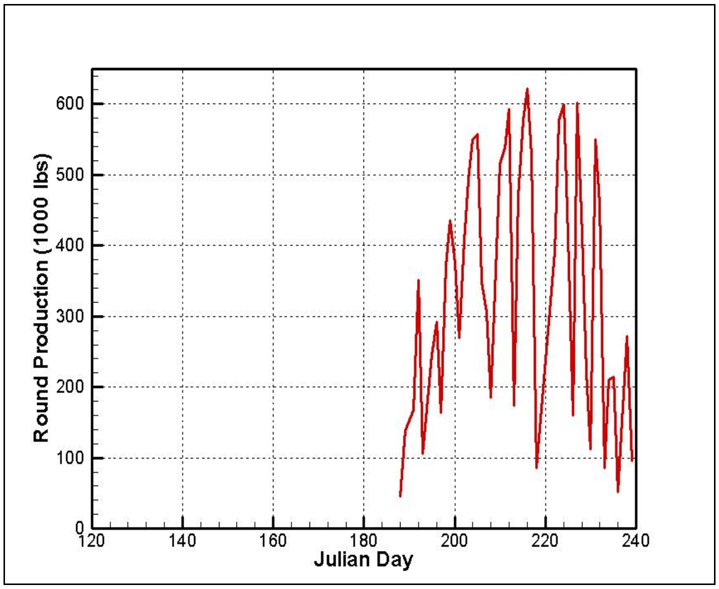


**Figure B-19. WCPC 1997 round production.**

Figure B-20 presents the time dependant daily average $BOD_u$ load to Ward Cove from the WCPC facility for July and August of 1997. The seafood processing plant typically operates in June, July, August and September. The discharge pipe from the plant is located near the bottom cove in approximately 30 meters of water. Due to the circulation pattern within Ward Cove (residual flow into the cove at the bottom and counterclockwise within the cove) this material is carried into the cove and moves into the areas of low dissolved oxygen.

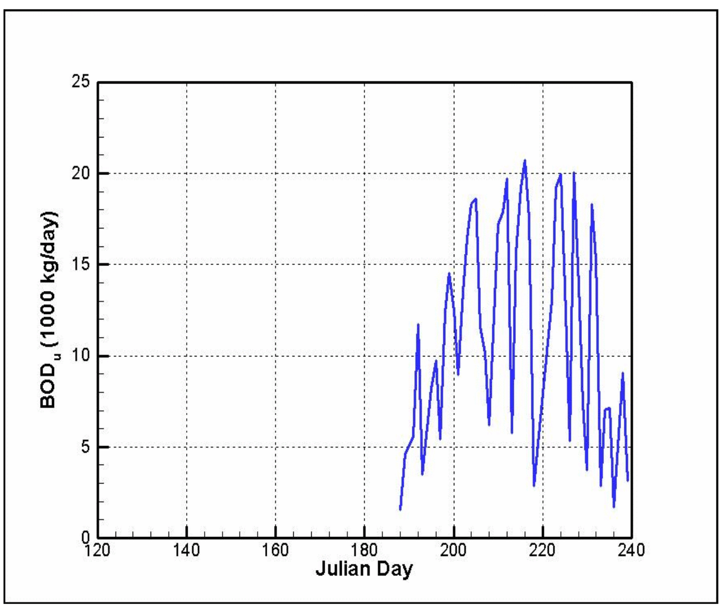


**Figure B-20. CBODu load from WCPC facility.**

### *Model Parameters*

Table B-2 presents the critical model input parameters that achieved the best overall fit of model results to date for the dissolved oxygen profiles. These parameters represent the decay of oxygen demanding material, the nitrification/ denitrification rates, and the key parameters relative to primary productivity within the system. In all cases the values fall within acceptable literature ranges for systems such as Ward Cove.

**Table B-2. Key WASP Kinetic Parameters**

| Parameter | Value |
|---|---|
| CBOD deoxygenation rate at 20E C ($day^{-1}$) | 0.3 |
| Nitrification rate at 20E C ($day^{-1}$) | 0.2 |
| Dinitrification rate at 20E C ($day^{-1}$) | 0.05 |
| Saturated growth rate of phytoplankton ($day^{-1}$) | 3 |
| Endogenous phytoplankton respiration rate at 20E C ($day^{-1}$) | 0.3 |
| Phytoplankton death rate ($day^{-1}$) | 0.01 |
| Light extinction ($m^{-1}$) | 0.1 |

### *Model/Data Comparisons*

As described above the primary comparison of the water quality model results to observed data were based on observed vertical dissolved oxygen profiles. To accomplish the model parameterization the following kinetic rates were adjusted.

- CBOD decay rate
- Nitrification/denitrification rate
- Primary productivity coefficients

The following presents comparisons between the simulated and measured conditions during the summer of 1997 for the dissolved oxygen. These simulations represent the best overall results achieved under the model parameterization discussed above and the limited available boundary and interior data. The model parameterization goal was to capture the primary temporal and spatial distribution of dissolved oxygen in the system, with special focus on capturing the vertical stratification conditions.

Figures B-21 and B-22 present comparisons of the vertical profiles of dissolved oxygen for stations 44 and 46, respectively. The results show that the model does simulate the degree of stratification and the vertical distribution of dissolved oxygen, although certain events are not captured well. Based on the limited temporal data for the vertical distribution of dissolved oxygen within the narrows, some of the errors may be a function of the limited boundary forcing data.

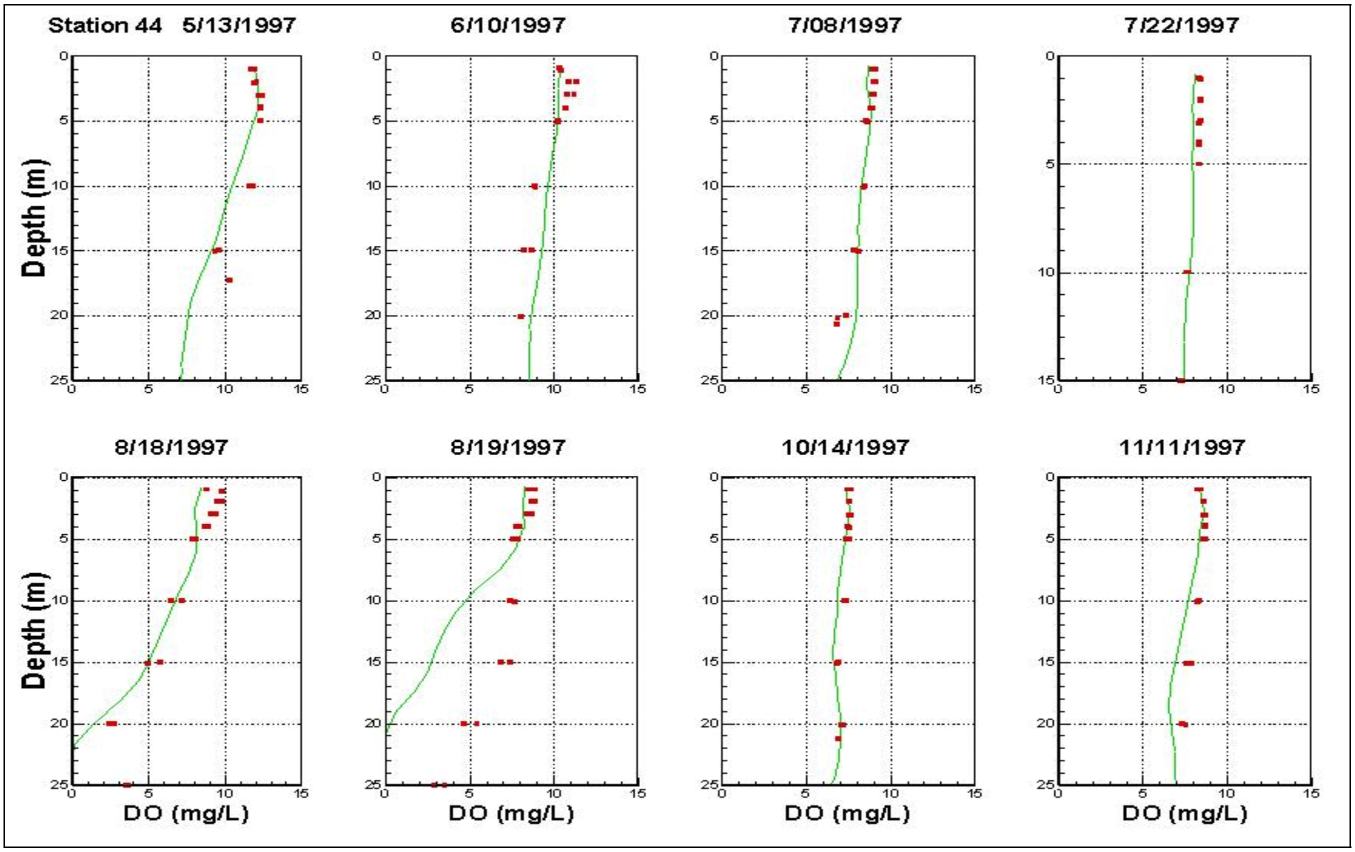


**Figure B-21. Comparisons of Dissolved Oxygen Profiles at Station 44.**

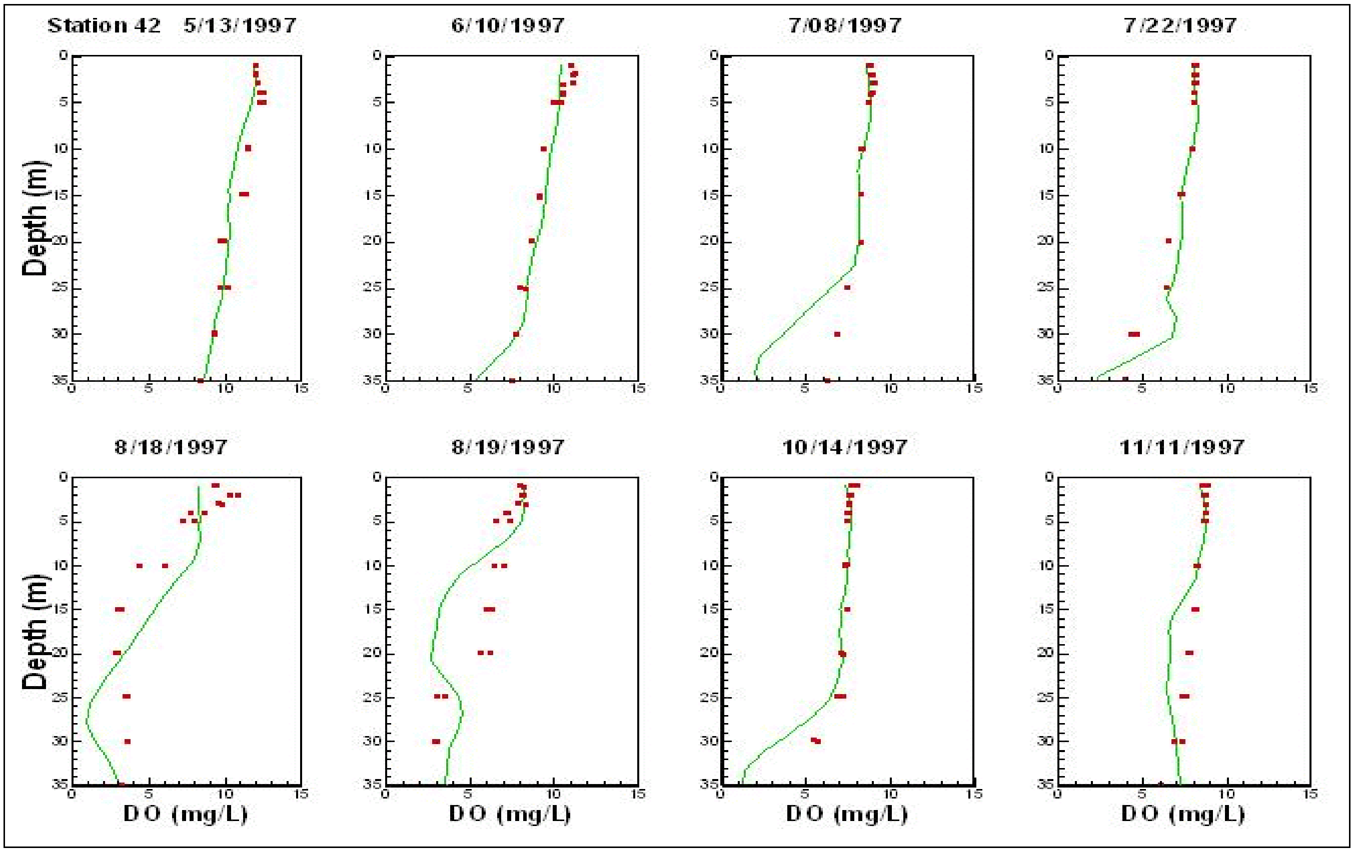


**Figure B-22. Comparisons of dissolved oxygen profiles at Station 46.**

## B.4 Relative Impact Evaluation

Evaluation of the historic data presented in Section 4 identified that a net deficit of dissolved oxygen exists within Ward Cove relative to the waters within the Tongass Narrows. Utilizing the water quality model described above, under a set of predetermined conditions, a relative impact evaluation was performed to identify the effects of the assumed SOD conditions presented above, and the WCPC discharge during the critical months of July and August. The goal of this exercise was to quantify the relative impact of each of the two primary dissolved oxygen deficit sources within the Cove.

The model simulation was run under the 1997 conditions from April through September. Three separate simulations were run, these were:

- Baseline Simulation: 1997 conditions with SOD set at a typical baseline level of 1.5 $g/m^2/d$ and no discharge from the WCPC facility.
- SOD Simulation: 1997 conditions with SOD set at the spatially distributed values described above and no discharge from the WCPC facility.
- Fully Loaded Simulation: 1997 conditions with SOD set at the spatially distributed values described above and measured discharge from the WCPC facility.

Figures B-23 through B-26 present snapshots of the dissolved oxygen profile under the three conditions described above from June through August. In addition to the dissolved oxygen profiles the WCPC discharge and surface to bottom density differences are shown. The density differences are presented to highlight the critical nature of the degree of stratification on the development of the dissolved oxygen deficit in the bottom waters. The results show that the most significant relative impacts to the system come from the WCPC discharge with an additional deficit of up to 2.0 mg/L created by the discharge. This is consistent with measurements showing the highest deficit existing at the time of the WCPC discharge peaks, with the comparison of the interior and exterior data showing similar ranges of dissolved oxygen deficit. In comparison the SOD impacts are small and isolated to the very near bottom waters.

The relative impact evaluation presents the net deficit in dissolved oxygen created by the bottom SOD and discharges within Ward Cove. This net deficit is superimposed on the background water quality conditions entering the cove from Tongass Narrows. Evaluation of historic data has shown that dissolved oxygen levels in the lower waters of Tongass Narrows are at or below the WQS of 5.0 mg/L at times. This provides conditions where no available capacity exists for additional deficit in Ward Cove while maintaining the designated uses of the waters.

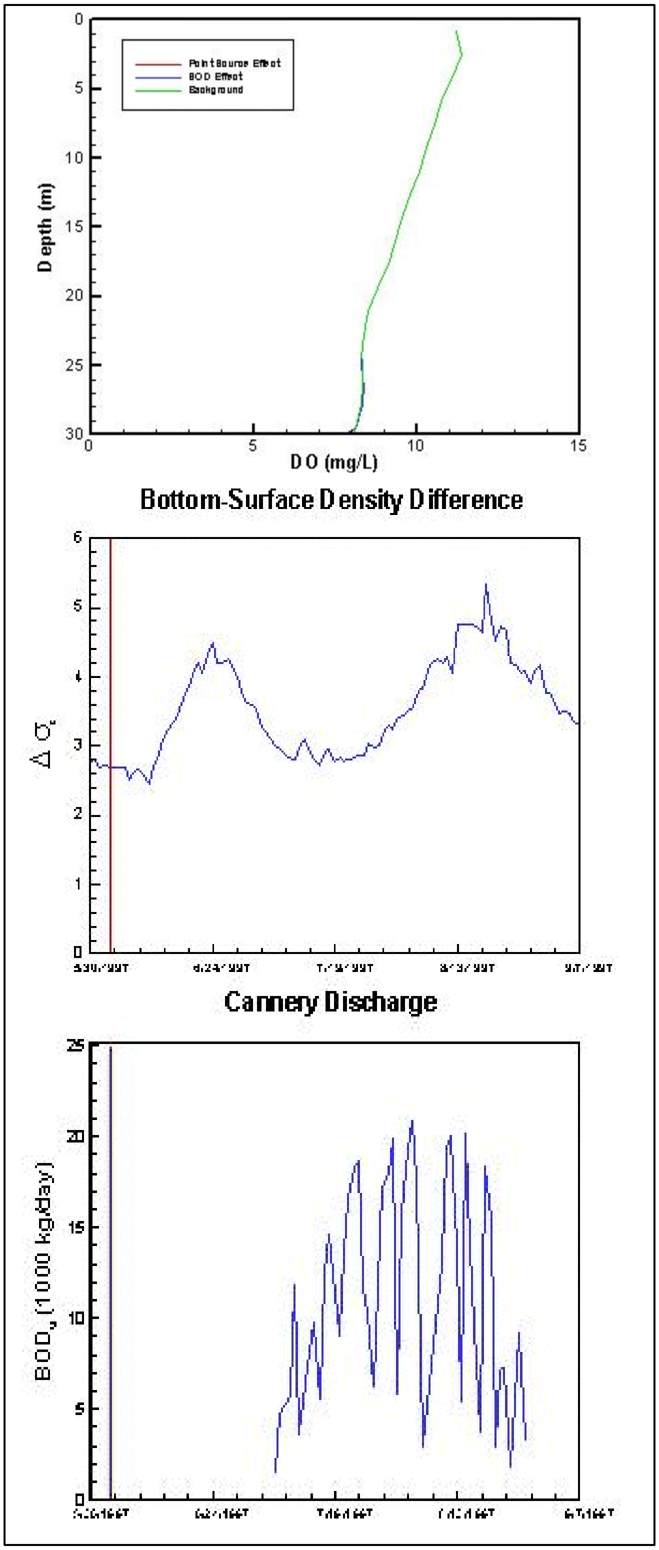


**Figure B-23. Simulated dissolved oxygen profile, vertical density difference, and WCPC discharge on June 3, 1997, at Station 44.**

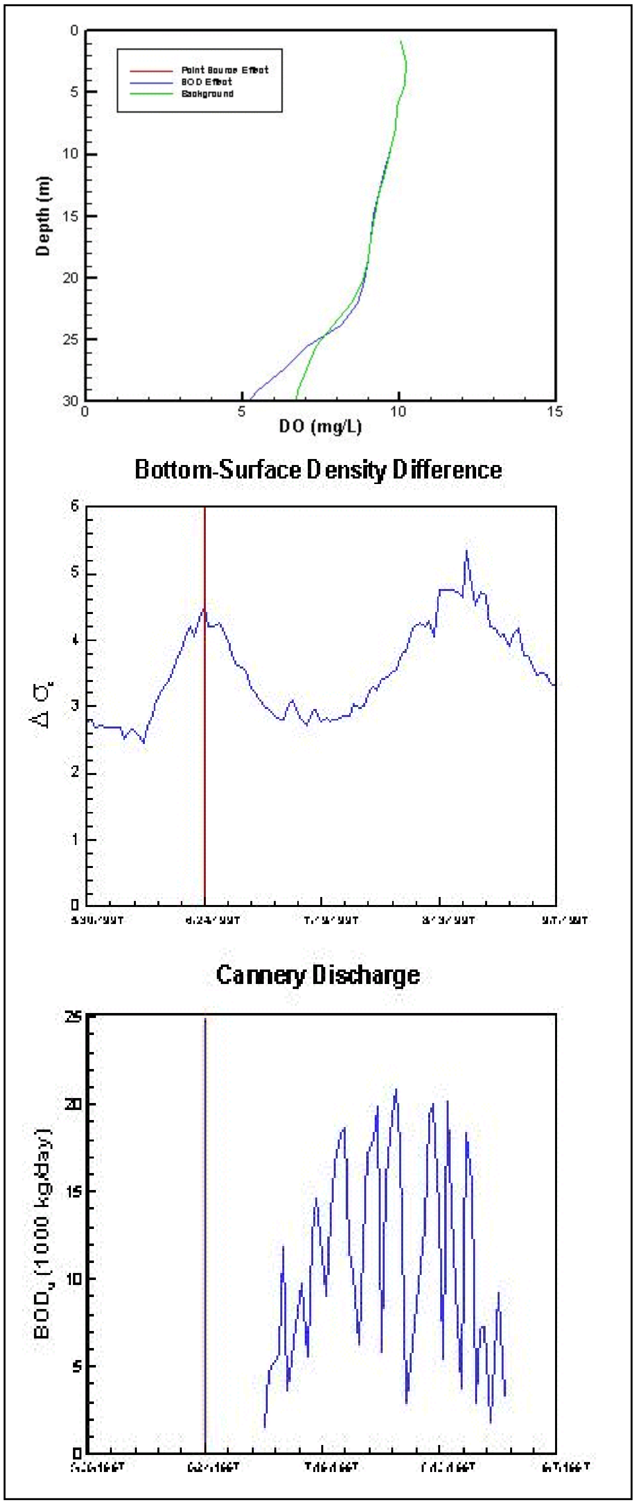


**Figure B-24. Simulated dissolved oxygen profile, vertical density difference, and WCPC discharge on June 24, 1997 at Station 44.**

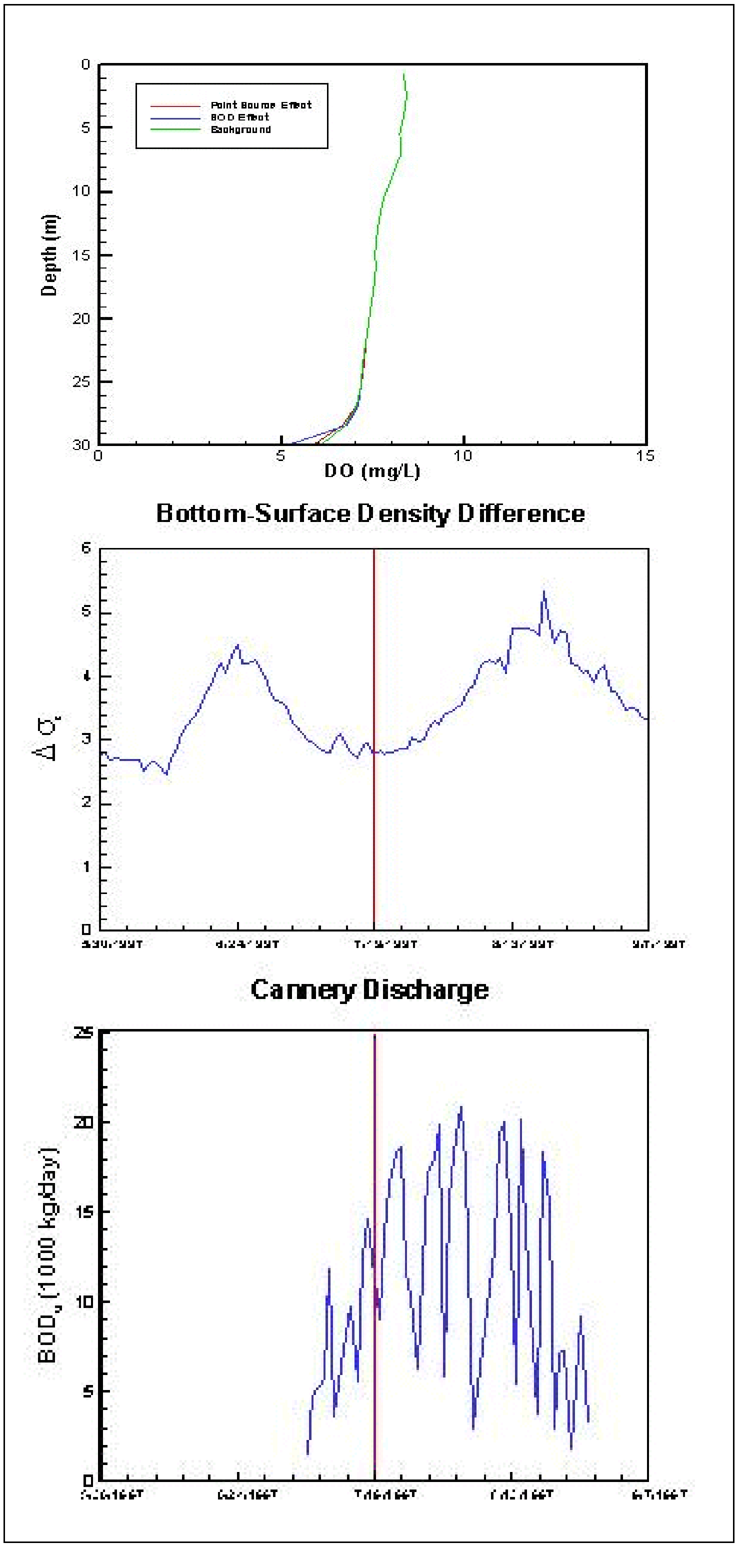


**Figure B-25. Simulated dissolved oxygen profile, vertical density difference, and WCPC discharge on July 19, 1997 at Station 44.**

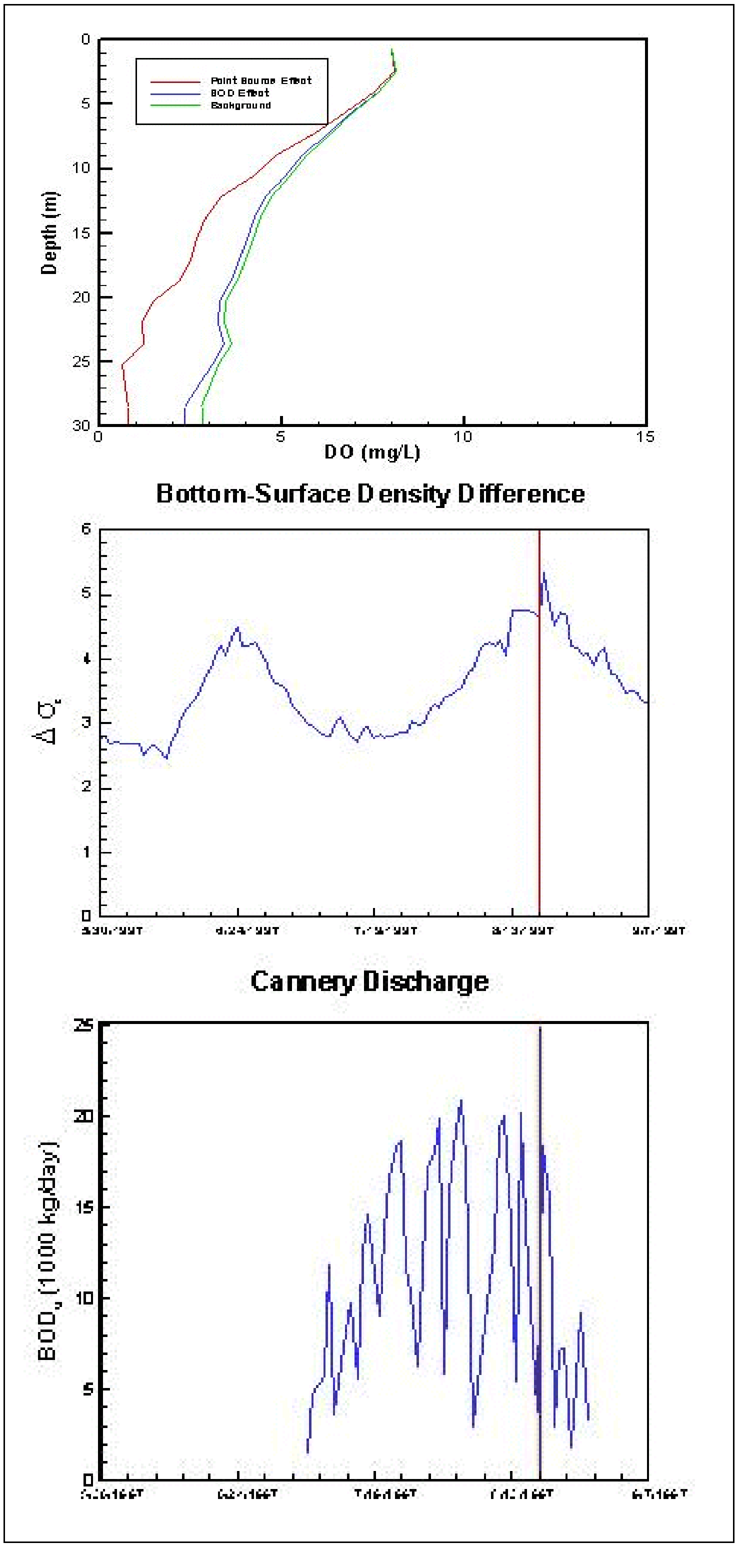


**Figure B-26. Simulated dissolved oxygen profile, vertical density difference, and WCPC discharge on August 18, 1997 at Station 44.**

# Appendix C. Vertical Profiles of Salinity, Temperature and Dissolved Oxygen

Figures C-1 through C-65 present vertical salinity profiles at the stations throughout Ward Cove in April, May, June, July and August of 1997. Figures C-66 through C-69 present temperature profiles at Stations 41 and 50 in April, May and June of 1997. Figures C-70 through C-134 present dissolved oxygen profiles at the stations in April, May, June, July and August of 1997.

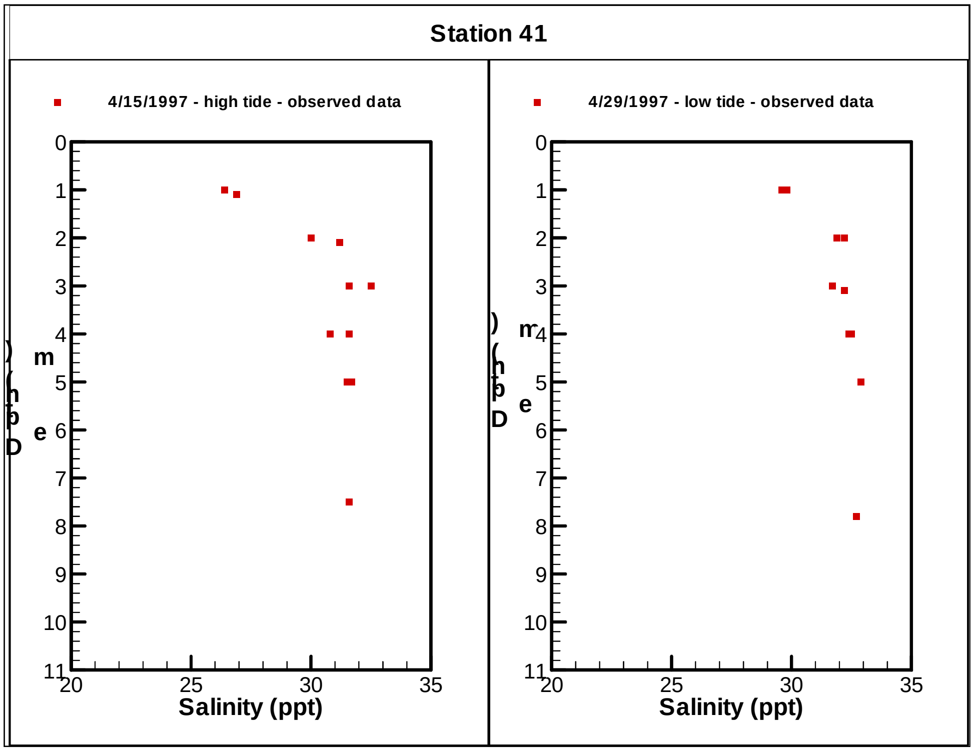


**Figure C-1. Salinity profiles at Station 41 measured in April 1997**

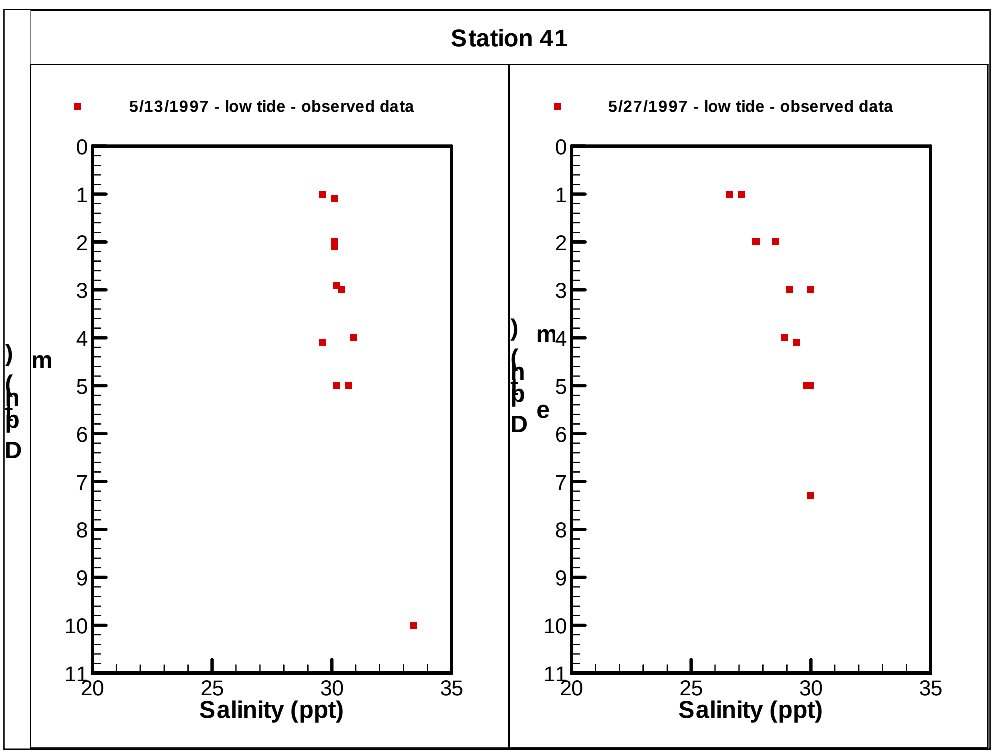


**Figure C-2. Salinity profiles at Station 41 measured in May 1997**

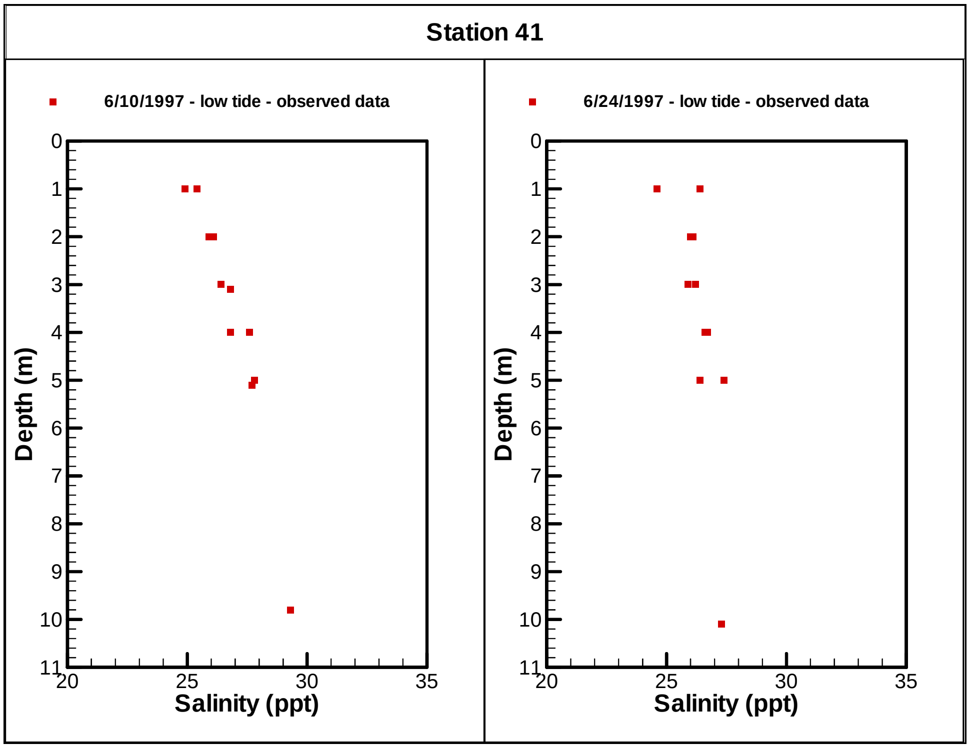


**Figure C-3. Salinity profiles at Station 41 measured in June 1997**

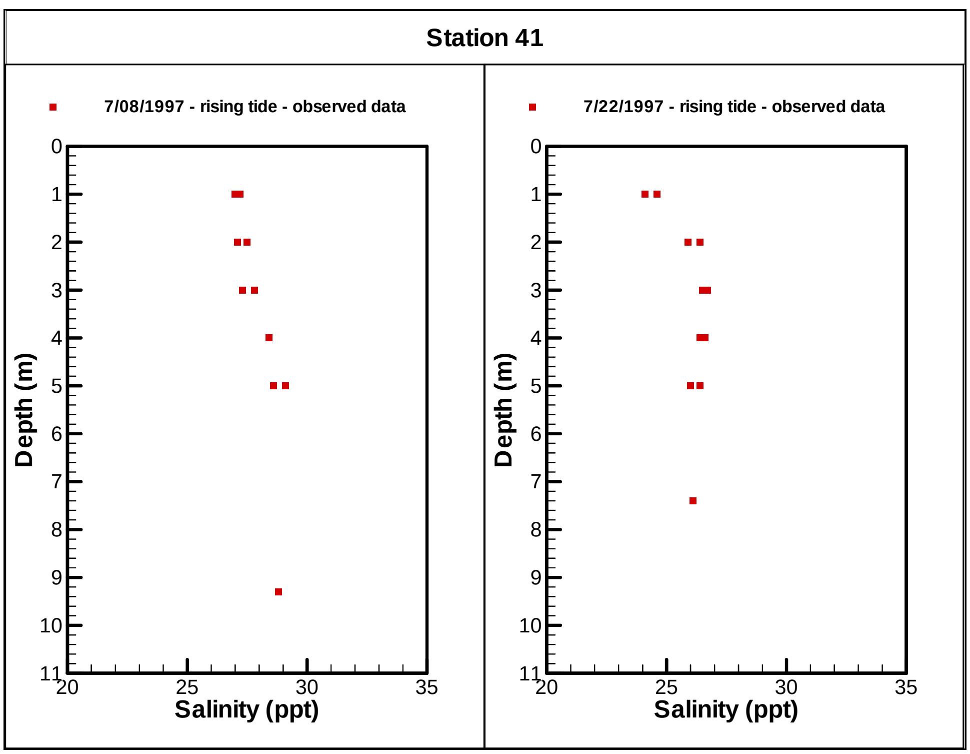


**Figure C-4. Salinity profiles at Station 41 measured in July 1997**

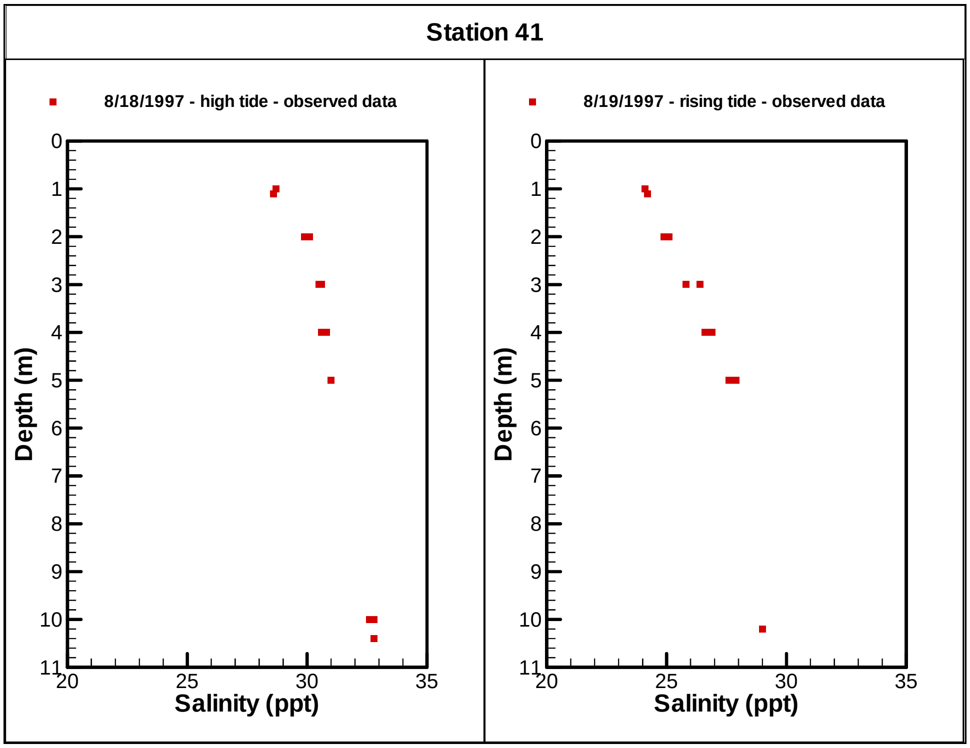


**Figure C-5. Salinity profiles at Station 41 measured in August 1997**

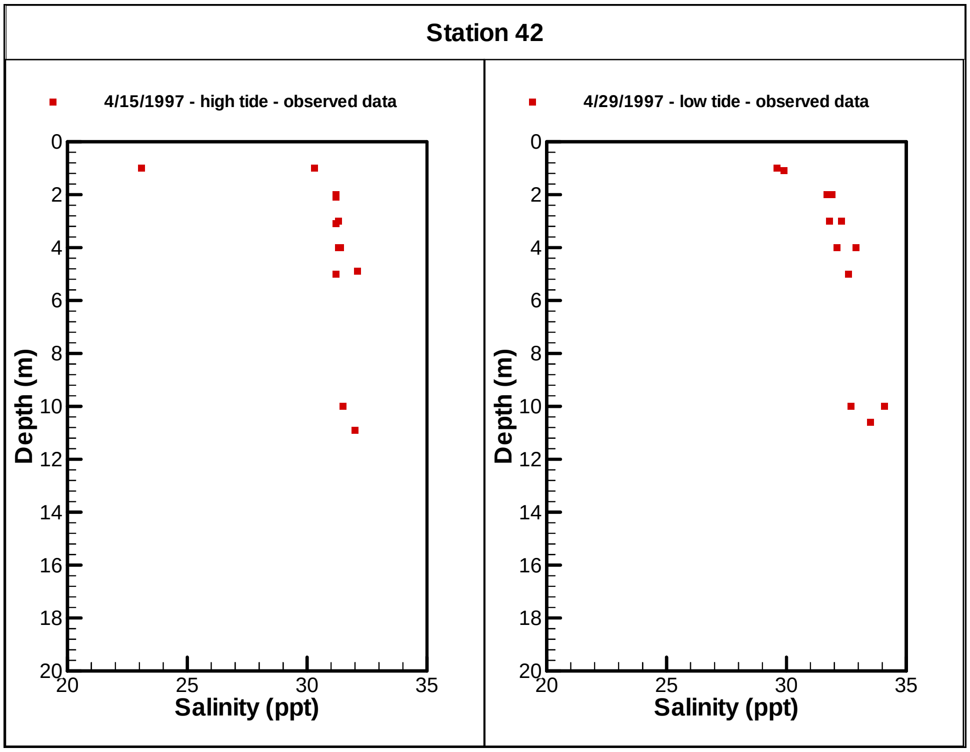


**Figure C-6. Salinity profiles at Station 42 measured in April 1997**

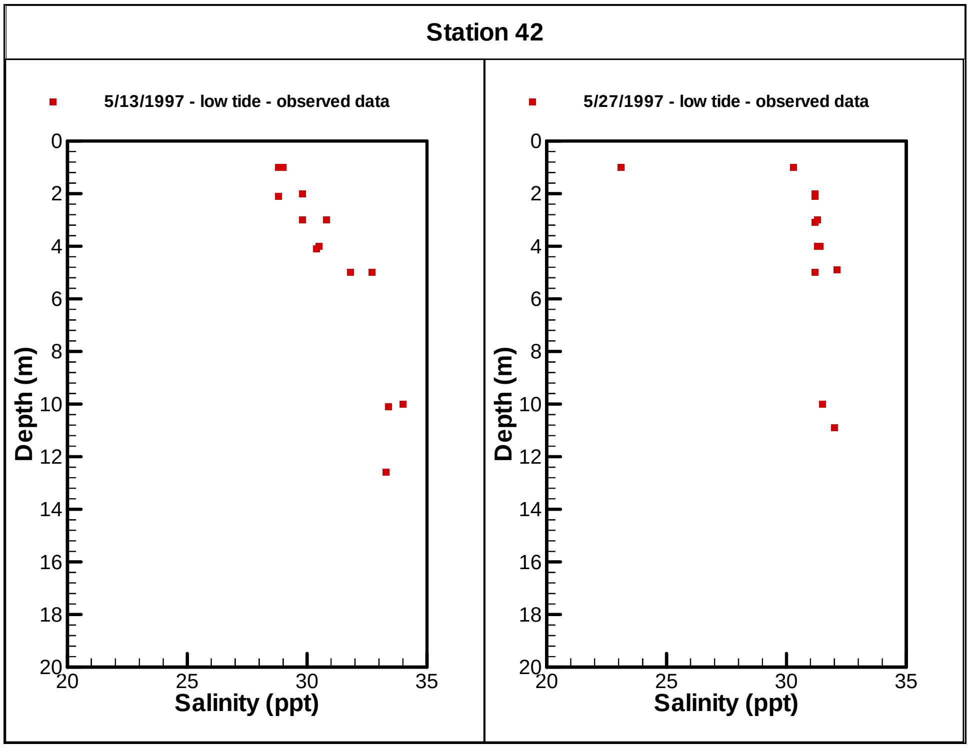


**Figure C-7. Salinity profiles at Station 42 measured in May 1997**

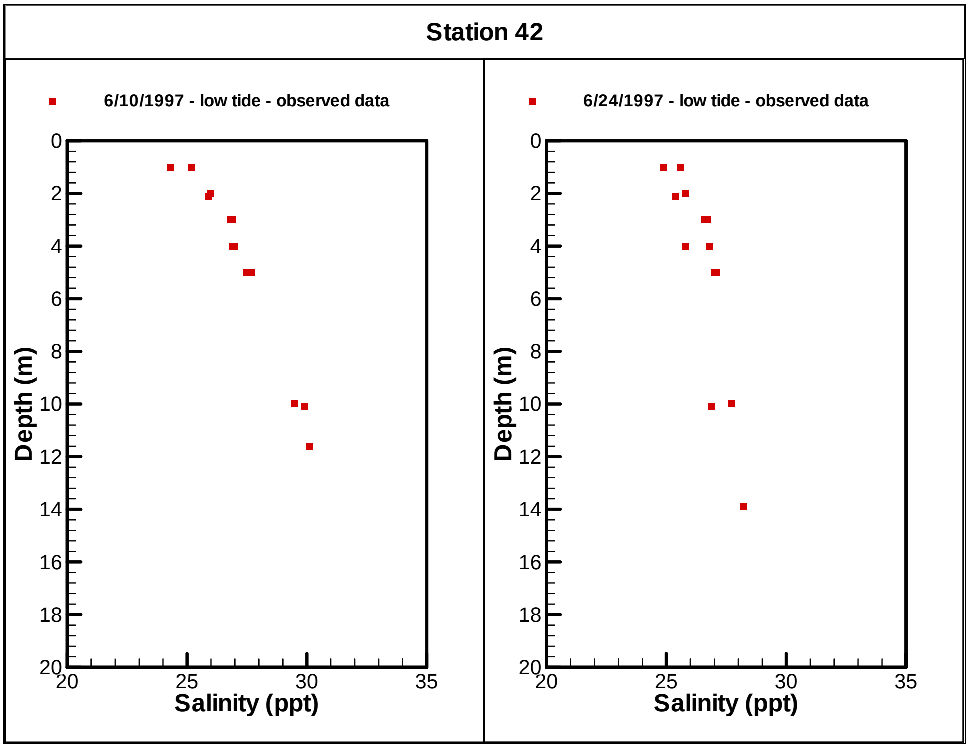


**Figure C-8. Salinity profiles at Station 42 measured in June 1997**

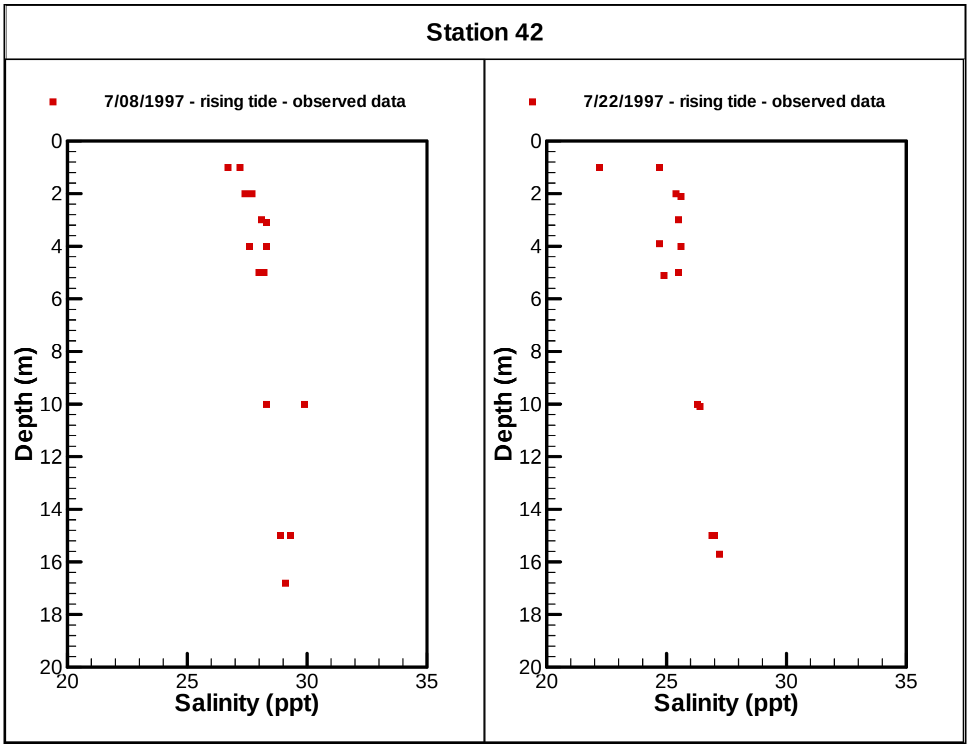


Figure C-9. Salinity profiles at Station 42 measured in July 1997

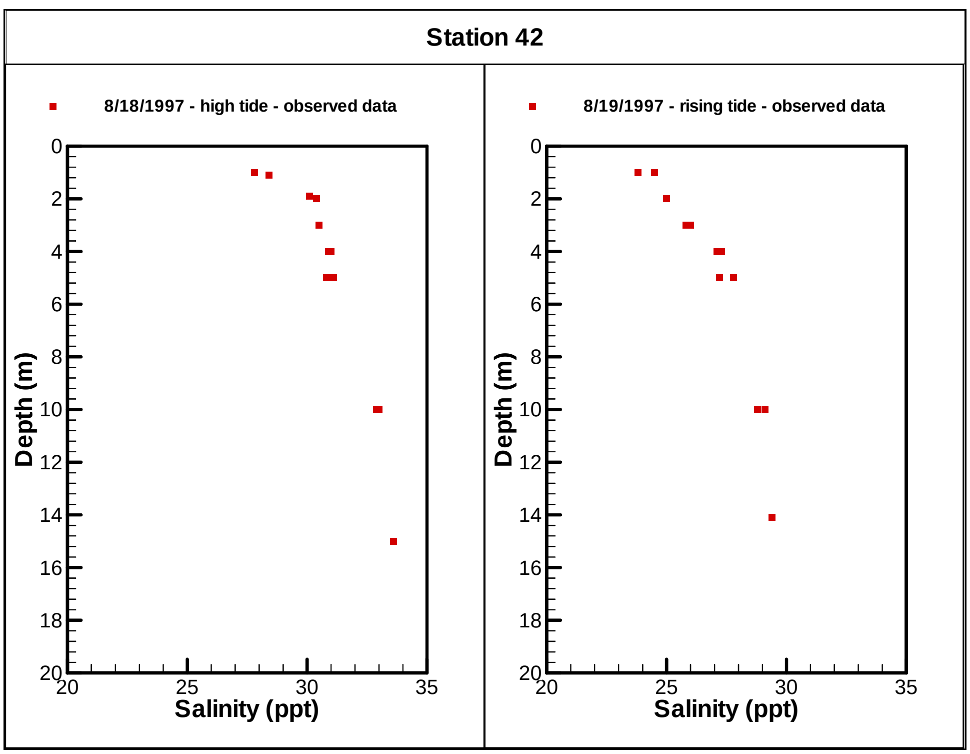


Figure C-10. Salinity profiles at Station 42 measured in August 1997

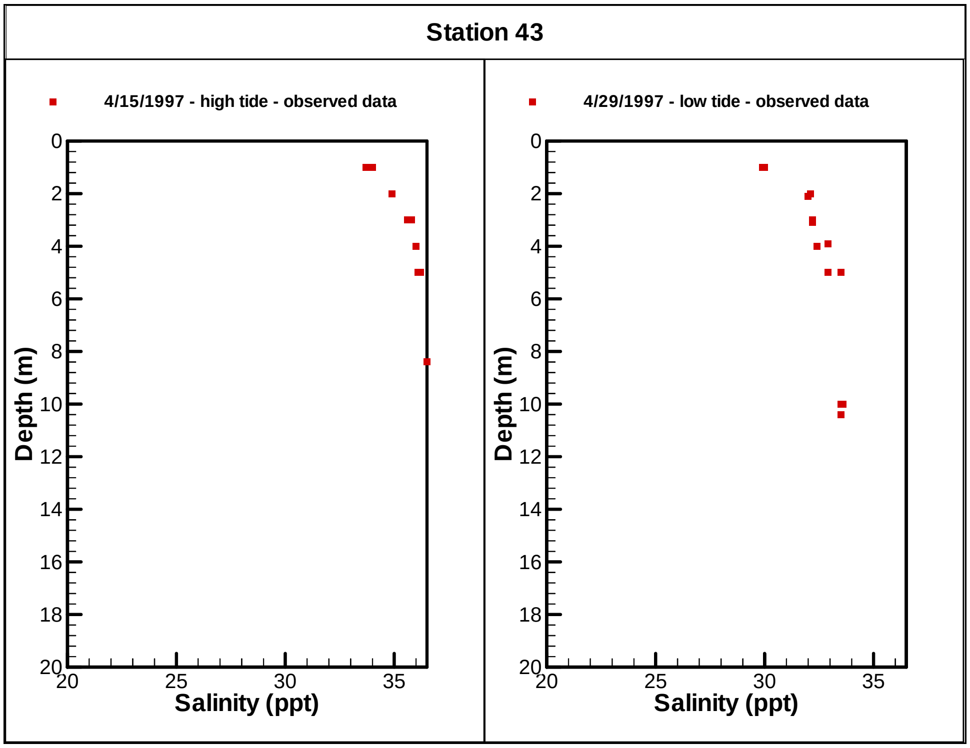


**Figure C-11. Salinity profiles at Station 43 measured in April 1997**

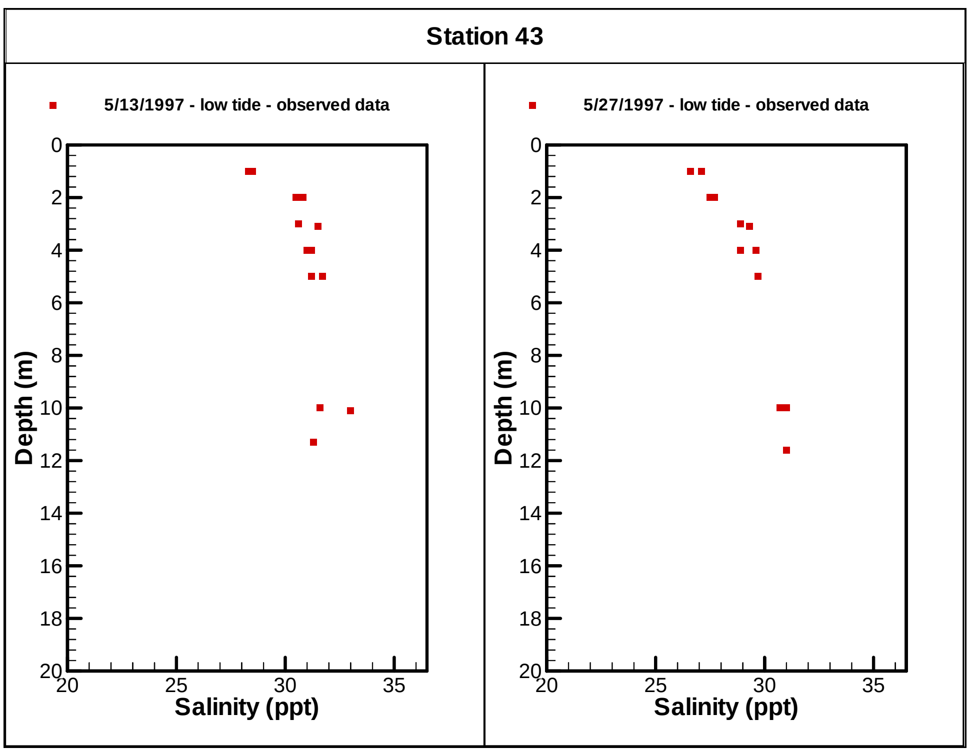


**Figure C-12. Salinity profiles at Station 43 measured in May 1997**

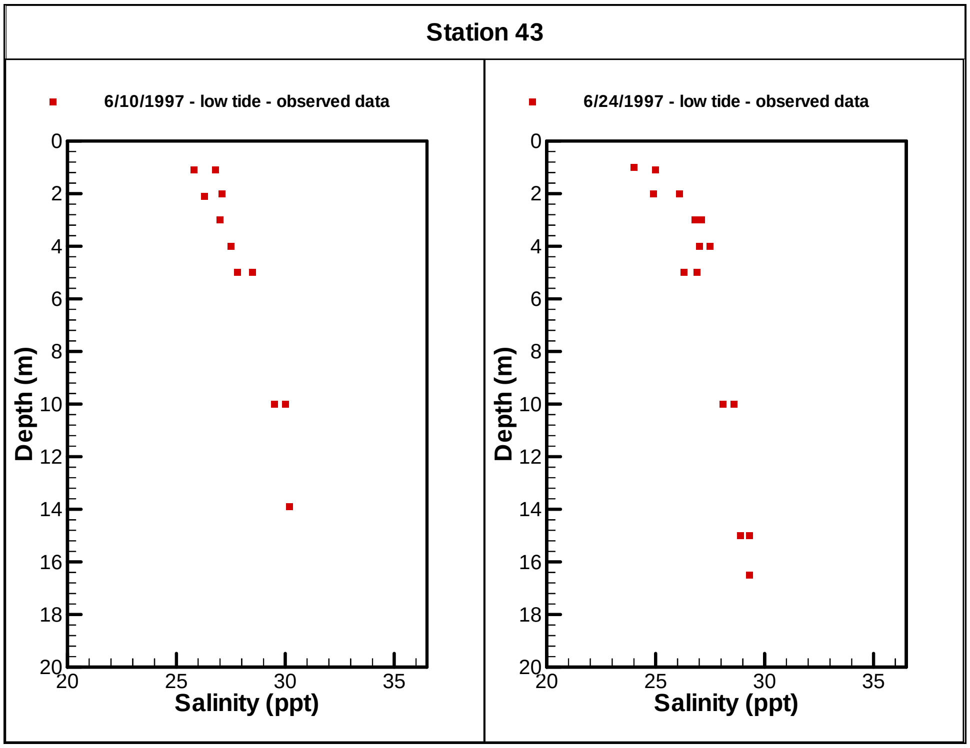


**Figure C-13. Salinity profiles at Station 43 measured in June 1997**

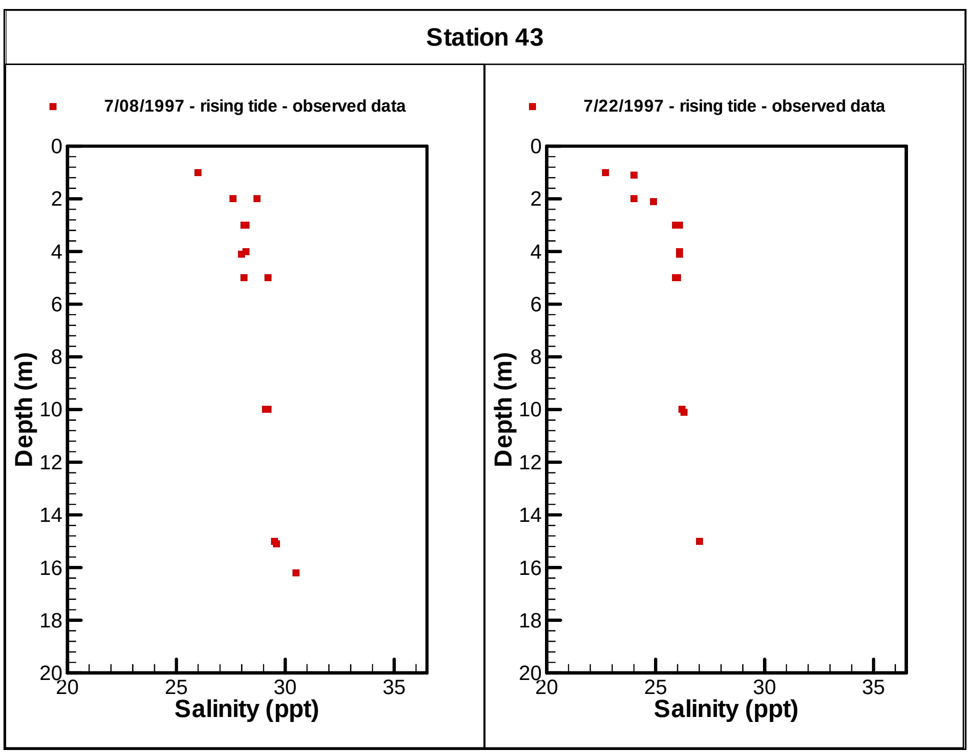


**Figure C-14. Salinity profiles at Station 43 measured in July 1997**

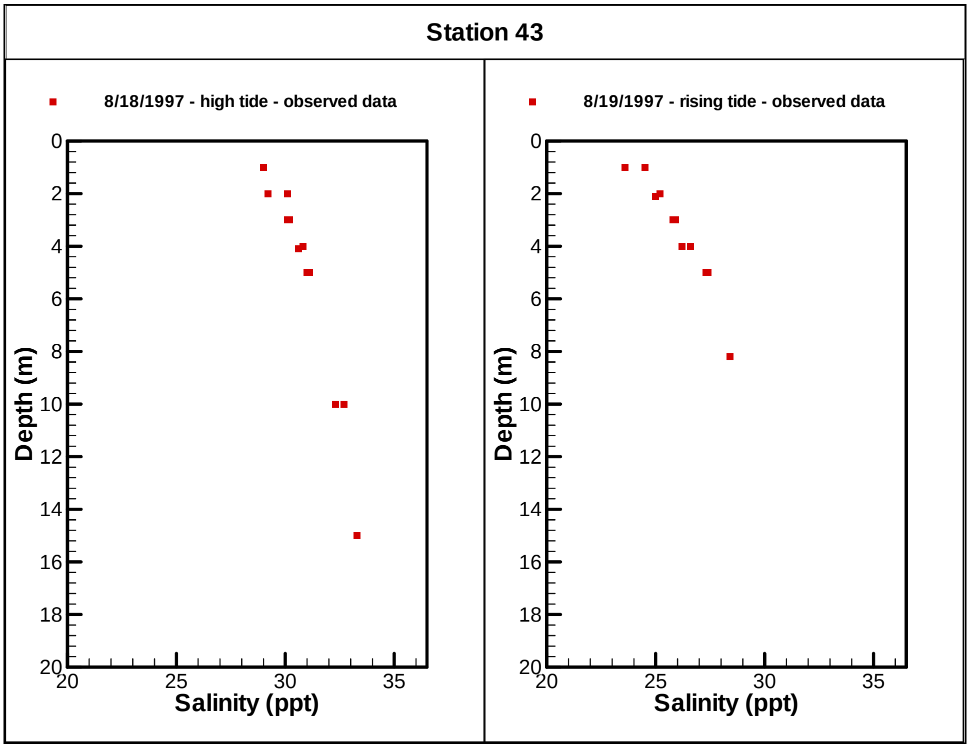


**Figure C-15. Salinity profiles at Station 43 measured in August 1997**

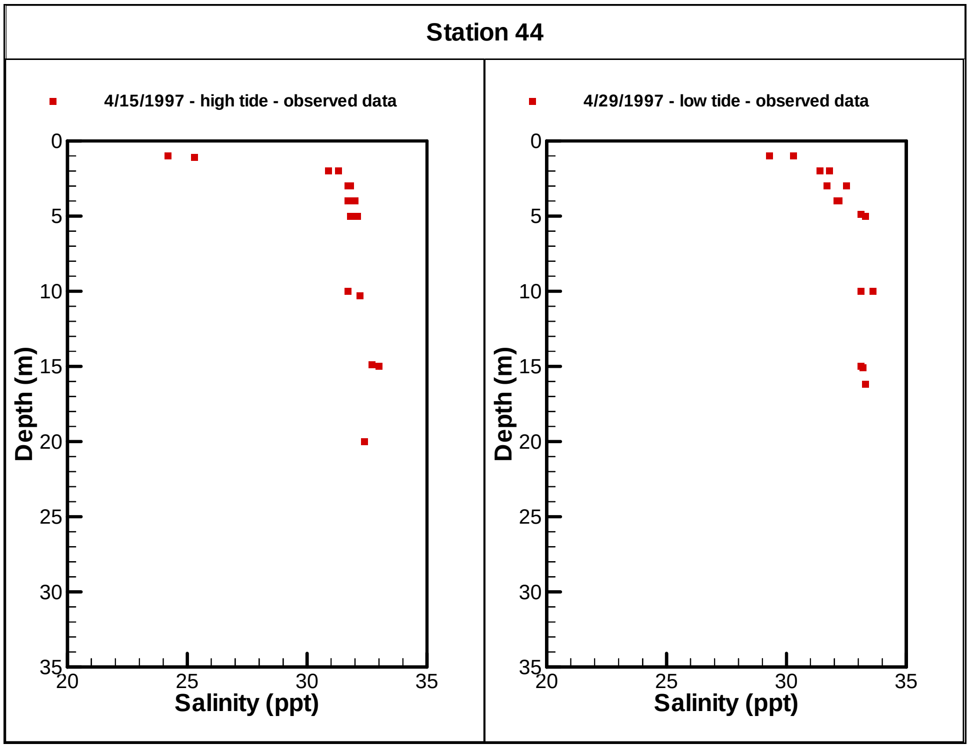


**Figure C-16. Salinity profiles at Station 44 measured in April 1997**

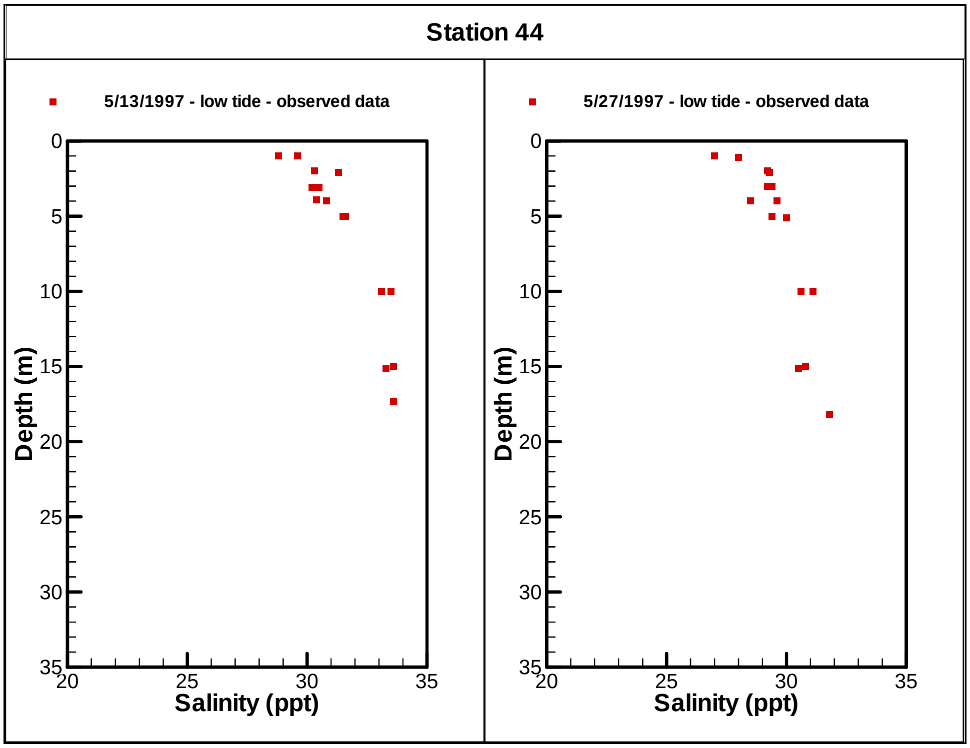


**Figure C-17. Salinity profiles at Station 44 measured in May 1997**

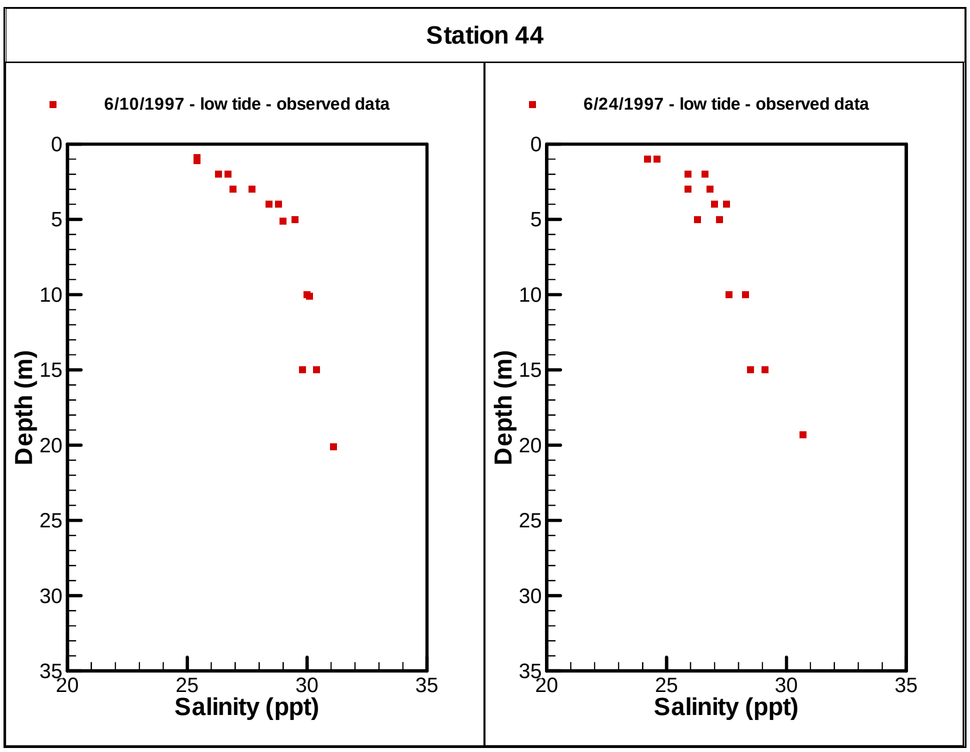


**Figure C-18. Salinity profiles at Station 44 measured in June 1997**

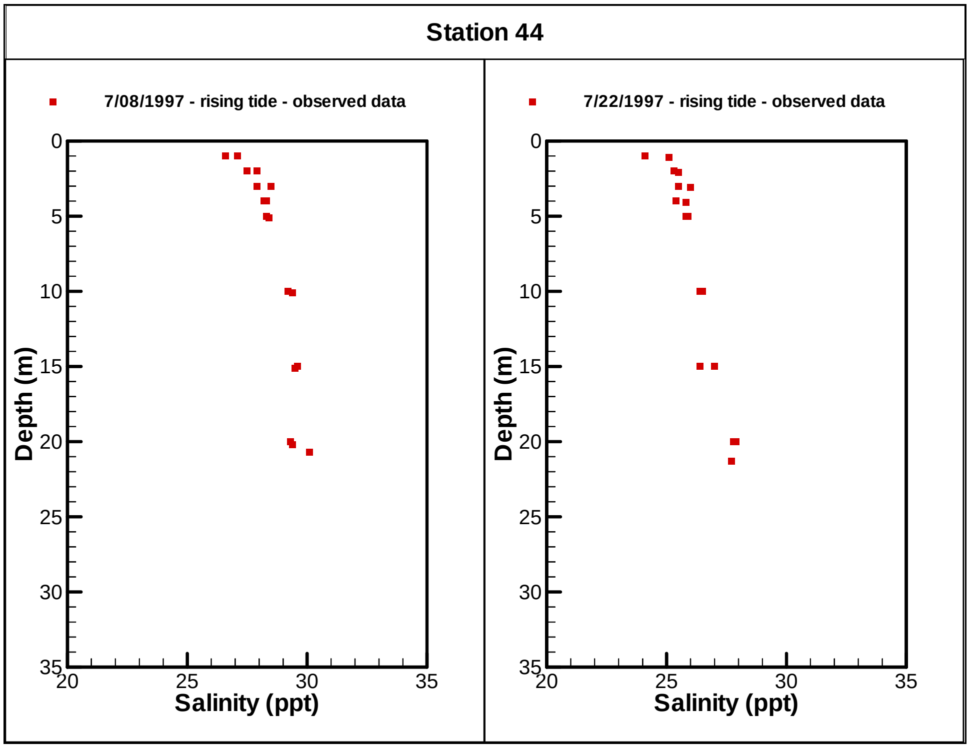


**Figure C-19. Salinity profiles at Station 44 measured in July 1997**

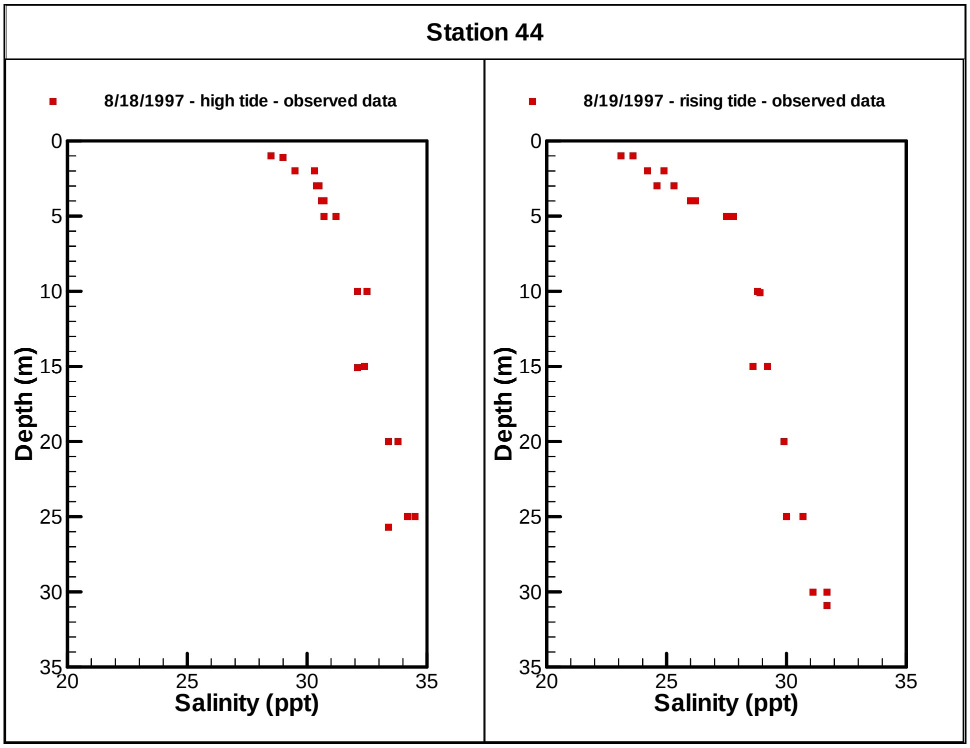


**Figure C-20. Salinity profiles at Station 44 measured in August 1997**

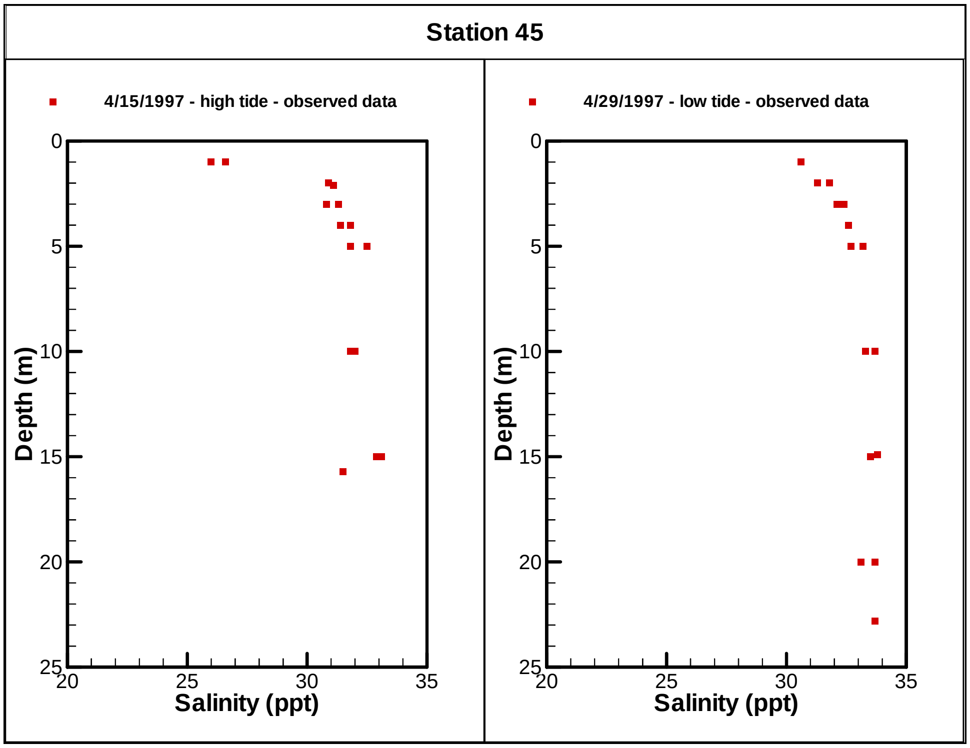


**Figure C-21. Salinity profiles at Station 45 measured in April 1997**

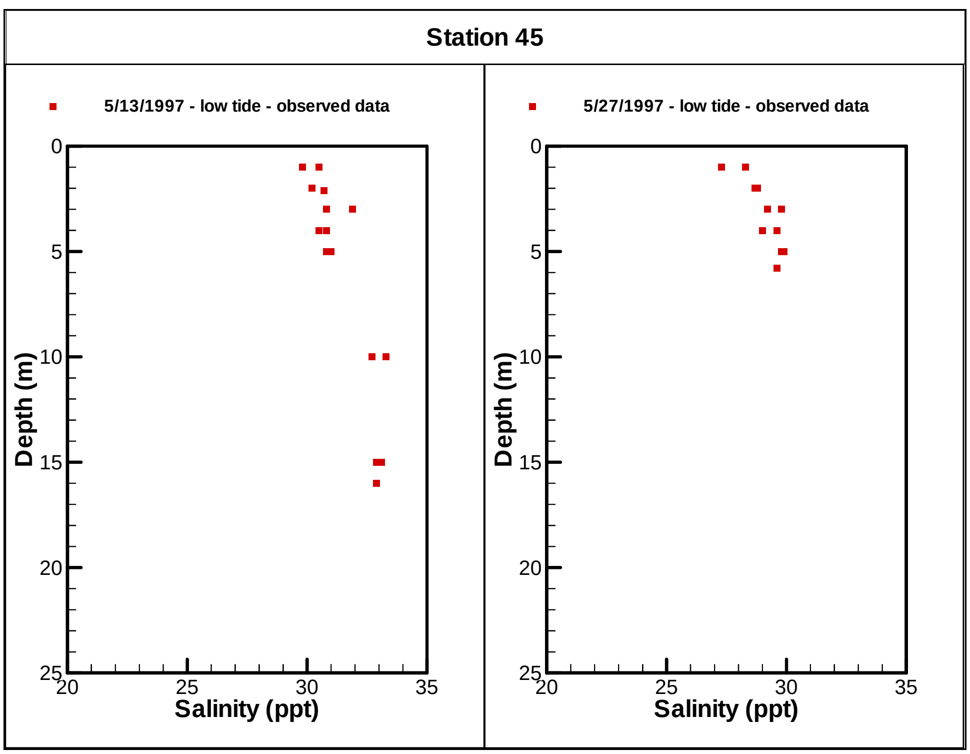


**Figure C-22. Salinity profiles at Station 45 measured in May 1997**

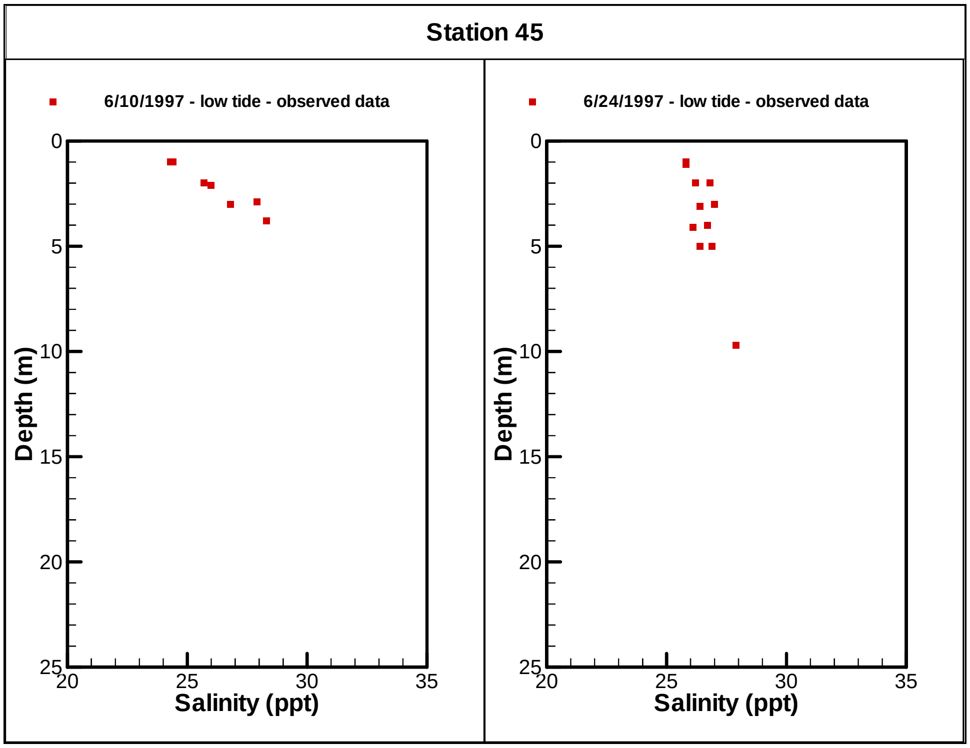


**Figure C-23. Salinity profiles at Station 45 measured in June 1997**

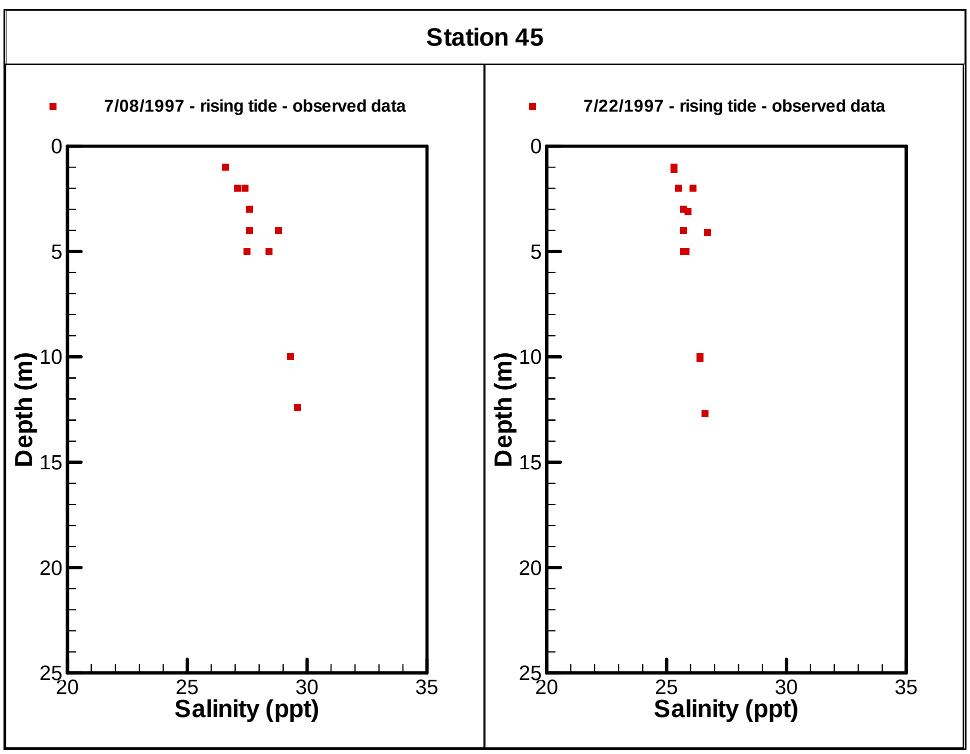


**Figure C-24. Salinity profiles at Station 45 measured in July 1997**

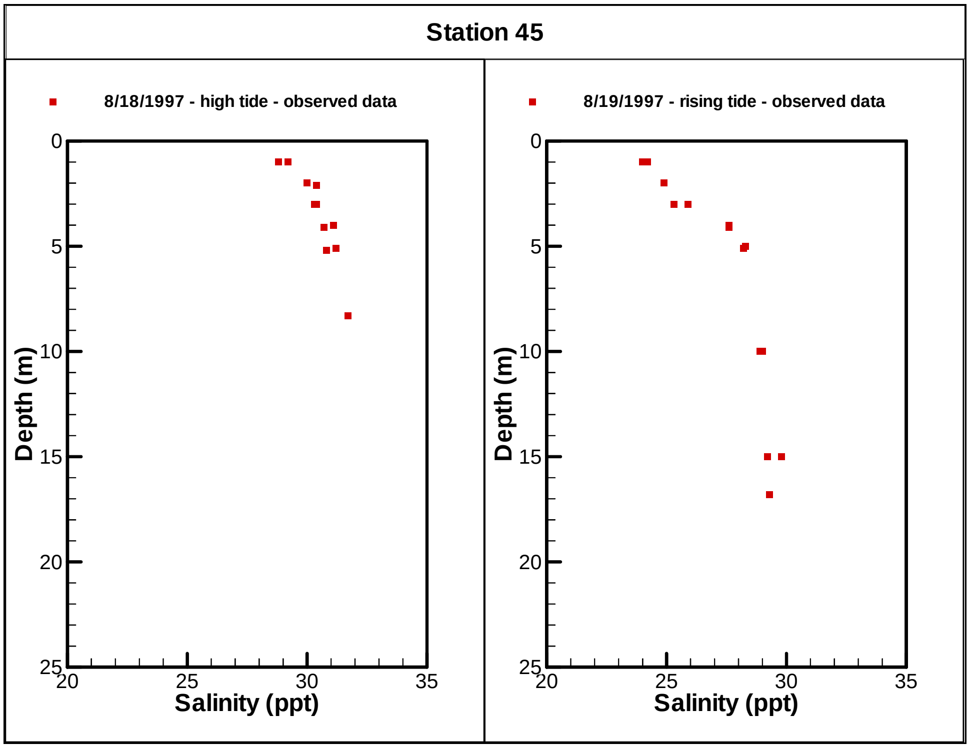


**Figure C-25. Salinity profiles at Station 45 measured in August 1997**

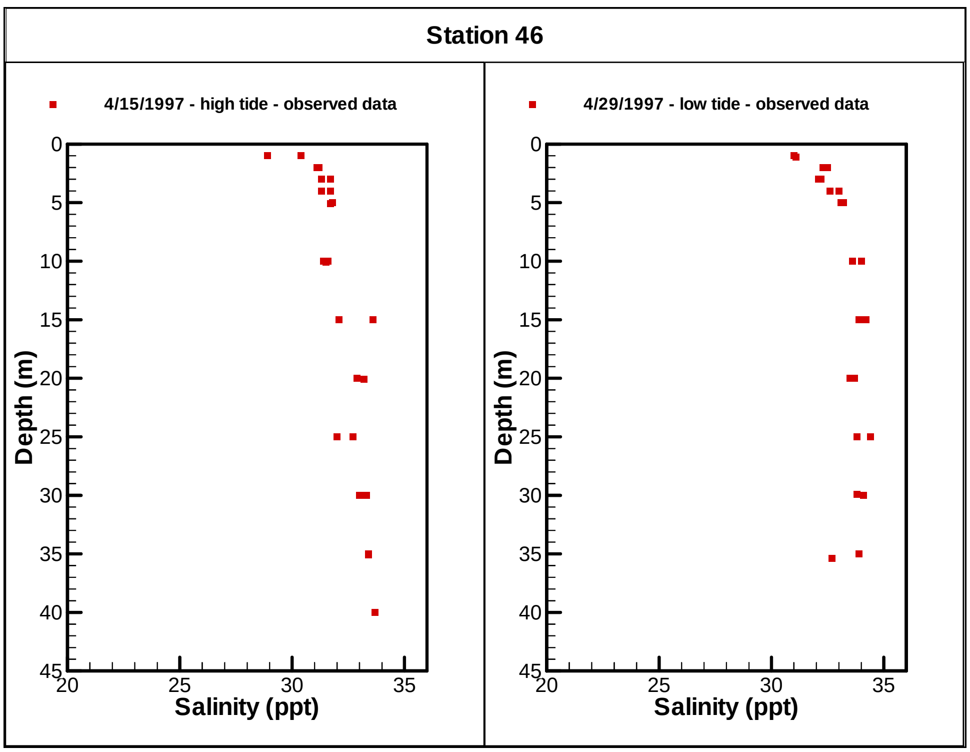


**Figure C-26. Salinity profiles at Station 46 measured in April 1997**

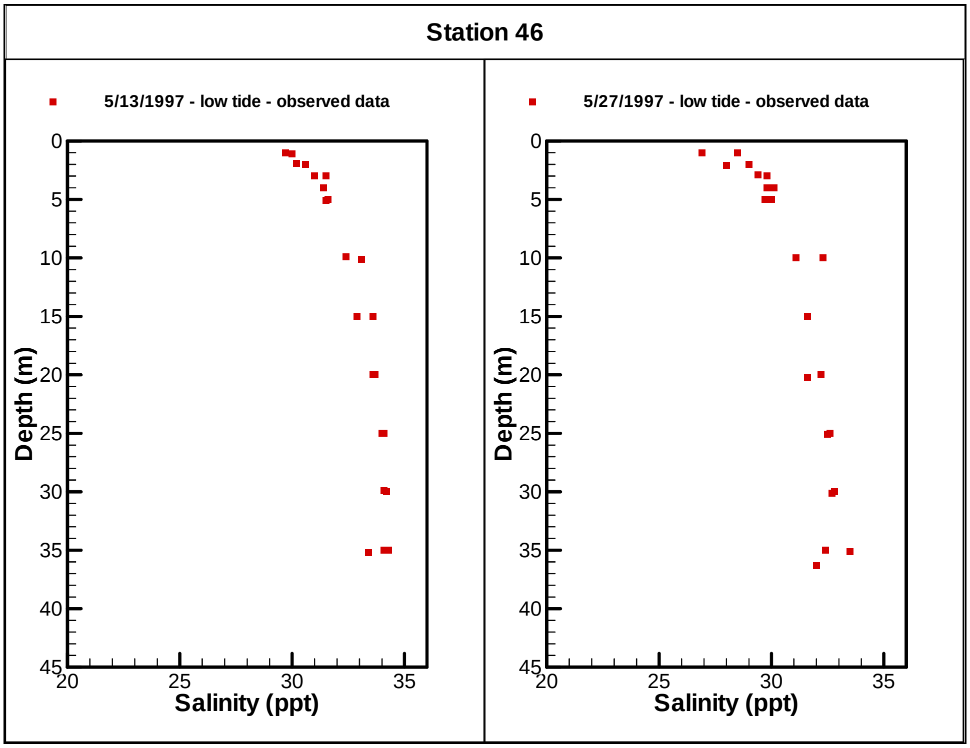


**Figure C-27. Salinity profiles at Station 46 measured in May 1997**

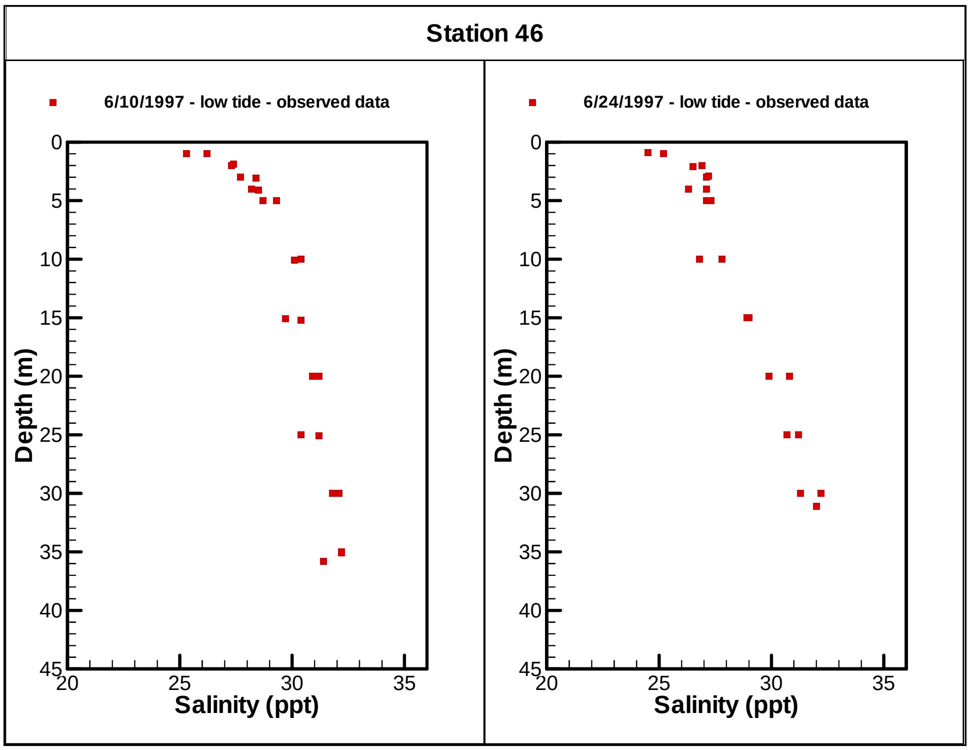


**Figure C-28. Salinity profiles at Station 46 measured in June 1997**

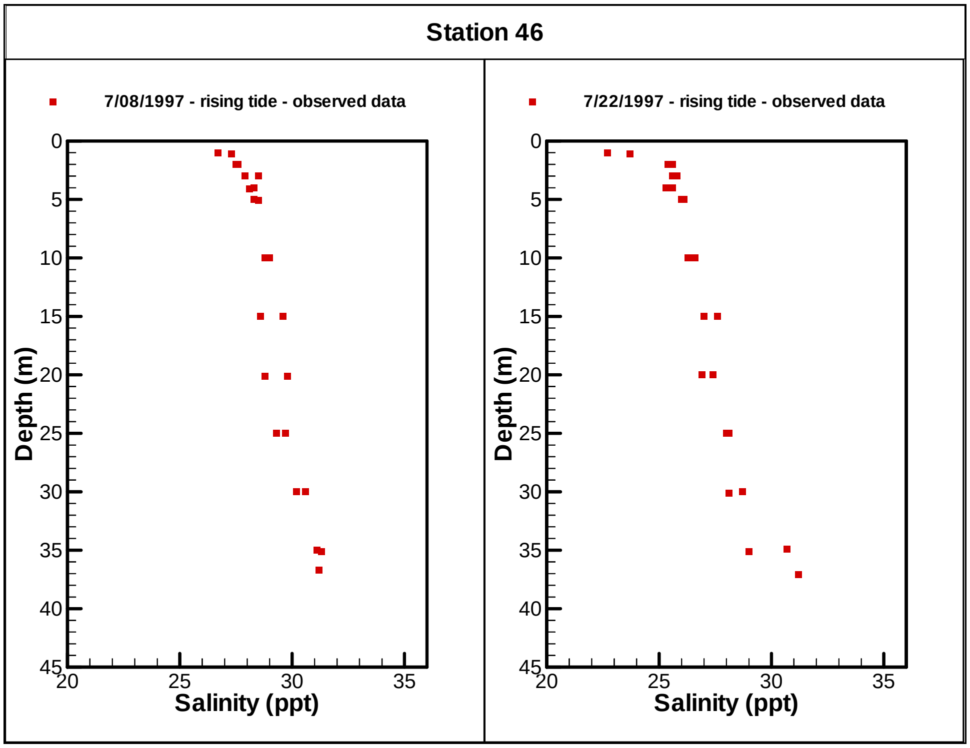


**Figure C-29. Salinity profiles at Station 46 measured in July 1997**

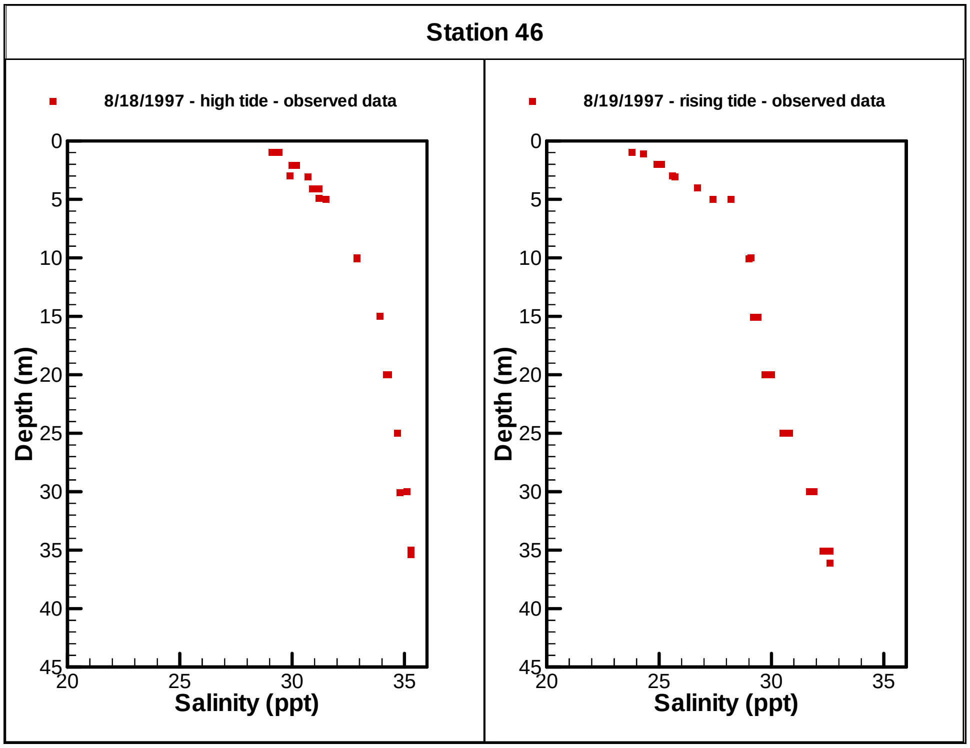


**Figure C-30. Salinity profiles at Station 46 measured in August 1997**

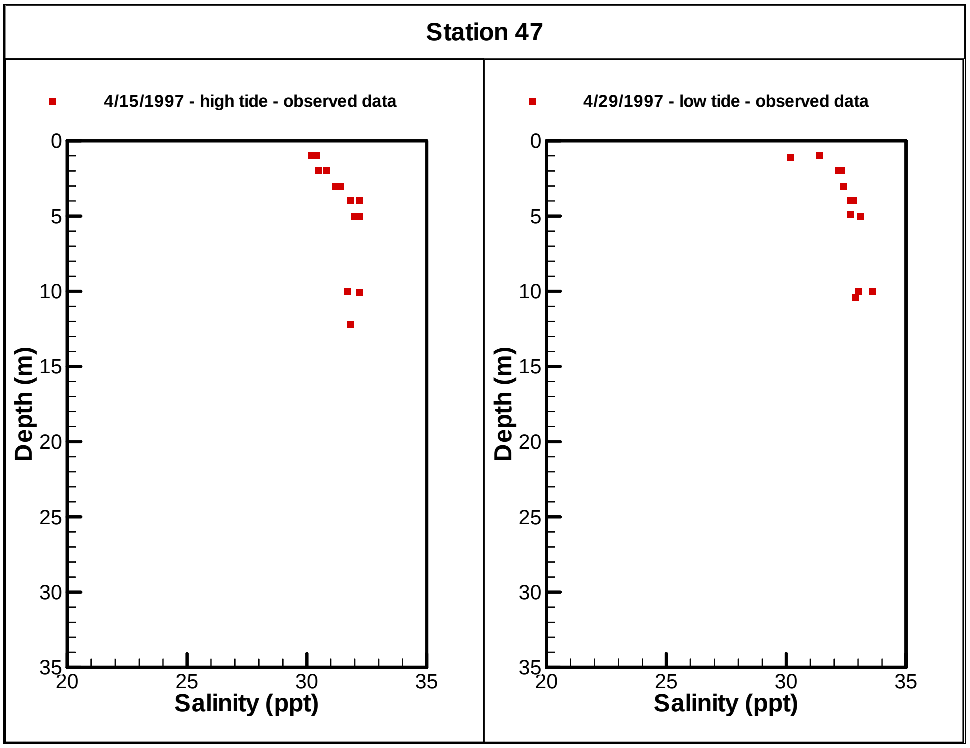


**Figure C-31. Salinity profiles at Station 47 measured in April 1997**

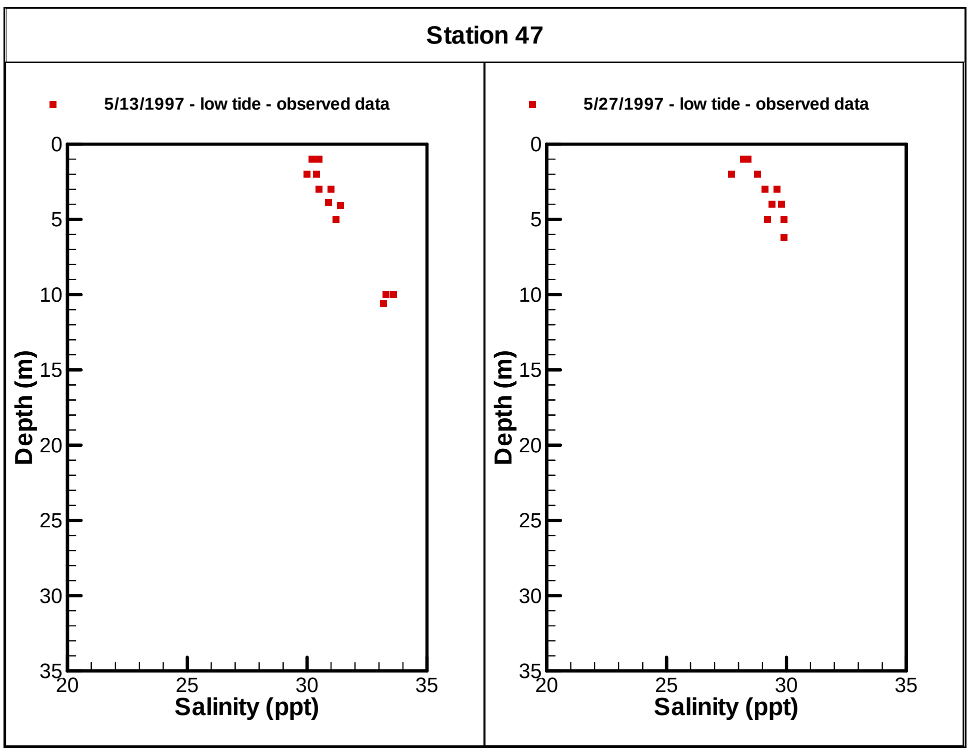


**Figure C-32. Salinity profiles at Station 47 measured in May 1997**

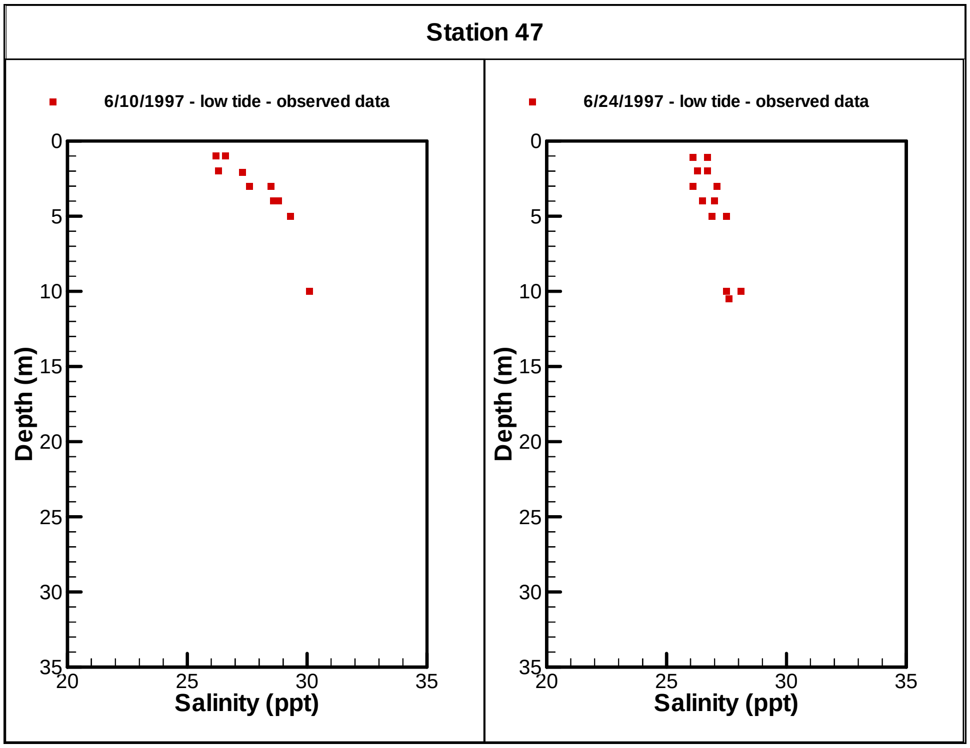


**Figure C-33. Salinity profiles at Station 47 measured in June 1997**

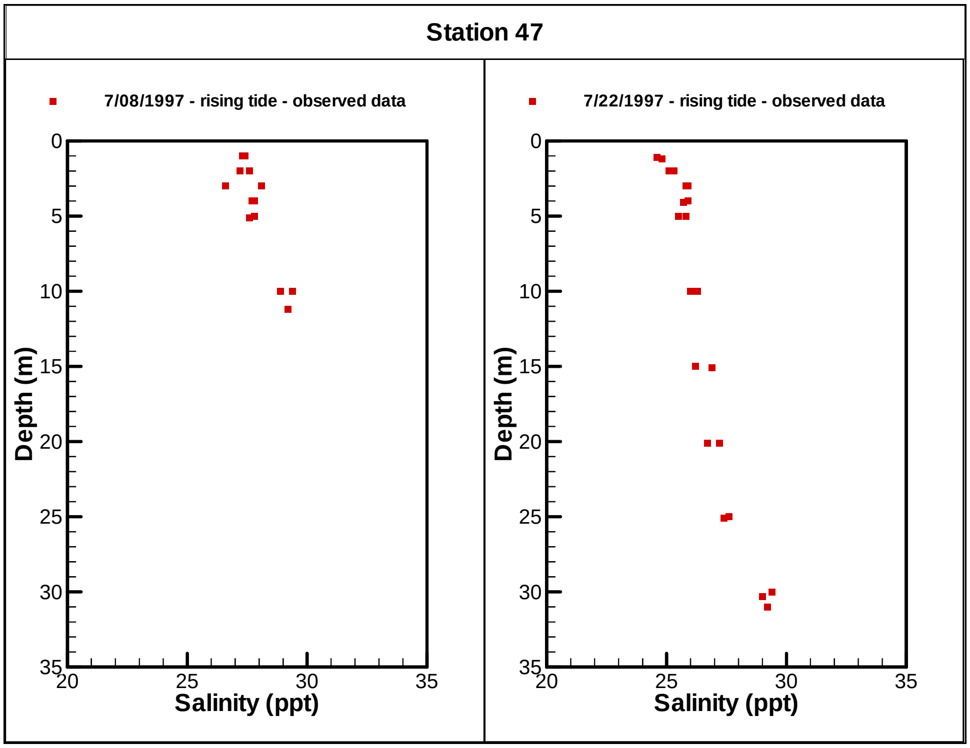


**Figure C-34. Salinity profiles at Station 47 measured in July 1997**

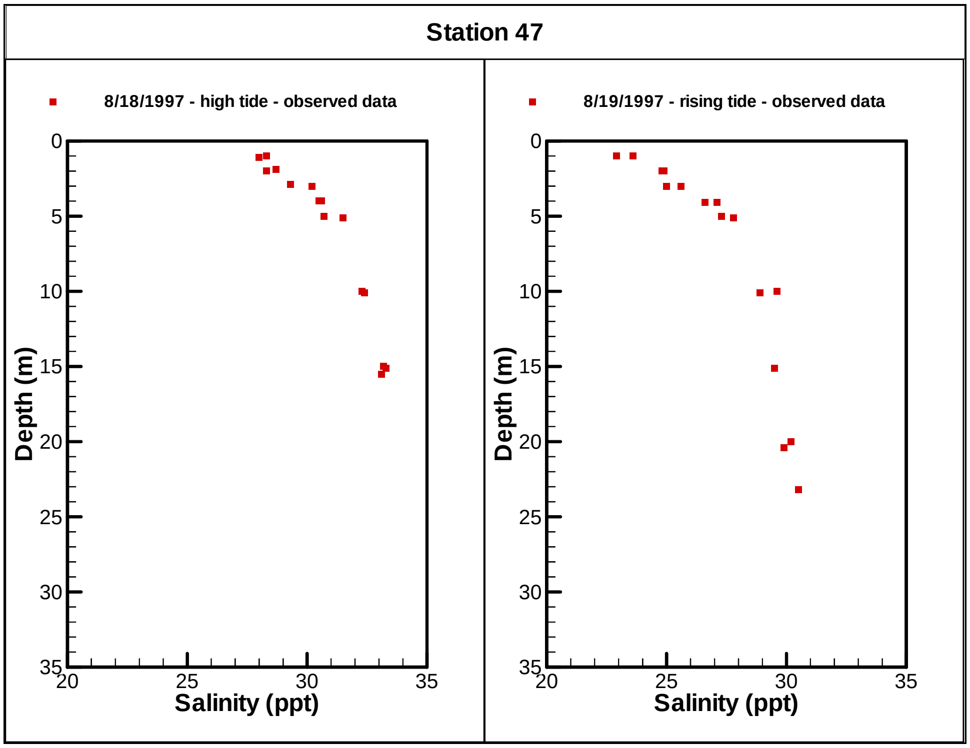


**Figure C-35. Salinity profiles at Station 47 measured in August 1997**

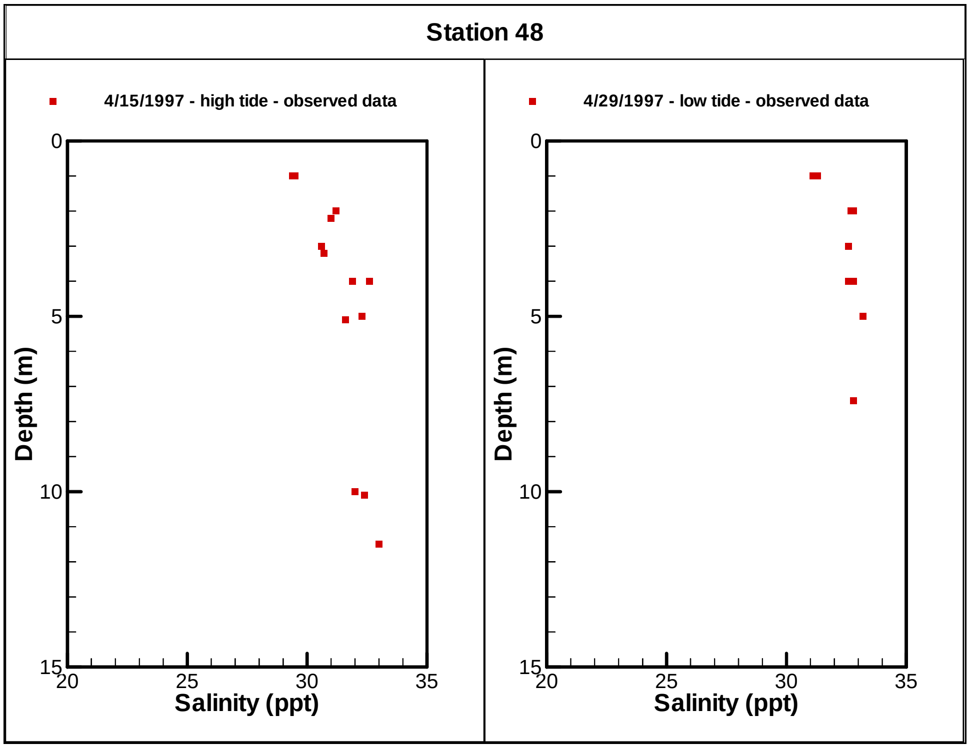


**Figure C-36. Salinity profiles at Station 48 measured in April 1997**

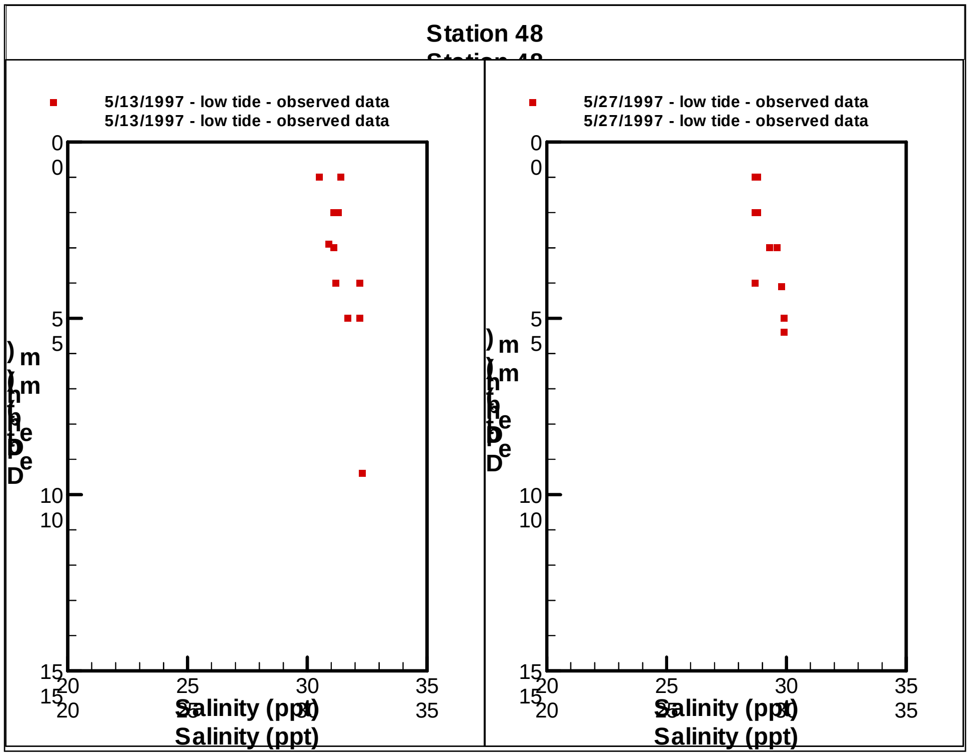


Figure C-37. Salinity profiles at Station 48 measured in May 1997

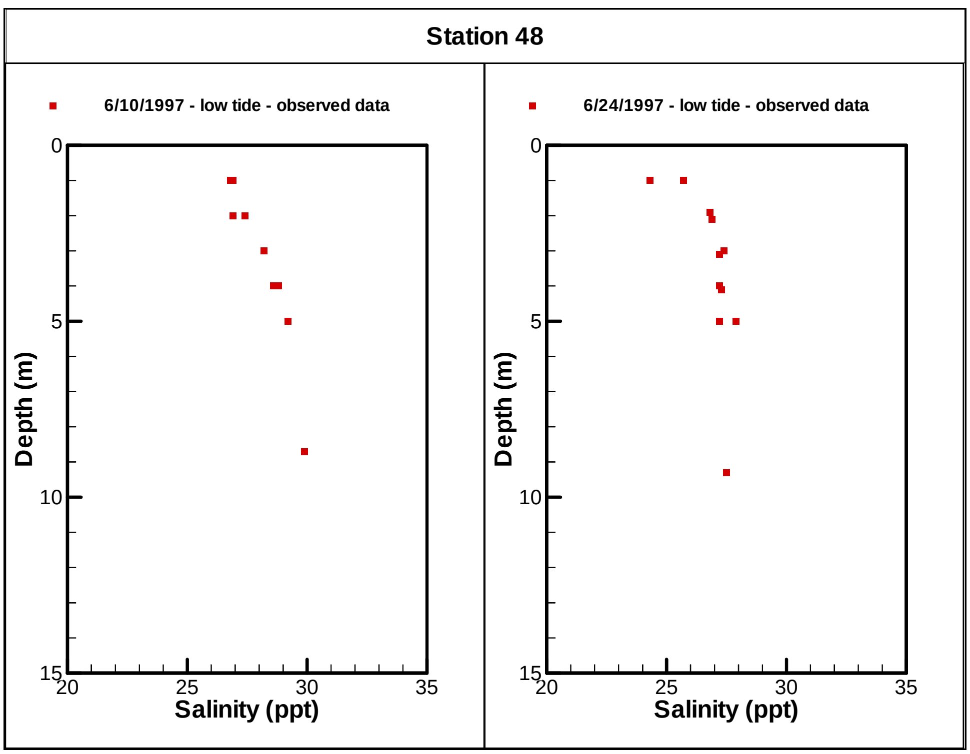


Figure C-38. Salinity profiles at Station 48 measured in June 1997

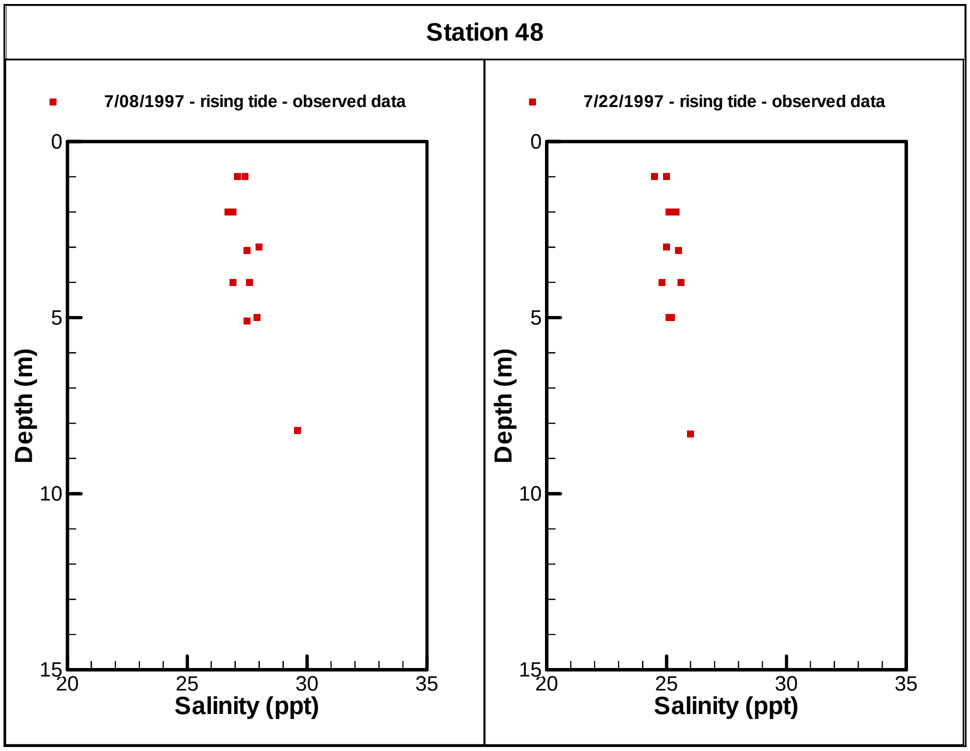


**Figure C-39. Salinity profiles at Station 48 measured in July 1997**

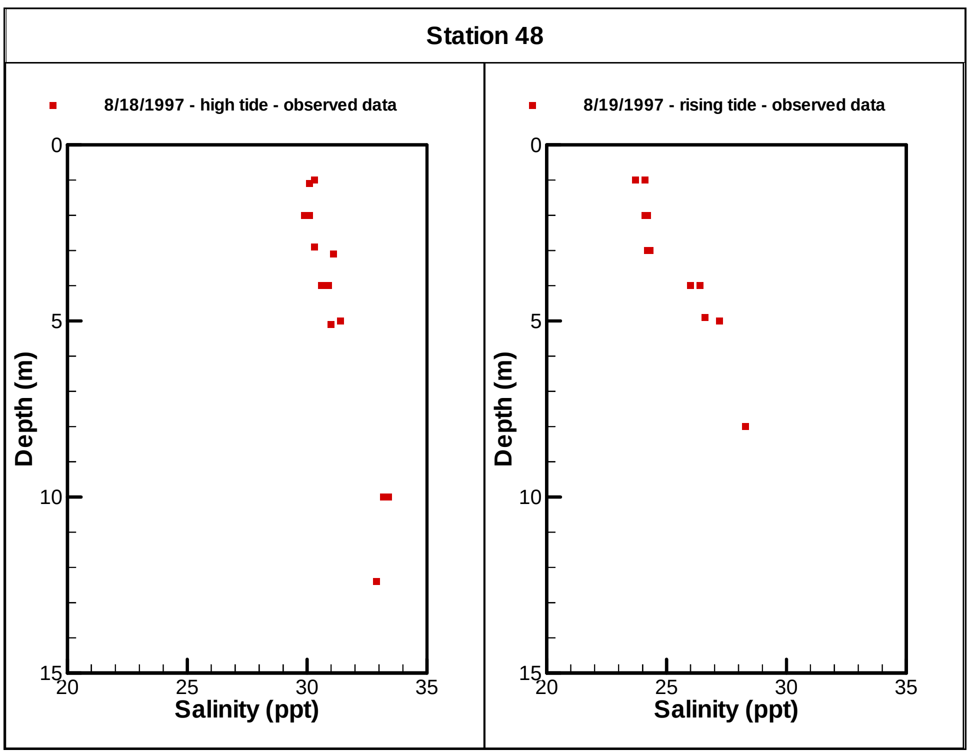


**Figure C-40. Salinity profiles at Station 48 measured in August 1997**

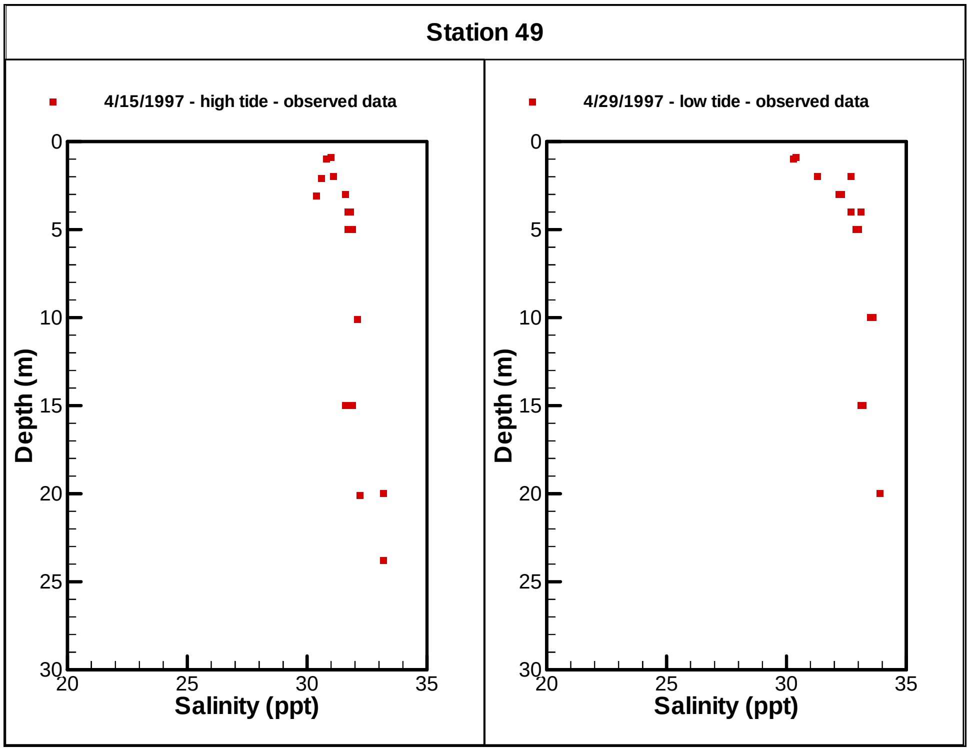


**Figure C-41. Salinity profiles at Station 49 measured in April 1997**

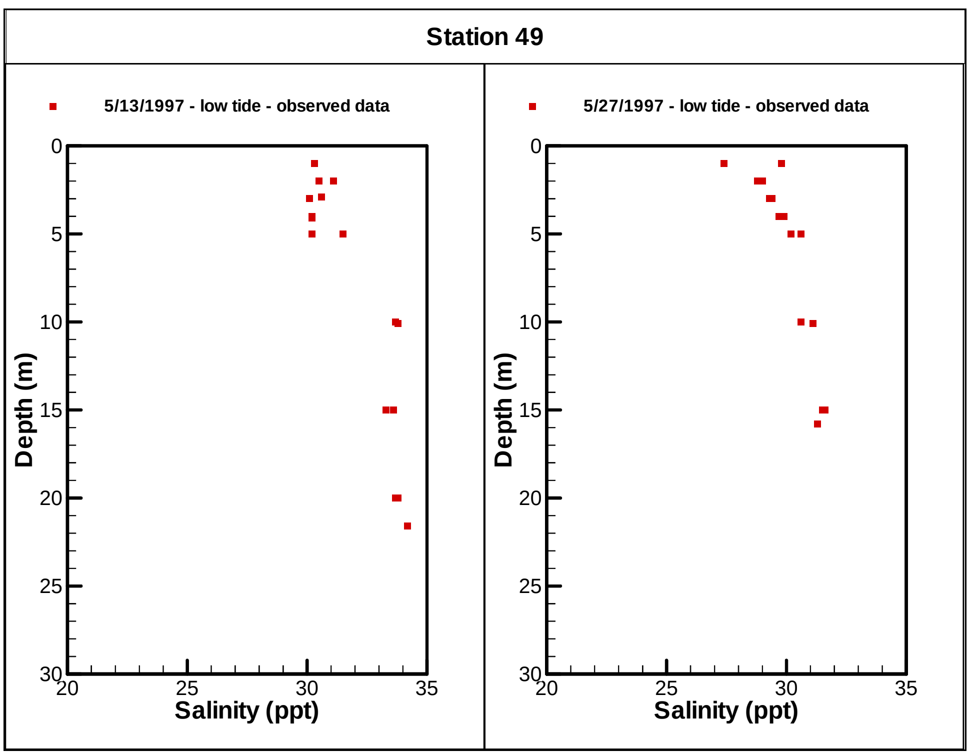


**Figure C-42. Salinity profiles at Station 49 measured in May 1997**

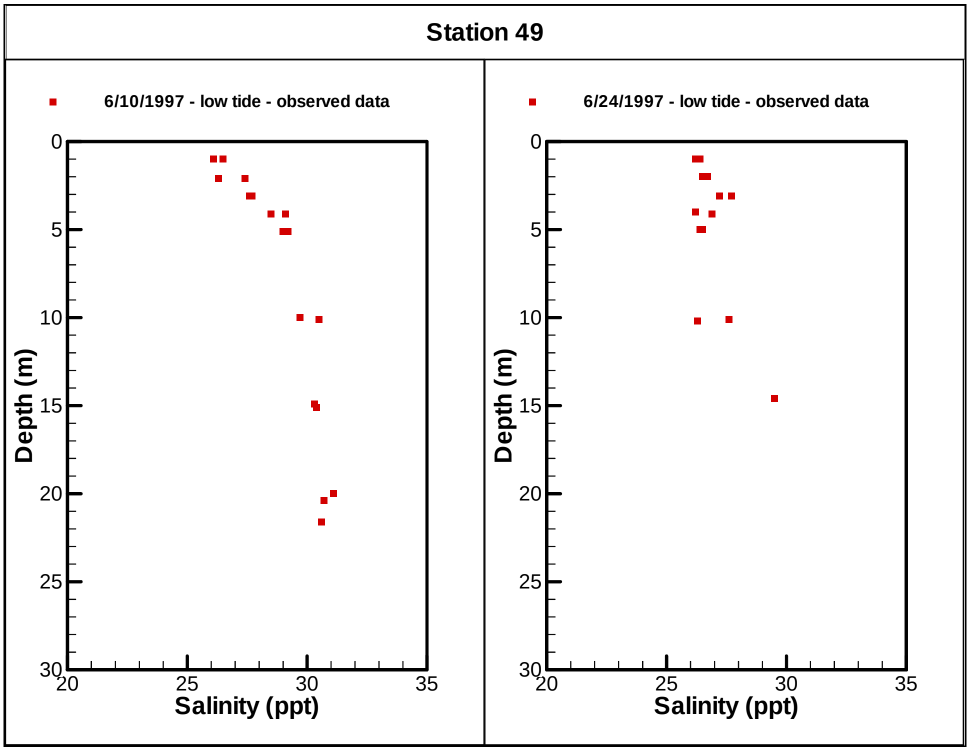


**Figure C-43. Salinity profiles at Station 49 measured in June 1997**

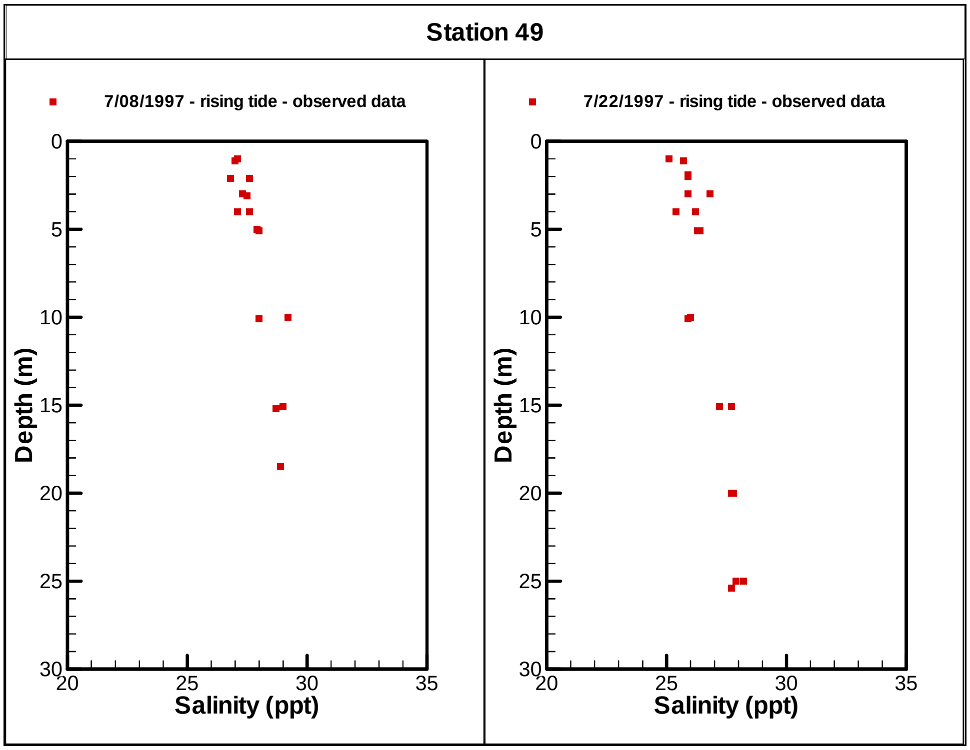


**Figure C-44. Salinity profiles at Station 49 measured in July 1997**

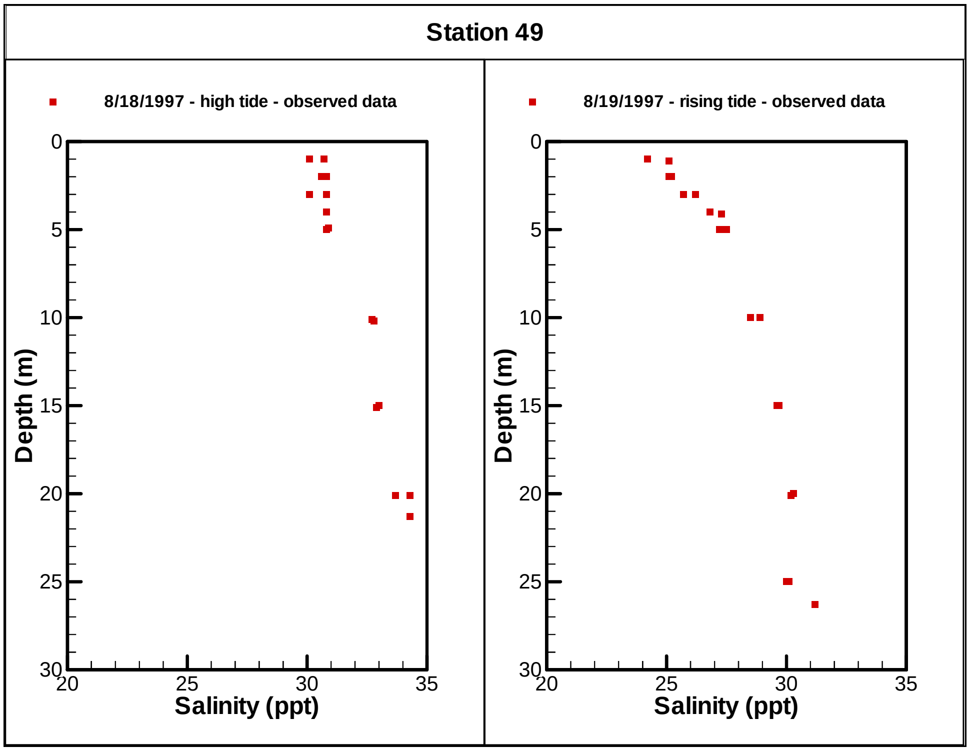


**Figure C-45. Salinity profiles at Station 49 measured in August 1997**

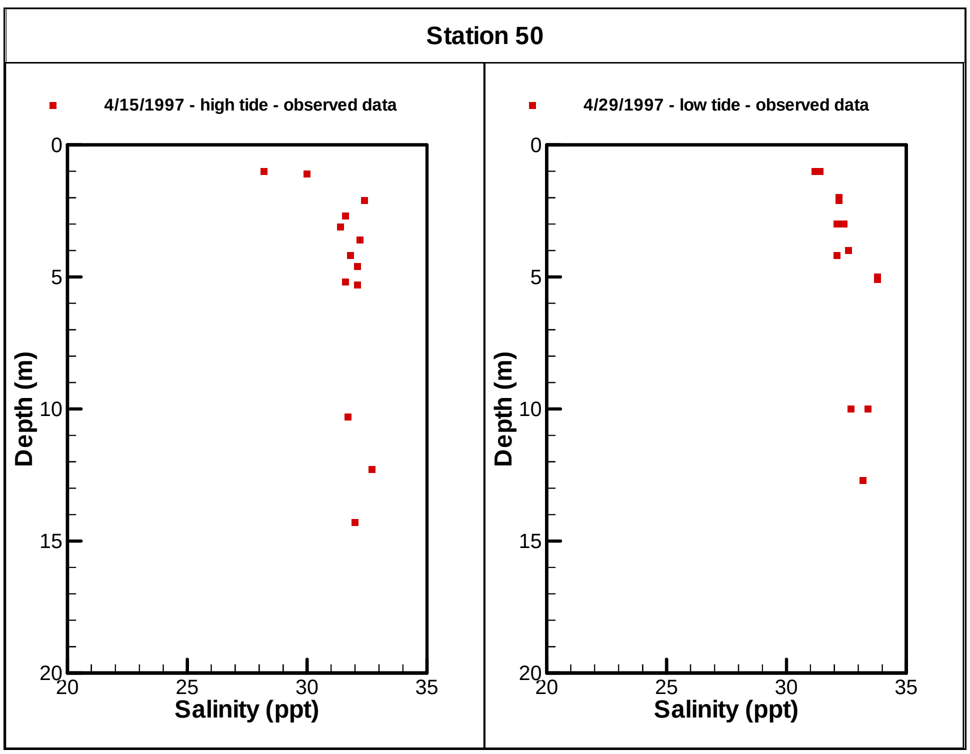


**Figure C-46. Salinity profiles at Station 50 measured in April 1997**

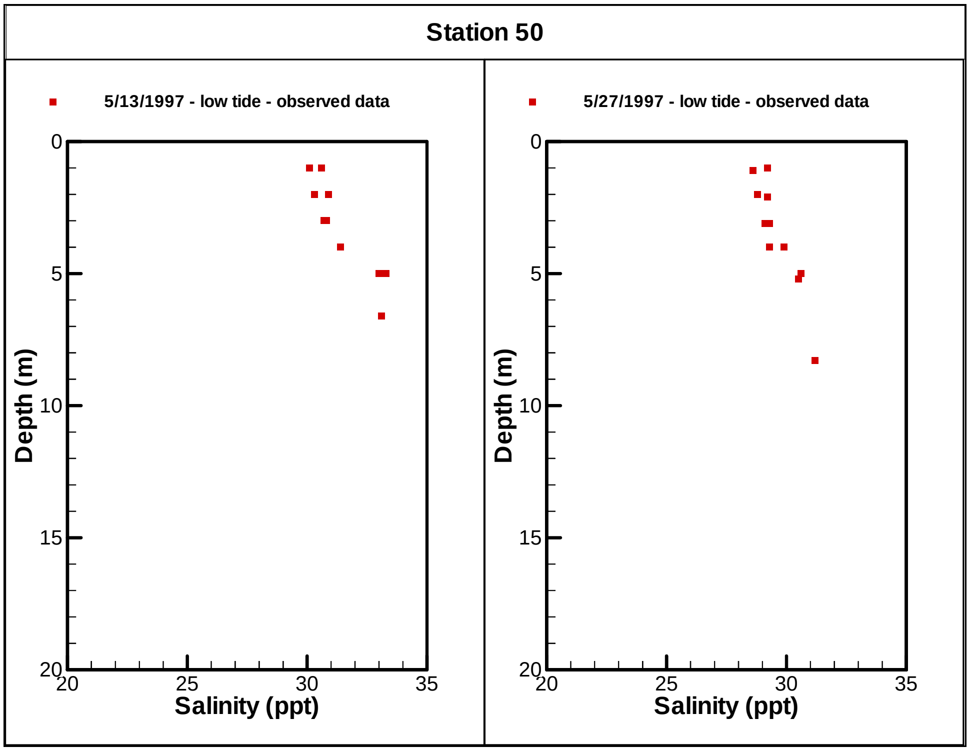


**Figure C-47. Salinity profiles at Station 50 measured in May 1997**

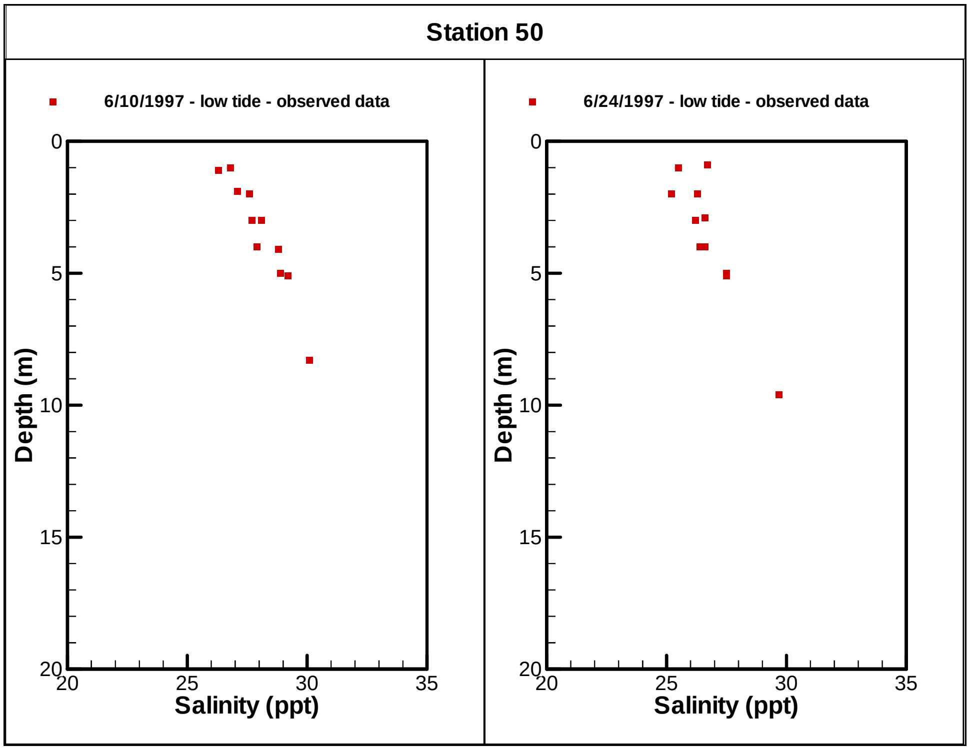


**Figure C-48. Salinity profiles at Station 50 measured in June 1997**

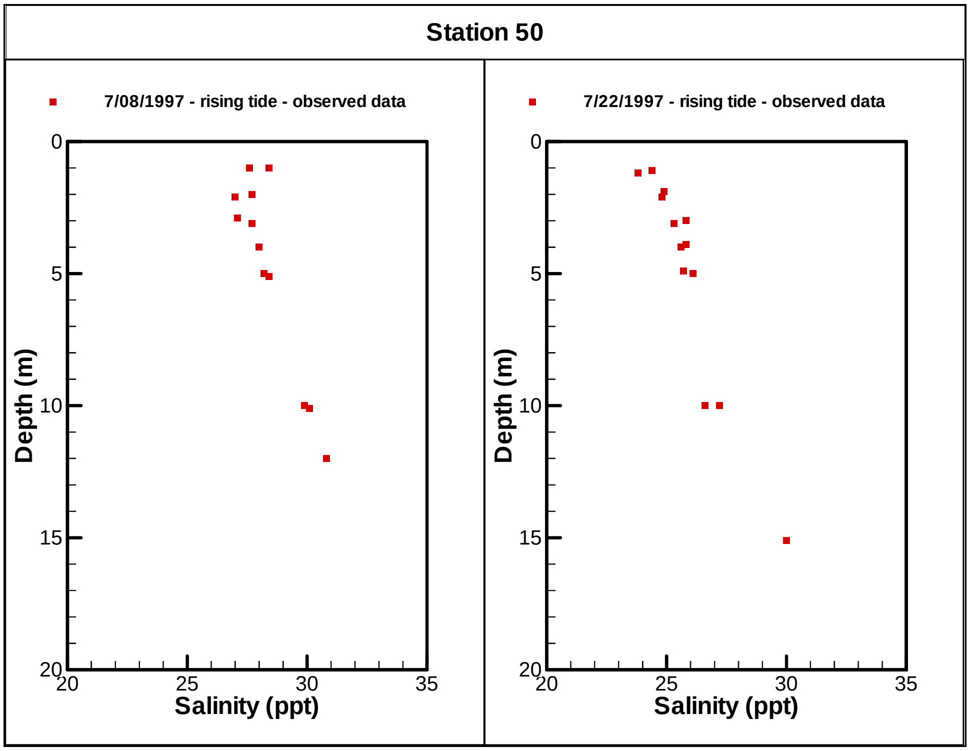


Figure C-49. Salinity profiles at Station 50 measured in July 1997

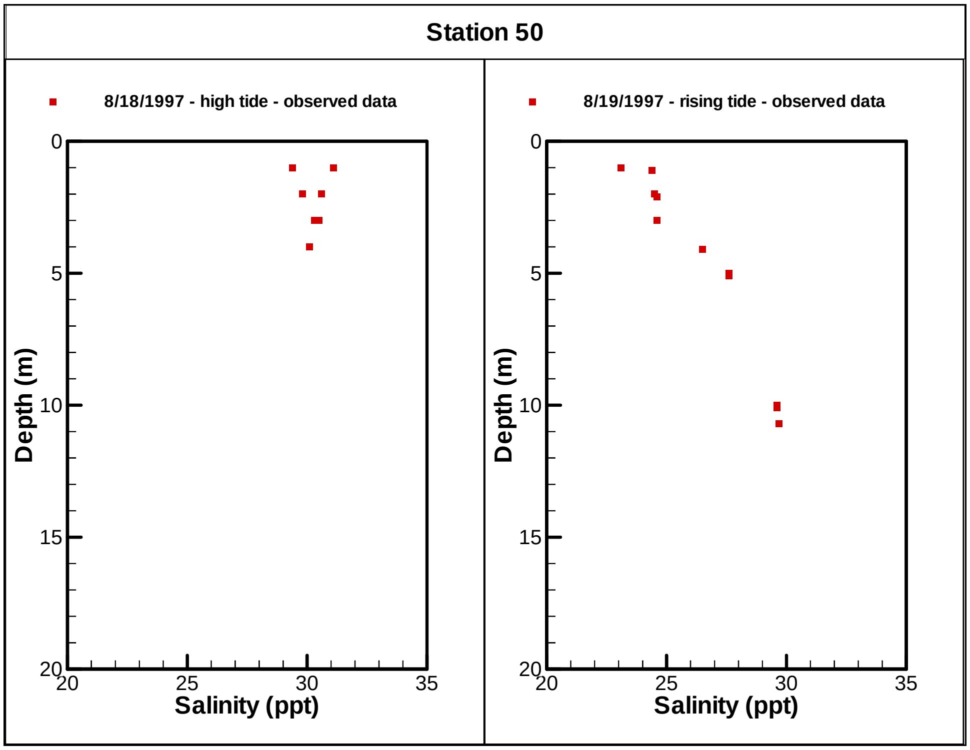


Figure C-50. Salinity profiles at Station 50 measured in August 1997

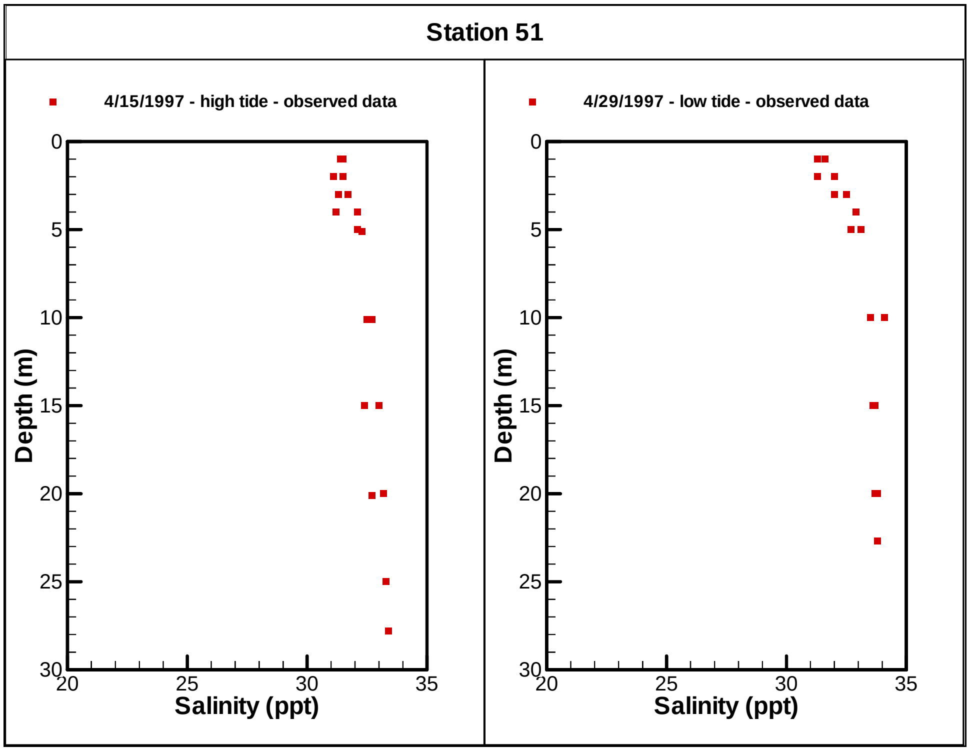


**Figure C-51. Salinity profiles at Station 51 measured in April 1997**

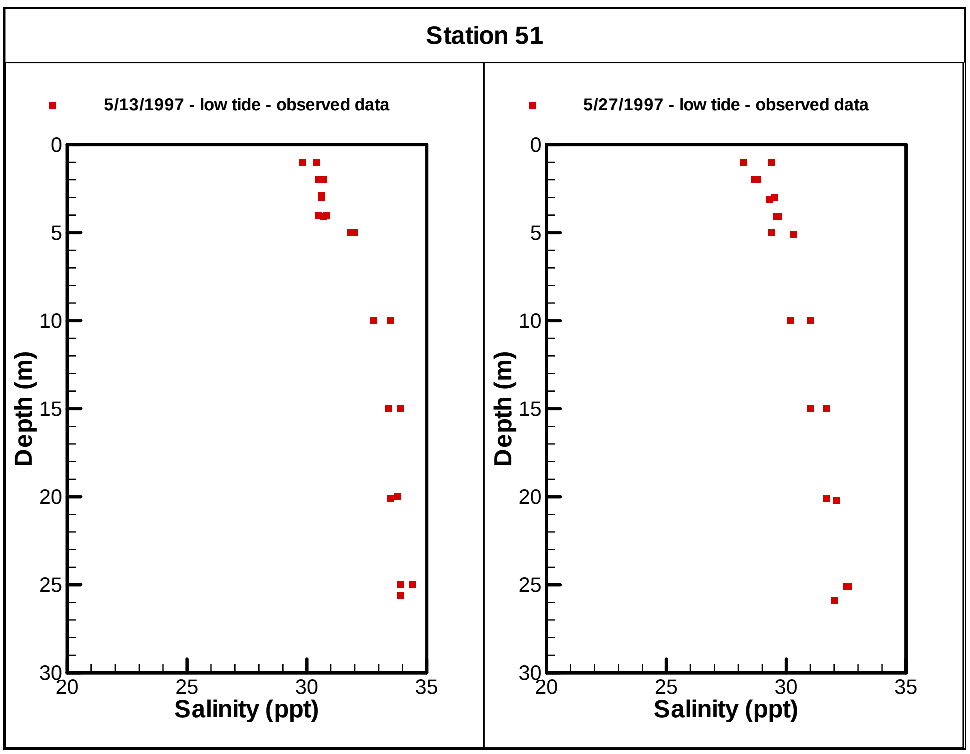


**Figure C-52. Salinity profiles at Station 51 measured in May 1997**

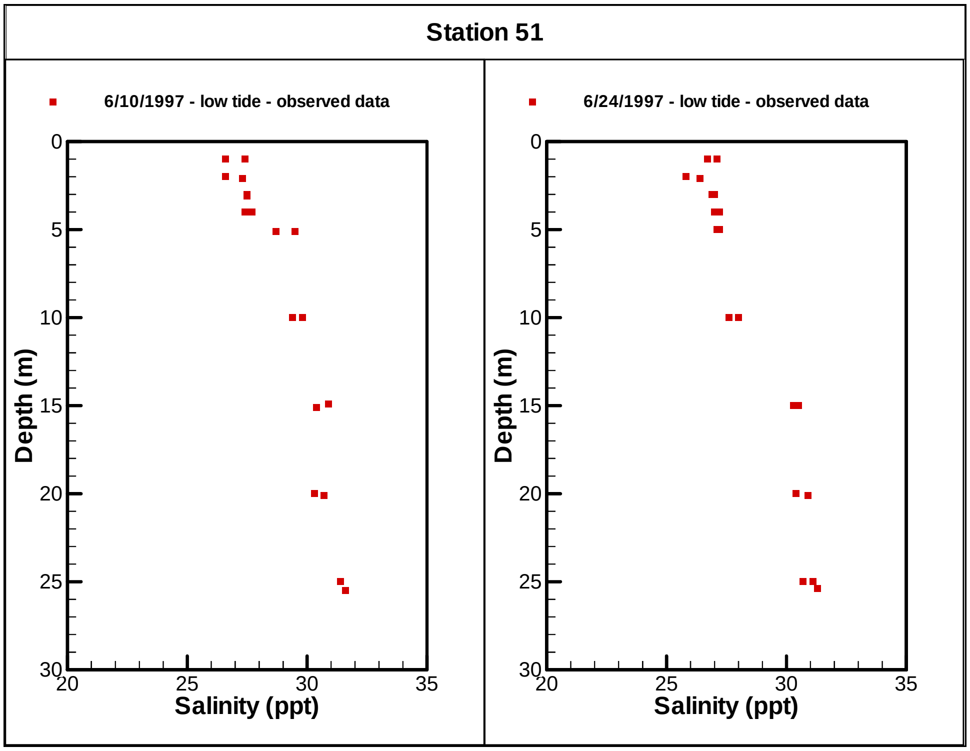


Figure C-53. Salinity profiles at Station 51 measured in June 1997

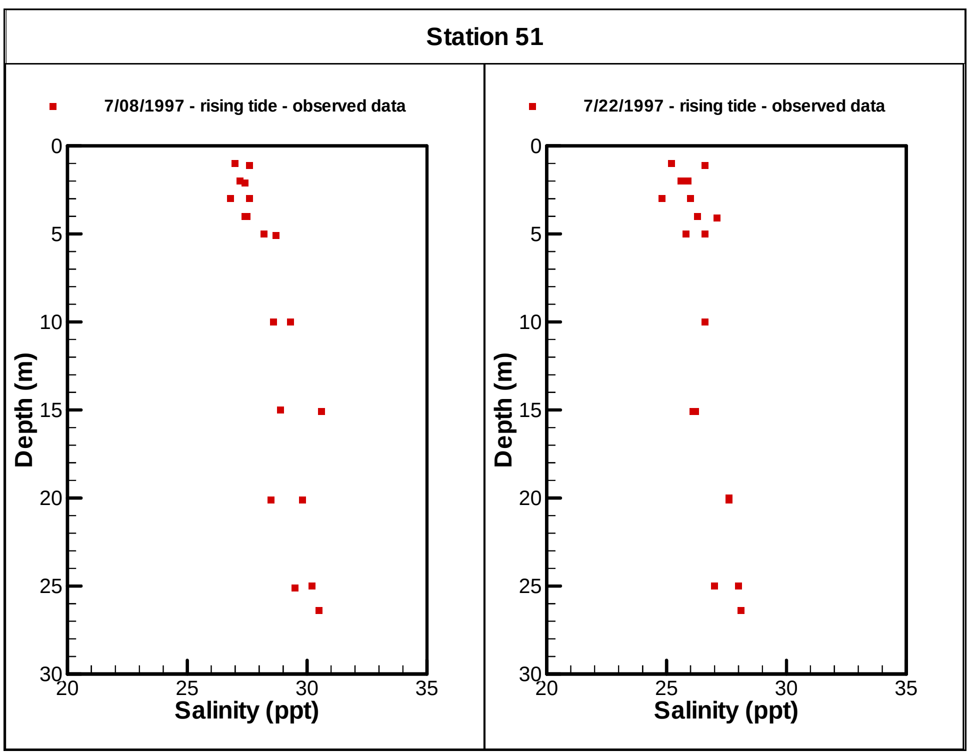


Figure C-54. Salinity profiles at Station 51 measured in July 1997

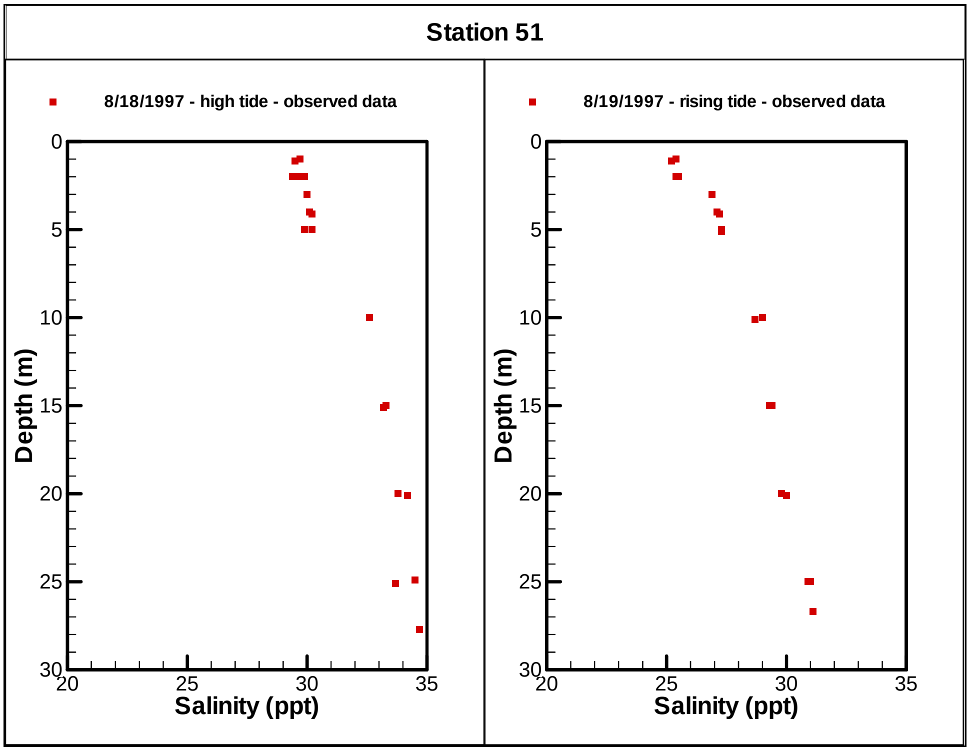


**Figure C-55. Salinity profiles at Station 51 measured in August 1997**

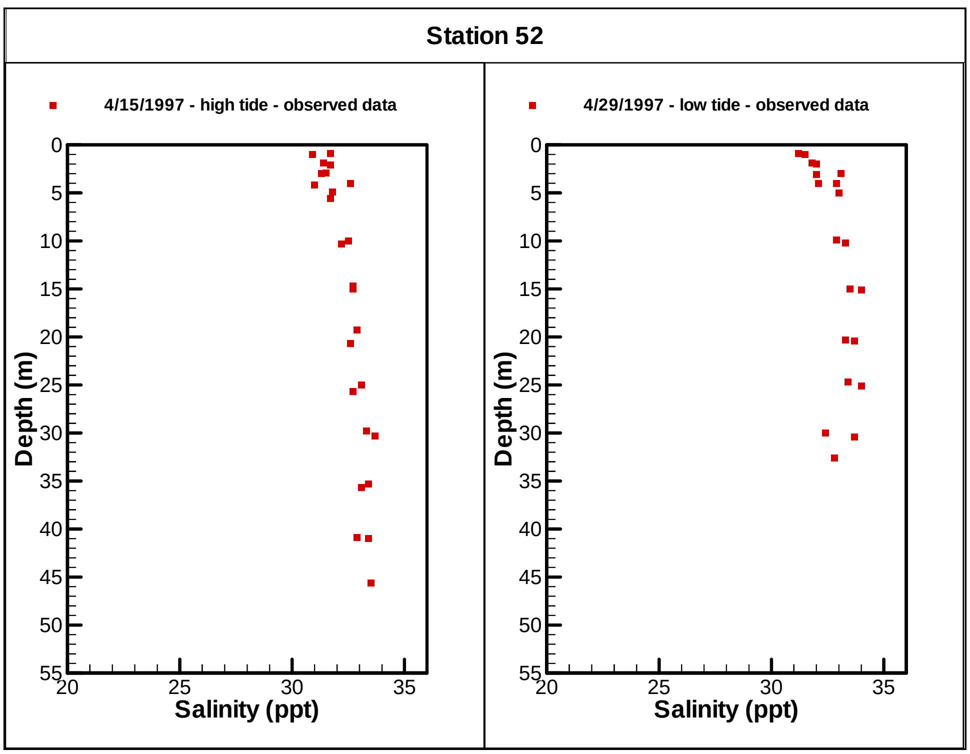


**Figure C-56. Salinity profiles at Station 52 measured in April 1997**

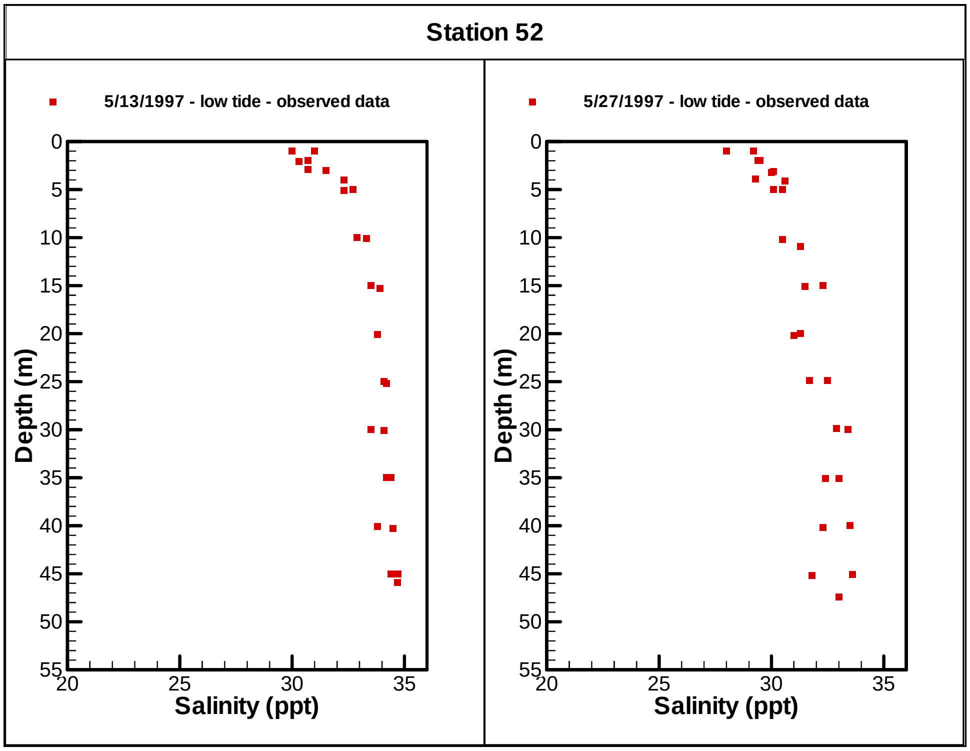


**Figure C-57. Salinity profiles at Station 52 measured in May 1997**

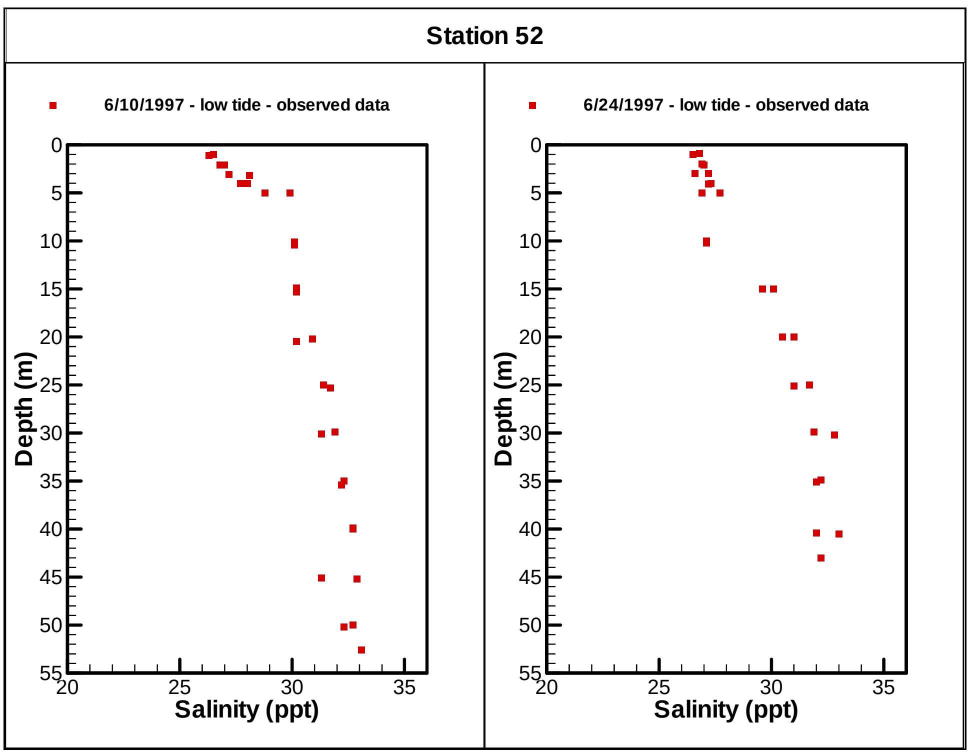


**Figure C-58. Salinity profiles at Station 52 measured in June 1997**

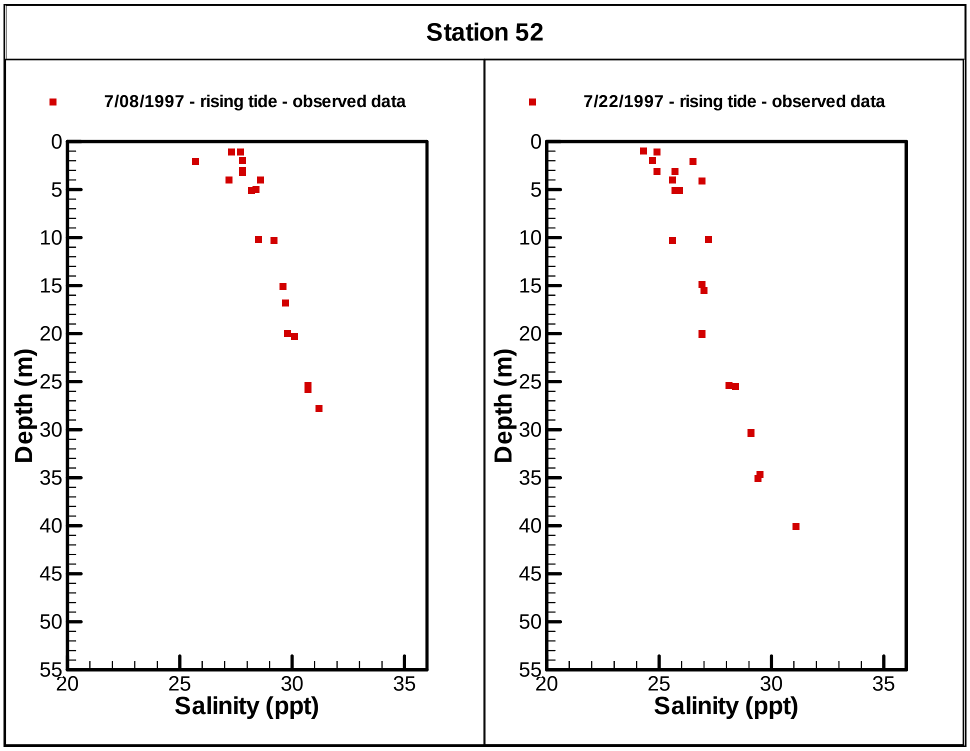


**Figure C-59. Salinity profiles at Station 52 measured in July 1997**

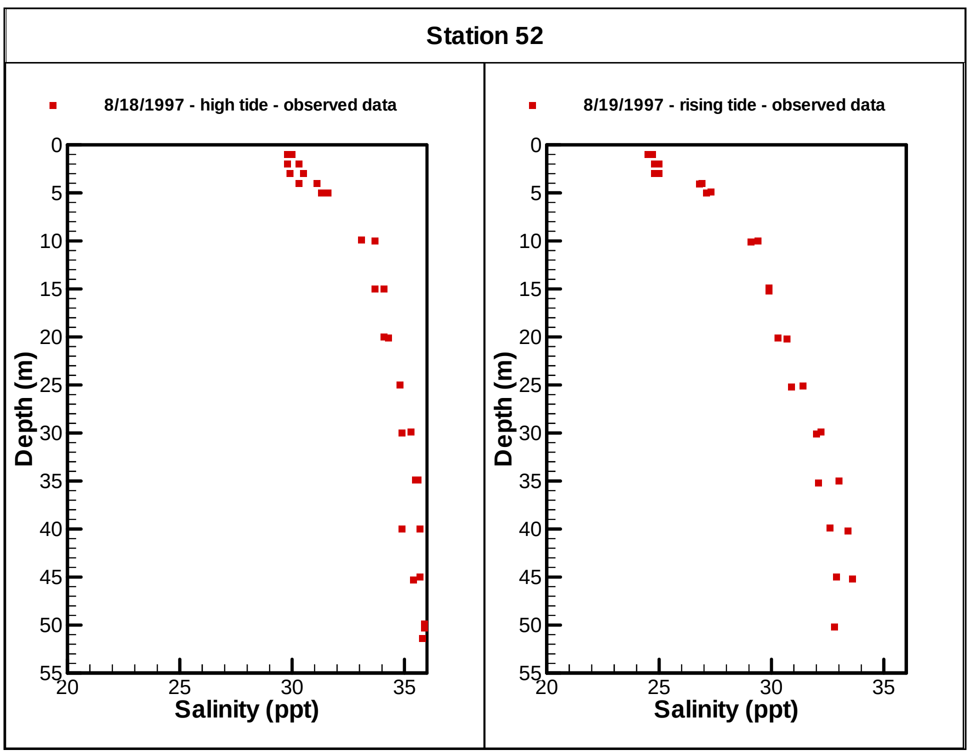


**Figure C-60. Salinity profiles at Station 52 measured in August 1997**

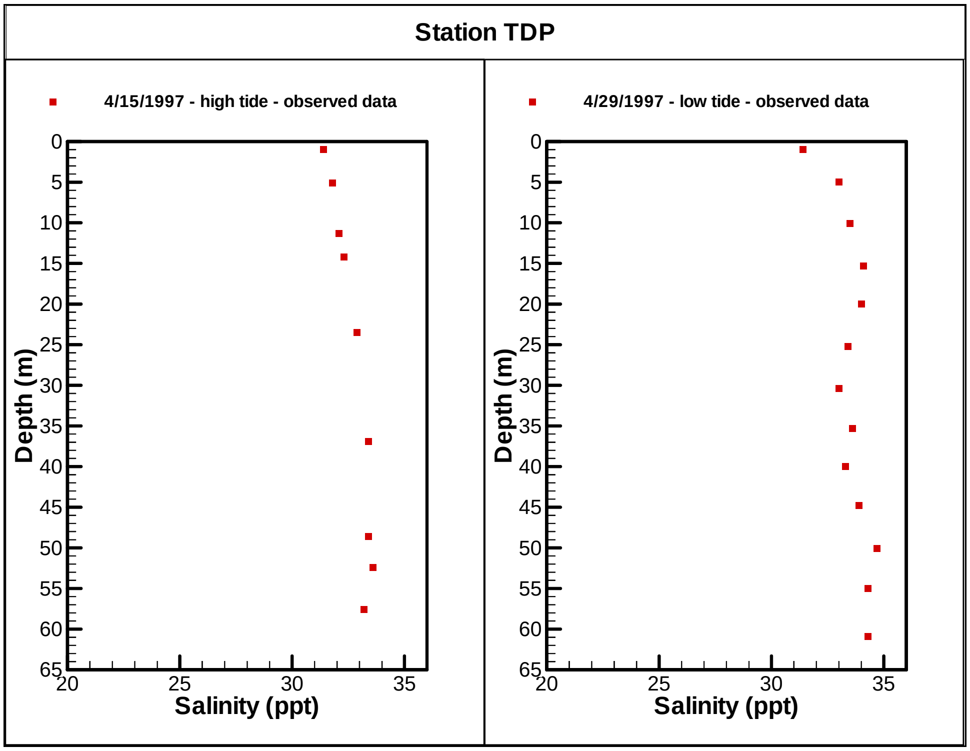


**Figure C-61. Salinity profiles at Station TDP measured in April 1997**

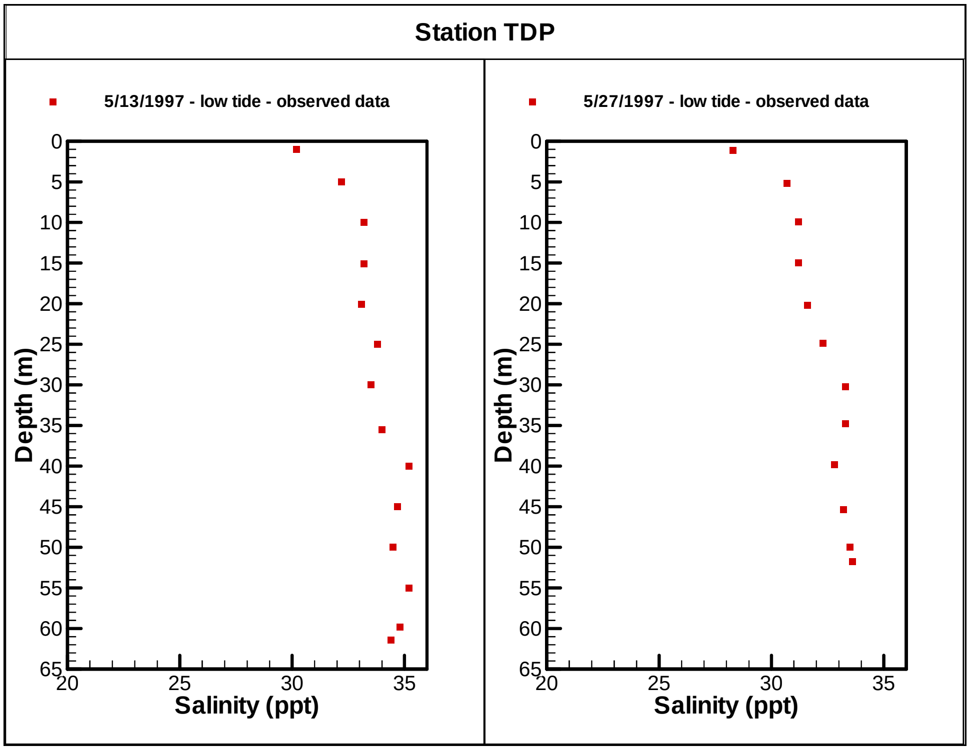


**Figure C-62. Salinity profiles at Station TDP measured in May 1997**

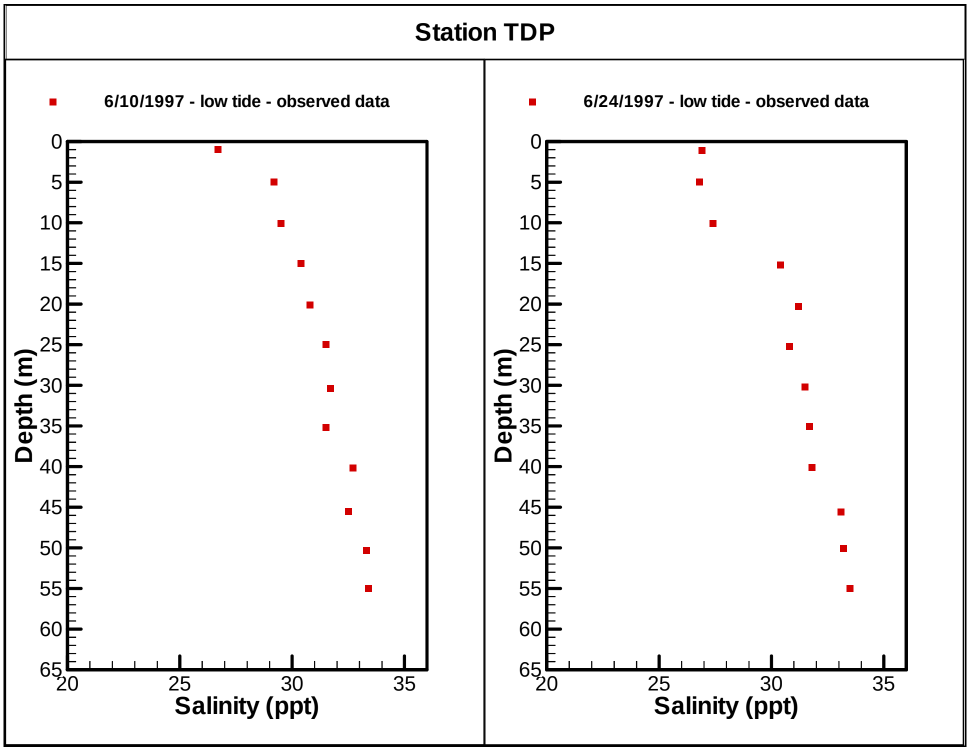


**Figure C-63. Salinity profiles at Station TDP measured in June 1997**

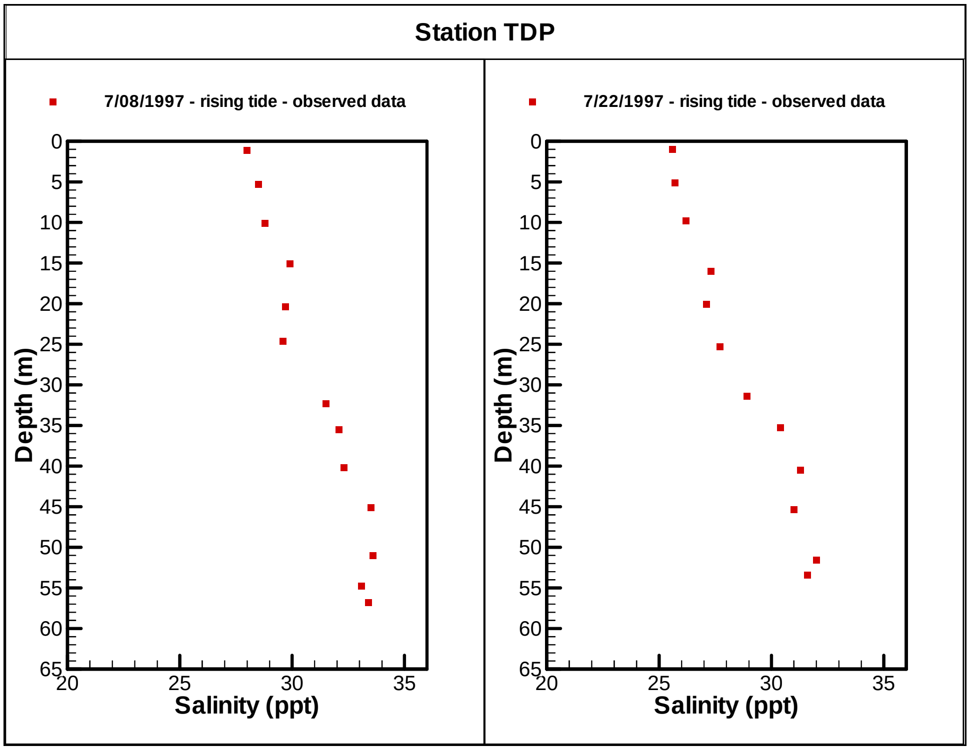


**Figure C-64. Salinity profiles at Station TDP measured in July 1997**

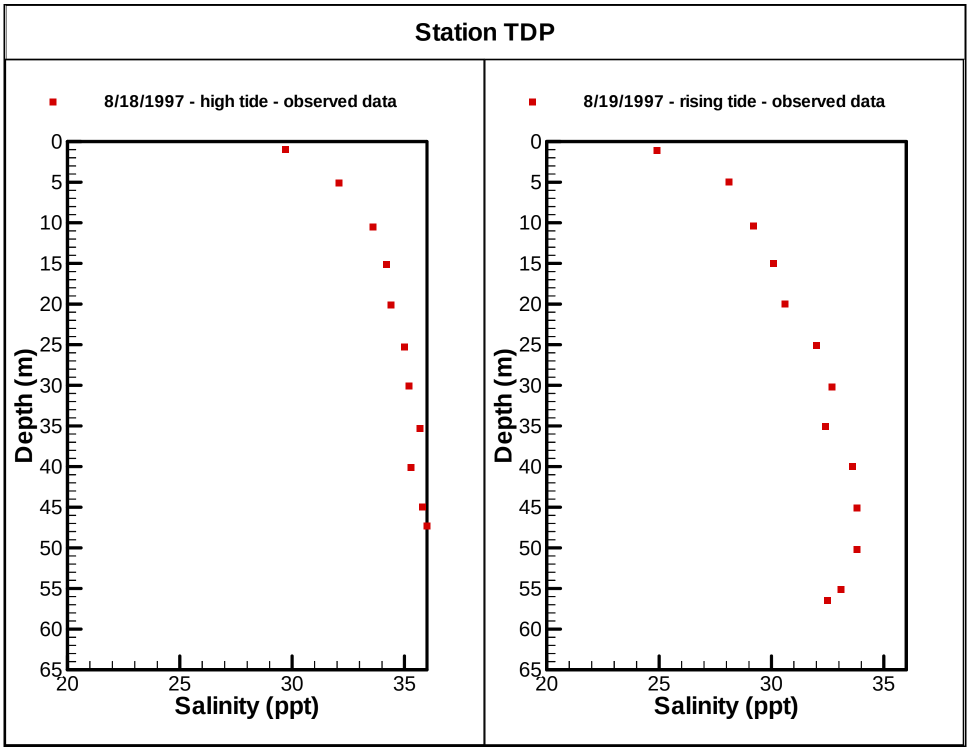


**Figure C-65. Salinity profiles at Station TDP measured in August 1997**

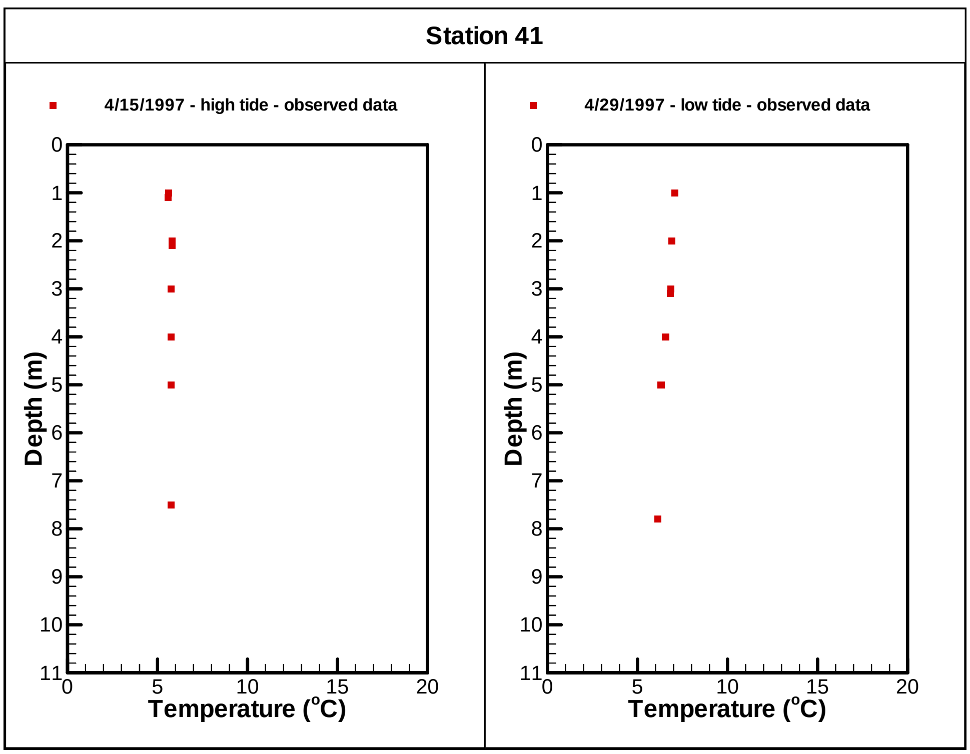


**Figure C-66. Temperature profiles at Station 41 measured in April 1997**

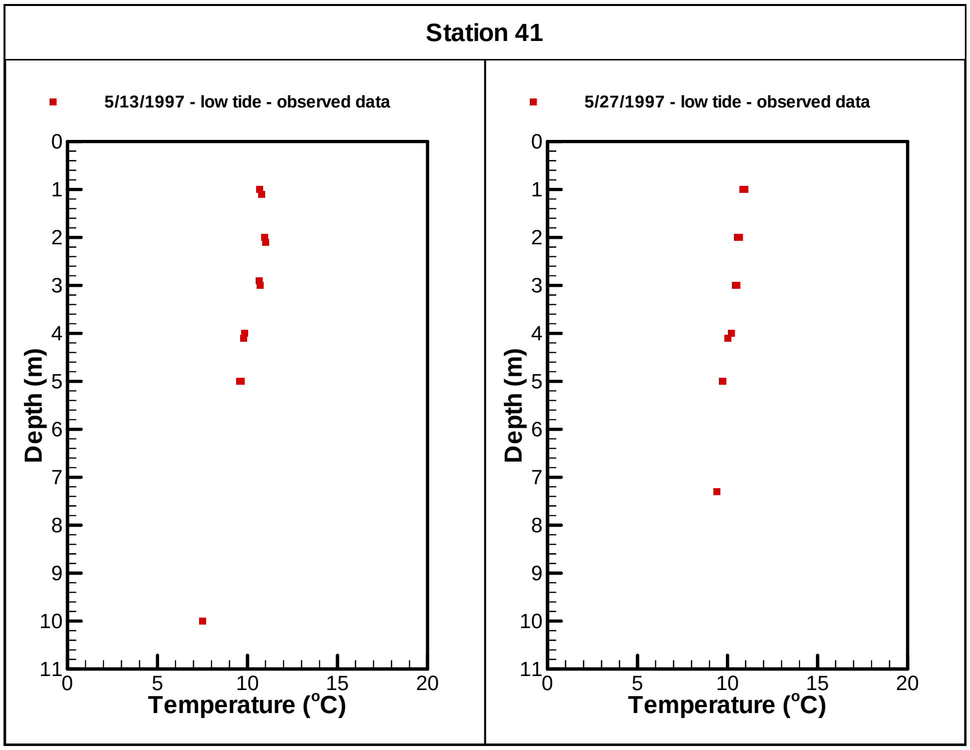


**Figure C-67. Temperature profiles at Station 41 measured in May 1997**

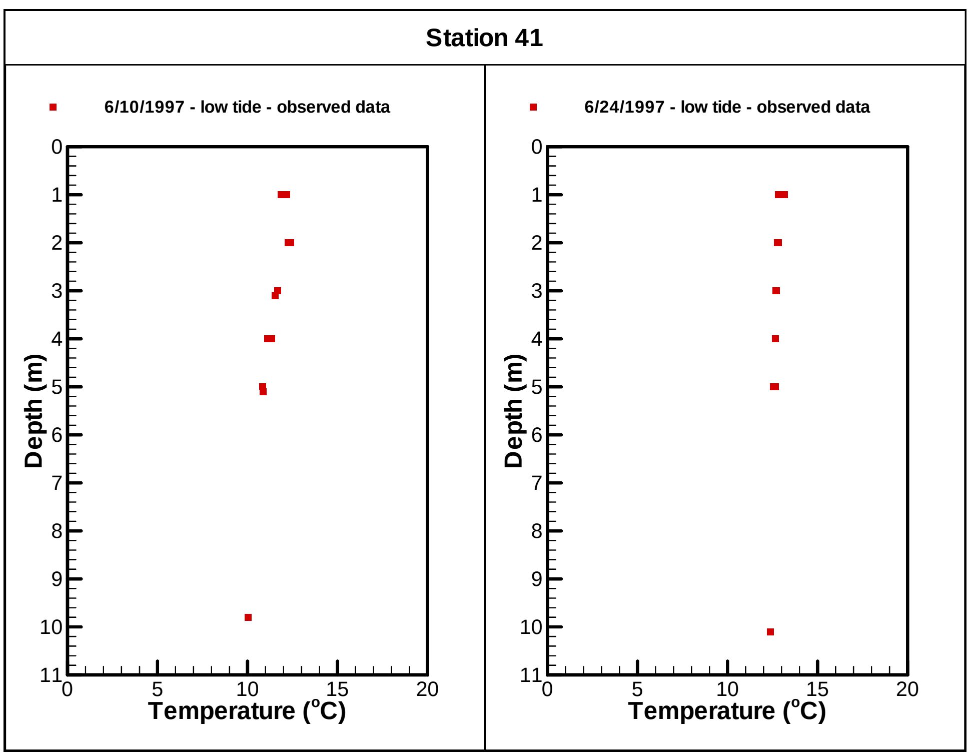


**Figure C-68. Temperature profiles at Station 41 measured in June 1997**

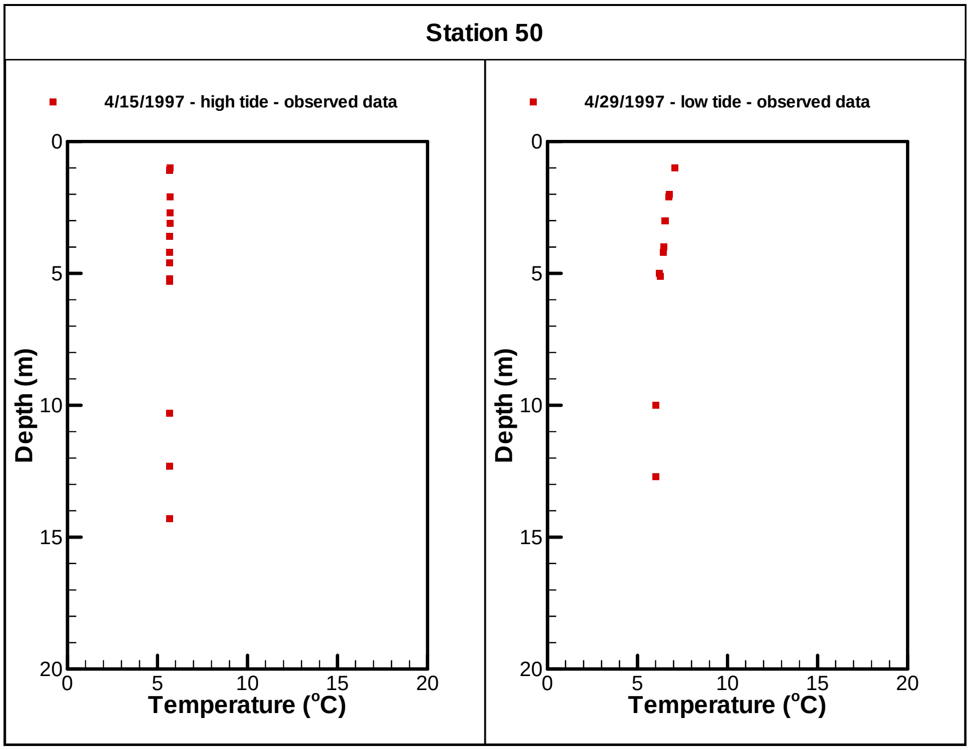


**Figure C-69. Temperature profiles at Station 50 measured in April 1997**

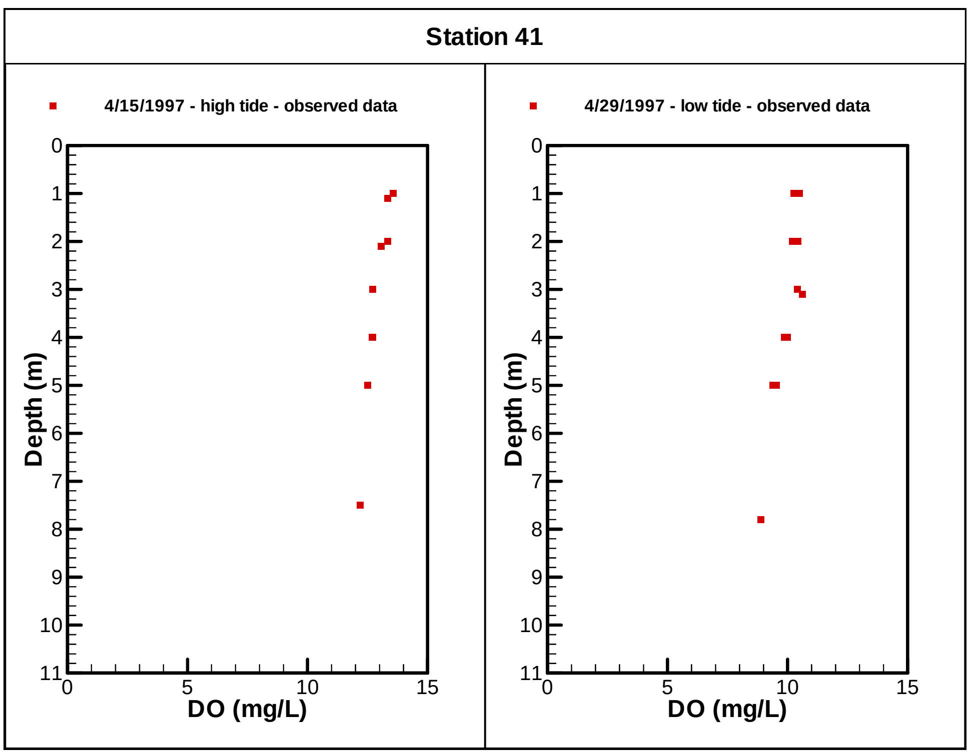


**Figure C-70. Dissolved oxygen profiles at Station 41 measured on April 1997**

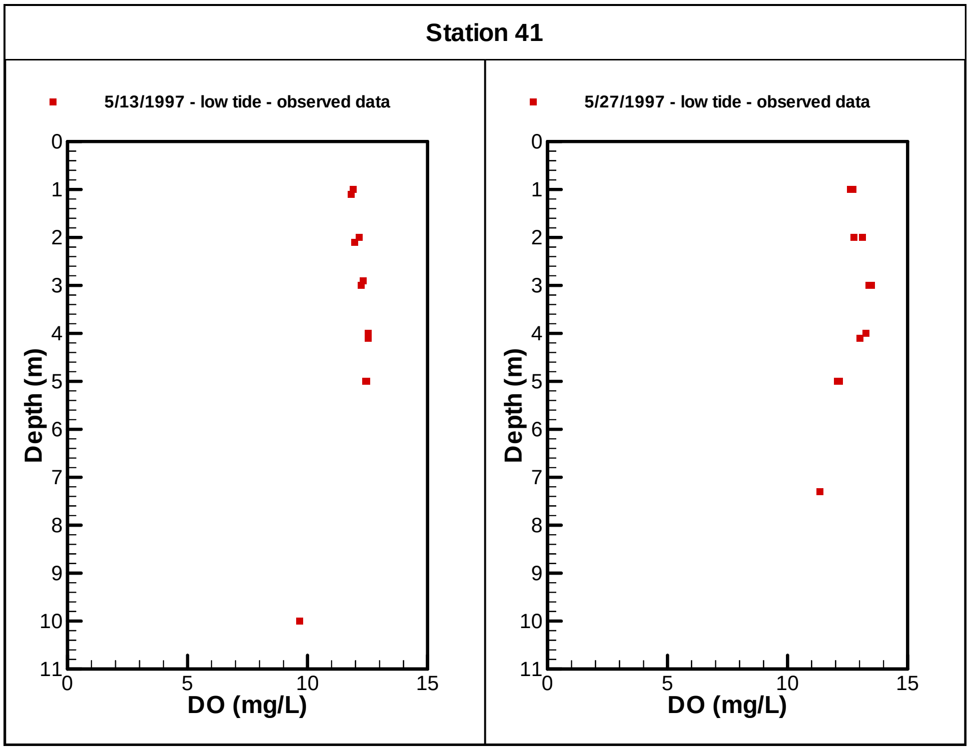


**Figure C-71. Dissolved oxygen profiles at Station 41 measured on May 1997**

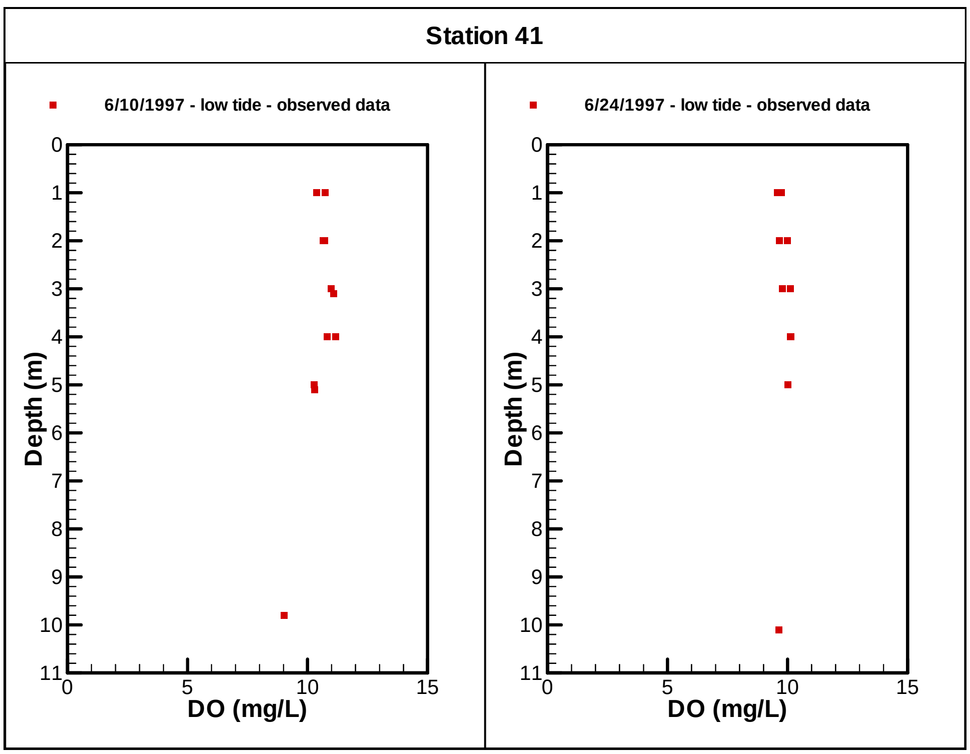


**Figure C-72. Dissolved oxygen profiles at Station 41 measured on June 1997**

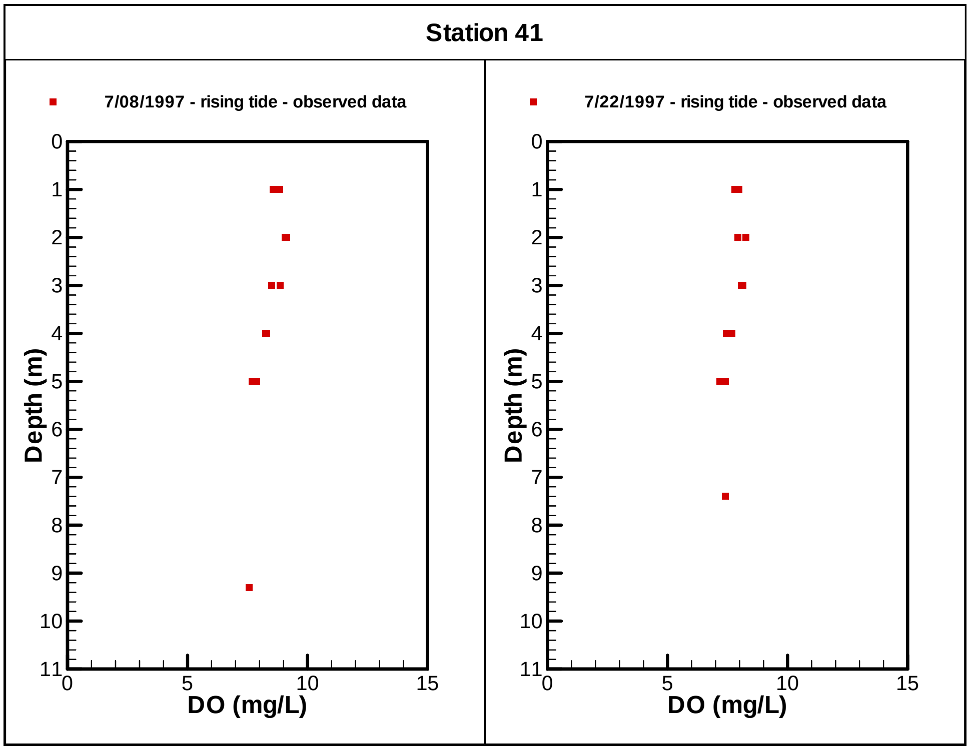


**Figure C-73. Dissolved oxygen profiles at Station 41 measured on July 1997**

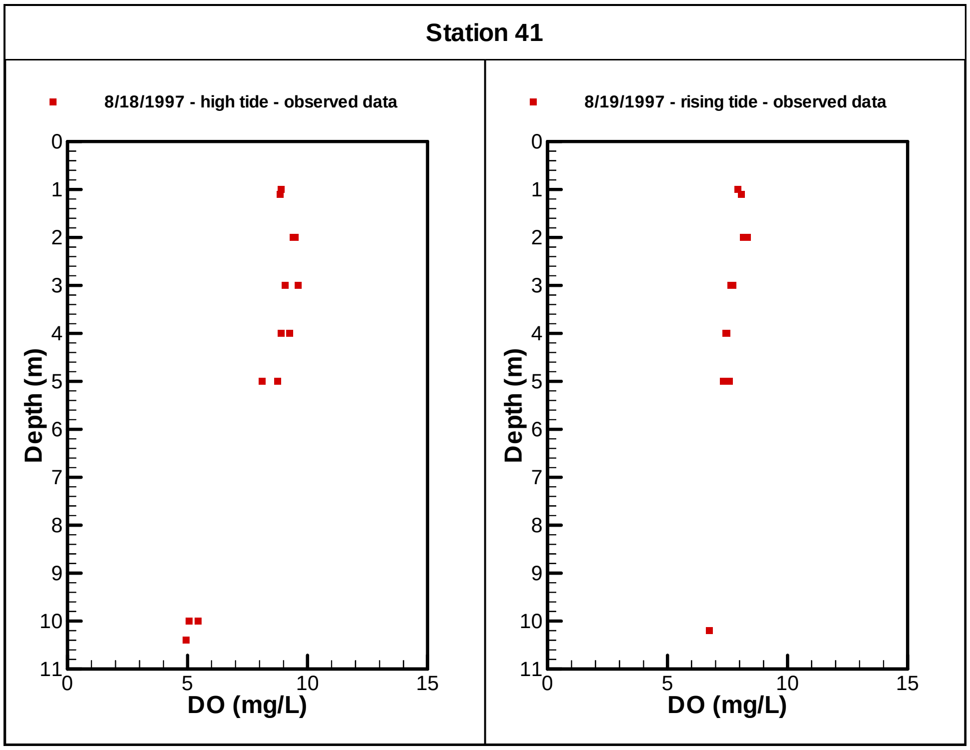


**Figure C-74. Dissolved oxygen profiles at Station 41 measured on August 1997**

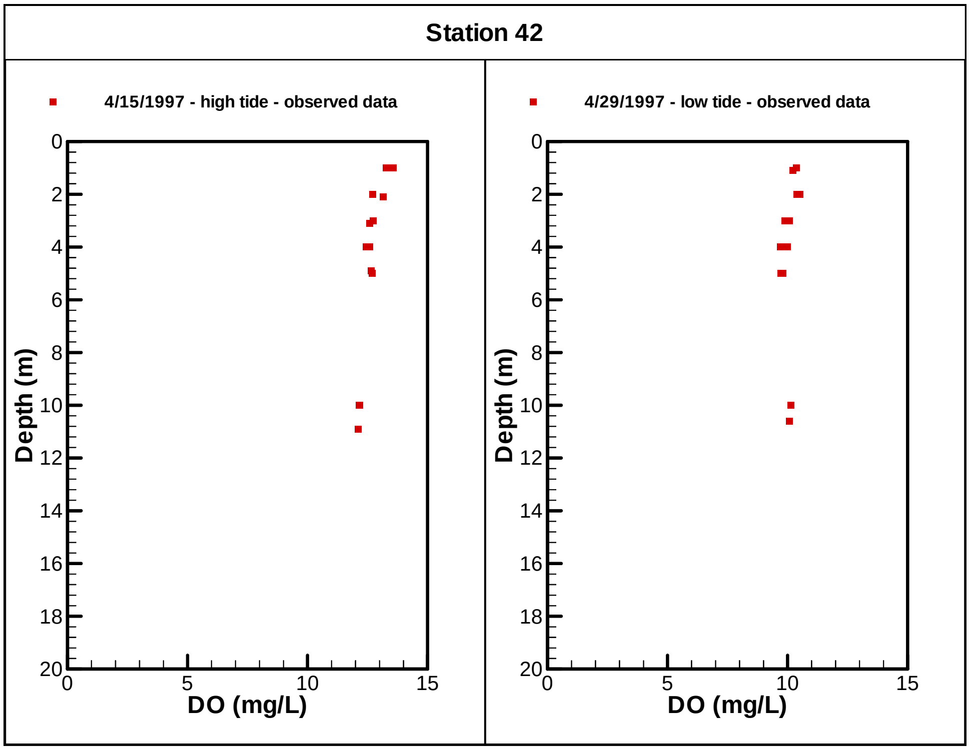


**Figure C-75. Dissolved oxygen profiles at Station 42 measured on April 1997**

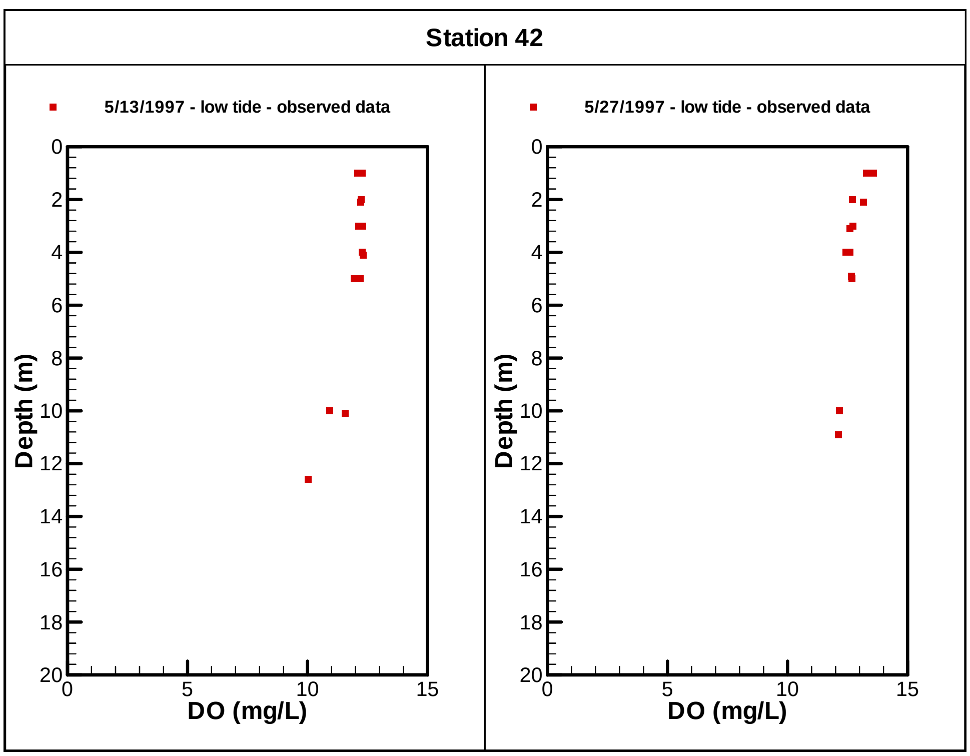


**Figure C-76. Dissolved oxygen profiles at Station 42 measured on May 1997**

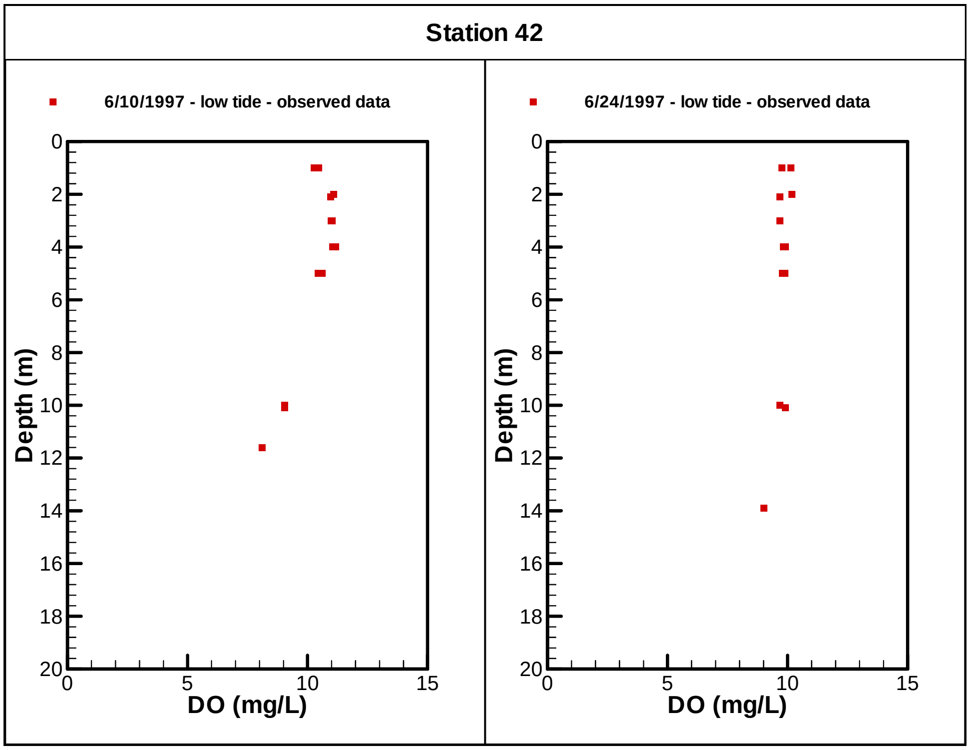


**Figure C-77. Dissolved oxygen profiles at Station 42 measured on June 1997**

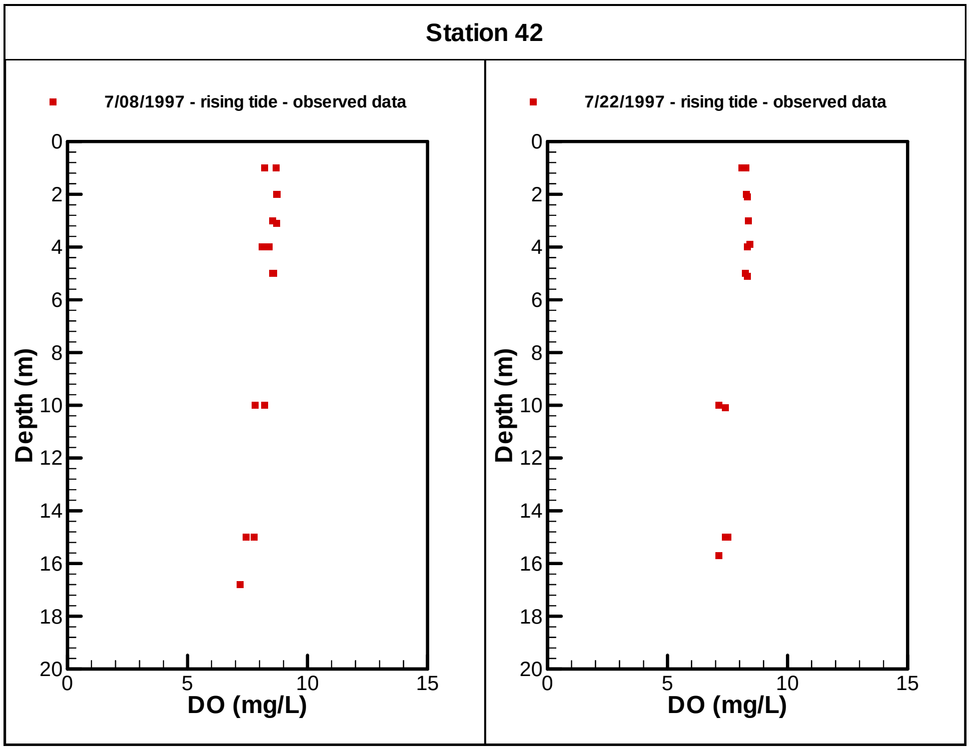


**Figure C-78. Dissolved oxygen profiles at Station 42 measured on July 1997**

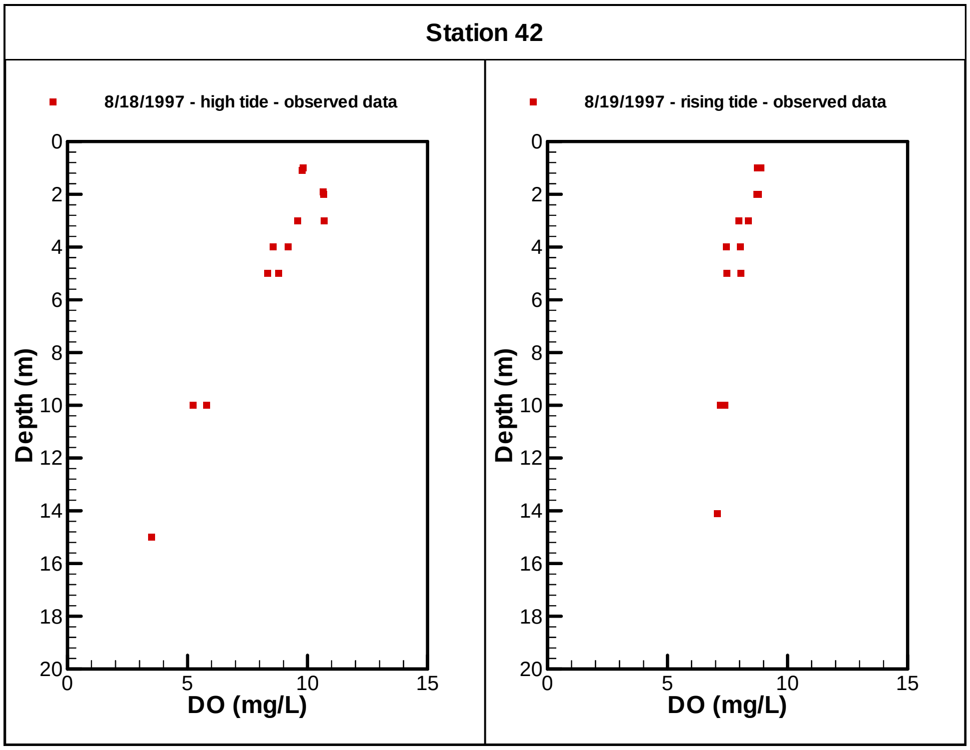


**Figure C-79. Dissolved oxygen profiles at Station 42 measured on August 1997**

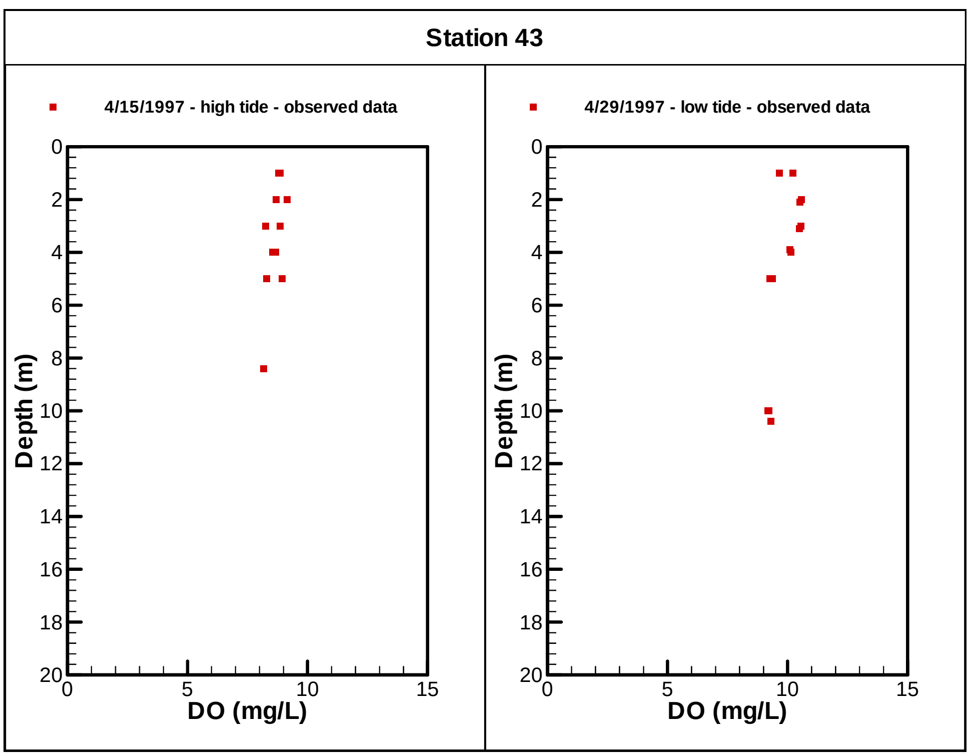


**Figure C-80. Dissolved oxygen profiles at Station 43 measured on April 1997**

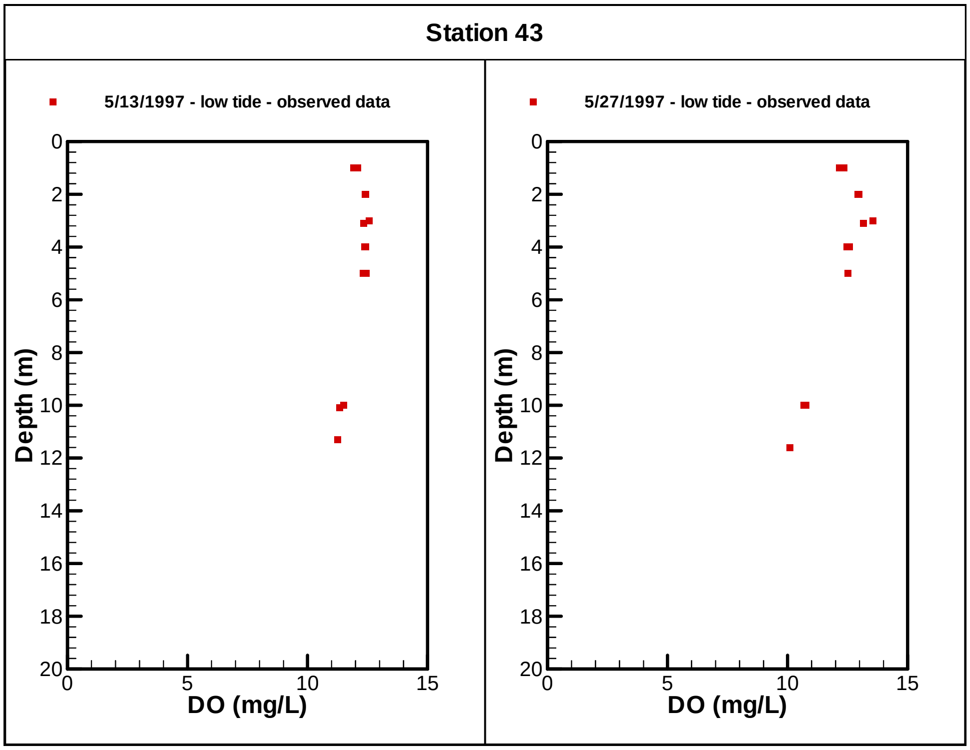


**Figure C-81. Dissolved oxygen profiles at Station 43 measured on May 1997**

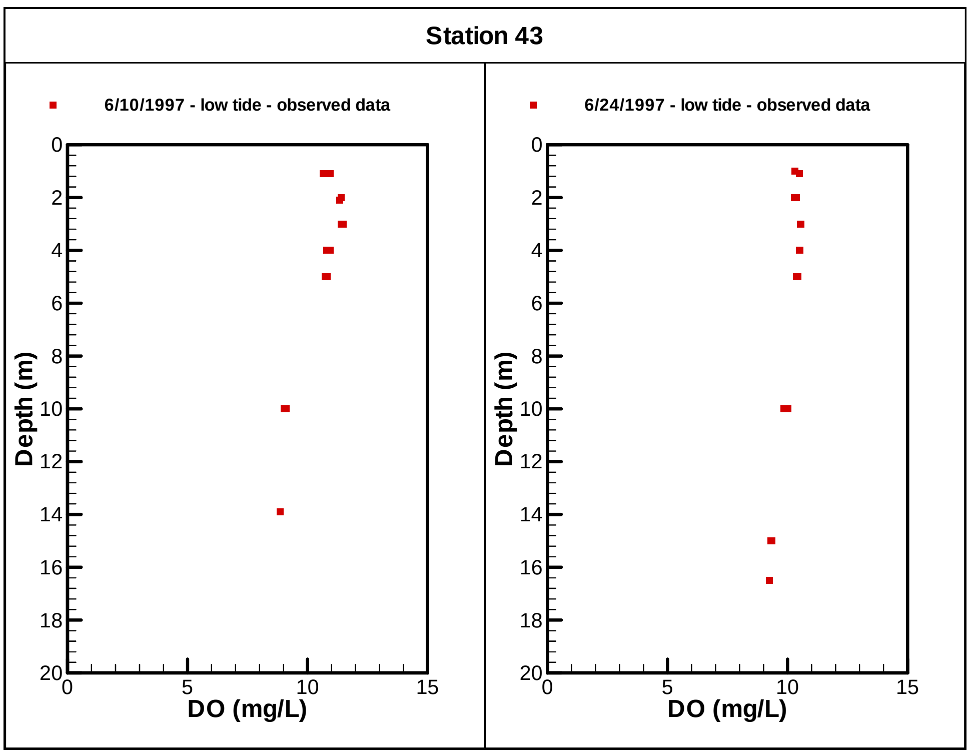


**Figure C-82. Dissolved oxygen profiles at Station 43 measured on June 1997**

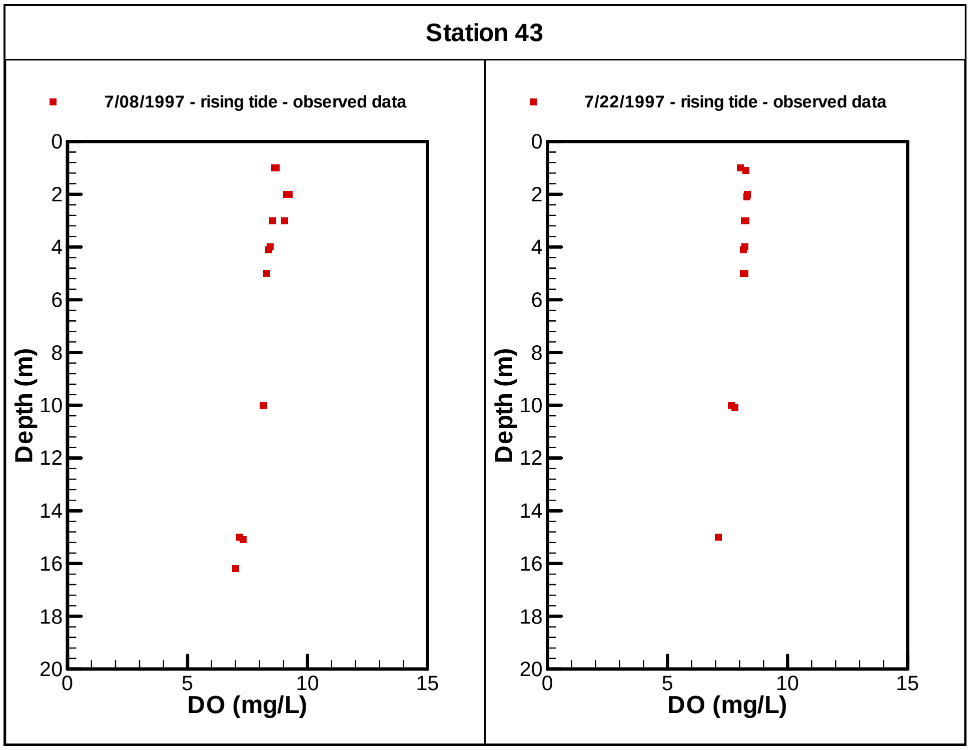


**Figure C-83. Dissolved oxygen profiles at Station 43 measured on July 1997**

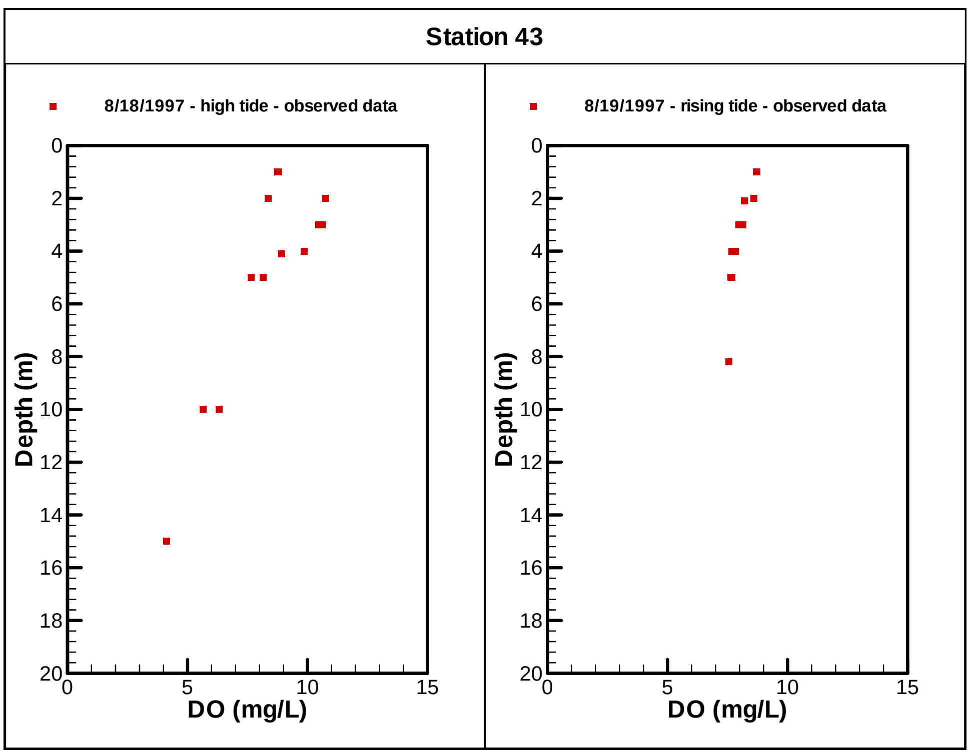


**Figure C-84. Dissolved oxygen profiles at Station 43 measured on August 1997**

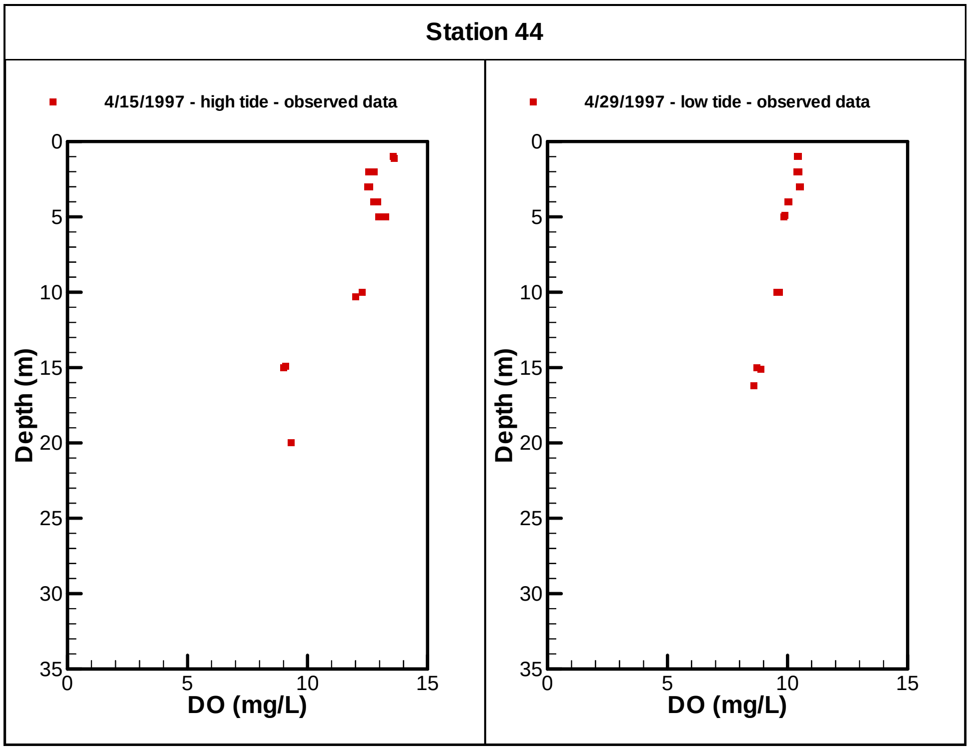


**Figure C-85. Dissolved oxygen profiles at Station 44 measured on April 1997**

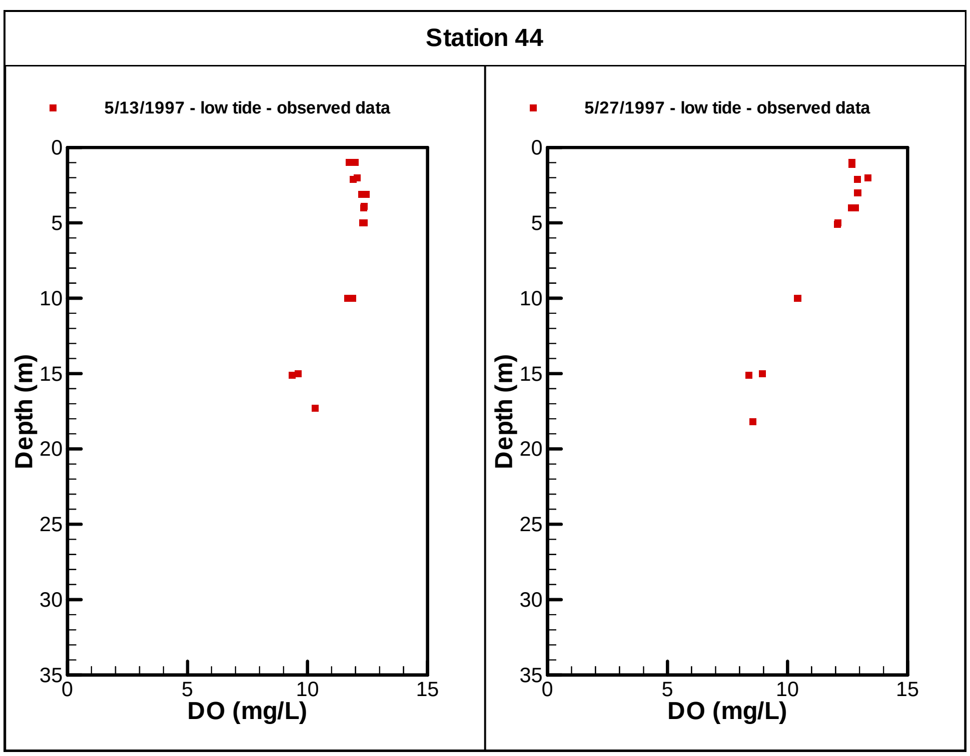


**Figure C-86. Dissolved oxygen profiles at Station 44 measured on May 1997**

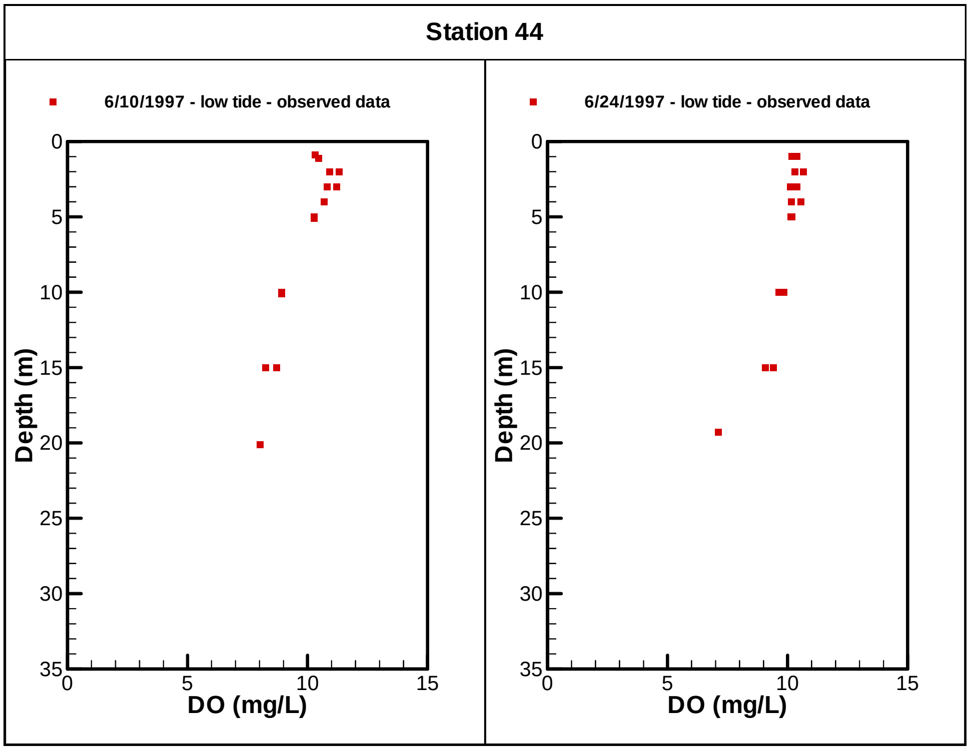


**Figure C-87. Dissolved oxygen profiles at Station 44 measured on June 1997**

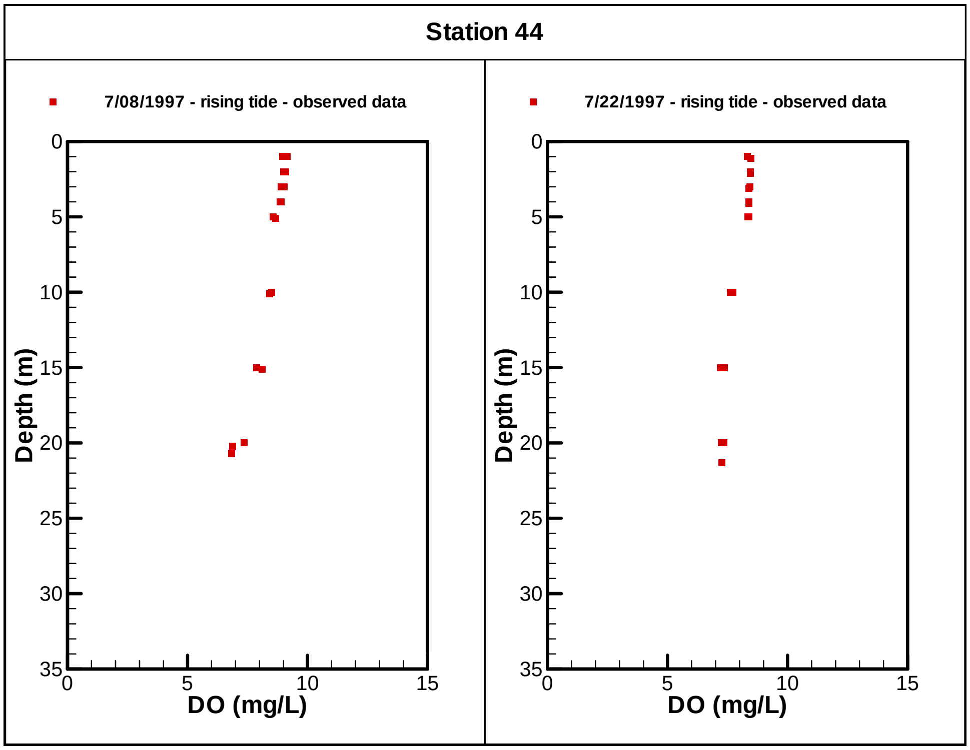


**Figure C-88. Dissolved oxygen profiles at Station 44 measured on July 1997**

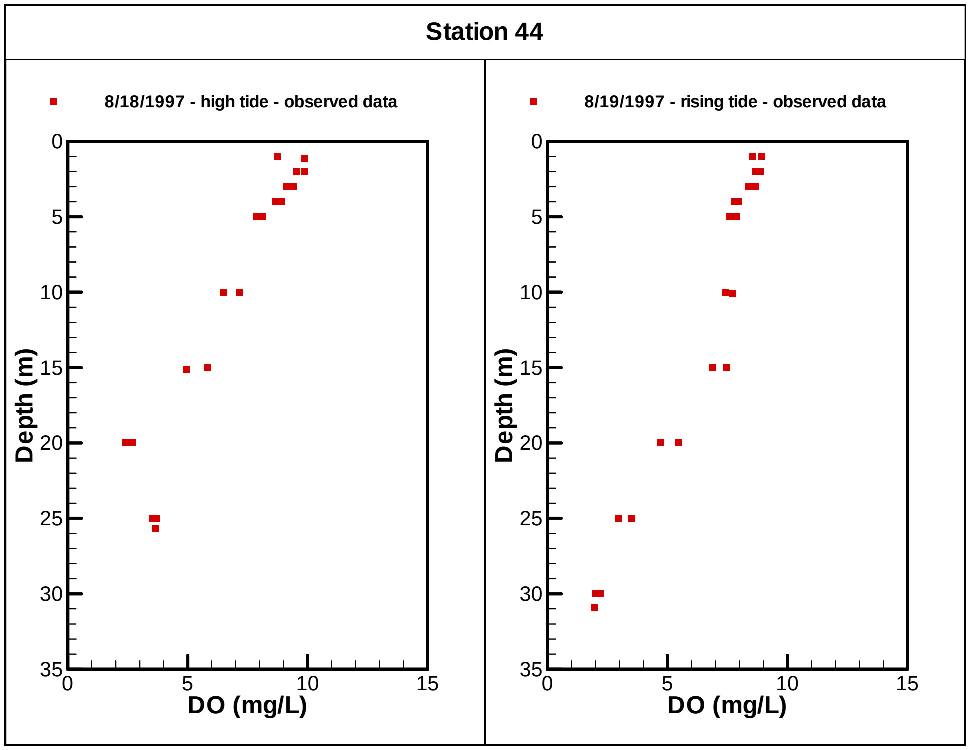


**Figure C-89. Dissolved oxygen profiles at Station 44 measured on August 1997**

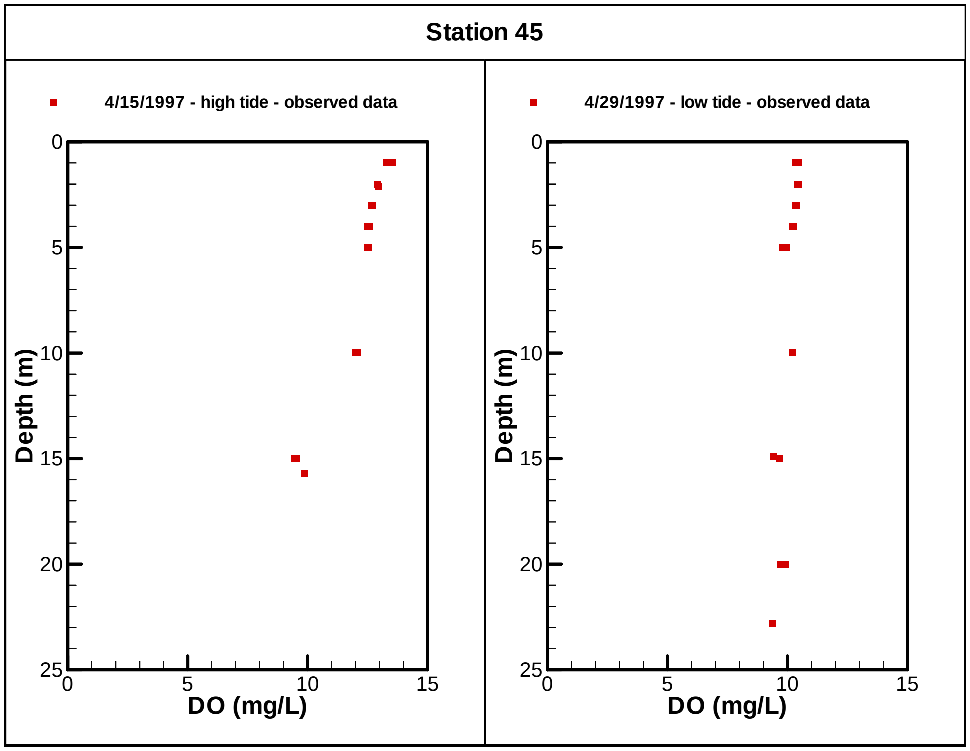


**Figure C-90. Dissolved oxygen profiles at Station 45 measured on April 1997**

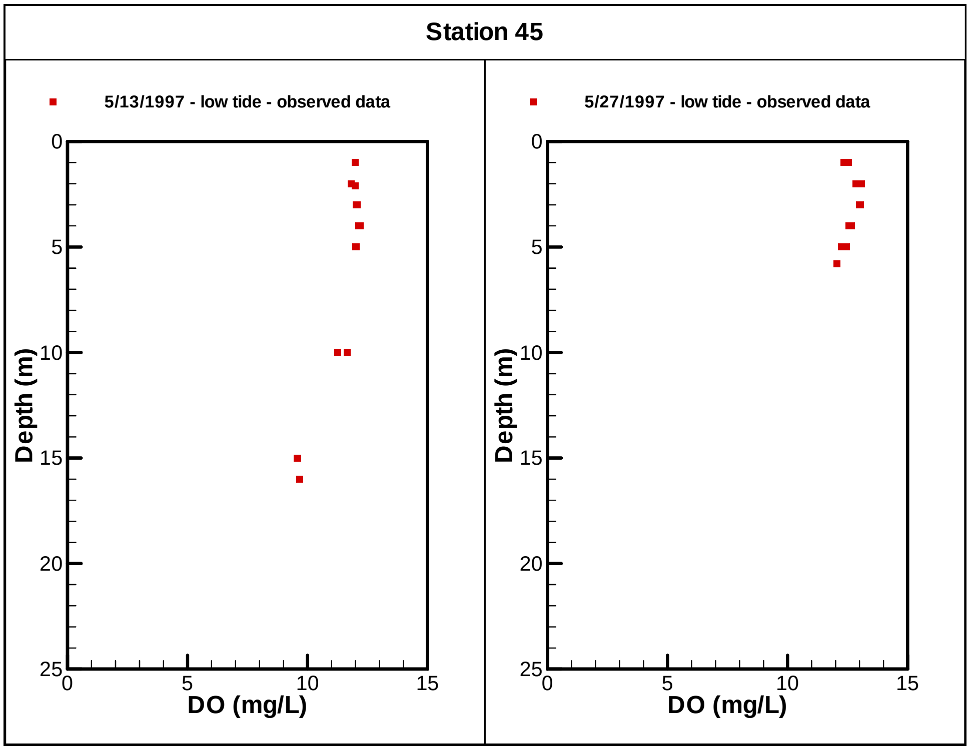


**Figure C-91. Dissolved oxygen profiles at Station 45 measured on May 1997**

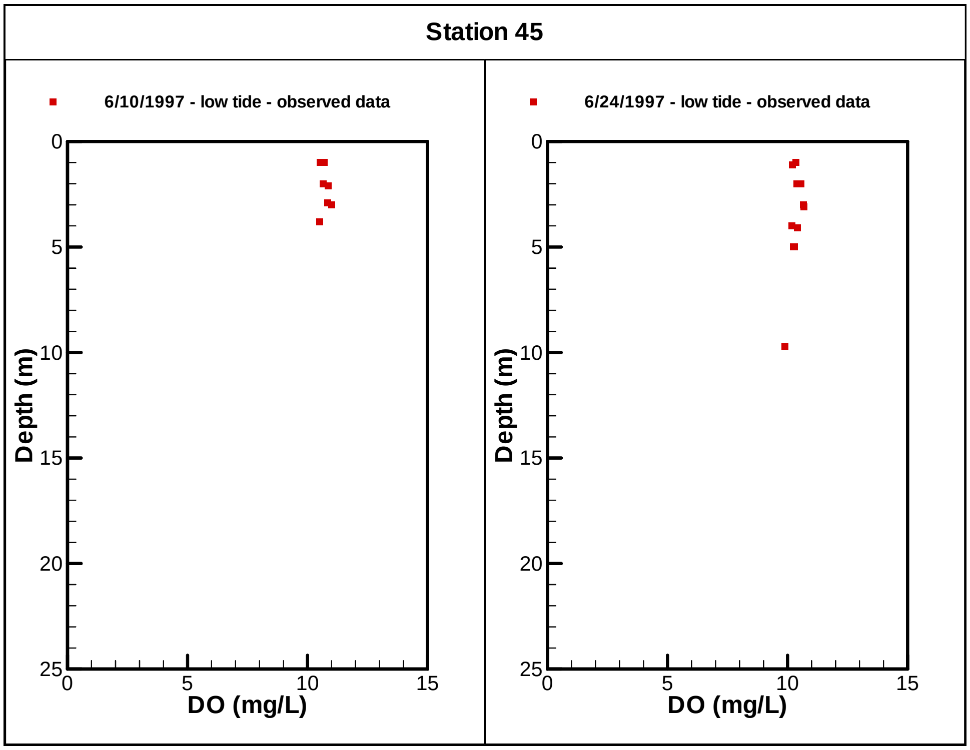


**Figure C-92. Dissolved oxygen profiles at Station 45 measured on June 1997**

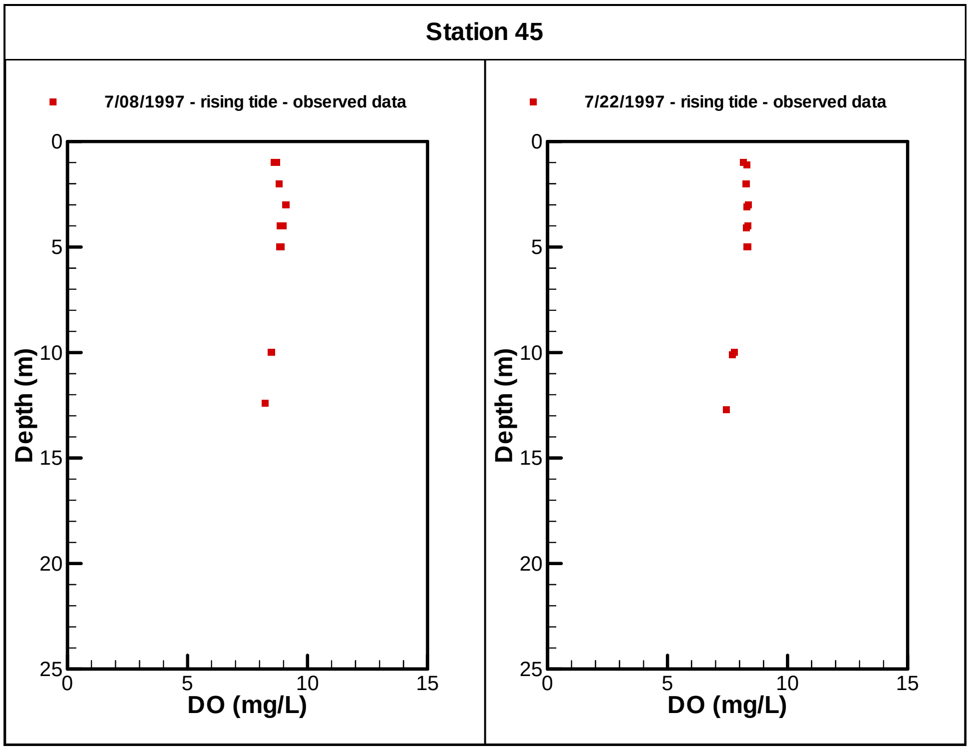


**Figure C-93. Dissolved oxygen profiles at Station 45 measured on July 1997**

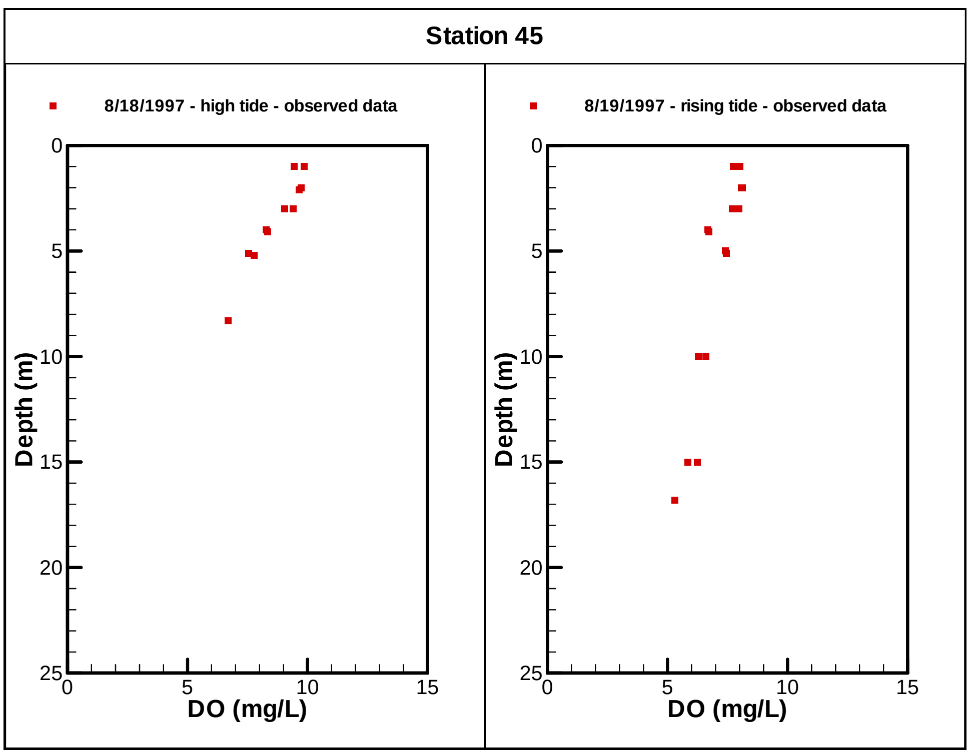


**Figure C-94. Dissolved oxygen profiles at Station 45 measured on August 1997**

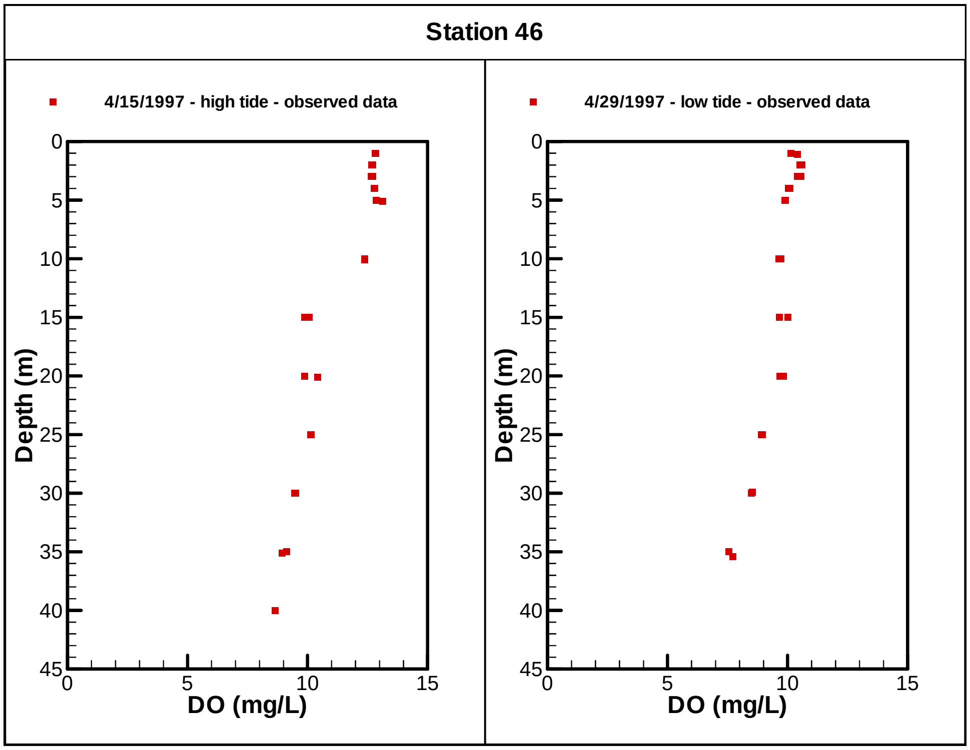


**Figure C-95. Dissolved oxygen profiles at Station 46 measured on April 1997**

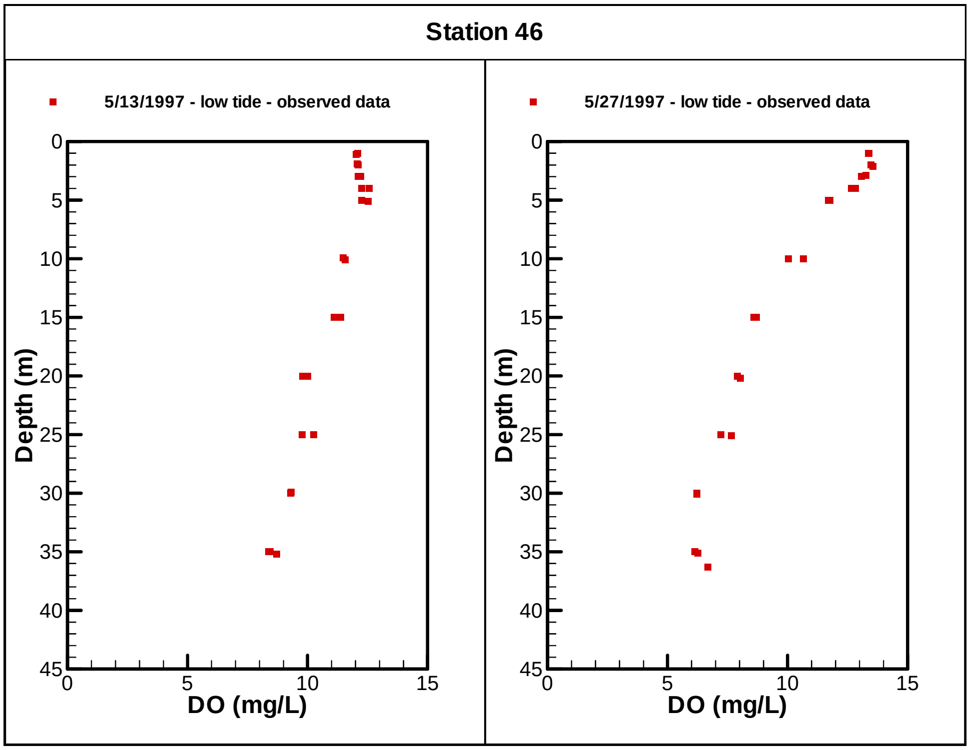


**Figure C-96. Dissolved oxygen profiles at Station 46 measured on May 1997**

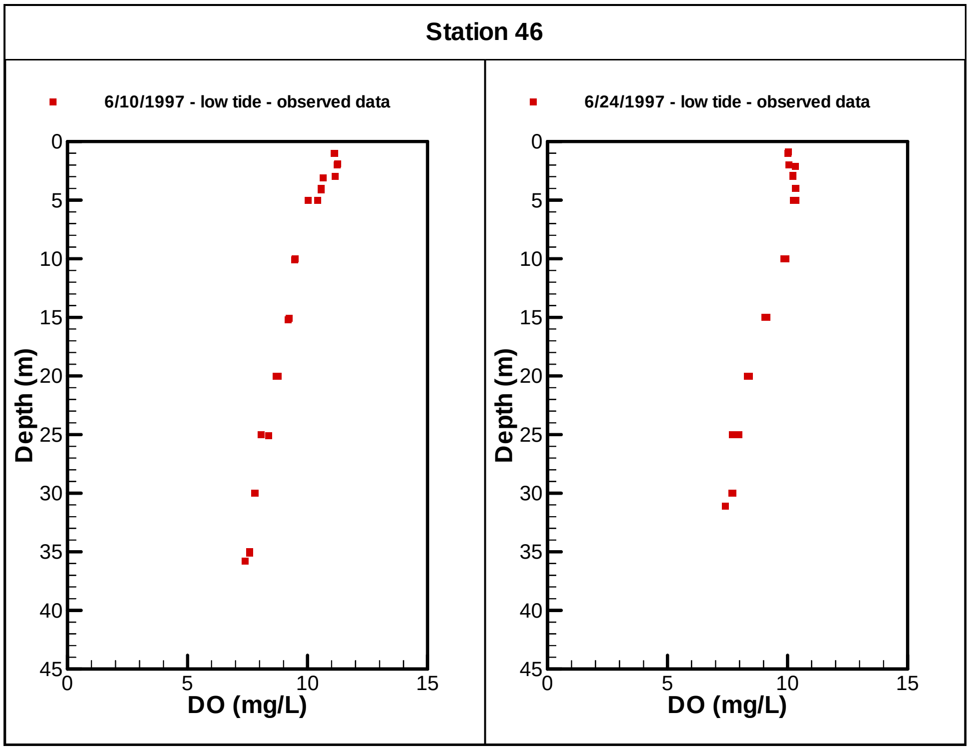


Figure C-97. Dissolved oxygen profiles at Station 46 measured on June 1997

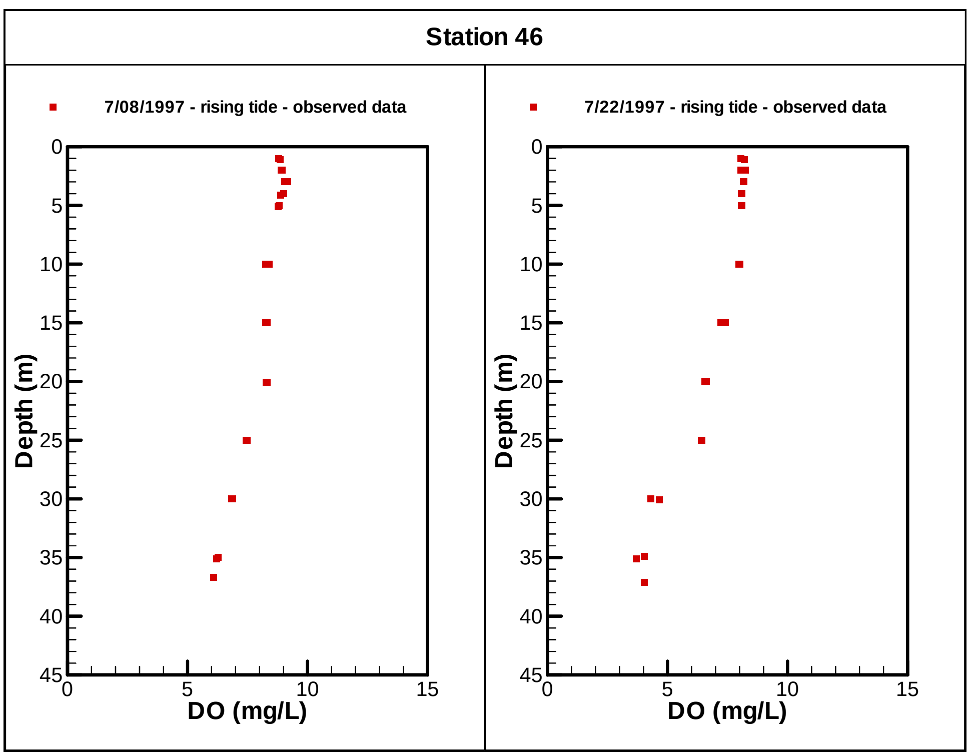


Figure C-98. Dissolved oxygen profiles at Station 46 measured on July 1997

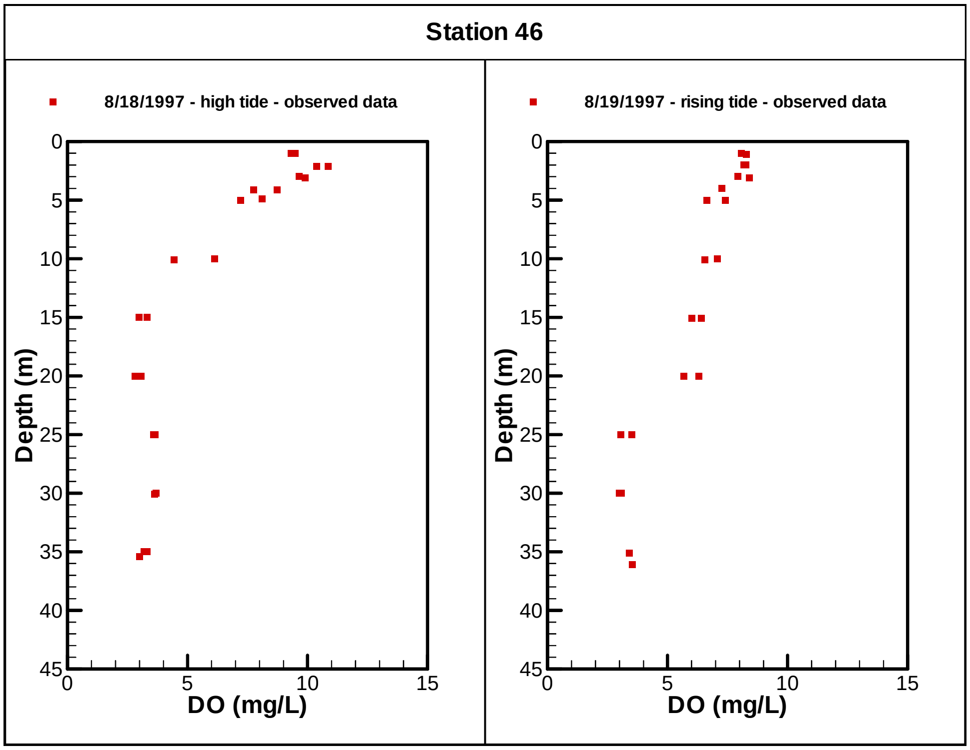


**Figure C-99. Dissolved oxygen profiles at Station 46 measured on August 1997**

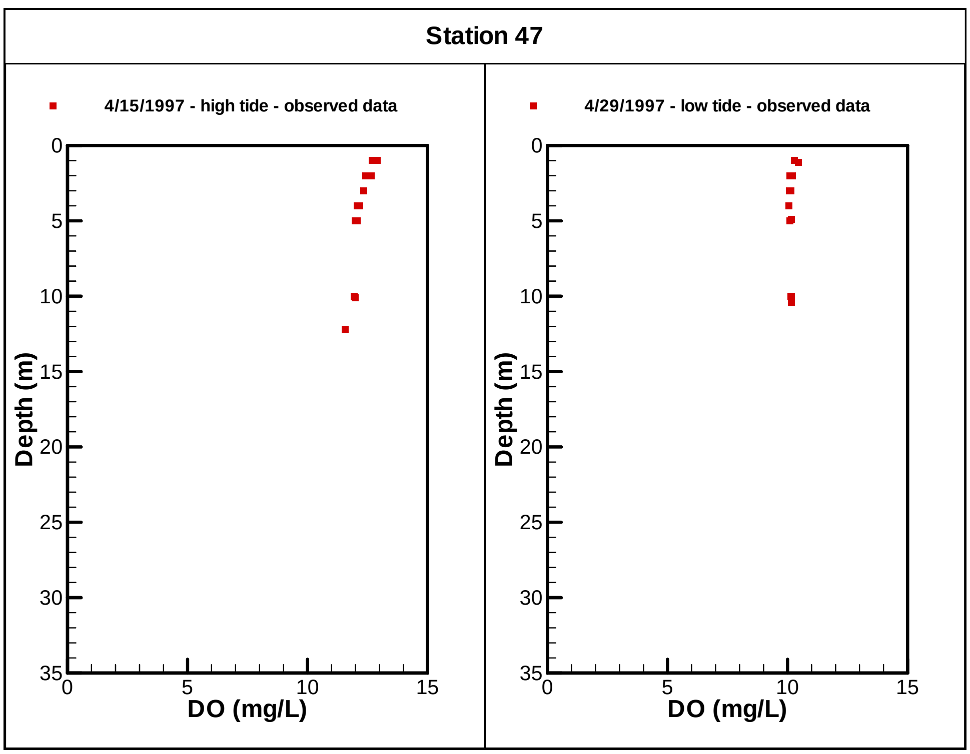


**Figure C-100. Dissolved oxygen profiles at Station 47 measured on April 1997**

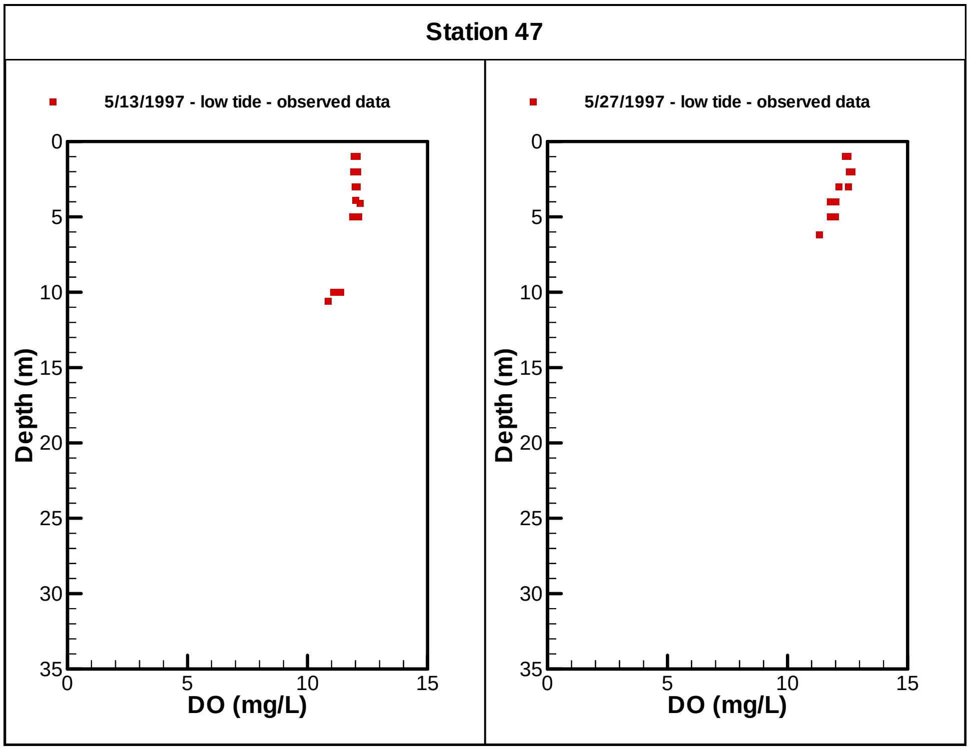


**Figure C-101. Dissolved oxygen profiles at Station 47 measured on May 1997**

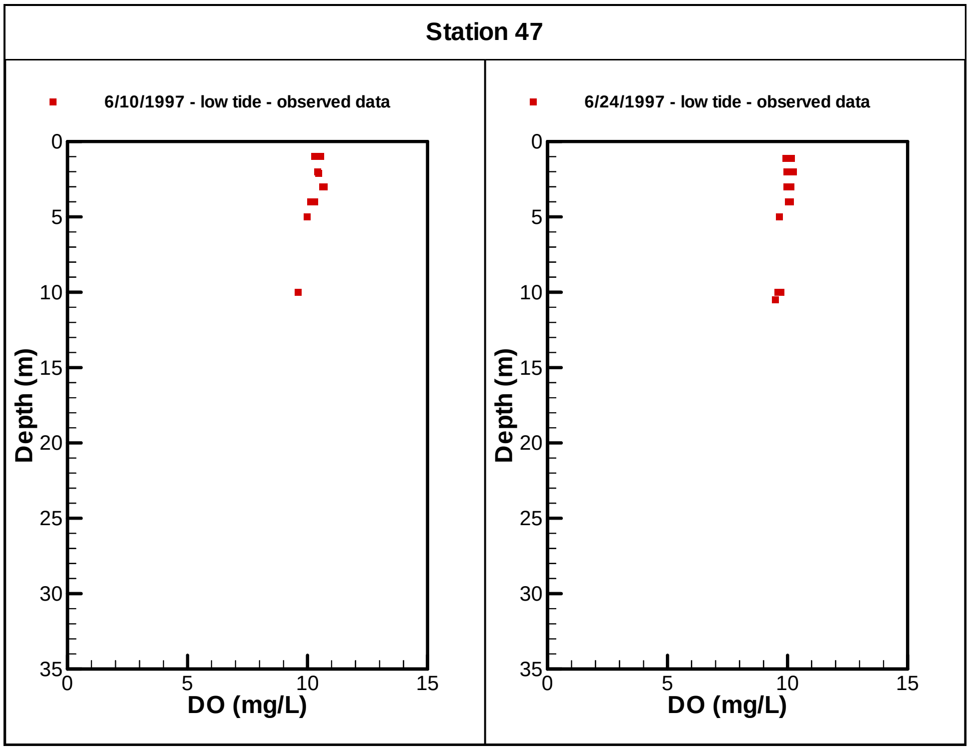


**Figure C-102. Dissolved oxygen profiles at Station 47 measured on June 1997**

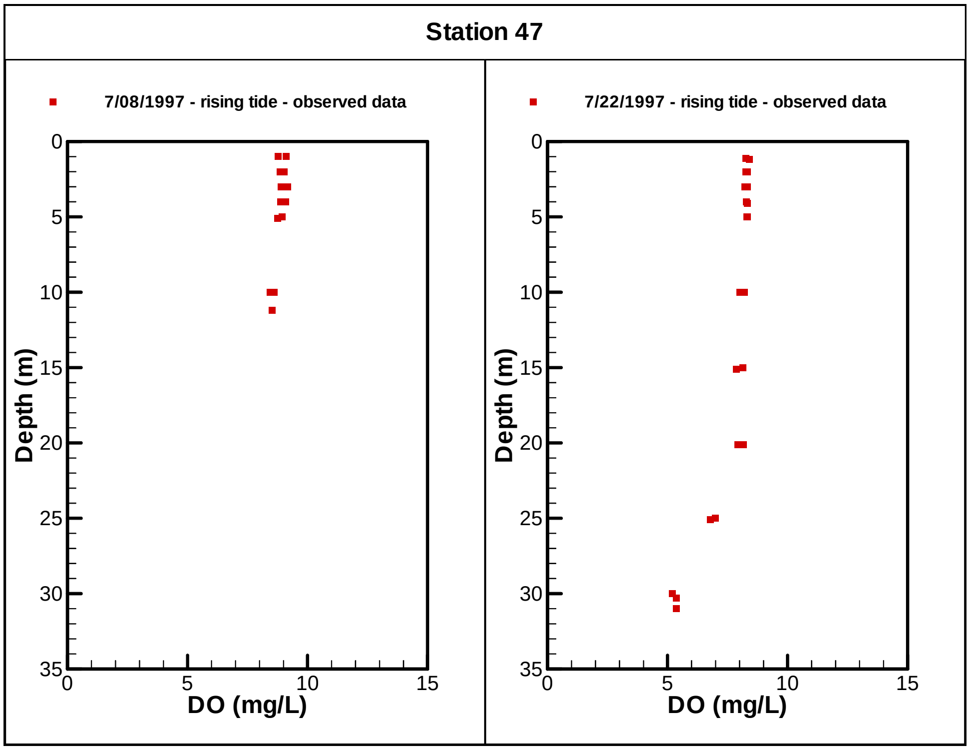


**Figure C-103. Dissolved oxygen profiles at Station 47 measured on July 1997**

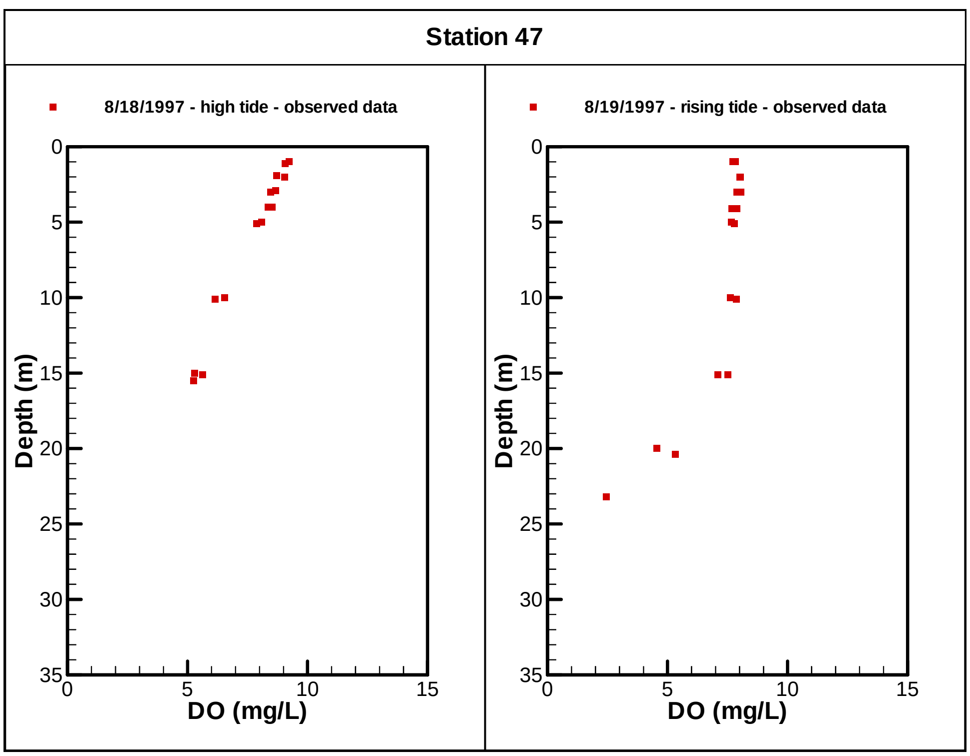


**Figure C-104. Dissolved oxygen profiles at Station 47 measured on August 1997**

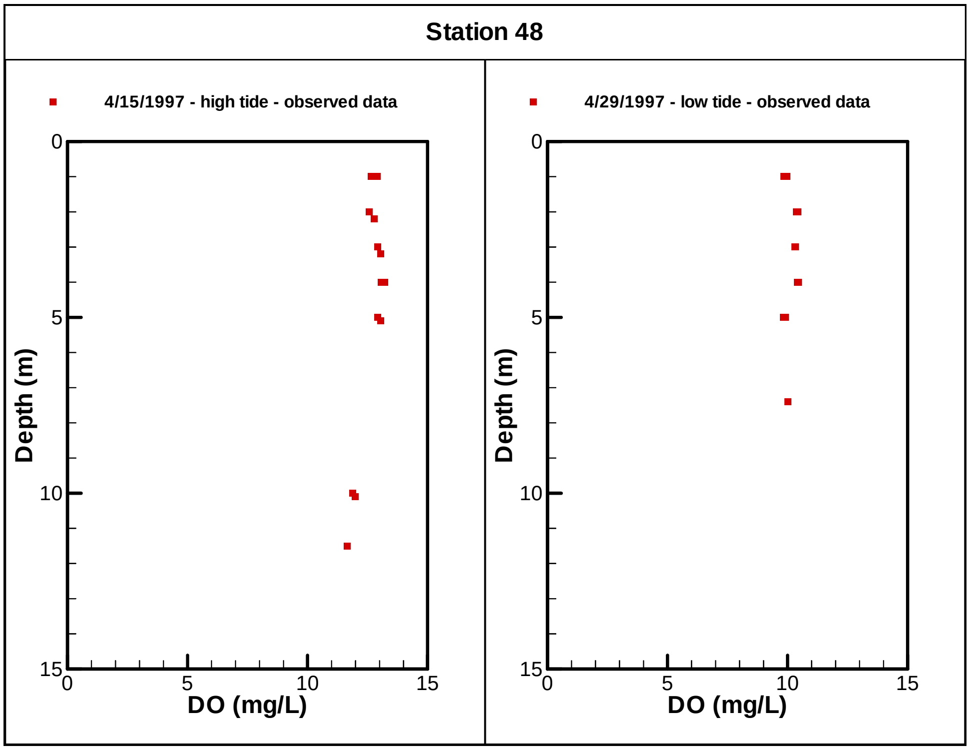


**Figure C-105. Dissolved oxygen profiles at Station 48 measured on April 1997**

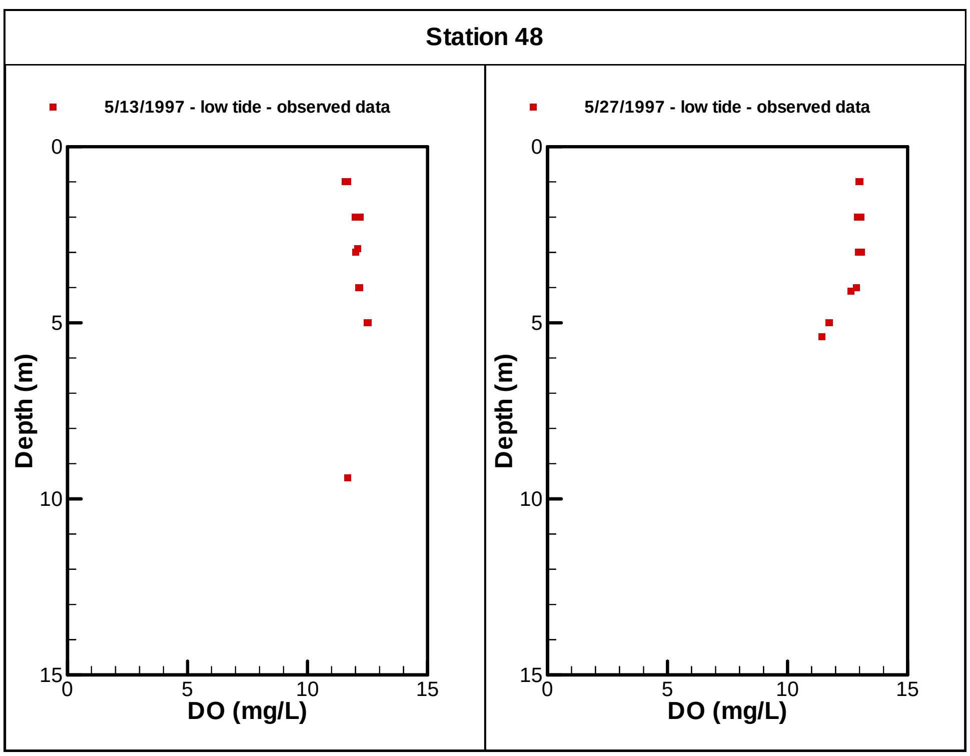


**Figure C-106. Dissolved oxygen profiles at Station 48 measured on May 1997**

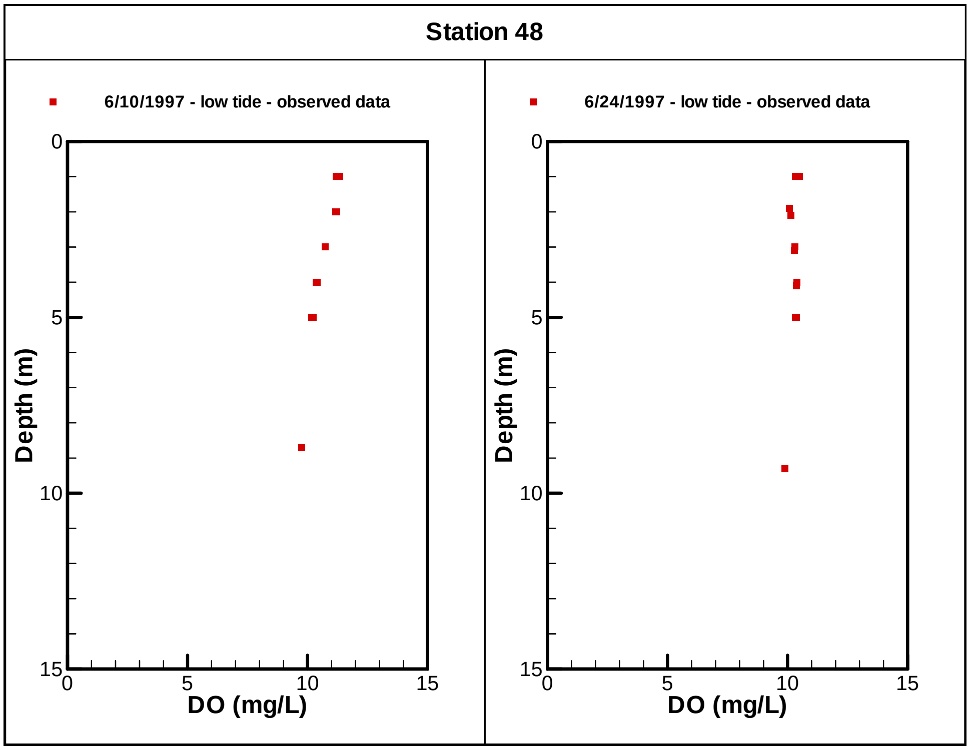


**Figure C-107. Dissolved oxygen profiles at Station 48 measured on June 1997**

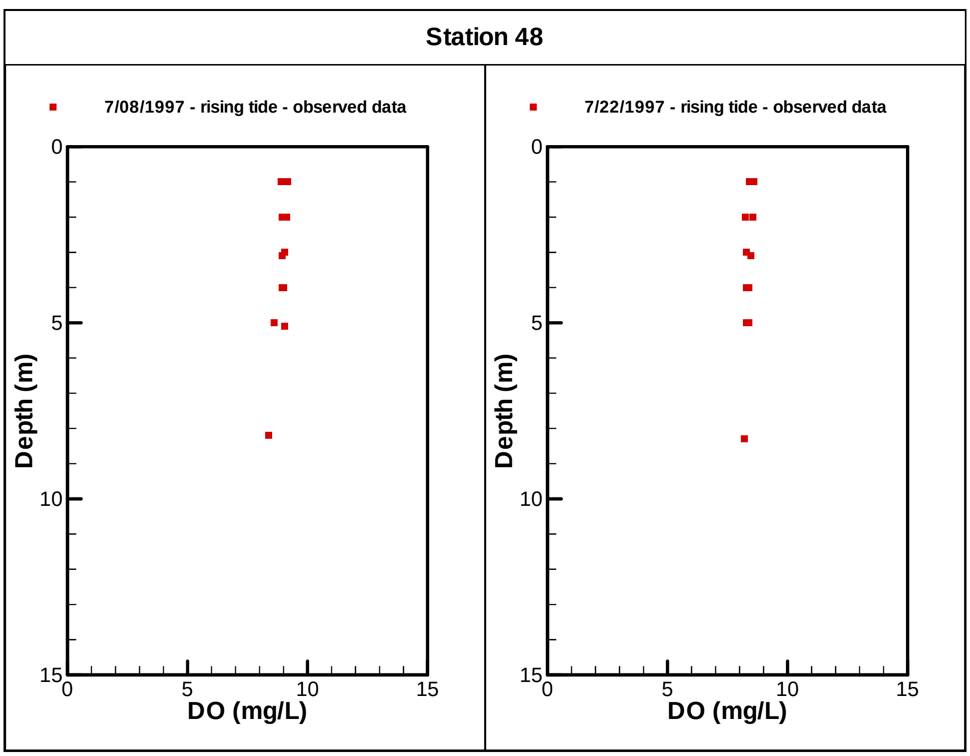


**Figure C-108. Dissolved oxygen profiles at Station 48 measured on July 1997**

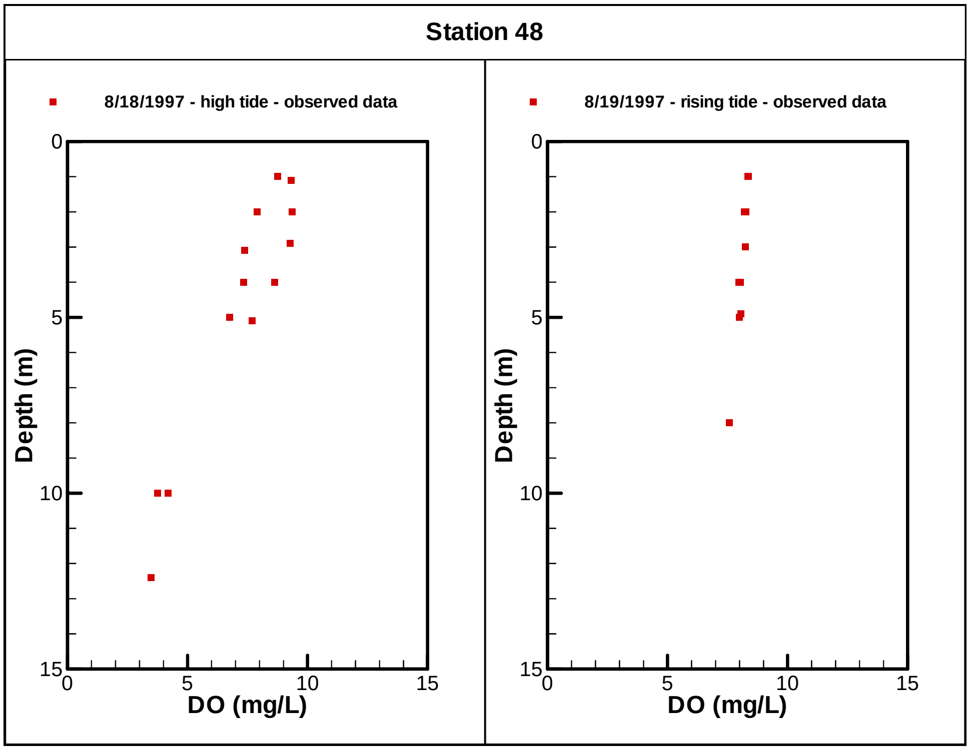


**Figure C-109. Dissolved oxygen profiles at Station 48 measured on August 1997**

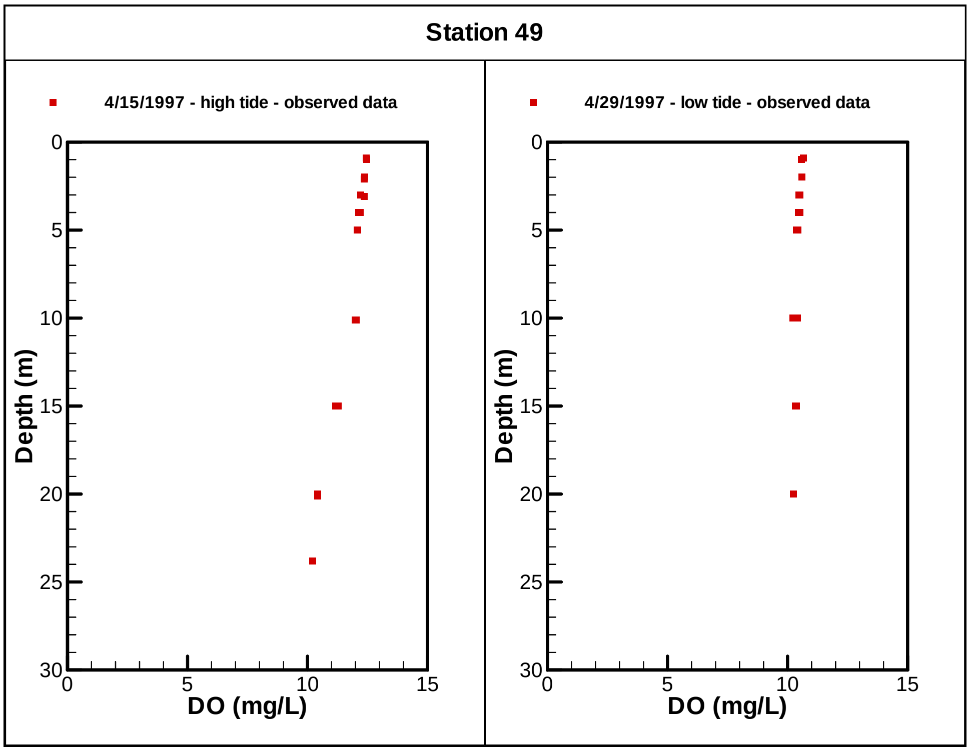


**Figure C-110. Dissolved oxygen profiles at Station 49 measured on April 1997**

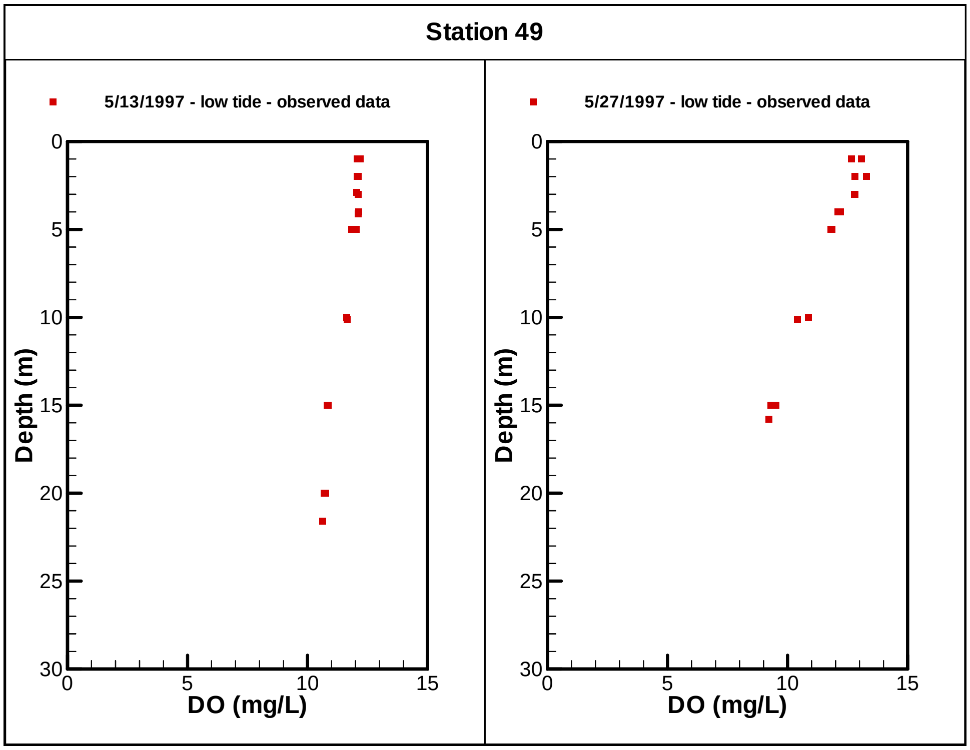


**Figure C-111. Dissolved oxygen profiles at Station 49 measured on May 1997**

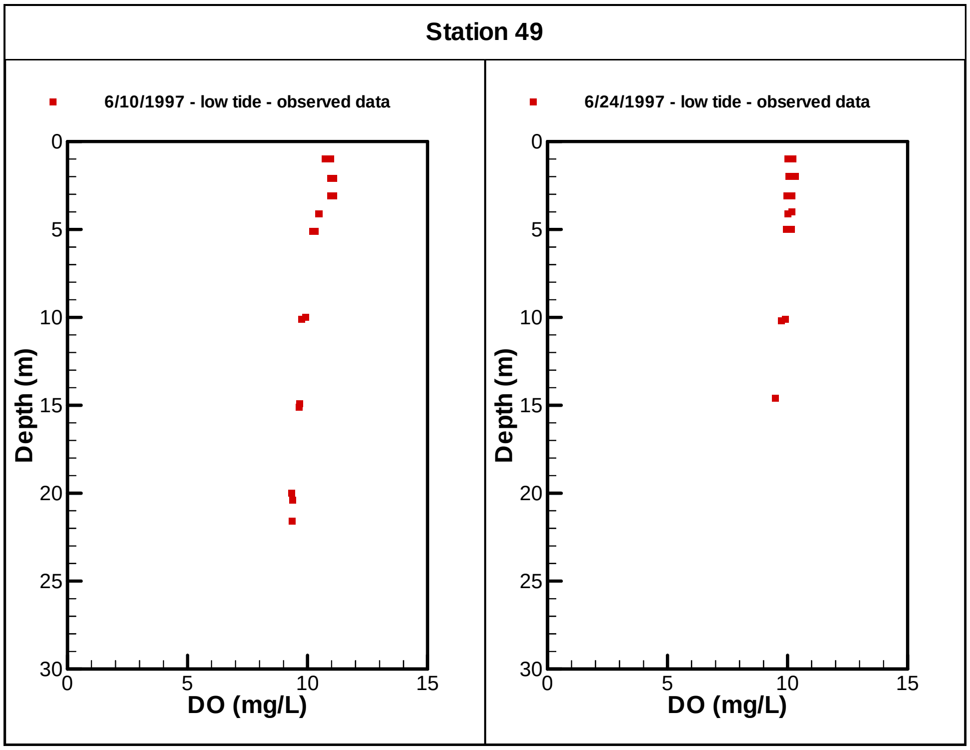


**Figure C-112. Dissolved oxygen profiles at Station 49 measured on June 1997**

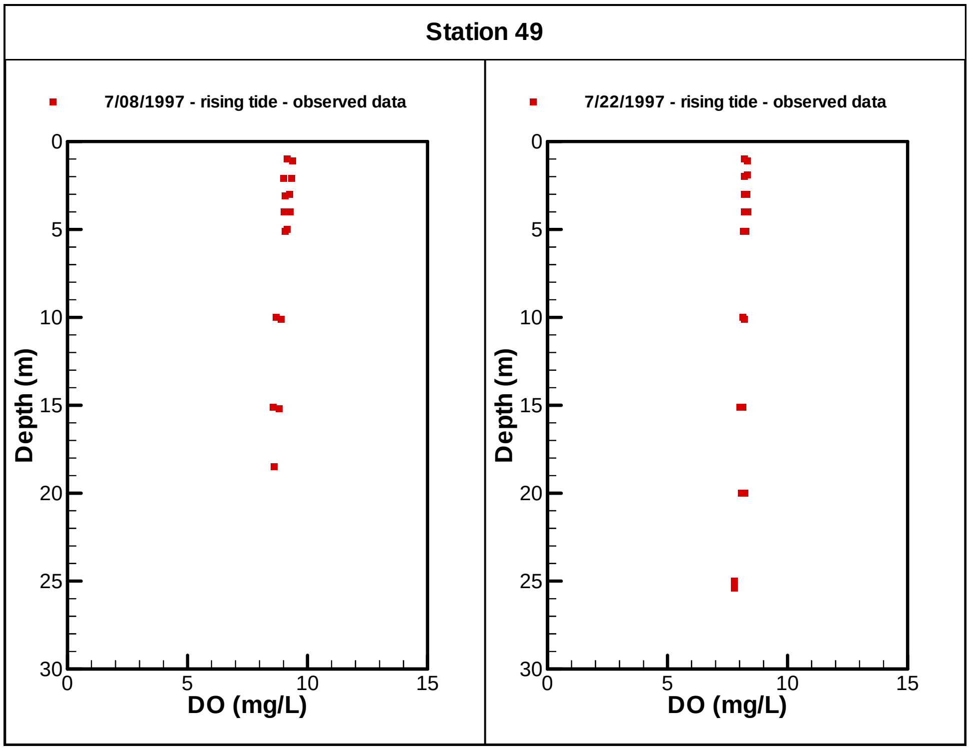


**Figure C-113. Dissolved oxygen profiles at Station 49 measured on July 1997**

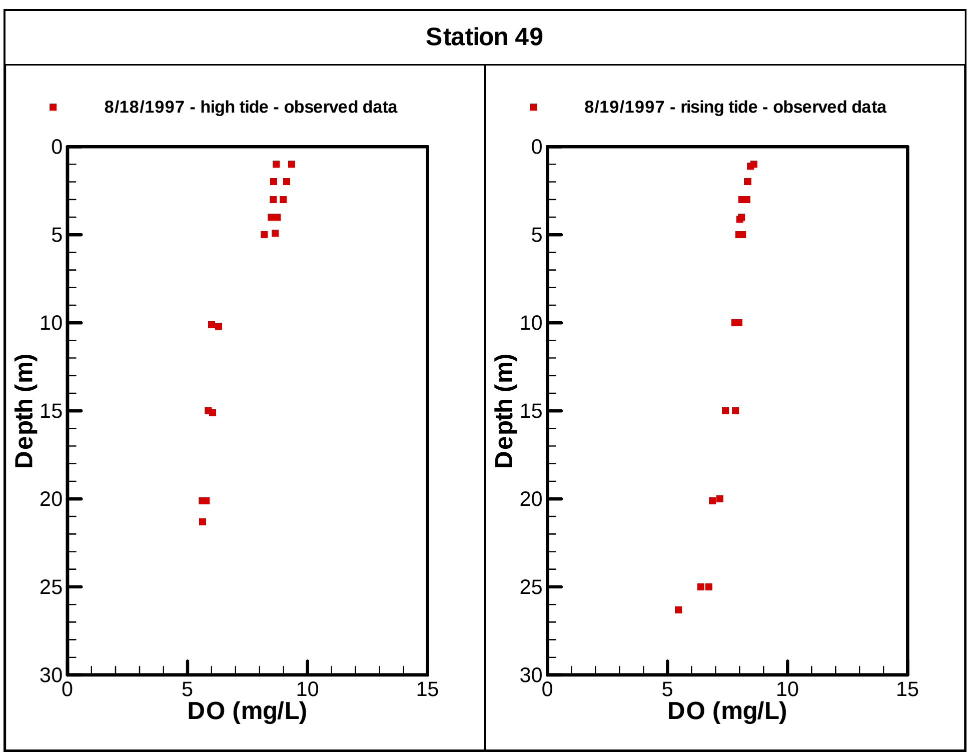


**Figure C-114. Dissolved oxygen profiles at Station 49 measured on August 1997**

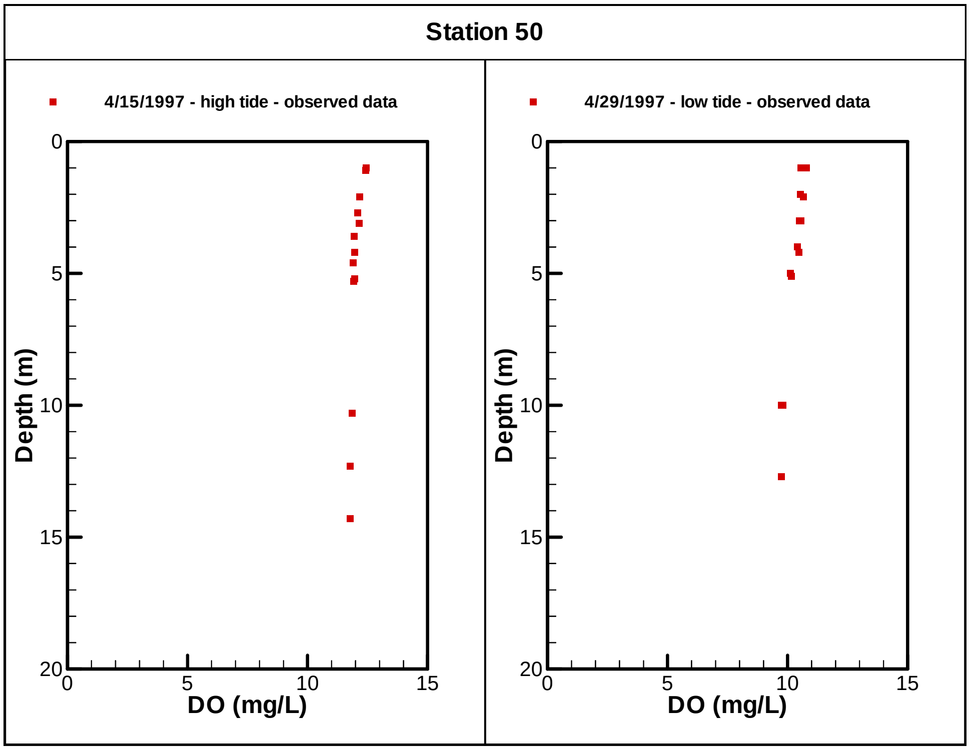


**Figure C-115. Dissolved oxygen profiles at Station 50 measured on April 1997**

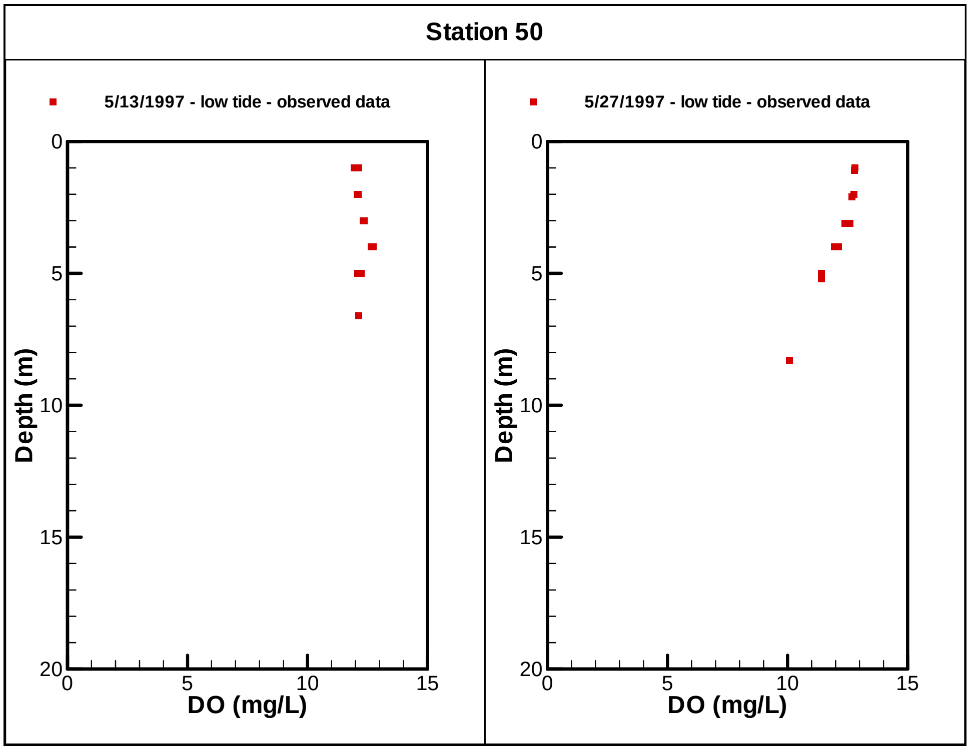


**Figure C-116. Dissolved oxygen profiles at Station 50 measured on May 1997**

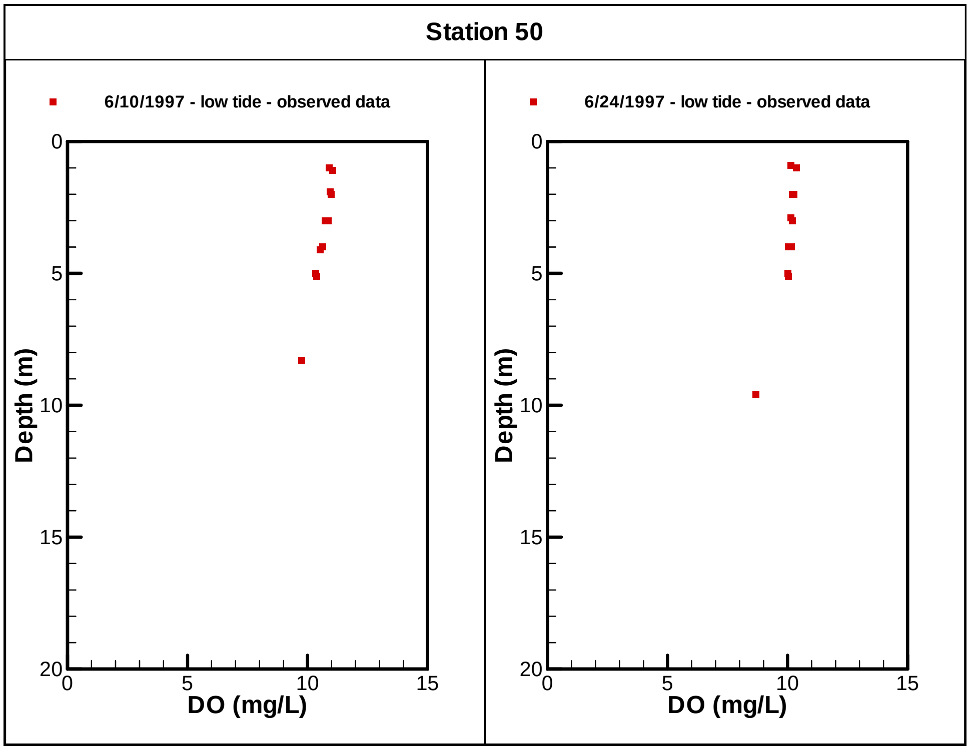


**Figure C-117. Dissolved oxygen profiles at Station 50 measured on June 1997**

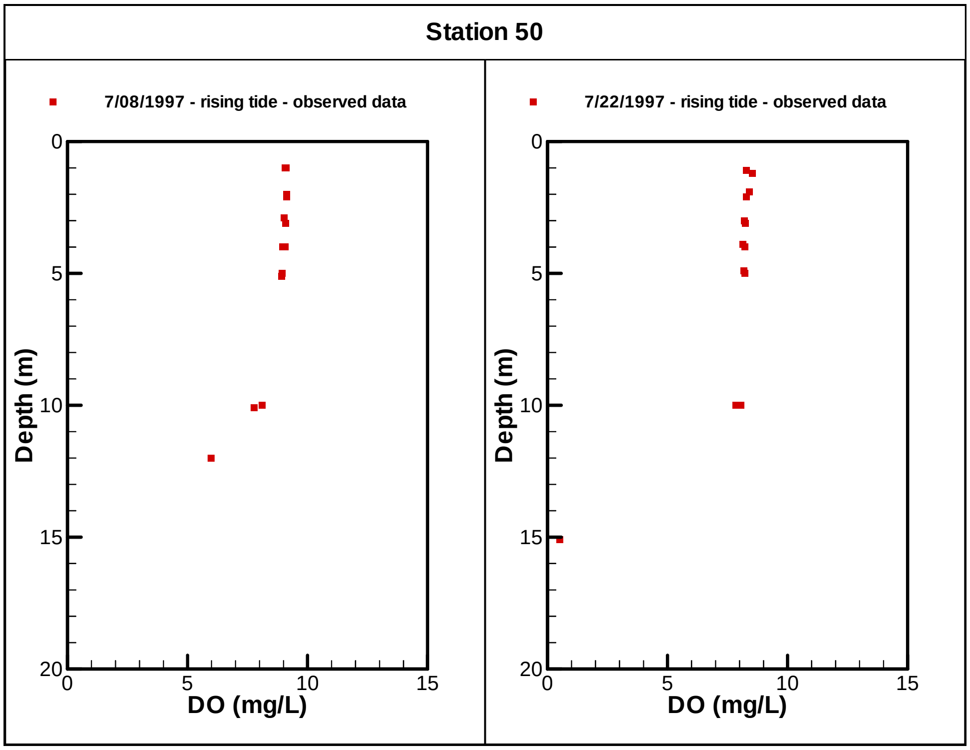


**Figure C-118. Dissolved oxygen profiles at Station 50 measured on July 1997**

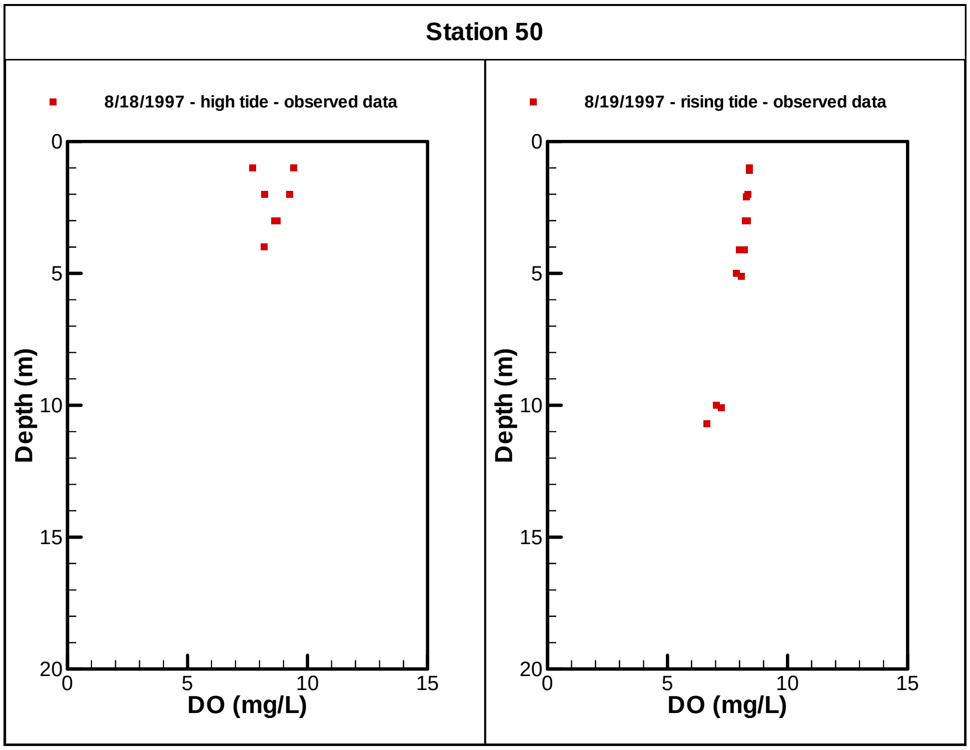


**Figure C-119. Dissolved oxygen profiles at Station 50 measured on August 1997**

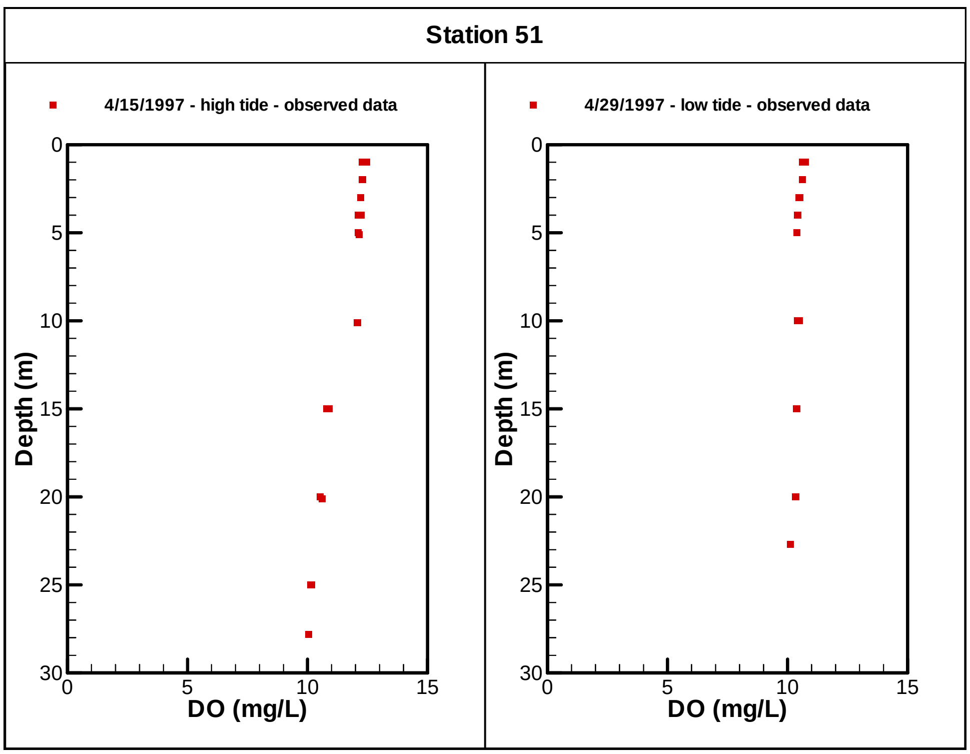


**Figure C-120. Dissolved oxygen profiles at Station 51 measured on April 1997**

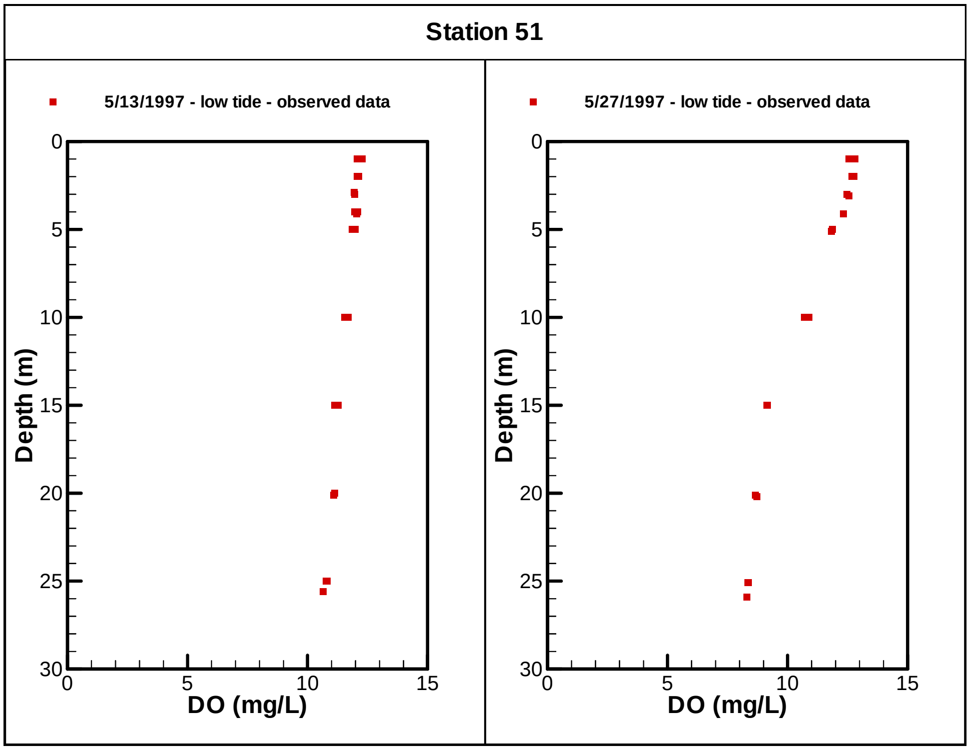


**Figure C-121. Dissolved oxygen profiles at Station 51 measured on May 1997**

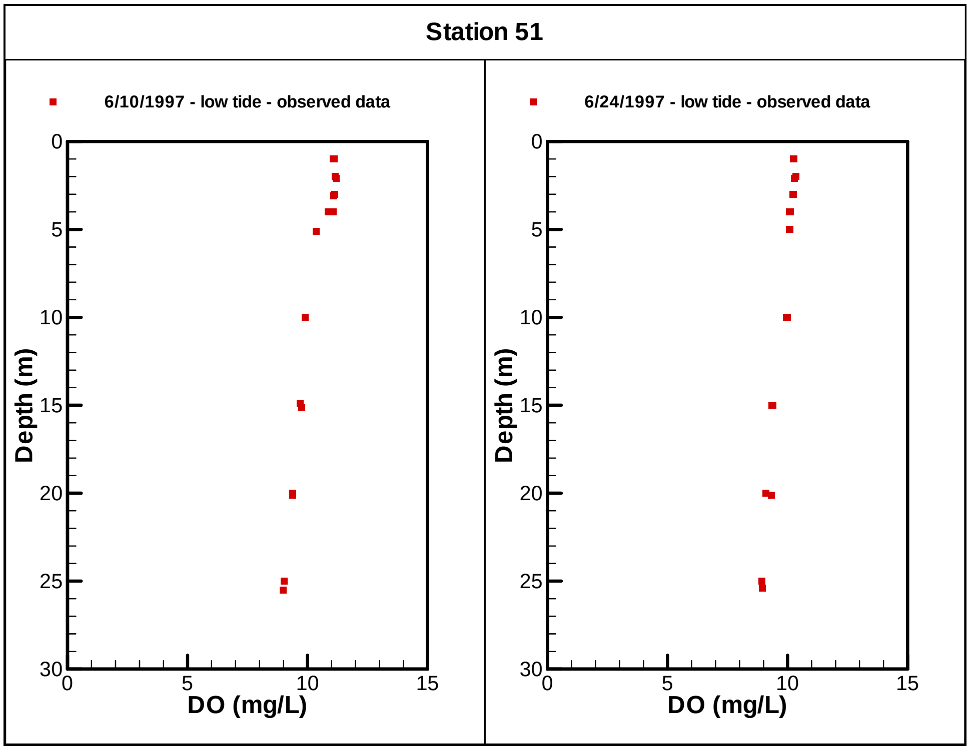


**Figure C-122. Dissolved oxygen profiles at Station 51 measured on June 1997**

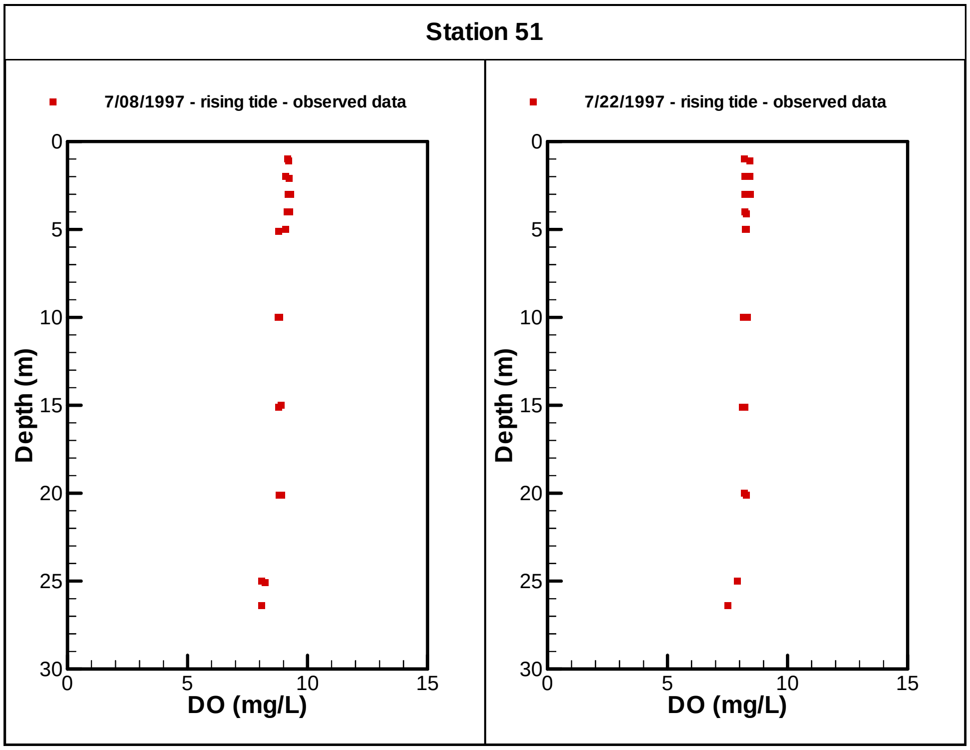


**Figure C-123. Dissolved oxygen profiles at Station 51 measured on July 1997**

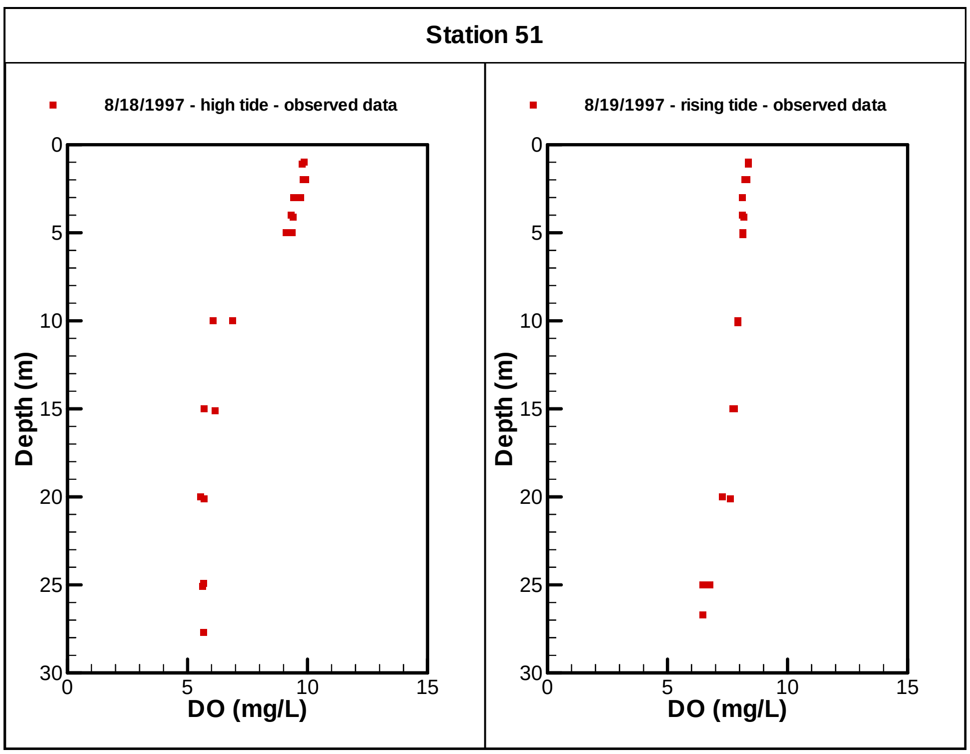


**Figure C-124. Dissolved oxygen profiles at Station 51 measured on August 1997**

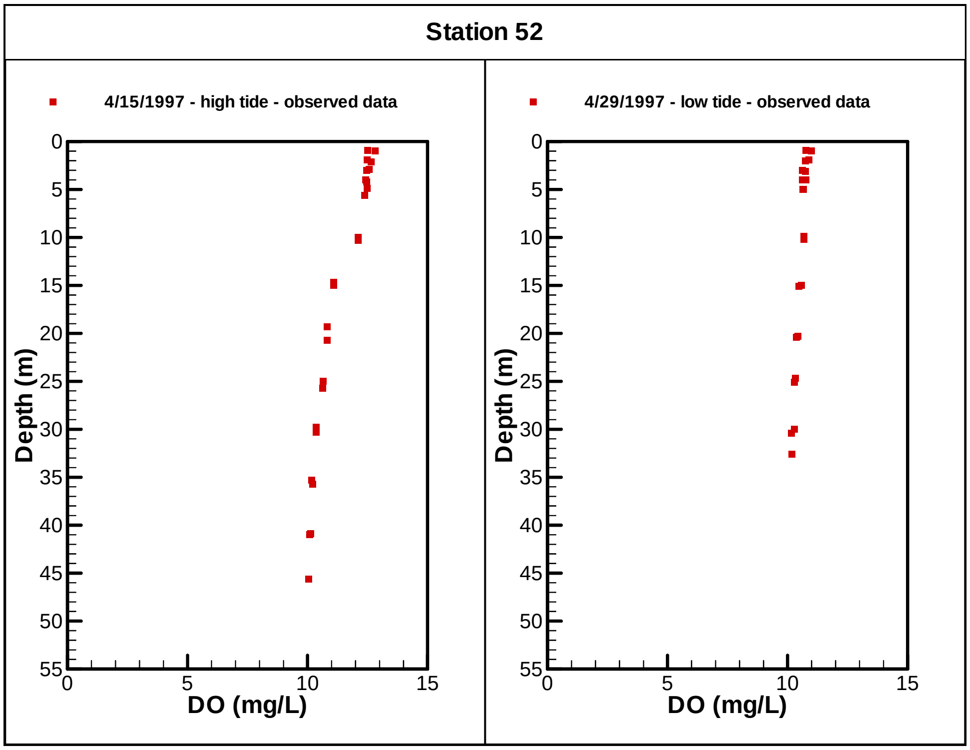


**Figure C-125. Dissolved oxygen profiles at Station 52 measured on April 1997**

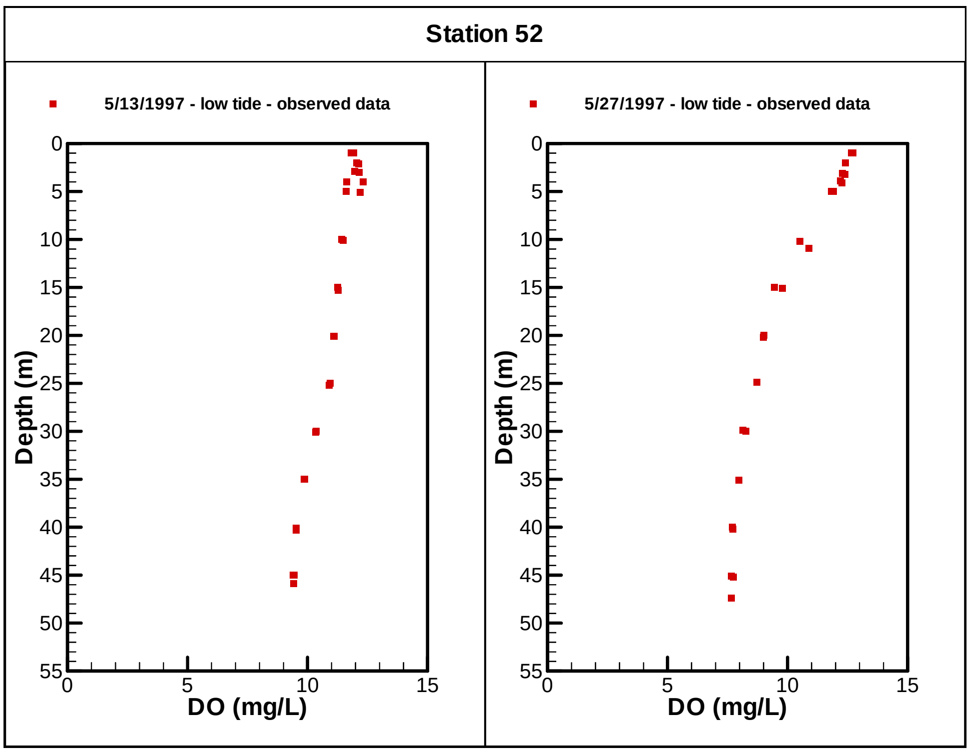


**Figure C-126. Dissolved oxygen profiles at Station 52 measured on May 1997**

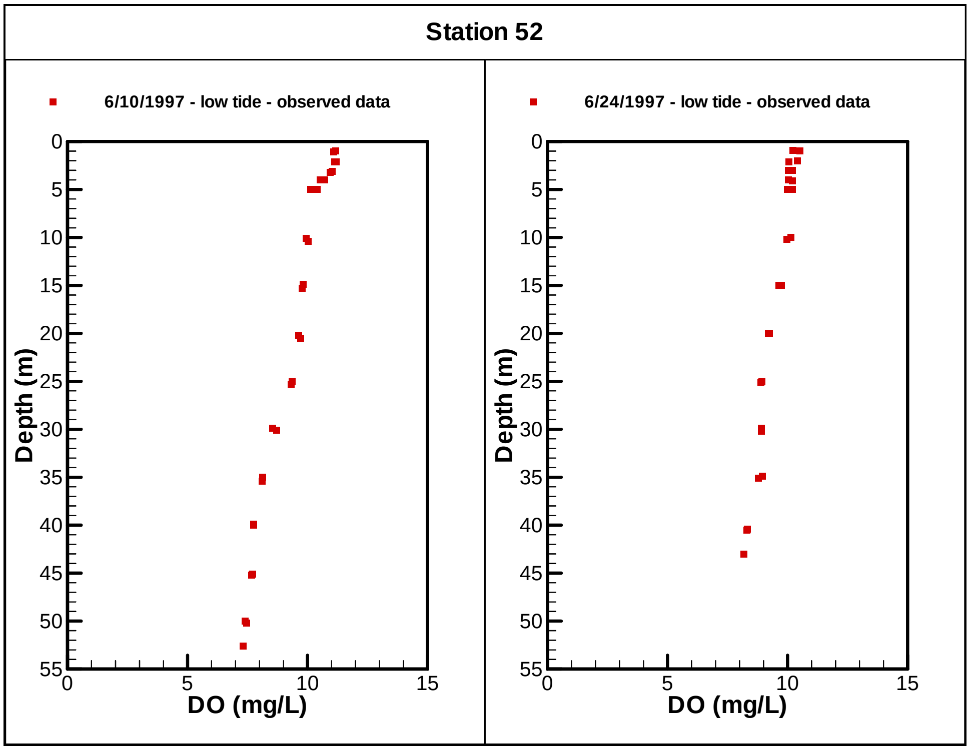


**Figure C-127. Dissolved oxygen profiles at Station 52 measured on June 1997**

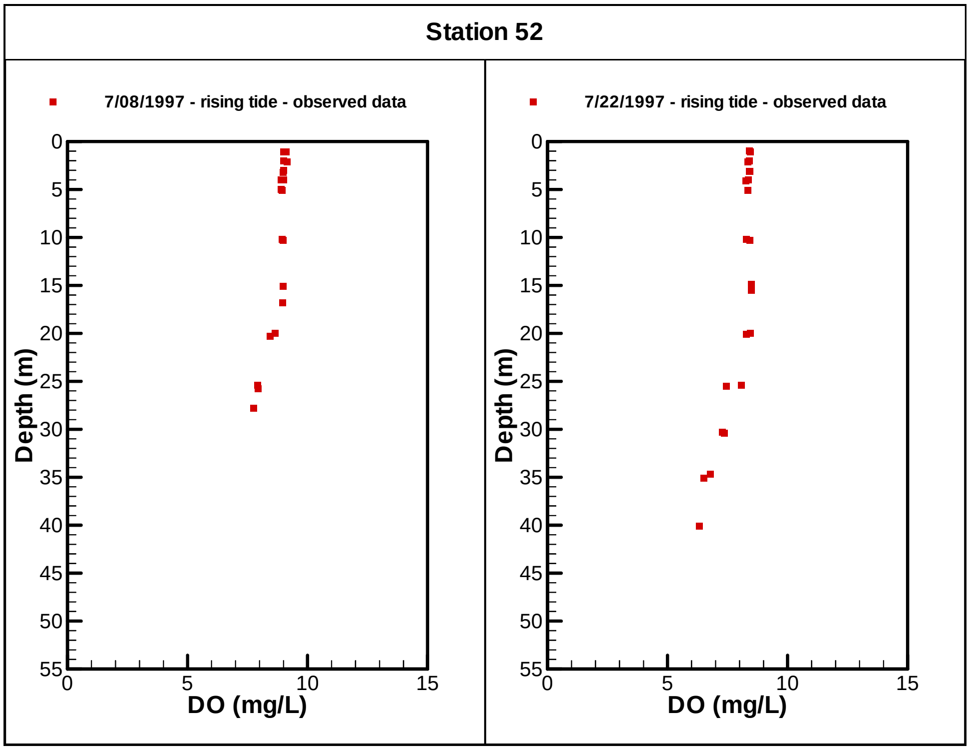


**Figure C-128. Dissolved oxygen profiles at Station 52 measured on July 1997**

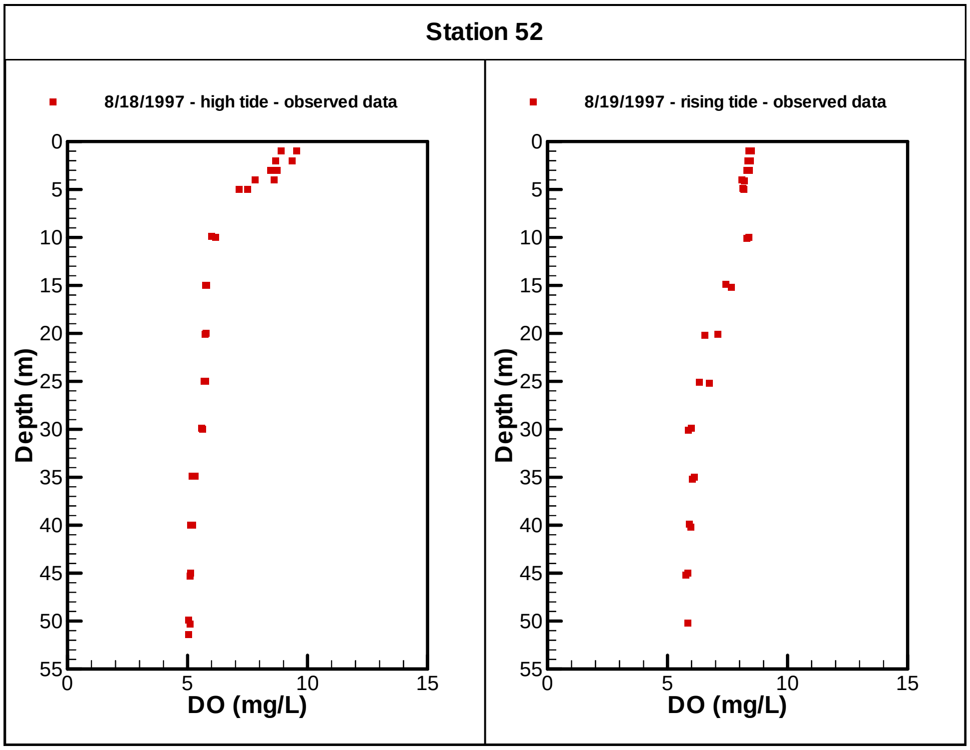


**Figure C-129. Dissolved oxygen profiles at Station 52 measured on August 1997**

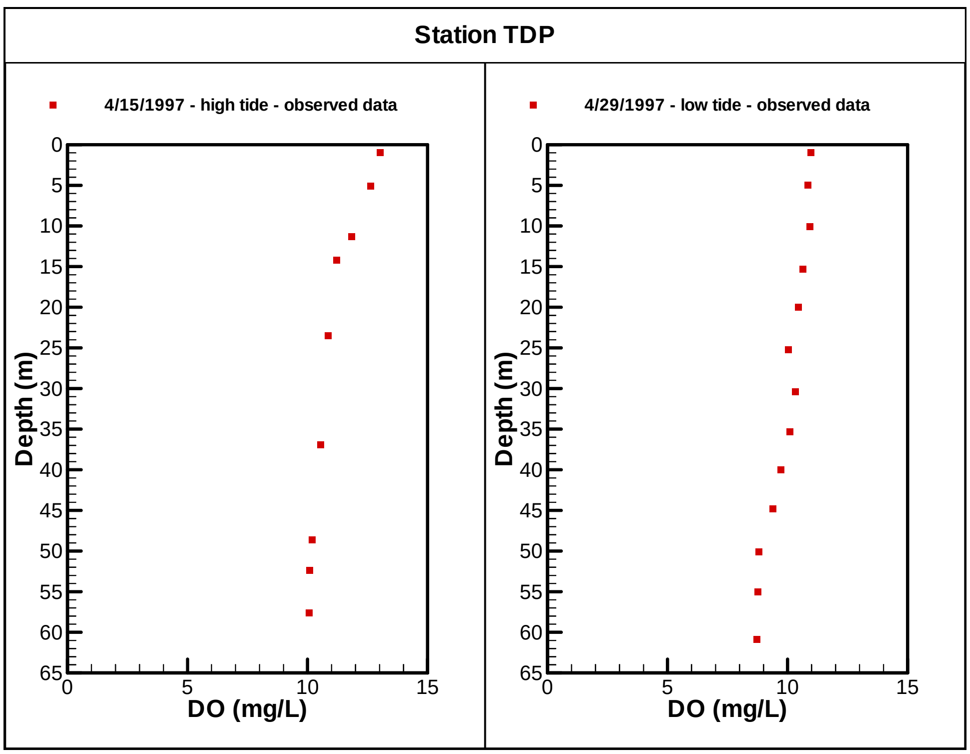


**Figure C-130. Dissolved oxygen profiles at Station TDP measured on April 1997**

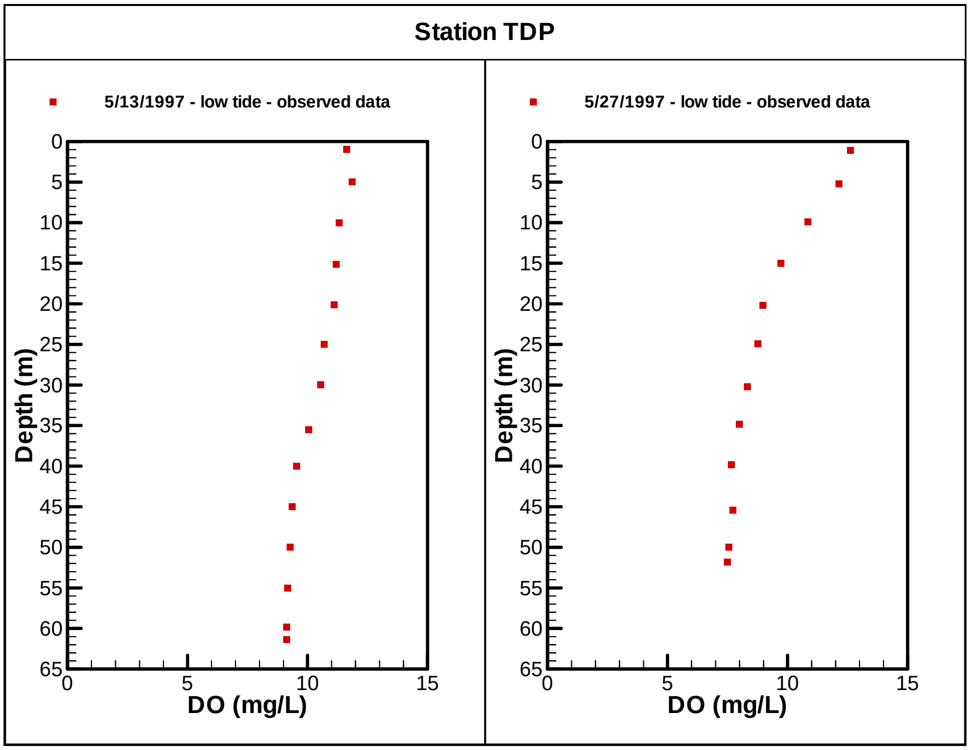


**Figure C-131. Dissolved oxygen profiles at Station TDP measured on May 1997**

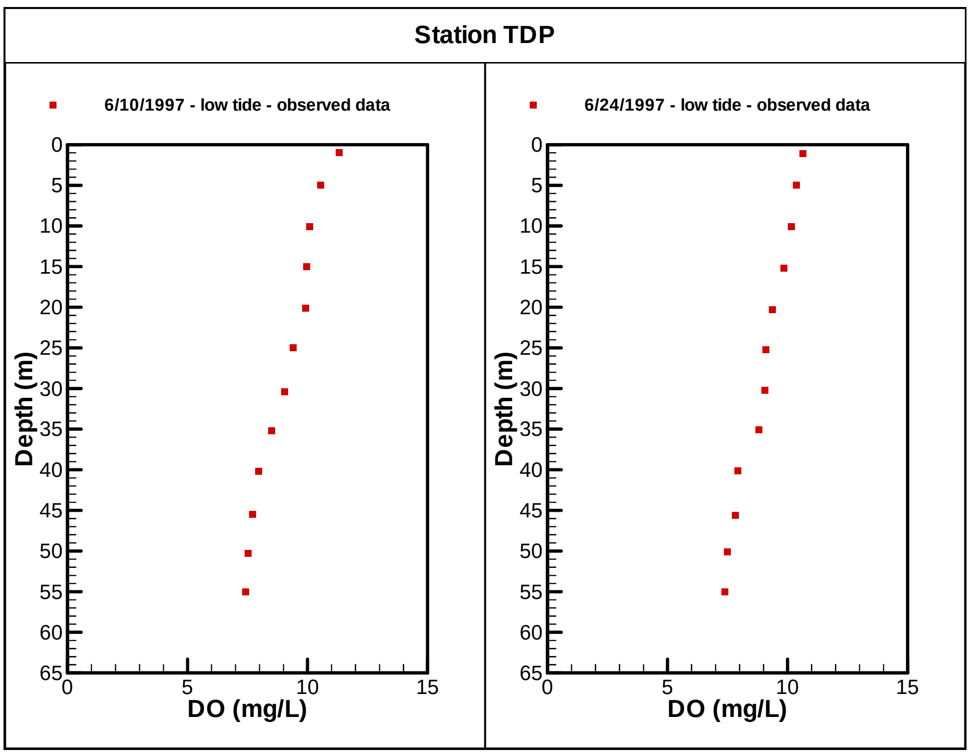


**Figure C-132. Dissolved oxygen profiles at Station TDP measured on June 1997**

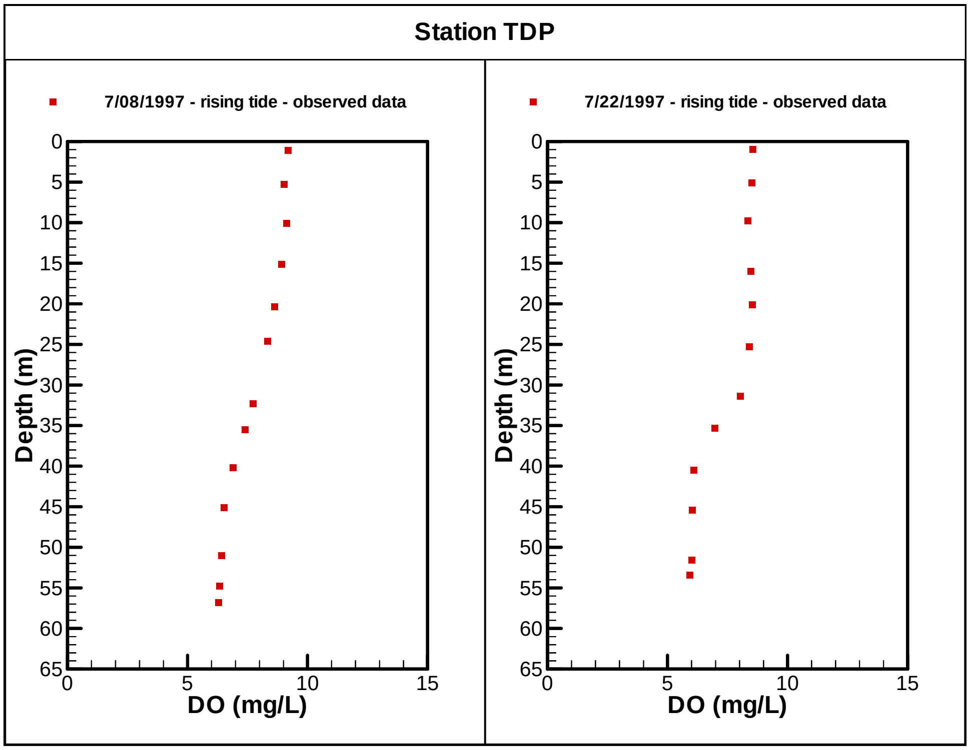


**Figure C-133. Dissolved oxygen profiles at Station TDP measured on July 1997**

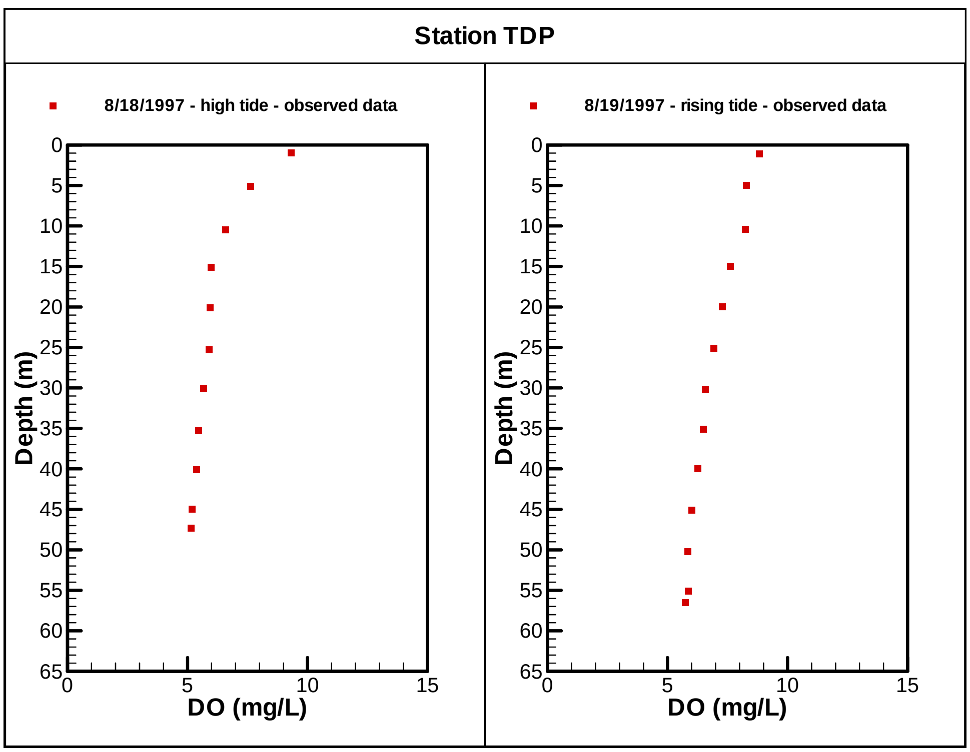


**Figure C-134. Dissolved oxygen profiles at Station TDP measured on August 1997**

# Appendix D.  Meteorological Data

Atmospheric data used in the modeling analysis of dissolved oxygen in Ward Cove were obtained from the NCDC Ketchikan Station (WBAN No. 25325). Figures D-1 to D-3 show the atmospheric pressure, air temperature (dry bulb) and relative humidity for the summer of 1997, respectively.

The short wave solar radiation was theoretically computed based on latitude and the fraction of cloud coverage measured at the Ketchikan Station. Figures D-4 and D-5 show the short wave solar radiation and fraction of cloud coverage respectively.

Figure D-6 shows wind direction and speed of all the occurrences of wind events during the summer of 1997 measured at Ketchikan. Figure D-7 presents the frequency of wind direction for the same period. Wind direction for this analysis is the direction towards which the wind is blowing. Winds blowing towards the southeast are the most frequent and winds blowing towards the northwest are the strongest. Figure D-8 shows the wind components in the north-south and east-west direction.

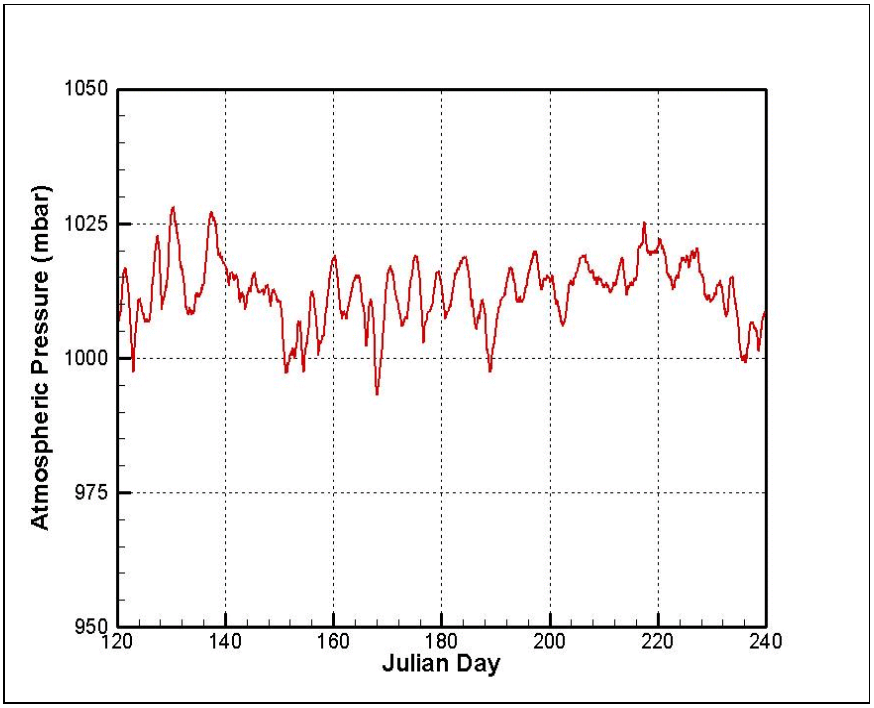


**Figure D-1. Atmospheric pressure measured at Ketchikan.**

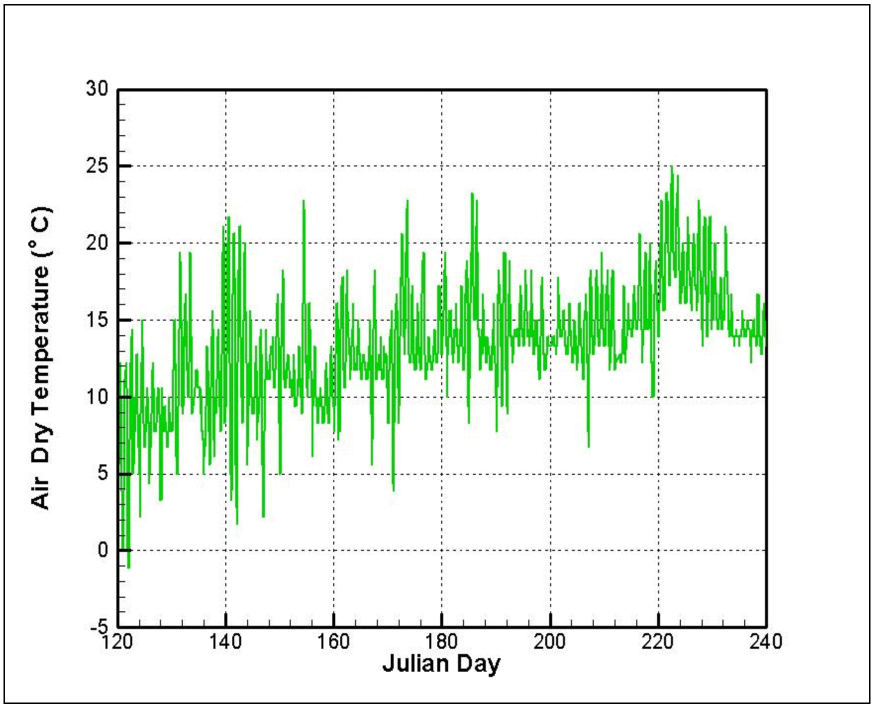


**Figure D-2. Air dry temperature measured at Ketchikan.**

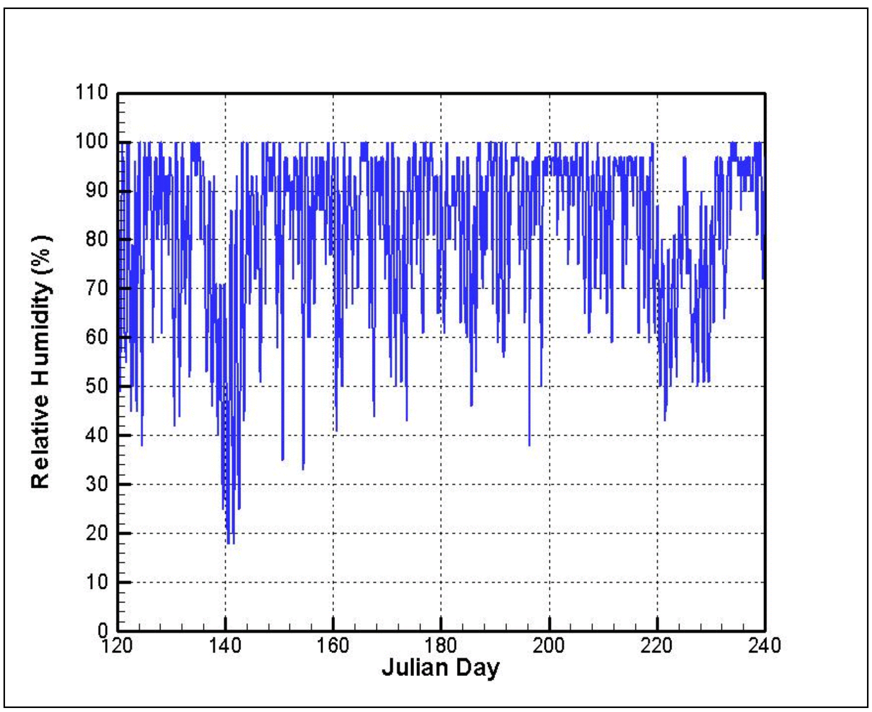


**Figure D-3. Relative humidity measured at Ketchikan**.

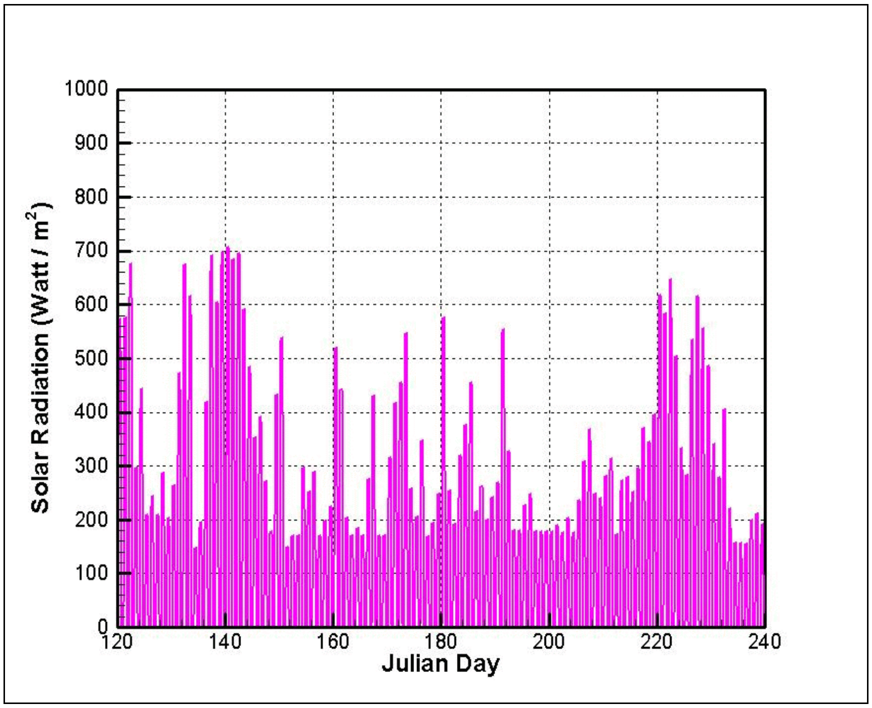


**Figure D-4. Calculated short wave solar radiation.**

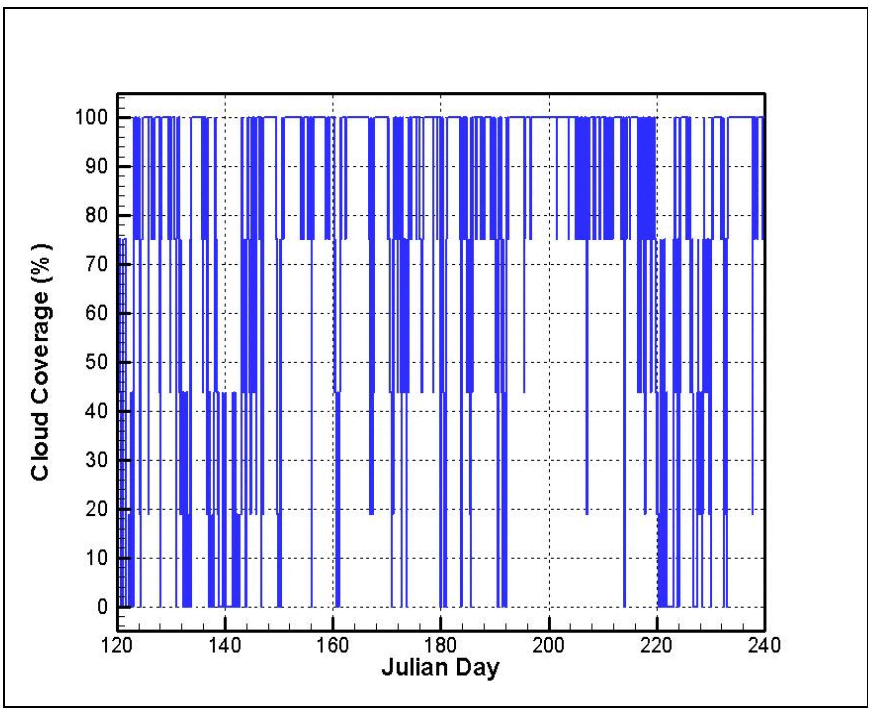


**Figure D-5. Cloud coverage measured at Ketchikan.**

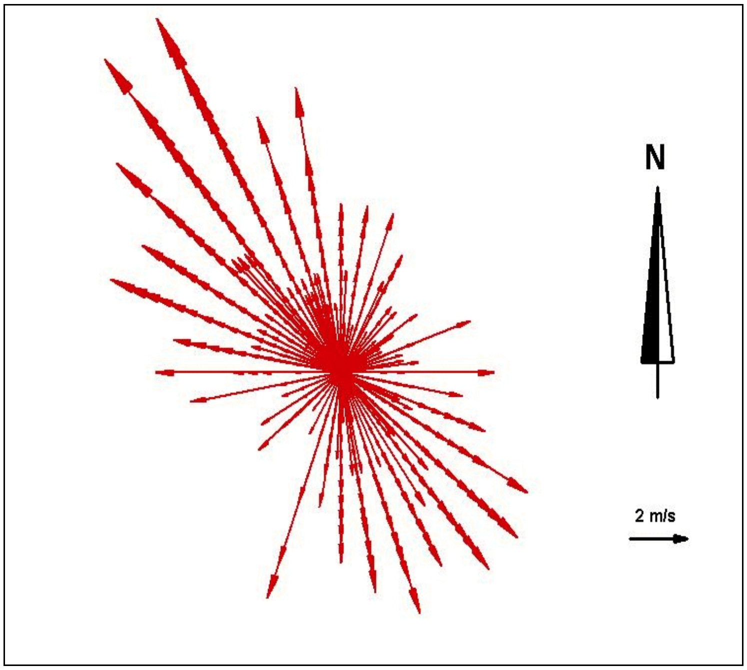


**Figure D-6. Wind direction and speed measured at Ketchikan. (Arrows point in the direction to which the wind is blowing).**

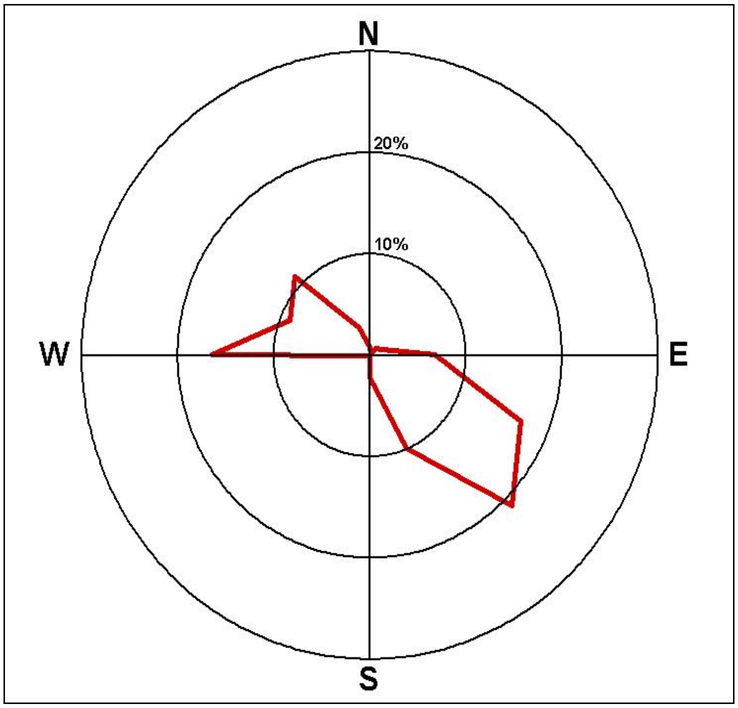


**Figure D-7. Frequency of occurrence of wind direction.**

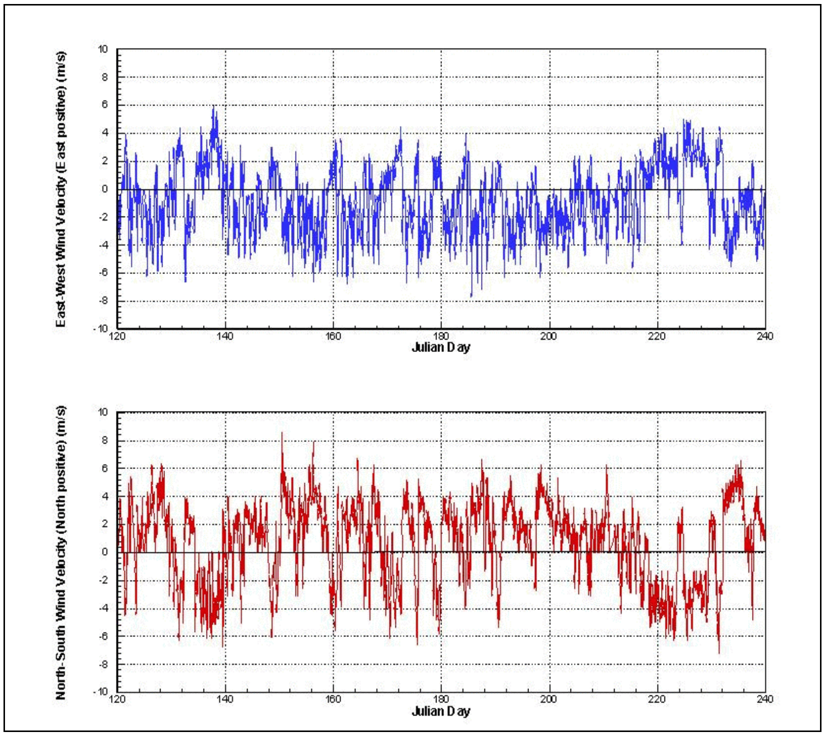


**Figure D-8. North-south and east-west wind components at Ketchikan.**

# Appendix E

# 2003 Dissolved Oxygen Monitoring Data in Ward Cove

The following tables present dissolved oxygen data collected in Ward Cove and Tongass Narrows on five dates: August 16, August 23, September 4, September 15, and September 28. At each station, data were recorded using a YSI instrument lowered from the surface with a reading taken at five meter depth increments. Water depth is shown in meters; dissolved oxygen values are in mg/L. Values less than the water quality criterion for dissolved oxygen, 5 mg/L, and shown in yellow. Values with an asterisk are assumed to be erroneous. The reference is a report prepared for the Alaska Department of Environmental Conservation by Tetra Tech, Inc.: Ward Cove Dissolved Oxygen Evaluation; Presentation and Assessment of Data; December 29, 2003.

**Figure E-1. Location of 12 Sample Stations in Ward Cove and Tongass Narrows. Nine stations were used in 2003.**

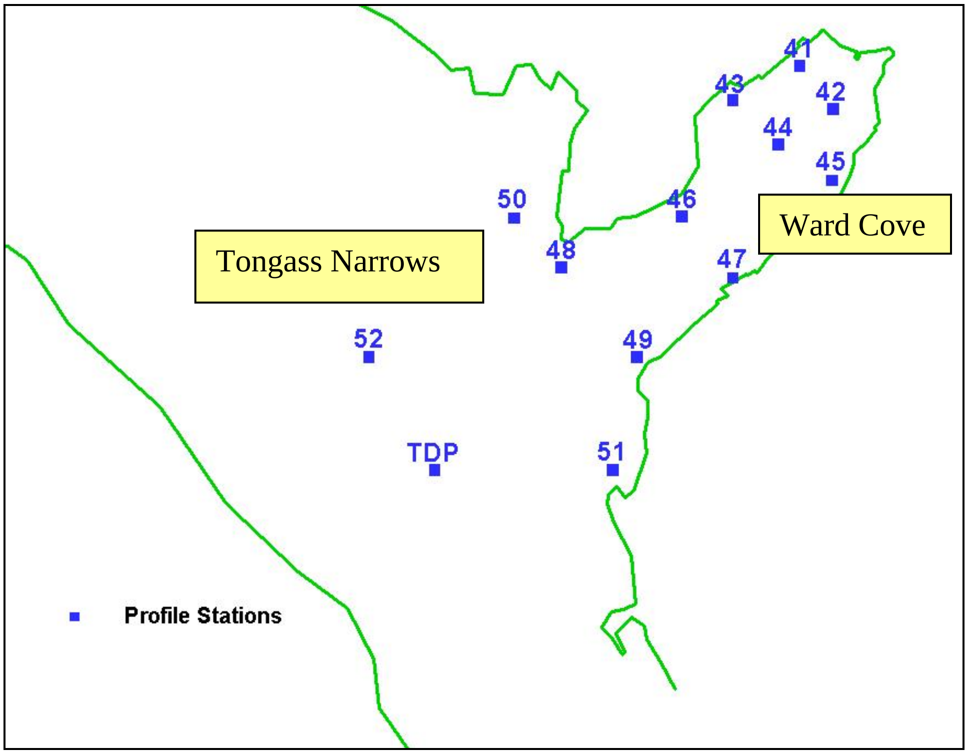

**Table E-1. August 16, 2003. Data are incomplete. Depths in meters; values in mg/L.**

| Station # /Depth | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 52 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | | | | | | 9.20 | 8.76 | 8.28 | |
| **5** | | | | | | 7.98 | 8.25 | 7.89 | |
| **10** | | | | | | 7.56 | 7.19 | 7.53 | |
| **15** | | | | | | 6.98 | 6.79 | 6.81 | |
| **20** | | | 6.55 | | 6.80 | 6.60 | 6.32 | 6.50 | |
| **25** | | | | | | 6.06 | 5.86 | 6.07 | |
| **30** | | | | | | | | | |

**Table E-2. August 23, 2003. Depths in meters; values in mg/L.**

| Station # /Depth | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 52 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 8.01 | 7.85 | 7.97 | 7.99 | 7.82 | 7.96 | 8.06 | 7.99 | 8.11 |
| **5** | 7.86 | 7.66 | 7.79 | 7.76 | 7.47 | 7.72 | 7.79 | 7.77 | 7.59 |
| **10** | 6.69 | 7.12 | 6.81 | 6.94 | 7.17 | 7.23 | 7.20 | 7.41 | 7.54 |
| **15** | 6.71 | 6.49 | 6.83 | 6.92 | 7.40 | 7.41 | 7.50 | 7.49 | 7.61 |
| **20** | | 6.38 | 6.61 | 7.36* | 7.11 | 7.41 | 7.41 | 7.53 | 7.55 |
| **25** | | 6.47 | 6.62 | | 7.16 | 7.25 | 7.36 | 7.24 | 7.39 |
| **30** | | | 6.14 | | 6.20 | 7.16 | 6.46 | 7.04 | 6.86 |
| **35** | | | | | | 6.46 | | | 5.67 |
| **40** | | | | | | 5.51 | | | 5.35 |
| **45** | | | | | | 4.64 | | | -- |
| **50** | | | | | | 4.07 | | | 4.76 |

**Table E-3. September 4, 2003. Depths in meters; values in mg/L.**

| Station # /Depth | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 52 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 7.17 | 6.99 | 7.06 | 7.18 | 7.07 | 7.17 | 7.06 | 7.20 | 7.44 |
| **5** | 5.95 | 5.91 | 6.62 | 6.67 | 6.63 | 6.64 | 6.93 | -- | 6.85 |
| **10** | 5.20 | 5.80 | 5.96 | 5.47 | 5.88 | 5.90 | 6.23 | 6.07 | 6.52 |
| **15** | | 5.55 | 5.38 | 5.57 | 5.58 | 5.90 | 5.61 | 6.05 | 6.19 |
| **20** | | 4.85 | 5.22 | 5.08 | 5.38 | 5.56 | 5.45 | 5.87 | 6.12 |
| **25** | | | | 5.06 | 5.16 | 5.59 | 5.63 | 5.54 | 5.85 |
| **30** | | | | 4.89 | 4.93 | 5.01 | 5.58 | 5.40 | 5.72 |
| **35** | | | | | 4.98 | 4.93 | 5.37 | 4.88 | 5.45 |
| **40** | | | | | 4.77 | 4.73 | | 4.59 | 5.11 |
| **45** | | | | | | 4.55 | | 4.67 | 4.85 |
| **50** | | | | | | 7.17* | | 4.42 | 4.58 |

* Presumed erroneous value

**Table E-4. September 15, 2003. Depths in meters; values in mg/L.**

| Station # /Depth | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 52 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 7.71 | 8.00 | 7.61 | 7.58 | 7.36 | 7.50 | 7.48 | 7.74 | 7.40 |
| **5** | 7.48 | 7.42 | 7.43 | 7.36 | 7.25 | 7.31 | 7.26 | 7.40 | 7.44 |
| **10** | 6.55 | 6.93 | 6.74 | 6.72 | 6.83 | 6.65 | 7.10 | 6.82 | 7.29 |
| **15** | | 6.23 | 6.83 | 6.61 | 6.61 | 6.76 | 6.77 | 6.98 | 7.20 |
| **20** | | 6.09 | 6.42 | 6.56 | 6.27 | 6.65 | 6.59 | 6.90 | 7.04 |
| **25** | | 5.65 | 5.98 | 6.44 | 6.37 | 6.41 | 6.54 | 6.54 | 6.81 |
| **30** | | 5.63 | 5.75 | 5.98 | 6.05 | 6.11 | 5.93 | 6.11 | 6.35 |
| **35** | | | 5.31 | 4.92 | 5.25 | 5.33 | | 5.60 | 5.80 |
| **40** | | | | | 5.14 | | | 5.24 | 5.33 |
| **45** | | | | | 4.75 | | | 4.87 | 5.11 |
| **50** | | | | | 4.44 | | | 4.71 | 4.84 |

**Table E-5. September 28, 2003. Depths in meters; values in mg/L.**

| Station # /Depth | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 52 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 7.51 | 7.43 | 7.51 | 7.59 | 7.70 | 7.62 | 7.80 | 7.91 | 7.81 |
| **5** | 6.97 | 7.23 | 7.17 | 7.07 | 7.52 | 7.15 | 7.30 | 7.34 | 7.33 |
| **10** | 6.31 | 6.96 | 6.61 | 6.60 | 7.24 | 7.09 | 7.09 | 7.22 | 7.33 |
| **15** | 6.05 | 6.44 | 6.36 | 6.30 | 6.71 | 6.96 | 6.91 | 6.96 | 7.20 |
| **20** | | 6.14 | 6.22 | 6.20 | 6.60 | 6.48 | 6.62 | 6.71 | 6.83 |
| **25** | | | 5.89 | 5.85 | 6.49 | 6.37 | 6.21 | 6.35 | 6.49 |
| **30** | | | | 5.48 | 6.09 | 6.06 | 5.81 | 6.03 | 6.38 |
| **35** | | | | | 5.89 | 5.62 | | 5.89 | 5.96 |
| **40** | | | | | 5.72 | 5.38 | | 5.68 | 5.34 |
| **45** | | | | | | 4.75 | | 5.05 | 5.12 |
| **50** | | | | | | | | | 5.01 |

# Appendix F

## Summary of Public Comments and ADEC Responses for the Draft Ward Cove TMDLs for Residues and Dissolved Oxygen

**Alaska Department of Environmental Conservation**
**555 Cordova Street**
**Anchorage, AK 99501**

**November 2006**

ADEC issued public notice that draft TMDLs for Residues and Dissolved Oxygen in Ward Cove were available for public review and comment from January 22 through March 8, 2006. ADEC held a public informational meeting concerning the draft TMDLs in Ketchikan on February 15, 2006. Four entities submitted written public comments to ADEC. The table on the following pages summarizes the comments received and presents ADEC's responses to those comments.

Acronyms:

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| ADEC | Alaska Department of Environmental Conservation |
| AOC | Area of Concern |
| DTSR | Detailed Technical Studies Report (Exponent, 1999) |
| RAO | Remedial Action Objectives |
| ROD | Record of Decision |
| USEPA | U.S. Environmental Protection Agency |
| ZOD | Zone of Deposit |
| WQS | Water Quality Standards |

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| 1 | Comment: Ward Cove looks great and is not visibly impaired. Whales, sea lions, seals, salmon, and many varieties of birds have been seen recently, along with lots of life in the intertidal zone. Recent dive reports indicate abundant sea life on the bottom of the cove. Sport fishermen regularly fish along Ward Creek near the Cove. The pulp mill boom crew regularly caught crabs in log storage areas when the mill was operating.<br><br>Response: With the exception of wood residues, sediment toxicity, and dissolved oxygen, as described in the TMDLs, the waters of Ward Cove appear to be meeting Water Quality Standards (WQS). The benthic assessment conducted by Ketchikan Pulp Company in 2004 as a requirement of the Superfund remediation project showed that, while biological recovery is taking place, biological impacts remain due to wood residues present in bottom sediments of the cove. |
| 2 | Comment: The proposed TMDL is more than adequate to insure continued remediation of the bottom of the cove. Responsible development should be allowed in the cove; disallowing industrial activity will simply move impacts to another site. Ship and barge unloading of logs should be allowed in addition to loading, including temporary log storage along the western shoreline.<br><br>Response: The TMDLs for wood residues and dissolved oxygen allow State and federal wastewater discharge permits for industrial activities in Ward Cove to be issued by ADEC and USEPA in conformance with the TMDLs. Allowable log-related activities include ship (and barge) loading and unloading, log storage along the western shoreline and elsewhere, and log transfer to and from land. |
| 3 | Comment: The TMDL does an excellent job of balancing the need to allow water quality to improve in the cove with the desires of the community to resume operations at the veneer plant and promote development on the other properties surrounding the cove.<br><br>Response: Comment noted. |
| 4 | Comment: The proposed residues loading capacity for the log storage area is slightly less than granted in the Ketchikan Borough's 2004 log storage permit.<br><br>Response: Compared to the Borough’s 2004 permit, the loading capacity for log storage areas in the final residues TMDL is reduced by 28 percent. The wasteload allocation, which will govern future discharge permits, includes a “margin of safety” that makes the effective reduction 35 percent. For log transfer areas, the final TMDL wasteload allocation is reduced by 19 percent. However, the loading capacities and wasteload allocations in the final TMDL are expressed as daily limits rather than annual limits, so the values appear much smaller. |

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| 5 | Comment: It is critical for the TMDL to ensure the integrity of the Superfund remedial action and the ability to monitor progress toward achieving the Remedial Action Objective of a "healthy marine benthic infauna community with multiple taxonomic groups."<br><br>Response: The residues TMDL was developed jointly with the USEPA, which oversees the Superfund program in Ward Cove. The Superfund Record of Decision (ROD) (USEPA 2000) acknowledges that timber processing activities are expected to be ongoing in Ward Cove. The TMDL allows future log storage and transfer within the Superfund Area of Concern (AOC), but not over areas of the bottom that received thin-capping remediation. |
| 6 | Comment: The Executive Summary states, "*The KPC pulp mill discharged large amounts of chemicals and pulp residues to Ward Cove during its years of operation, 1954 to 1997*." This implies that the level of discharge of chemicals and pulp residues was unchanged from the first years of operation. This is incorrect, as the mill instituted substantial treatment measures starting in the early 1970s.<br><br>Response: ADEC has clarified that most chemical and pulp residue discharge occurred in the early years of operation. Section 5, Pollutant Sources, discusses the details of discharge controls established over time for various pollutants. |
| 7 | Comment: The Executive Summary states, "*Results showed that three sand-capped areas and one shallow natural recovery area (not sand-capped) have achieved biological recovery; five other natural recovery areas tested have not achieved biological recovery but are making significant progress.*" Only three strata in natural recovery areas require further monitoring of recovery progress.<br><br>Response: ADEC has clarified that non-recovered areas are "three other natural recovery areas." |
| 8 | Comment: Section 2.1. The presence of an extensive tide flat and tidal basin at the mouth of Ward Creek suggests that organic matter from other sources, such as the creek, may be important considerations in developing the TMDL for wood debris associated with the LTF and LSA.<br><br>Response: While Ward Creek is recognized in the TMDL as a source of sediments deposited in the cove, it is not expected to be a significant source of wood residues. |
| 9 | Comment: Section 2.1. The discussion of subsurface flow conditions in Ward Cove seems weak and speculative. Average current velocities do not provide any indication of the peak tidal and estuarine flows that could be used meaningfully for comparisons with critical sediment erosion velocities. Current surveys from KPC's outfall relocation and |

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| | permitting process for the pulp mill in the mid 1990s should be incorporated in this analysis.<br><br>Response: This section is a general discussion of subsurface currents. ADEC believes that detailed analysis of current velocities and sediment erosion is not necessary to development of the TMDLs. |
| 10 | Comment: In Section 2.2, acres per 10,000 square meters should be 2.47, not 2.57.<br><br>Response: ADEC has made this clarification. |
| 11 | Comment: Section 3.1 states, "*Exceedance of the residues standard in Ward Cove most directly affects the designated use of growth and propagation of fish, shellfish, other aquatic life, and wildlife.*" This and subsequent statements are highly speculative about conditions that "may be" or "might" occur. This section should make use of actual observations within Ward Cove and should include the results about recovery and the benthic community documented in the 2005 monitoring report.<br><br>Response: This section is a general discussion of potential effects of wood residues on designated uses; however, ADEC has reduced the use of speculative terms. The 2005 benthic monitoring report is covered in Section 4.1, Water Quality Analysis, Residues. |
| 12 | Comment: Section 3.1. Paragraphs 3, 4, and 5 are unclear. They should identify known stressor relationships from the scientific literature and relate them to the specific categories of exposed biota and conditions in Ward Cove. For example, paragraph 5 seems to equate stress caused by hypoxia to non-mobile life stages of some fish species with that in benthic invertebrates. However, tolerances of benthic infauna are likely to be greater than those of fish eggs and embryos.<br><br>Response: This section is a general discussion to explain the nature of impact concerns for aquatic life. As indicated by the citation following each paragraph, the text is based on a report prepared in 2003 by EPA specifically to evaluate the effects of reduced dissolved oxygen on the fish and invertebrate resources in Ward Cove. ADEC has determined that more specific analysis of this issue is not required. |
| 13 | Comment: Section 3.4. Although existing wood residues may not be seasonally affected, the condition of biological communities can be highly dependent on seasons and may be affected by seasonal disturbances that are independent of residues and which may vary from year to year. Therefore some consideration needs to be provided for this kind of variability, which is the basis for assessing the residues target. |

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| | Response: A TMDL must consider seasonal variation in pollutant loadings, waterbody response, or impairment conditions that can affect the development and expression of the TMDL. While seasonal factors may be complex and variable, ADEC believes that they are not significant to the development and expression of the residues TMDL. |
| 14 | Comment: Section 4.1 states, "*The area surveyed, on the east shoreline approximately 1/4 mile south of the mouth of Ward Creek, is outside of the wood waste area documented by the Superfund assessment.*" Given that the remedial investigation performed by KPC was designed to assess the entire cove, it would be more accurate to state that the area surveyed was outside the AOC.<br><br>Response: The statement is intended to indicate that wood residues at the East LTF site are outside of and in addition to the wood waste area documented by the Superfund Detailed Technical Studies Report (DTSR). |
| 15 | Comment: Section 5.1 states, "*Initially, KPC had no discharge permit or regulation of its discharge.*" KPC did have a discharge permit issued by the Alaska Water Pollution Control Board at the start of operations in Ward Cove.<br><br>Response: ADEC has clarified this statement. |
| 16 | Comment: Section 5.1 states, "*The pulp mill effluent contained highly processed pulp residues that had a high oxygen demand and could degrade in sediments to form ammonia, sulfides, and other toxic substances. If ammonia and sulfides are formed at high enough levels in the sediments, they can contribute to the toxicity of sediments and deplete oxygen in the process. The effluent also contained chemicals, including resin acids, phenols, and dioxins and furans.*" This paragraph is poorly worded and misleading. Oxygen depletion due to the natural decomposition of organic-rich sediments that resulted from the pulp mill discharges led to the production of ammonia and sulfides. Based on KPC's Detailed Technical Study Report, dioxins, furans, resin acids, and phenols are not chemicals of concern in Ward Cove.<br><br>Response: ADEC has clarified this paragraph. |
| 17 | Comment: Section 5.1, Wastewater Discharge. Paragraph 5 states, "The discharge permit expired at the end of 2003." The discharge permit did not expire, but was administratively extended; please delete this sentence.<br><br>Response: ADEC has clarified this statement. |
| 18 | Comment: Section 5.1, Log Storage. Log transfer, not log storage, was the source of sunken logs. |

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| | Response: Sunken logs are distributed over roughly 75 percent of the cove. ADEC has changed this statement to "log storage and transfer.' |
| 19 | Comment: Section 5.1, Log Transfer. The East LTF was operated only occasionally and mostly by operators other than KPC. The statement here implies that it was operated continuously.<br><br>Response: ADEC has clarified this statement. |
| 20 | Comment: Section 5.2, Nonpoint Sources. The "load" from Ward Creek is mentioned, but there's no quantitative information or comparison with bottom water entering from Tongass Narrows. These natural sources of organic matter will ultimately define the benthic community habitat in both the natural recovery and the thin capped portions of the AOC in the absence of LTF or LSA point sources. Consequently, it is important to recognize their relative contributions to put into perspective the potential influence of any additional organic enrichment associated with a permitted LTF or LSA.<br><br>Response: The estimated organic (BOD) load from both Ward Creek and Tongass Narrows was included in the computer model prepared for the dissolved oxygen TMDL by Tetra Tech, Inc., as indicated in Section 4.2, and thus is reflected in that TMDL. The residues TMDL recognizes (Section 6.1, Log Storage Areas) that naturally-deposited organic matter contributes to sediment accumulation and influences benthic habitat. However, ADEC is aware of no information to quantify deposited organics (i.e., biological detritus) from either Ward Creek or Tongass Narrows to apply to the residues TMDL. ADEC's model for developing the residues TMDL is based on wood residues content in sediment as reflected in scientific and other literature, and does not include quantification of either deposited organics or organics derived from infauna. |
| 21 | Comment: Section 6.1, Residues and Loading Capacity. This section indicates that the 188 acres in Ward Cove already affected by wood wastes are targeted for inputs of additional material. The targeted area includes the thin cap and natural recovery areas within the AOC, but excludes the 62 acres in Ward Cove that do not have deposits of wood. It seems that these 62 acres would have a higher tolerance for low levels of organic enrichment and should be included in the TMDL.<br><br>Response: First, the TMDL excludes areas that received Superfund thin capping from receiving future wood wastes. Second, the 62 acres not having documented wood residues on the southeast side of the cove, for the most part, are areas not used in the past for log storage and transfer and are not likely to be used in the future. ADEC believes that future discharge and accumulation of wood residues should be limited to the area affected by existing wood residues (identified by Superfund maps), and to the site of the East LTF (not included on the Superfund |

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| | maps). By keeping future wood residues off the 62 acres, that area can serve as a reference for biological recovery, and can provide organisms for colonization of recovering areas. |
| 22 | Comment: Section 6.1, Loading Capacity, Log Storage Areas. Paragraph 3 states, "The major source of settleable sediment likely is Ward Creek at the head of the cove. Ocean detritus presumably contributes to sediment accumulation, but it might decompose in varying degrees." This paragraph seems to be inconsistent with statements made in Section 5.2 (Nonpoint Sources) that indicate that natural sources of organic material are unlikely to contribute significantly to residues in Ward Cove. Dismissing "ocean detritus" because it might decompose doesn't make a lot of sense. A higher rate of degradation implies that it might also have a higher BOD and would be influential in structuring the benthic community.<br><br>Response: ADEC has clarified that the reference in Section 5.2 to natural sources concerns wood residues, not ocean detritus. |
| 23 | Comment: Sections 3.3 and 6.1. Please clarify whether the 40 percent wood waste by volume is derived from the 40 percent TVS value developed by the Hylebos Wood Debris Group or on the 40 percent by volume value generated in the unpublished Walker study.<br><br>Response: The 40 percent wood waste by volume figure is based most directly on the 1997 report prepared by the U.S. Army Corps of Engineers and the Washington Department of Ecology and on the 1984 Kathman, et al. study, both discussed in Appendix A of the TMDL. The maximum acceptable level of wood residues content in sediment, as interpreted by ADEC, is 50 percent by volume (not TVS). As a conservative factor, ADEC has reduced the level to 40 percent wood waste by volume for application in the Ward Cove TMDL. |
| 24 | Comment: Section 6.1, Loading Capacity, Log Storage Areas. The natural sedimentation rate of 0.35 cm/year is only one factor that influences the relative volume of wood in sediments. Other factors that seem equally, if not more, important in a low depositional environment are natural rates of decomposition and erosion.<br><br>Response: The natural sedimentation rate of 0.35 cm/year is a "net rate," derived from the historical sediment record, and so inherently accounts for decomposition and erosion over time. For wood wastes, ADEC has no information concerning natural rates of decomposition and erosion, and therefore cannot incorporate these factors into the TMDL. However, ADEC believes that the wood-volume model used in the residues TMDL, based on literature, largely accommodates those factors. Further, the TMDL incorporates conservative factors to account for uncertainties. |

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| 25 | Comment: Section 6.1, Loading Capacity, Log Storage Areas. The proposed wasteload allocations rely on sedimentation rate data for Ward Cove that are not high quality and are not representative of current conditions or the cove as a whole. Baseline monitoring to establish actual sedimentation rates in a project area should be required as part of a permit application.<br><br>Response: The Superfund DTSR states that the sedimentation rate probably is representative of the cove. The DTSR notes further that the rate likely is representative after cessation of the pulp mill discharge, and that the rate has been essentially constant at the monitored location for the last 100 years or more. Because the calculated sedimentation rate is based on a single sample, additional assessment of sedimentation rate would be desirable. However, the TMDL must be based on available data. Determination of sedimentation rate is not likely to be a requirement of a discharge permit application or of a discharge permit. It would be better to monitor biological recovery directly than to monitor sedimentation rate. |
| 26 | Comment: Section 6.1, Loading Capacity, Log Storage Areas. It seems unlikely that the depositional rate of 1.15 cm of wood per five years could be measured reliably using present techniques and considering the depth of the cove in the AOC. The impacts of 1.15 centimeters of wood waste on top of an already impaired area could be more detrimental than on top of native sediments.<br><br>Response: The TMDL establishes a wood residues volume discharge limit, and not a limit on actual thickness of wood residues accumulation. The figure of 1.15 cm wood residues accumulation in five years is not a standard of measurement for accumulation of wood residues on the bottom but is the basis for calculating the volume discharge limit. Monitoring requirements concerning volume of material discharged will be established in discharge permits. Innovative monitoring requirements are included in the current log storage discharge permit issued in 2004 by ADEC to the Ketchikan Gateway Borough and transferred in 2006 to the Renaissance Ketchikan Group. Discussion of specific monitoring issues is beyond the scope of the TMDL. Final comment noted. |
| 27 | Comment: Section 7.1, Monitoring, Residues. The only monitoring specifically cited is that currently performed by KPC for the 80-acre area of concern in Ward Cove. KPC's monitoring program was not designed or intended to be used to measure biological recovery for purposes of the residues TMDL, which covers a broader area of Ward Cove over a projected timeframe of 40 years.<br><br>Response: The TMDL does cover a broader area than KPC's monitoring. Although limited to the AOC and two reference areas outside the AOC, KPC's monitoring is extremely useful to the residues TMDL. Goals for biological recovery under the ROD and under the TMDL are very similar. KPC's |

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| | monitoring of chemistry, toxicity, biological metrics, and taxonomy likely will help determine whether the TMDL target is met in the areas monitored. While the TMDL supports additional monitoring of biological recovery, none presently is planned by ADEC or EPA. Monitoring might be conducted in the future by the agencies or as a requirement of discharge permits or other activities. |
| 28 | Comment: Alaska's Water Quality Standards do not permit establishment of a zone of deposit (ZOD) in an impaired waterbody. The standards require ADEC to protect designated uses of waters, and prohibit ADEC from authorizing activities that will further degrade an impaired waterbody. The TMDL cannot allow accumulation of any residues that will impede the biological recovery process. The antidegradation provision allows ADEC to authorize a reduction in water quality in a ZOD only if the existing water quality exceeds the standards, which Ward Cove does not.<br><br>Response: The TMDL limits for Ward Cove are intended to protect designated uses in the waterbody as a whole, and to allow biological recovery to continue in log storage areas, even with future bark discharge and accumulation. The exception to biological recovery is the one acre allocated to log transfer activities, which is established as an impact zone.<br><br>A zone of deposit (ZOD) may be used to implement the TMDL through a permit. Alaska's regulations do not prohibit establishing a ZOD in an impaired waterbody. The water quality standards (WQS) and the antidegradation requirements may be exceeded in a ZOD.<br><br>The TMDL is consistent with the antidegradation policy. The wasteload allocation for wood debris is calculated to achieve the residues target for the Ward Cove TMDL, which is a level of residues that will support the achievement of stable, balanced benthic communities in more than 75 percent of the area covered by wood residues on the bottom of Ward Cove. The wasteload allocation will not further degrade the 46 acres where a small amount of wood debris is allowed to accumulate and is calculated to allow recovery in this area. The one-acre transfer area is currently significantly degraded; however, the TMDL requires removal if 10 cm of wood debris accumulates, and the area is de minimus so that the overall target still will be achieved. |
| 29 | Comment: ADEC has not justified the decision to allow additional wood waste accumulation in 25 percent of the area presently covered with wood debris. Simply because in natural communities disturbances occur such that only 75 percent of the community can be expected to be at Stage III, it does not follow that it is reasonable to allow 25 percent man-made disturbance. The fact that natural recovery is spotty offers no support at all for the notion that further degradation will not inhibit designated uses. ADEC has failed to meet its burden of showing that load allocations proposed in the draft TMDL will not impede the biological recovery process for Ward Cove. The most likely outcome of additional residues deposition is a reduced and slower recovery rate. |

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| | Just as the bottom waters of the cove have no remaining assimilative capacity for dissolved oxygen reduction, it should be determined that there is no remaining assimilative capacity for residues until at least 75 percent of the cove has recovered.<br><br>Response: Achieving 75 percent of an area with mature "Stage III" communities is a biological recovery standard. It is not the basis for allowing future wood residues accumulation in 25 percent of the area with existing wood residues. The wasteload allocation for future wood residues in 25 percent of the area with present accumulation of wood waste is intended to allow biological recovery to proceed in log storage areas and in the waterbody as a whole (excepting only the one-acre log transfer area). The basis in science and management practice for these allocations is explained in Section 6.1 of the TMDL. |
| 30 | Comment: ADEC bases the permissible volume of residues discharge on wood waste content of 40 percent. However, wood debris is unlikely to fall uniformly over the bottom. Wood debris likely will make up a much higher percent of the sediment volume in the area where it falls.<br><br>Response: This situation is clearly recognized in the TMDL in Section 6, Loading Capacity, Log Storage Areas. However, if there is greater bark accumulation in some areas, there must be less bark accumulation in other areas in order to comply with the volume limit on a per acre basis. Monitoring requirements likely will be implemented in discharge permits to assure compliance with bark discharge limits. |
| 31 | Comment: The draft TMDL for dissolved oxygen establishes the WQS as the wasteload allocation, rather than a quantified assimilative capacity. How will ADEC determine whether a proposed new source will impact bottom waters, particularly given the seasonal stratification changes in Ward Cove?<br><br>Response: In the final TMDL for dissolved oxygen, as in the public review draft, the loading capacity is set at the WQS level of 5 mg/L, which is a concentration-based limit. In the draft, the wasteload allocation was set as "not established." In the final TMDL, the wasteload allocation is set as "no point source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L from June through September. 'Measurable decrease' means a decrease in dissolved oxygen level greater than 0.2 mg/L." Assuring compliance with the dissolved oxygen TMDL will be the responsibility of USEPA and ADEC in issuing discharge permits. Analysis, modeling, monitoring, and other tools may be employed. |
| 32 | Comment: Now that the cannery is closed, the associated ZOD for fish waste also should be closed. The pile of fish waste should be removed or its impacts remediated to alleviate impacts to oxygen depression in bottom waters. |

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| | Response: The TMDL provides no wasteload allocation for future deposit of fish wastes in Ward Cove, so the zone of deposit in effect is "closed." The TMDL does not address removal of existing fish waste residues. ADEC does not believe at this time that removal of the fish waste residues is necessary. Fish waste piles tend to diminish in size fairly rapidly with time through consumption, decomposition, and dispersal. They will reduce to hard materials that express relatively little continuing oxygen demand. |
| 33 | Comment: No basis exists in the WQS for allowing a 40-year timeframe before achieving standards, and allowing further discharges to already impaired areas during that time. The Superfund DTSR estimated a 40-80 year timeframe for recovery of wood waste areas. The 40-year goal for recovery stated in this TMDL is unrealistically low. Pulp wastes are expected to recover most rapidly; the timeframe for decomposition of bark and logs is on the order of decades to hundreds of years.<br><br>Response: It is the function of a TMDL, not the WQS, to establish timeframes for recovery in impaired waters. The residues TMDL target of biological recovery in more than 75 percent of the affected area in 40 years is the same target used in the Silver Bay (Sitka pulp mill) wood residues TMDL. The Ward Cove Record of Decision states that natural processes are estimated to take 8 to more than 20 years to provide recovery of healthy benthic communities. Clearly, timeframes are uncertain and are variable for different types of wood residues. The time for dense accumulations of logs to decompose and disappear is unknown and likely is greater than 40 years. ADEC believes that 40 years is a reasonable time to achieve biological recovery in sediments containing both pulp and bark residues. Apart from the logs, Ward Cove sediments are not piles or mats of pulp and bark residues. They are, as stated in the DTSR, "soft, fine grain sediments," and "watery, black, flocculent material" with "varying amounts of wood debris (e.g., wood chips, bark)." Superfund assessment and monitoring show that both pulp and bark wastes in sediments are in advanced decomposition and that biological recovery is in process. ADEC believes that biological recovery will continue to advance, as is typical in recovering wood waste environments. |
| 34 | Comment: Pages 10 and 12. The discussion of tides and currents fails to address whether the cove has the capacity to adequately flush sediment and toxics. This makes ADEC's conclusion that there appears to be no area of stagnation within Ward Cove arbitrary and unsupported by substantial evidence.<br><br>Response: The statement that there appears to be no area of stagnation is based on the DTSR, which states that current data do not reveal the presence of stagnation zones. It may be the case that Ward Cove does not have a great capacity for flushing benthic materials out of the bay; however, flushing of |

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| | sediment and toxics is not a factor in developing the residues TMDL. |
| 35 | Comment: Page 13, Section 2.3. No mention is made of the proposed Alaska Marine Highway System port facility in Ward Cove. How would these operations impact the cove and its recovery?<br><br>Response: Recognition of possible Alaska Marine Highway System porting and the proposed Inter-Island Ferry terminal in Ward Cove has been added to appropriate sections of the TMDL. If established, these facilities could remove some area from use for log storage and transfer, for both moorage and navigation. Otherwise, ADEC does not expect these facilities to have a significant effect on the TMDL or on recovery in the cove. |
| 36 | Comment: Page 15, Recreation. ADEC reports in the TMDL that because of the industrial nature and inaccessibility of the shoreline, little recreational use occurs. This is inconsistent with ADEC's own information developed for the Ketchikan Borough's log storage permit, which refers to a salmon sport fishery at the mouth of Ward Creek, commercial scenic boat tours, and personal use crab pots.<br><br>Response: The statement that little recreational use occurs refers to the shoreline, due to its industrial nature and inaccessibility, not to the cove in general. ADEC has clarified this section. |
| 37 | Comment: Page 27. The dive surveys conducted in Ward Cove do not indicate recovery of bottom sediments, which should have healthy benthic communities. The single benthic species identified in the November 2004 dive survey at the log lift—teredo worms—is indicative of a highly impacted benthic community.<br><br>Response: No claim is made that recovery is achieved; however, ADEC believes that the presence of large numbers of worms (they might not have been teredo worms) and the large halibut, Dungeness crab, shrimp, and bullheads noted in the 2004 dive survey indicate that progress is being made toward biological recovery. Dive surveys simply record observations of epifauna present and do not evaluate infauna. |
| 38 | Comment: Page 27. The TMDL states that "substantial developing macroinvertebrate communities are present on the bottom of Ward Cove." This is inconsistent with the July 2003 dive survey that found little marine life evident.<br><br>Response: The reference to macroinvertebrate communities is based on the fauna observed in the 2004 log lift dive survey. The Superfund 2004 monitoring project, also discussed in this section, confirms the presence of developing infaunal communities on the bottom of Ward Cove. ADEC has clarified the |

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| | reference to state that "substantial developing biological communities are present on the bottom of Ward Cove." |
| 39 | Comment: Page 28. The presumption that recovery of complex benthic communities will continue to advance is unsupported by the evidence presented. So far, the only areas showing recovery are those that were sand capped by the Superfund project and one of the natural recovery areas.<br><br>Response: As the TMDL indicates, the 2004 Superfund monitoring report found that three sand-capped areas and one natural recovery area were biologically recovered. The report states that biological communities in three other natural recovery areas "have not progressed as far along the recovery spectrum," and are "characteristic of organically enriched environments…dominated by a few opportunistic species." However, toxicity and total carbon content have declined in the latter areas. The number of species present cove-wide was twice as many as found in 1992. ADEC believes that the non-recovered areas are making significant progress and that recovery of complex benthic communities will continue to advance. |
| 40 | Comment: Page 39. Since the landfill leachate discharge is continuing, it should be identified as current rather than historical.<br><br>Response: This section discusses operations of Gateway Forest Products, which terminated in 2002. Relocation of the continuing landfill leachate discharge is discussed in the preceding Ketchikan Pulp Company section. |
| 41 | Comment: Page 39. The TMDL states that the "the log supply to the veneer mill could be delivered entirely by barge, avoiding the need to secure permits for log storage in the water." If so, is it reasonable to take any risk of impeding Ward Cove's recovery by authorizing additional residue?<br><br>Response: The new owner of the veneer mill has indicated that logs likely will be delivered by barge and not placed in the water. However, the TMDL accommodates not only possible log storage and transfer by the veneer mill, but also by ship loading and unloading and transfer of logs from land to water. For logistical and economic reasons, operators believe some log storage in water may be necessary, even when barging is the primary means of transport. |
| 42 | Comment: Page 43. The TMDL states, "Because future sources of wood waste residues could occur in Ward Cove, and because the zones of deposit provision of the WQS provides a mechanism for ADEC to allow the deposit of residues by establishing limits in a discharge permit, allowance can be made in the TMDL for an amount of future wood waste accumulation that will not significantly impede the biological recovery |

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| | process on the bottom of Ward Cove." How can ADEC reconcile this reasoning with the core principle that TMDLs must be based on scientific analysis and reasonable assumptions?<br><br>Response: The quoted text has been modified in the final TMDL to state, "The scientific studies reviewed and analysis conducted in developing this TMDL support an allowance in the TMDL for an amount of future wood waste accumulation that will not significantly impede the biological recovery process on the bottom of Ward Cove. Alaska's water quality standards allow the deposit of residues by establishing limits in a discharge permit." The scientific analysis and reasonable assumptions employed in the TMDL appear in subsequent portions of Section 6.<br><br>The residues target, loading capacity, wasteload allocations, and margin of safety as described in the TMDL are supported by scientific analysis and reasonable assumptions. A zone of deposit may be used to implement the TMDL through a permit. The zone of deposit regulations are not relevant to determine the loading capacity of wood debris in Ward Cove to allow recovery and achieve the residues water quality standard. |
| 43 | Comment: Page 44. Why is it relevant that there may be new sources of wood waste discharges? There could be people who want to re-establish the cannery, but no BOD allocation is provided for that, because the DO standard is already violated. Similarly, Superfund relies on source control to support toxic recovery in the cove. With no assimilative capacity available for wood waste, the wood products industry should not be treated differently.<br><br>Response: The wasteload allocation for dissolved oxygen in the final TMDL has been modified to: "no point source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L from June through September." This limits but does not prevent future discharges of oxygen-demanding material. A TMDL is required to address both existing and future discharges; potential operators of log storage and transfer are known to exist. The residues TMDL sets limits for future wood residues that will allow recovery to proceed within log storage areas and within the waterbody as a whole. The Superfund ROD acknowledges continuation of the timber industry in Ward Cove. |
| 44 | Comment: Allowing additional wood waste is inconsistent with how the DO and toxics water quality violations are being handled. It appears that ADEC is treating the wood products sources with a great deal more latitude than other industries in complying with water quality criteria, particularly considering that residues violations are far more widespread and will take much longer to recover. |

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| | Response: There is no TMDL for toxics; the matter is deferred to the Superfund sediment remediation project. The modified limit in the final dissolved oxygen TMDL is indicated above, and must be met in future discharge permits. The residues TMDL establishes specific and conservative limits for future wood residues accumulation that will allow benthic recovery to proceed. |
| 45 | Comment: Page 45, Table 6-1. The Superfund project did not map the full area of Ward Cove with respect to wood waste. The actual percentage is unknown and may be greater than 75 percent.<br><br>Response: It is stated in Section 4.1, Water Quality Analysis, Residues, that wood residues cover at least 75 percent of the bottom of Ward Cove, and that the entirety of Ward Cove remains on the 303(d) list because there is no information to show that the remaining 25 percent of the bottom does not contain wood residues and is biologically healthy. |
| 46 | Comment: Page 46. This loading capacity would only be appropriate if the cove were not already impaired and if the sedimentation rate were known with accuracy. As it is, it allows further degradation of an already impaired waterbody and is only supported by incomplete and inconclusive scientific data.<br><br>Response: The loading capacity is intended to allow biological recovery to proceed both within log storage areas and in the waterbody as a whole. ADEC reviewed available and relevant scientific literature in preparing the TMDLs and does not regard this literature as incomplete or inconclusive. |
| 47 | Comment: Page 48, Wasteload Allocations. Wasteload Allocations need to take into account existing conditions and impairments at the time the permit is issued, not waiting 10 years to be revised or recalculated. Any necessary monitoring to document bottom conditions and sedimentation rates should be conducted by the applicant and submitted as part of the permit application.<br><br>Response: A discharge permit must be issued in conformance with a TMDL. However, a TMDL is always subject to modification to address new conditions and information. A TMDL modification can be effected in parallel with the process to issue a permit. Because of uncertainties in Ward Cove, adaptive management may be required in the TMDL and in discharge permits issued. The permit process will determine what information must be provided by an applicant. |
| 48 | Comment: Pages 4 and 9. For dissolved oxygen, use of the term “loading capacity” in conjunction with the water quality standard of 5 mg/l is incorrect. The loading capacity of Ward Cove should be numerically described. The proposed TMDL for dissolved |

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| | oxygen does not provide sufficient information so that a new source could determine whether its discharge is likely to be permissible. If dissolved oxygen in waters below the picnocline in summer months is already at or below 5 mg/l due to natural causes and/or existing wastes, the loading capacity for oxygen should be zero.<br><br>Response: ADEC determined that the best expression of loading capacity for dissolved oxygen in Ward Cove is the WQS level of 5 mg/L; adoption of this WQS level is inherently protective of uses of the waterbody. A concentration-based loading capacity is an acceptable approach, and has been used in other TMDLs. There is not sufficient monitoring information at present to establish loading capacity as a numeric limit. In fact, loading capacity might be variable depending on location within the waterbody. The wasteload allocation is stated as: "no point source loading of oxygen-demanding substances that will cause a measurable decrease in dissolved oxygen level below 5.0 mg/L from June through September." "Measurable decrease" means a decrease in dissolved oxygen level greater than 0.2 mg/L. This allocation is a numeric limit that will allow the acceptability of discharge sources to be determined. Depending on the nature of a proposed discharge, additional monitoring might be required either with application or in operation. |
| 49 | Comment: Page 55, Section 7.1. The monitoring for residues outlined in this section is inadequate. At a minimum, monitoring should include: recovery monitoring in the cove as a whole every 10 years; baseline monitoring for any proposed permit; annual monitoring of log storage and transfer; closure monitoring for ZODs associated with log storage and transfer; and DO monitoring every five years to support possible delisting.<br><br>Response: ADEC supports appropriate monitoring respecting residues and dissolved oxygen, but does not have resources available to commit to monitoring or the ability to require monitoring outside of discharge permits. Discharge permits (other than for ship loading and unloading) likely will contain monitoring requirements that are deemed appropriate to conditions in Ward Cove. ADEC may pursue additional monitoring in the future if funding is available. |
| 50 | Comment: Appendix A, page A-2. Given that wood waste thickness of several feet covers at least 50 percent of the bottom of Ward Cove, how can the studies referring to wood waste thickness of 1 centimeter possibly be relevant?<br><br>Response: It is important to recognize that wood wastes (other than logs) do not exist on the bottom surface of the cove as a discrete pile or layer of bark pieces or pulp waste. Rather, the bottom material is soft sediment containing wood waste fragments. According to Superfund studies, the bottom is soft, fine grain sediment, watery and flocculent at the surface, containing varying amounts of wood wastes, in a state of advanced decomposition. Measured thickness of organic sediments varies from less than one foot to roughly 10 feet. Biological |

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| | activity in bottom sediments generally is limited to depths of a few to several centimeters so the immediate surface layer is the zone relevant to biological recovery and the TMDL. The cited studies examined biological activity in wood waste thicknesses varying from zero to 15 centimeters. |