CHAPTER

10 MONITORING AND RESEARCH NEEDS

Tracking CCMP Objectives

The Clean Water Act (CWA) section 320(b)(6) specifies that each Management Conference shall "...monitor the effectiveness of actions taken pursuant to the plan," with the following two primary goals:

1. measure the effectiveness of the management actions and programs implemented under the Comprehensive Conservation and Management Plan (CCMP); and
2. provide essential information that can be used to redirect and refocus the CCMP during implementation.

In the technical sense, monitoring often entails collecting a series of observations over time. This repetition of measurements over time for the purpose of detecting change distinguishes monitoring from inventory and assessment. For example, maximum daily temperatures could be measured over a summer to assess if high temperatures might limit fish populations under existing conditions; this is an assessment. However, if water temperatures are measured over several years to determine the effect of upstream management activities on water temperature, this is monitoring.

The Tillamook Bay Monitoring Plan (TBMP) is described herein. It is structured so as to answer both implementation and effectiveness types of questions:

1. Are the goals and objectives of the Plan being met?
2. Is the health of the ecosystem changing?

The first type of question is programmatic in nature and addresses Plan implementation issues. The second type of question is environmental in nature, and focuses on changes in ambient conditions, ecological functions, and biological populations and communities. To effectively evaluate the success of the Plan, it will be necessary to track both the extent to which the actions laid out in the Plan are being implemented and the environmental effects, or lack thereof, of those implemented actions.

Implementation Monitoring

Programmatic implementation monitoring will help to keep managers informed regarding the implementation status of various programs and the degree to which programs are or are not achieving their intended outcomes. With this information, managers can modify the Plan or actions as needed to achieve the desired outcomes outlined in the Plan. Where appropriate, resources could be redirected to ensure that desired outcomes are achieved.

Implementation, or programmatic, monitoring is designed to answer such questions as: "Is the CCMP being implemented at the level of commitment specified in the CCMP goals, targets, and measures of success?" "Are the actions in the Plan having the desired effects?" "Does the Plan need to be changed?" We will monitor the effectiveness of implementation based on achieving the goals, targets, or measures of success defined in the CCMP. Many actions in the CCMP lend themselves to this type of administrative monitoring. Implementation monitoring establishes accountability on the part of the designated lead organizations for specific actions outlined in the CCMP. It can also be used to verify whether an educational outreach program has reached its target audience.

The Tillamook County Performance Partnership will develop an on-line, Web-based accountability system that will house all monitoring data at the Tillamook Coastal Watershed Resource Center (TCWRC). This system will track projects and costs so that citizens and resource agencies have access to information regarding implementation activities through the Internet.1 In addition, all data will be available in hard copy form for those without access the World Wide Web. When appropriate, monitoring results will be entered into a monitoring database, then into a Geographical Information System (GIS) to display spatial data. The GIS system has been established by the TBNEP and will be maintained by the TCWRC. The Performance Partnership will establish the monitoring database, which will also be maintained at the TCWRC. The intent is that all data will be Web-accessible (*e.g.* data collected by or for the Program) or Web-linked (*e.g.* DEQ Storet database).

1 Example: A Key Habitat objective is to "enhance 500 miles of riparian habitat in the 0-500' elevation band to healthy condition by 2010." Information contained on the Internet might include: data on how many miles of streambank had been fenced and planted to date; the cost of the project to date; source(s) of funding; and a GIS layer showing the location of fenced/planted areas. For more information, see Chapter 8: Implementation and Finance.

Effectiveness Monitoring

Effectiveness monitoring answers broader ecological questions: "Is the ecological integrity of the Bay and Watershed changing?" "Is water quality improving or getting worse, and by how much?" Effectiveness monitoring lends itself more toward an assessment of success in attaining CCMP goals and objectives than to the implementation of specific actions. This type of monitoring requires a statistically sound analysis of environmental data of known quality and confidence. For each CCMP Objective, associated monitoring parameters provide a measurement of success. For example, to monitor the CCMP Objective "Achieve at least a 25% reduction in bacteria loads to rivers" we will measure fecal coliform and *E. coli* bacteria concentrations at numerous sites in the Watershed. See Pages 8-8 and 10-5 for more details.

The environmental monitoring component of the TBMP is designed to provide data that can be directly compared to the quantifiable objectives in each Action Plan. It builds upon recently conducted characterization studies and existing monitoring efforts. It seeks to promote cooperation among agencies and stakeholders by incorporating and coordinating efforts into an integrated monitoring plan, increasing the scope and resolution of existing efforts, improving the timeliness of data analyses, and making the results available to a diverse group of agencies and stakeholders in a timely manner.

The TBMP will incorporate existing and planned monitoring efforts, or elements from those programs, identify critical information gaps, and attempt to standardize and coordinate future monitoring efforts. This will minimize duplication of effort among agencies, reduce the cost of monitoring, and provide integrated results to the scientific, regulatory, and stakeholder communities in an efficient and timely manner.

Standardized sampling, analytical methods, and quality assurance/quality control (QA/QC) protocols will be adopted to ensure that monitoring information collected by the various partners in this effort are of high quality and are directly comparable. Where new QA/QC plans are needed, the Performance Partnership will act as the central figure in developing and implementing a strong quality assurance program.

Monitoring Workplans

Fifteen monitoring workplans are divided into three categories. Core monitoring workplans are those activities required to determine whether the stated CCMP environmental goals and objectives are being met. Research workplans are those activities developed to provide the additional information required to make good management decisions as identified in specific action plans. Citizen workplans build upon ongoing efforts to support citizen involvement and development of bioindicators.

Core Monitoring Workplans

Bacteria Monitoring
Temperature Monitoring
Total Suspended Solids Monitoring
Riparian Assessment
Stream Channel and Habitat Assessments
Tidal Wetland Assessments
Submerged Aquatic Vegetation Survey
Forest Road Surveys
Fish Monitoring (Rivers)

Research Monitoring Workplans

Fish Use of the Estuary
Benthic Invertebrate Inventory (Bay)
Ecological Interactions Among Eelgrass, Oysters, and Burrowing Shrimp
Nutrient Monitoring

Citizen Monitoring Workplans

Benthic Macroinvertebrate Monitoring (Rivers)
Plankton Monitoring

BACTERIA MONITORING

Program Objective (Core)

Determine long-term trends in bacteria loading and short-term variations in bacteria concentrations in relation to DEQ water quality standards.

Monitoring Question(s)

Is the concentration (flow-weighted average concentration and peak concentration) of fecal coliform bacteria (FCB) in the lower reaches of the Tillamook, Trask, and Wilson Rivers increasing or decreasing (and by how much) during typical storm events during the summer, fall, winter, and spring seasons over time scales of years to decades?

Are the storm loads of FCB increasing or decreasing (and by how much) during typical seasonal storm events in the Tillamook, Trask, and Wilson Rivers over time scales of years to decades?

How often and for what length of time does each of the five rivers violate DEQ's water quality criteria for *Escherichia coli* bacteria? Are there trends in the frequency and/or duration of those water quality standard violations over time scales of years to decades?

CCMP Objectives

Achieve at least a 25% reduction in bacteria loads to rivers (Apparent trends by 2005. Statistically significant trends by 2010).

Achieve at least a 25% reduction every four years in the number of days that the rivers are not in compliance with water quality standards for bacteria.

Program Description

Water quality in rivers to Tillamook Bay has often exceeded, and continues to exceed, DEQ standards for water contact for pathogens (*i.e.*, fecal coliform bacteria or *E. coli*). Fecal bacteria inputs into the Bay above FDA standards have forced periodic closure of oyster and other shellfish harvesting.

In Tillamook Bay the shellfish industry is regulated by federal standards which specify the use of fecal coliform bacteria (FCB), whereas DEQ currently uses the measurement of *E. coli* for water contact in both the rivers and the Bay. Fecal coliform was the standard until 1996. FCB has been the most long-standing and widely-used indicator of fecal contamination. FCB has been selected to represent fecal contamination because of its widespread use *and* its linkage to regulation of the shellfish industry in the Bay.

The DEQ, ODA, and others have monitored bacteria in Tillamook Bay and its Watershed for many years. For a historical perspective of these

efforts, please refer to Table 4-4 in the TBNEP *Environmental Characterization Report*.

These programs will support Oregon Plan workplans DEQ2S, DEQ8S, DEQ20S, DLCD1, DSL2, DSL20, ODA1, and ODA2.

TBNEP Source and Transport Studies

1996–1997	River Water Quality Scoping Study
1997–ongoing	Storm Sampling in the Tillamook Bay Watershed
1997–ongoing	Routine Sampling in the Wilson River
1997–1998	Source Identification of Fecal Coliform Delivered to Tillamook Bay
1997–1998	Organism Movement for Various Manure Handing Practices
1996–1998	Constructed Wetlands

DEQ Ambient Water Quality Monitoring

DEQ continues to implement a long-standing periodic monitoring program in support of water quality compliance/enforcement and TMDL development. Monitoring is conducted approximately quarterly, with synoptic programs added as needed.

ODA/DEQ National Shellfish Sanitation Program

ODA and DEQ conduct monthly monitoring at 20 sites in the Bay to ensure compliance with the National Shellfish Sanitation Program, administered in Oregon by ODA. Additional water and shellfish meat samples are collected to fulfill the requirements of annual and triennial FDA reviews. Pathogen monitoring in the Bay will be continued by ODA/DEQ under the auspices and requirements of this program.

TBNEP Storm Sampling

The storm sampling design was developed based on results of the initial scoping study (Sullivan *et al.* 1998), the first year of storm sampling, and earlier efforts. FCB in the Tillamook Basin are highly episodic in nature and the short term variability makes it difficult to quantify long term trends. For that reason, the monitoring program uses a storm-based approach to assess trends in the fluxes of bacteria from the Watershed to the Bay. Sullivan *et al.* provides baseline data for achieving the following Water Quality objective: Achieve at least a 25% reduction every four years in the number of days that the rivers are not in compliance with water quality standards for bacteria.

Citizen Water Quality Compliance Monitoring
In addition to agency monitoring, the program will use a citizen monitoring effort which includes periodic (5 samples/month) measurements of *E. coli* to evaluate the extent to which Tillamook area rivers violate DEQ's water quality standards.

Date Initiated
1996 TBNEP Storm Sampling.
1997 TBNEP Citizen Compliance Monitoring.

Coordinating Agency
TBNEP/TCPP.

Funding Agency
TBNEP/TCPP.

Monitoring Parameters
Fecal coliform bacteria (rivers - membrane filtration: Bay - A-1 tube)
E. coli (Colilert)
Flow
Precipitation
Salinity/Conductivity
Temperature

Stations
Storm Monitoring: Primary sites on the Tillamook, Trask and Wilson Rivers (see Figure 10-1).

Compliance Monitoring: At least at the downstream primary sites for all 5 rivers for *E. coli*.

Frequency
Storm Monitoring: Eight storms per year in the rivers.
FCB will be measured during selected moderate to large storm events (*e.g.*, > 2 in [5 cm] of precipitation in 4 days) each year. These will include two fall (Sept. 16-Nov. 30), two winter (Dec. 1-Feb. 15), two spring (Feb. 16-June 20), and two summer (June 21-Sept. 15) storms. The summer storms will be of necessity smaller. During each storm, six to eight samples will be collected at each site and analyzed for bacteria.

Compliance Monitoring: Five samples per month for *E. coli* in the rivers.

Sample Collection
Storm Monitoring: Quantify changes that occur in bacterial concentrations and loads in rivers. Concentration reflects the number of bacteria (or bacterial colony forming units (CFU) per volume of river water. Load reflects the number of bacteria flowing down the rivers per unit time. It is best to attempt to do that using several approaches, anticipating a high degree of temporal variability. These will include analyzing for trends in bacterial fluxes associated with specific storm types, and deter-mining flow-weighted storm average concentrations and total storm loads.

Measure FCB at the primary downstream sites on the Tillamook, Trask,

and Wilson Rivers. During each storm, six to eight samples (plus QA samples) will be collected at each site and analyzed for bacteria. Within each season and combination of seasons, storms will be classified in an 8-cell matrix. An effort shall be made to constrain the number of storms actually sampled to only a few of these types. Data will be analyzed for trends in bacterial fluxes associated with specific storm types, flow-weighted storm average concentrations, and total storm loads. Results of bacterial concentrations and flow-weighted loads will be compared from year to year by evaluating results obtained for each storm type for which a sufficient number of storms are successfully monitored (≥10). A strawman storm classification system has been proposed. Within each season and combination of seasons, individual cells in an 8-cell matrix will be used as the basis for classifying storm events. This matrix will be based on two possible values for each of three parameter choices:

- rainfall intensity - high or low;
- total storm size - large or moderate; and
- length of precipitation-free (< 1" [25 mm]) period prior to storm – long or short.

Compliance Monitoring: Collect *E. coli* samples at (at least) the downstream primary monitoring sites five times per 30 days. Analyze using the Colilert™ system. Determine the extent to which the DEQ freshwater bacteria standard is exceeded (30 day log mean of 126 *E. coli* per 100 ml based on a minimum of five samples with no single sample exceeding 406 organisms per 100 ml).

Data Management

TBNEP collected data: Relational Database (Microsoft Access/SAS).
DEQ/ODA data: Linked to Storet.

Related Monitoring Programs

Total Suspended Solids Monitoring
ODA Tillamook Bay Shellfish Sanitation Program

Anticipated Cost

$45,000 Storm Monitoring/year
$8,000 Compliance Monitoring/year
$25,000 Bay Monitoring/year
$25,000 River Gauges/year

Shellfish Management Areas, Oyster Leases, and Water Quality Monitoring Sites in Tillamook Bay

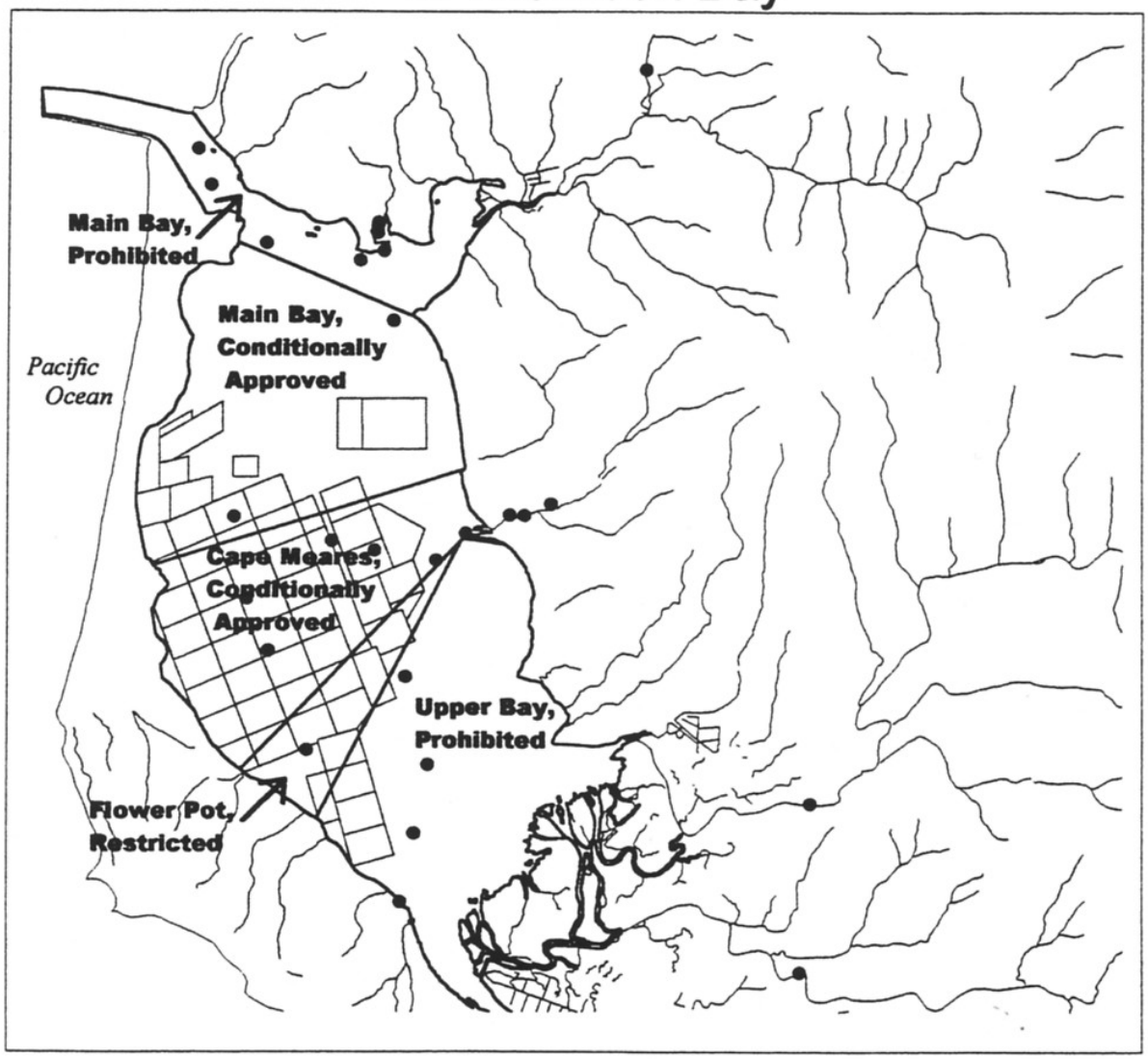
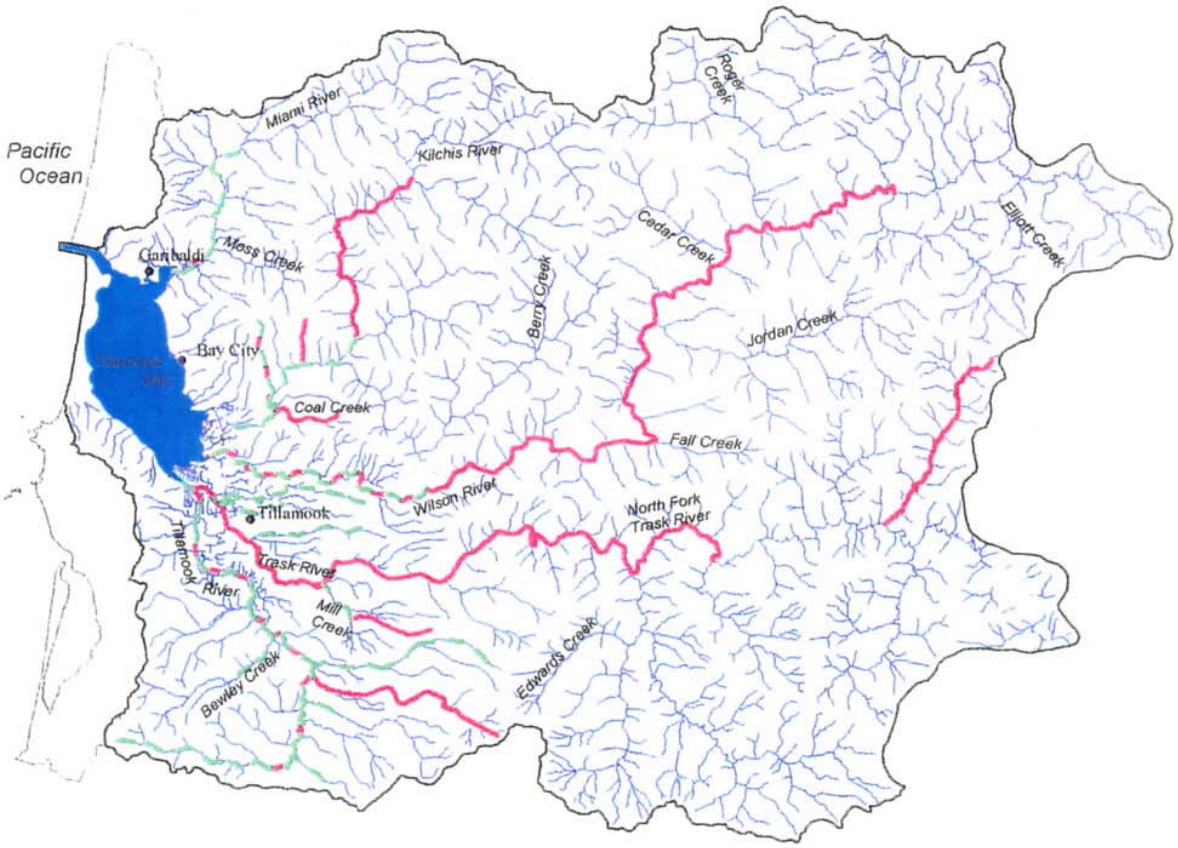


Figure 10-1.

DEQ 303(d) Listed Streams and Waterbodies for Tillamook Bay Watershed



No warranty expressed or implied is made regarding the accuracy or utility of the data on any other system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data. It is also strongly recommended that careful attention be paid to the contents of the metadata file associated with these data. The Tillamook Coastal Watershed Resource Center shall not be held liable for improper or incorrect use of the data described and/or contained herein.

Figure 10-2.

TEMPERATURE MONITORING

Program Objective (Core)

To determine the daily maximum temperatures of the rivers during summer months.
To quantify changes in the number of days per year that daily maximum temperatures in the rivers exceed water quality criteria.
To determine the spatial extent of water temperature exceedences during summer months in the rivers.

Monitoring Question(s)

What is the frequency and duration of temperature excursions above threshold values (expressed as daily maxima) in the rivers and what is the spatial extent of such excursions?

Are there trends (increasing or decreasing) in the frequency, duration or extent of temperature excursions above threshold values in the rivers over time scales of years to decades?

CCMP Objective

Achieve instream temperatures that meet salmonid habitat requirements by 2010. (The average of the daily maximum water temperature over a moving 7-day period shall not exceed 17.8ºC [64.8ºF]).

Program Description

Temperatures in several rivers in the Tillamook Basin have been measured above 64.8ºF, temperature conditions in the range of stressful to lethal for salmonid fish. The monitoring program will measure temperature to more precisely quantify the frequency, duration, and extent of temperature excursions above threshold values in each of the rivers. To develop a temperature TMDL, DEQ conducted baseline monitoring at 40 sites in the Miami, Trask, Tillamook, and Wilson Rivers in 1997. Based on those data, DEQ deployed continuous temperature monitors at 60 locations in the Tillamook Bay Watershed from May−September, 1998.

In 1994, ODF initiated a monitoring program (ODF14) to record stream temperatures and physical characteristics of a variety of streams under various silvicultural activities allowed under the water protection rules. The objective of the program is to determine the effectiveness of the forest practice rules in maintaining stream temperature at the site and watershed scales.

Temperature monitoring by DEQ and ODF will continue, with support from the Tillamook Bay Watershed Council and the Performance Partnership to assess the current status of water temperature conditions in the Basin. These activities will support OPSW workplans DEQ1S, DEQ2S, DEQ7S, DEQ8S, DEQ19S, ODFWIB3, ODF14S, ODA1, DLCD1, and ONHP2.

Date Initiated	1997.
Coordinating Agency	DEQ.
Funding Agency	DEQ.
Monitoring Parameters	Temperature Flow Shade
Frequency	20 continuous monitors during periods of low flow (June through September). 10 continuous monitors during salmonid spawning (May, October).
Sample Collection	Follow established DEQ protocols for OPSW. Continuous temperature recorders with suitable range for water: resolution of ±0.2ºC and accuracy of ±0.3ºC. Data collected every 30 minutes. Pre and post deployment checks conducted in the laboratory against traceable NIST thermometer within ±0.2ºC. Logger must check within ±0.5ºC at two temperatures (one temperature in the 5-15ºC range and one in 15-25ºC range). Audit field checks recommended once per month. Accuracy ±0.5ºC and resolution of ±0.2ºC. Loggers must be within ±1.5ºC on the field check.
Data Management	Use DEQ template for data entry. Linked to DEQ: LASAR, STORET.
Related Monitoring Programs	Bacteria Monitoring Stream Channel and Habitat Assessments Fish Monitoring (Rivers) Riparian Assessments
Anticipated Cost	$25,000/year

Table 10-1. Stations for Proposed DEQ 1999 Temperature Monitoring Program

STORET#	SITE NAME	JUNE TO SEPTEMBER	SPAWNING (MAY) (OCTOBER)
	MIAMI RIVER BASIN		
412120	Miami River @ Moss Creek Rd.	X	X
412180	Miami River @ Stuart Creek Rd.	X	
	KILCHIS RIVER BASIN		
412188	Kilchis River @ Curl Rd.	X	
405613	NF Kilchis River @ RM 1.2 Bridge	X	X
405989	SF Kilchis River @ Mouth	X	
	WILSON RIVER BASIN		
405758	Wilson River downstream of Cedar Creek	X	X
405763	Wilson River @ Hwy. 6 (Lee's Camp)	X	
405760	North Fork Wilson River upstream of West Fork of North Fork	X	X
405759	West Fork of North Fork Wilson River @ Mouth	X	
405992	South Fork Wilson @ Mouth	X	X
405988	Devils Lake Fork Wilson @ Mouth	X	
405768	Cedar Creek @ Mouth	X	X
	TRASK RIVER BASIN		
405770	Trask River @ Trask Fish Hatchery	X	
412190	North Fork Trask River @ Mouth	X	
405778	Trask River downstream of Bark Shanty Creek		X
405776	Trask River downstream of Clear Creek		X
405774	South Fork Trask River upstream of East Fork of South Fork	X	
405986	East Fork of South Fork Trask River @ Mouth	X	X
405777	Middle Fork of NF Trask River @ Mouth	X	
405775	North Fork of North Fork Trask River @ Mouth	X	
	TILLAMOOK RIVER BASIN		
412120	Tillamook River @ Bewley Creek Rd.	X	X
412151	Tillamook River @ Yellow Fir Rd.	X	

TOTAL SUSPENDED SOLIDS MONITORING

Program Objective (Core)

To quantify changes in the storm loading of total suspended solids (TSS) to the Bay from the Trask, Wilson, and Kilchis Rivers.
To quantify changes in the storm loading of TSS in selected subwatersheds that are the focus of intensive erosion control actions.

Monitoring Question(s)

Are storm loads of TSS to Tillamook Bay from the Trask, Wilson, and Kilchis Rivers increasing or decreasing (and by how much) over time scales of years to decades?

Are the storm loads of TSS increasing or decreasing (and by how much) in subwatersheds that become the focus of intensive erosion control activities?

CCMP Objectives

Achieve instream suspended sediment concentrations that meet salmonid habitat requirements by 2010.

Achieve at least a 25% reduction in sediment loads to rivers. (Apparent trends by 2005. Statistically significant trends by 2010.)

Program Description

Environmental monitoring for erosion and sedimentation trends will consist of storm-based monitoring of total suspended solids (TSS) near the mouths of the three rivers that contribute the largest sediment loads to the bay: Wilson, Trask, and Kilchis Rivers. Storm loading of TSS will also be monitored in selected subwatersheds that become the focus of intensive erosion control activities, such as culvert repair or replacement, road decommissioning, landslide stabilization, etc.

The highest concentrations and loads of TSS are found in the Wilson and Trask - and to a lesser extent, the Kilchis - Rivers. TSS monitoring only in these three rivers, and only at the primary (downriver) monitoring site on each is recommended at this time. This will measure changes over time in the cumulative flux of TSS from both the forested and a large portion of the agricultural lands in each of these watersheds.

ODF uses its Forest Road Surveys to identify potential sources of sediment to streams. ODA will monitor compliance with SB 1010 to determine the extent that agricultural practices contribute to sedimentation. As erosion control efforts are implemented within the basin, it will be advantageous to monitor for the effectiveness of these actions. Because the watersheds are large (especially the Wilson and Trask River watersheds) and contain a multitude of erosional source areas (*i.e.*, mass wasting, road cuts, etc.), it is likely that the results of erosion control efforts implemented in part of the Watershed will not be readily evident at the downriver monitoring sites. An effort will be made to concentrate erosion control efforts (*i.e.*, culvert repair, slope stabilization, road decommissioning) to the extent practical within a limited number of subwatersheds, and these - and perhaps also

	one or more reference (control) subwatersheds - will be monitored for TSS during four to six large storm events each year. The effects of these erosion control efforts are expected to be evident in the subwatershed monitoring results, but not necessarily at the full watershed scale. Monitoring will support OPSW workplans ODFWIB2S, ODFWIB3S, ODF1S, ODF2S, ODF3S, ODF4S, ODF5S, ODF13S, ODA1, DEQ1S, DEQ2S, DEQ4S, DEQ5S, DEQ8S, DEQ19S, DEQ34S, ODOT2, DSL5, DSL6, DLCD1, and ONHP2.
Date Initiated	1996.
Coordinating Agency	TBNEP/TCPP.
Funding Agency	TBNEP/TCPP.
Monitoring Parameters	Total Suspended Solids Flow Precipitation
Stations	Primary sampling sites (lower rivers, see Figure 10-1) on the Trask, Wilson, and Kilchis Rivers. Downstream of selected enhancement activities.
Frequency	At least 6 storms per year.
Sample Collection	Measure TSS at the primary downstream sites on the Wilson, Trask, and Kilchis Rivers during each of six large storms (*i.e.*, when the Wilson River flows exceed 6,000 cfs). During each storm, six to eight samples (plus QA samples) should be collected at each site and analyzed for TSS. Data will be analyzed to estimate the total annual TSS load per river, using observed discharge and a quantification of the relationship between measured TSS and river discharge.
Data Management	TBNEP collected data: Relational database (Microsoft Access/SAS). DEQ collected data: Linked to Storet.
Related Monitoring Programs	Forest Road Surveys Stream Channel and Habitat Assessments Bacteria Monitoring
Anticipated Cost	Storm Monitoring: Included in cost for Storm Monitoring Subwatershed Monitoring: $40,000/year

RIPARIAN ASSESSMENT

Program Objective (Core)

Track the abundance and distribution of riparian areas in the Tillamook Bay Watershed.

Monitoring Question(s)

Is the length of continuous riparian habitat changing along rivers and streams in the agricultural lowlands and forested uplands over time scales of years to decades?

CCMP Objectives

Enhance 200 miles of forested riparian habitat to healthy riparian condition by 2010.

Enhance 500 miles of riparian habitat in the 0-500' elevation band to healthy condition by 2010.

Program Description

Monitoring will be required to achieve the CCMP goal to "assess, protect and restore riparian habitat." The CCMP recognizes that protecting and restoring continuous riparian habitat along rivers and streams throughout the Watershed will improve water quality, sediment loading, and salmonid habitat. The extent to which riparian habitat borders water courses in the forested uplands and urban, rural, and agricultural areas will be periodically monitored, at least once every five years.

Monitoring to determine the extent of riparian area will use either remote imagery or aerial photography, in conjunction with the proposed tidal wetland surveys. The riparian zone surveys will not have to provide exhaustive coverage of all water courses in the Watershed. A statistically-based random sampling of stream reaches defined on the basis of grid squares will provide the required information.

Riparian condition (HRC) will be determined using field assessment as outlined in HAB-06. Trained staff NRCS, ODA, ODF, ODFW, or County staff will assess whether or not each area meets these management objectives: (1) create shade to meet instream water temperatures; (2) produce woody debris; (3) filter out excess sediments, organic material, pesticides, and other pollutants in surface runoff; and (4) stabilize streambank.

Assessments will support the following OPSW workplans: ODFWIBS2, ODFWIB3, ODFWIVA1, ODFWIVB2, ODF4S, ODF5S, ODF8S, ODF11S, ODF24S, ODA1, DEQ1S, DEQ2S, DEQ34S, OPRD2, DLCD2, DLCD3, DLCD4, and ONHP2.

Date Initiated

2000.

Coordinating Agency

TBNEP/TCPP.

Funding Agency ODA/ODF.

Monitoring Parameters

Aerial Surveys:	**Field HRC:**
Riparian buffer width and extent	Stream shading
Percent conifer	Vegetative cover
Percent hardwood	Width
	Structure and species composition
	Floodplain connectivity
	Bank stability

Stations The survey covers the extent of Tillamook Bay Watershed.

Frequency Aerial surveys at least every five years.

Sample Collection Environmental monitoring of riparian habitats will be conducted every five years, beginning in 2000. Satellite Landsat Thematic Mapper (TM) multispectral imagery, or an alternative remote sensing approach, will be used to classify land cover and provide the required information.

The riparian surveys will not have to provide exhaustive coverage of all water courses in the Watershed. A statistically-based random sampling of riparian areas defined on the basis of grid squares will provide the required information.

This approach will allow standardized mapping classification of several key habitat types simultaneously, over a relatively large area and over a short period of time. The classified land cover information will be readily compatible with the geographic information system (GIS) system at the TCWRC. Habitat maps will be constructed every five years and habitat gains and losses will be tabulated.

Ground-truthing will be used to refine the land classifications and environmental measurements, coinciding with the imaging collected as part of the survey, and incidentally by other agencies, organizations, and individuals.

Guidelines set for imaging specify that they can be taken during periods of low or no wind and clouds, and with sufficient identifiable land area to assure accurate plotting of riparian areas.

Data Management GIS ArcInfo/ArcView according to TCWRC specifications.

Related Monitoring Programs
Coordinate with Tidal Wetlands Assessments
Coordinate with Submerged Aquatic Vegetation Survey
Stream Channel and Habitat Assessments

Anticipated Cost $75,000 every 5 years

STREAM CHANNEL AND HABITAT ASSESSMENTS

Program Objective (Core)

Provide quantitative information on habitat condition for streams in the Tillamook Bay Watershed.

Monitoring Question(s)

Are there changes in key indicators of instream habitat quality (*i.e.,* pool/riffle ratio, presence of large wood, sediment particle size distribution) over time scales of years to decades in critical stream segments prioritized for protection or restoration?

CCMP Objectives

Enhance 100 miles of upland instream habitat by 2010.
Enhance 200 miles of forested riparian habitat to healthy riparian condition by 2010.
Enhance 500 miles of riparian habitat in the 0–500' elevation band to healthy condition by 2010.

Program Description

The spawning and rearing habitat of anadromous salmonids in the Tillamook Basin extends from the mouth of the Estuary to the headwaters of its five major tributary rivers. The TBNEP funded ODFW to conduct Stream Channel and Habitat Assessments (OPSW Monitoring Task 4): More than 300 miles of stream were surveyed between 1995 and 1998. Quantitative stream habitat information is needed to evaluate habitat quality, estimate juvenile seeding levels, develop and calibrate habitat based escapement models, and to expand the applicability of abundance and habitat relationships to all coastal regions. The associated riparian components assess current riparian condition and the future contribution of riparian trees to large woody debris, and identify areas that may be important for the maintenance of beaver populations and areas that may benefit from hardwood conversions. On agricultural lands, riparian surveys identify the contribution of shrubs and trees to stream shade and may be useful in determining the effectiveness of efforts to improve riparian condition conducted under SB 1010.

Using a stratified random sampling design, ODFW will continue habitat inventories at approximately 20 sites in the Tillamook Bay Watershed per year. These data will also support watershed assessments and help identify and prioritize critical segments of streams for habitat protection and restoration efforts. Results of these surveys will be entered into the TBMP database and analyzed numerically and spatially.

The assessments support OPSW workplans: ODFWIB2S, ODFWIB3, ODFWIB4, ODFWIVA6, ODFWIVA8, ODF4S, ODF5S, ODF11S, ODF14S, ODF16S, ODF24S, ODF34S, ODF59S, ODA1, DSL2, DLCD2, DLCD3, DEQ2S, DEQ5S, DEQ8S, DEQ12S, DEQ19S, ONHP2, ODOT2, and OPRD2.

Date Initiated 1990.

Coordinating Agency ODFW.

Funding Agency ODFW.

Continued stream assessments are part of the USFS and BLM PACFISH monitoring programs. ODFW continues to support permanent Aquatic Inventory Staff but funding for new field work is contingent on R&E Board allocations and contract support from ODF, BLM, USFWS, industrial forest landowners groups, and other sources.

Monitoring Parameters

Basin name
Stream name
Stream order, drainage area, and drainage density
Elevation at the confluence with the receiving channel and at the end of the survey
ODFW-EPA regions and sub-regions, geology, and soils of the basin
Stream flow
General community structure and size composition of riparian vegetation
Description of fish species and stocks present, management concerns, and linkage to other databases or research projects
Flow regulation
General description of land use and ownership in the basin

Contacts	Gravel available
Pool area	Shade
Pool frequency	LWD pieces
Residual pool depth	LWD volume
Riffle width/depth ration	LWD key pieces
Silt/sand/organic matter	LWD recruitment potential

Stations Stratified random sampling, 20/year, budget permitting.

Frequency Annual.

Sample Collection Methods for Stream Habitat Surveys: Aquatic Inventory Project. Natural Production Program: Oregon Department of Fish and Wildlife.

Data Management GIS ArcInfo/ArcView according to TCWRC specifications.

Related Monitoring Programs

Riparian Assessments	Forest Road Surveys
Temperature Monitoring	Fish Monitoring (Rivers)
Tidal Wetland Assessments	

Anticipated Cost $50,000/year

TIDAL WETLAND ASSESSMENTS

Program Objective (Core)

Track the abundance and distribution of tidal wetlands in Tillamook Bay.

Monitoring Question(s)

Are there changes in area of tidal wetlands that are accessible to fish and other aquatic biota?

Is the spatial extent of tidal wetland habitat changing over the scales of years to decades?

Are visual indicators of tidal wetland habitat quality (*i.e.*, vegetation composition, percent open water) changing over time scales of years to decades?

CCMP Objectives

Enhance 750 acres of tidal wetland by 2010.
Enhance 100 acres of freshwater wetland by 2010.
Upgrade 50% of all tide gates by 2010.

Program Description

The near-bay hydrology has been seriously modified since the last century by diking, ditching, tidegate installation, and other human modifications to the landscape. The concomitant loss of a large percentage of the original tidal wetlands that surrounded the Bay is recognized as an important ecological threat to salmonids and other aquatic species. CCMP actions will focus on the protection and enhancement of existing tidal wetlands and also the restoration of former tidal wetland areas.

Tidal wetland monitoring will focus on aerial extent and distribution, measures of open water and vegetation coverage, and improved access to fish and other aquatic biota. This monitoring will be conducted via remote sensed imagery every five years.

Ground-truthing will occur as part of other ongoing monitoring programs. As Tillamook County and cities develop and enforce riparian ordinances, they (along with DSL) will survey wetlands on residential areas within their jurisdiction. ODA/NRCS will identify wetlands as they develop farm plans under SB 1010. ODFW identifies wetlands as part of the stream channel and habitat assessment program.

The assessments will support OPSW workplans: ODOT 15, ODOT 19, ODFW1B2S, ODA1, DSL13, DSL16, DSL17, DSL18, DSL19, DLCD3, DLCD4, DEQ10S, and ONHP2.

Date Initiated (1) 1999, (2) 1999, (3) 1997.

Coordinating Agencies ODA, Tillamook County, DSL.

Funding Agencies ODA, Tillamook County, DSL.

Monitoring Parameters
Aerial extent of tidal wetlands
Open water
Vegetation coverage
Number of tide gates replaced
Amount of available aquatic habitat for salmonids

Stations The survey covers the tidal portion of Tillamook Bay Watershed.

Frequency Aerial surveys at least every five years.

Sample Collection Environmental monitoring of key habitats will be conducted every five years, beginning in 2000. Satellite Landsat Thematic Mapper (TM) multispectral imagery, or an alternative remote sensing approach, will be used to classify land cover. Ground-truthing will be used to refine the land classifications and environmental measurements.

The tidal wetlands surveys will not provide exhaustive coverage of all water courses in the Watershed. A statistically-based random sampling of tidal areas defined on the basis of grid squares will provide the required information. This approach will allow standardized mapping classification of several key habitat types simultaneously, over a relatively large area and over a short period of time. The classified land cover information will be readily compatible with the geographic information system (GIS) system at the TCWRC. Habitat maps will be constructed every five years and habitat gains and losses will be tabulated.

Guidelines set for imaging specify that images may be taken only at low tide, during periods of low turbidity and low or no wind and clouds, and with sufficient identifiable land area to assure accurate plotting of habitat. Ground-truthing data to coincide with the imaging is collected as part of the survey, and incidentally by other agencies, organizations, and individuals.

Data Management GIS ArcInfo/ArcView according to TCWRC specifications.

Related Monitoring Programs
Coordinate with Tillamook Bay Riparian Assessments
Coordinate with Submerged Aquatic Vegetation Surveys
Stream Channel and Habitat Assessments
Fish Use of the Estuary

Anticipated Cost Contained in Riparian Monitoring

SUBMERGED AQUATIC VEGETATION SURVEY

Program Objective (Core)

Track the abundance and distribution of eelgrass beds in Tillamook Bay.

Monitoring Question(s)

Is the spatial extent of eelgrass beds in the estuary changing over time scales of years to decades?

Are there changes in eelgrass density or other visual indicators of changes in eelgrass health over time scales of years to decades?

CCMP Objective

No net decline in eelgrass beds (baseline = 363 hectares).

Program Description

Eelgrass (*Zostera* spp.) meadows contribute to estuarine water quality and provide habitat for many aquatic species, including salmonids. Eelgrass has also been identified as Essential Fish Habitat in Amendment 14 to the Pacific Coast Salmon Plan and is consistent with Goal 6 of the OPSW.

In 1995, the TBNEP used a prototype airborne imaging system to collect multispectral data for Tillamook Bay at a 1-meter spatial resolution to:

(1) accurately map eelgrass beds throughout Tillamook Bay in order to establish an initial baseline of eelgrass bed density and distribution and

(2) identify a means of monitoring the Bay environment in terms of cover and substrate that is both accurate and cost effective.

Vegetation was assigned to one of six classes, and substrate was assigned to one of four classes. During this survey, eelgrass beds were found to cover nearly 11% of the area (approximately 363 hectares) of Tillamook Bay with the majority of the dense beds in the northern half of the Bay. (Strittholt and Frost 1996). Field surveys as part of the eelgrass monitoring project and as part of the ODFW benthic surveys verified the accuracy of this assessment.

Continued surveys will support OPSW workplans: ODFW1B2S, ODFWIVB2, ODF28S, DSL17, ONHP2, and DLCD3.

Date Initiated

1995.

Coordinating Agency

TBNEP/TCPP.

Funding Agency

TBNEP/TCPP.

Monitoring Parameters

Terrestrial plants
Green algae
Dense mixed algae
Dense eelgrass
Sparse eelgrass
Sparse mixed algae on dark substrates
Sparse mixed algae on light substrates
Sand/gravel
Mud/sand
Organic debris
Developed
Water

Stations

The survey covers the extent of Tillamook Bay.

Frequency

Aerial surveys at least every five years.

Sample Collection

Multispectral sensor imaging (AirCam^{TM}) mounted on light aircraft. Data collection requires over four hours during extreme low tide, during which high resolution (~1 meter) images are captured. Three spectral bands mimic bands 1 (blue), 3(red), and 4 (infrared) of Landsat TM. More than 300 separate frames are collected and georeferenced. Color photographs should be taken at the same time to provide an additional resource to improve the classification of digital files. For detailed collection methods and post-processing requirements, see Strittholt, J. R. and P. A. Frost. 1996. Determining Abundance and Distribution of Eelgrass (*Zostera* spp.) in Tillamook Bay Estuary, Oregon Using Multispectral Airborne Imagery.

Guidelines set for imaging specify that images may be taken only at low tide, during maximum delineation of submerged aquatic vegetation (SAV), during periods of low turbidity and low or no wind and clouds, and with sufficient identifiable land area to assure accurate plotting of beds.

Ground-truthing for eelgrass extent and distribution to correlate with imaging will occur through the Eelgrass, Oyster, and Burrowing Shrimp Study and incidentally by other agencies, organizations, and individuals (*e.g.*, during fish or benthic studies, or other research).

Data Management

ArcInfo/ArcView according to TCWRC specifications.

Related Monitoring Programs

Coordinate with Ecological Interactions Among Eelgrass, Oysters, and Burrowing Shrimp
Coordinate with Riparian Assessment
Coordinate with Tidal Wetlands Assessment
Benthic Invertebrate Inventory (Bay)
Fish Use of the Estuary

Anticipated Cost

$40,000/survey

FOREST ROAD SURVEYS

Program Objective (Core)	To determine forest road condition and risks to aquatic habitat.
Monitoring Question	Is there a measurable reduction in erosion and sedimentation from forest roads?
CCMP Objectives	Upgrade 1,400 miles of forest roads on state and private lands by 2010. Decommission 50 miles of forest management road by 2010.
Program Description	In studies of forest lands in western Oregon and Washington, foresters identified fire, and soil exposure and compaction as the principal factors responsible for surface erosion. Roads cause the greatest soil exposure and compaction. ODF, in cooperation with the TBNEP, established road survey protocols and has inventoried many of the roads in the Tillamook Forest. This inventory will guide ODF sediment monitoring on a watershed level and prioritize road upgrade projects. Road surveys focus on drainage structures, looking for culvert failure and/or other evidence of sediment delivery to stream channels. This effort supports OSPW workplans: ODF1S, ODF2S, ODF4S, ODF5S, ODF13S, ODF15S, ODF16S, ODF33S, ODF34S, ODF35S, ODFWIB2S, ODFWIB3, ODFWIB4, and WRDS21.
Date Initiated	1996.
Coordinating Agency	ODF.
Funding Agency	ODF.
Monitoring Parameters	General road characteristics Symptoms of road erosion Conditions of culverts and bridges Risks of sidecast landslides Potential for sediment delivery to streams
Stations	Tillamook State Forest.
Frequency	Annually.

Sample Collection Surveys will be conducted according to ODF or OFIC protocols. See Mills K. 1997. Forest Roads, Drainage, and Sediment Delivery in the Kilchis River Watershed. Appendix 1: Oregon's Forest Road Construction and Maintenance Rules.

Data Management GIS ArcInfo/ArcView according to TCWRC specifications. Linked to ODF.

Related Monitoring Programs
Total Suspended Solids Monitoring
Stream Channel and Habitat Assessments
Fish Monitoring (Rivers)

Anticipated Cost $75,000/year

FISH MONITORING (RIVERS)

Program Objective (Core)

(1) Temporal estimates of the number of fish (salmonid and non-salmonid) migrating past the monitoring site(s);
(2) Estimates of between-year variability in the number of juvenile salmonids produced;
(3) Estimate of monitoring efficiency; and
(4) Data that would support development of an index to evaluate the effects of management actions on juvenile salmonid production in the Basin.

Monitoring Question(s)

Is the number of outmigrants of salmonid species in the Wilson and Kilchis Rivers changing over the time scales of years to decades?

CCMP Objective

Achieve ODFW wild fish production and escapement goals[2] by 2010.

Program Description

Fish monitoring in freshwater habitat will support the monitoring objectives of the OPSW. *In this context* the primary questions for the monitoring program are as follows:

Is the Oregon Plan contributing to a positive change in the productive capacity and resilience of Oregon=s aquatic ecosystems as indicated by salmon and the cultural values and ecological processes dependent upon salmon?

Is the Oregon Plan promoting recovery of naturally reproducing populations of salmon in sufficient abundance and across a sufficient geographic and

[2] ODFW estimated production and escapement goals for coho and chum salmon, described in the table and text below, in its Oregon Coastal Salmon Restoration Initiative plan. There are no production estimates for other salmonid species.

Table 10-2. Estimate of coho salmon production potential and spawner needs for Tillamook Watershed.

Spawner Escapement Goal	Marine Survival Rate of Brood	Production Potential			
		Spawning Habitat Quality Utilization			Total Return (Recruitment)
		High	Moderate	Poor	
17,100	10%	8,100	8,500	16,400	33,000
5,700	5%	4,000	4,300		8,300
2,000	3%	2,400			2,400

Note: Tillamook Bay, primarily the Kilchis and Miami rivers, hosts Oregon's largest population of **chum** salmon. The largest number of chum harvested the Bay was 264,570 in 1928 (Oakley 1962). If the catch represented 40.7% of the total population, similar to estimates derived for the fishery after the late 1940's, then since the 1960s the maximum estimated run has peaked at only 47,000 (or about 7% of the historic peak run into the Bay). Current evidence indicates that the potential maximum run of chum salmon is about 47,000 fish in Tillamook Bay with existing environmental conditions. Recruitment (return) of chum salmon by brood year (ages 3 through 5 combined in successive years of returns) has ranged between 2,608 (1957 brood year) and 34,729 (1970 brood year) where estimates of the age composition of the run were available.

temporal range, proximity (spatial organization), and diversity of habitats to ensure that salmon species can persist in a variable environment?

Some of the most useful kinds of information for assessing the status and trends of anadromous salmonid populations include the number of adults returning to spawn (escapement), the number of fish harvested, and smolt production. ODFW has periodically estimated escapement in the Tillamook Watershed using "peak counts" since the 1950s. Steelhead and cutthroat trout populations have been estimated using resting pool counts since the mid 1960s. Additional information has been gathered through creel surveys and commercial harvest records. ODFW will continue this type of monitoring under OPSW workplan ODFWIA1: Establish new escapement goals.

As part of the Oregon Plan, the ODFW and other resource agencies initiated an extensive juvenile and adult salmonid sampling program along the coast. The TBNEP, in cooperation with ODF and ODFW, supported OPSW Monitoring Task 9: "Core Area" and "Index Area" Monitoring of Habitat and Populations. The program counted outmigrating smolts by installing traps at two index sites (the Little South Fork Kilchis River and Little North Fork Wilson River). The results of the first year of monitoring showed that Chinook fry and fingerling density in the LNF Wilson was the highest of the fourteen coastal streams monitored by ODFW, and that this density was also relatively high in the LSF Kilchis. The Tillamook Bay Watershed has the last healthy chum salmon populations in Oregon. The densities of steelhead smolts and cutthroat par were also among the highest of the ODFW monitored coastal streams. However, coho salmon smolt density was relatively low in the LNF Wilson and only one other ODFW monitored stream had smolt densities as low as the LSF Kilchis.

This monitoring program directly supports OPSW workplans: ODFWIA, ODFWIB, and ODFWIIB while providing essential information to guide virtually every other OPSW workplan developed to date.

Date Initiated 1997.

Coordinating Agency ODFW.

Funding Agency ODF/TBNEP/ODFW.

Monitoring Parameters
Fish species, size, age
Fish development (smoltification) class
Weather conditions
Cone rotations
River levels

Stations LNF Wilson.
LSF Kilchis.

Frequency Annually: first week of March through end of migration period (mid-summer).

Sample Collection Rotary juvenile screw traps will be operated 24 hours per day, seven days per week and monitored at least once per day (additional monitoring may be required during high flow periods). Captured fish will be removed from the trap, anesthetized (MS-222), and measured to the nearest millimeter for fork length. Each fish will be identified to the species level and assigned to an appropriate size group. Size classes will be ≤90 mm, 91–120 mm, 121–160 mm, 161–200 mm, 201–280 mm, and ≥281 mm. Each day up to 30 fish from each species and size group will be marked with a caudal fin notch and released into an area of quiet water, preferably within 50-100 meters upstream from the trap site. All of the fish captured within a size class will be marked when the trap catch is less than 30 fish in a given size group. All marked fish will be released at dusk each evening.

Recaptured fish will be used to estimate trap efficiency by dividing the number of marked fish released by the number of marked fish recaptured in the corresponding time interval. This rate will be multiplied by the total number of fish captured to estimate the total number of fish passing the trap site each week. Weekly estimates will be summed to obtain an estimate of the total number of fish passing the trap site during the trapping season. A bootstrap method will be used to estimate the variance for each weekly population estimate for each size group. The variance from each week will be summed to estimate the variance for the total number of migrants passing the trap site. Records will be kept of all fish and amphibians captured (sculpins, lamprey, dace, salamanders, etc.), but trap efficiencies and population estimates will only be made for salmonids.

Data Management Monitoring data compiled in Microsoft Excel.

Related Monitoring Programs ODFW Spawning and Resting Pool Counts and Creel Surveys
Stream Channel and Habitat Assessments
Fish Use of the Estuary

Anticipated Cost $40,000/year

FISH USE OF THE ESTUARY

Program Objective (Research)

To provide reliable information on fish species composition and relative abundance that can be used as an index to long-term trends in the fish community of Tillamook Bay.

To monitor food habits of selected fish species through time as an index to long-term trends in fish food resources.

To develop a quantitative baseline information on the numbers and species of fish using relatively undisturbed salt marsh habitat in Tillamook Bay.

Monitoring Question(s)

Are there changes in habitat use by salmonids in the Bay over the time scales of years to decades?

CCMP Objective

Research findings to develop estuarine bioindicators and track progress in achieving estuarine restoration objectives.

Program Description

Long-term data sets for fish distribution and abundance are lacking for Tillamook Bay. In summer 1998, the TBNEP sponsored a study to examine fish use of the estuary, the first comprehensive survey since the ODFW surveys in the late 1970s. One objective was to help design a long-term monitoring program based on fish use of the major habitat types in Tillamook Bay. Sampling design emphasizes fish use of salt marsh habitat because salt marsh habitat is most likely to be affected by future habitat restoration programs (*e.g.*, dike breaching) and shoreline development. Efforts will focus on identifying sampling techniques and sampling locations that will provide reliable, quantitative information on fish abundance and distribution. A variety of physical, chemical, and biological measurements are collected in conjunction with the fish sampling to characterize habitat conditions at each sampling site. The fish monitoring program is designed to integrate with monitoring efforts that focus on other biological, physical, and chemical components of the estuarine ecosystem.

Additional special studies might focus on food sources for juvenile salmonids. Gut analyses of juvenile Chinook showed that the fish were eating mostly terrestrial insects. The importance of salt marsh habitat as an important source should be explored in addition to its importance as habitat.

Date Initiated

1998.

Coordinating Agency

TBNEP/TCPP.

Funding Agency TBNEP/TCPP.

Monitoring Parameters
Fish species
Fish size (fork length for fish species with forked tails, standard length for other species)
Water temperature (surface and bottom)
Dissolved oxygen (surface and bottom)
Salinity (surface and bottom)
Turbidity (surface and bottom)
Site location - dGPS
Habitat conditions
Tidal stage

Stations Six regions of the Bay have been identified for location of sampling sites (Fig 10-4). Three sampling locations within each of the six regions will be sampled by beach seine.

Trawling sites will be Garibaldi Harbor and the lower end of the Bay City Channel.

Fyke net sites will be selected in third or fourth order channels within the lower and upper regions of the salt marsh (outside of cattle grazing areas). A random selection process will be used to identify three sites from the list of potential sites.

Frequency
Beach Seining - bi-weekly from May through mid-July.
Trawling - bi-weekly from May through mid-July.
Fyke Net - bi-weekly from May through mid-July.

Sample Collection Detailed sampling protocols can be found in "Tillamook Bay Fish Use of the Estuary" prepared by Ellis Ecological Services and TeraStat Consulting Group, 1999.

Beach Seining - 0.63 mm mesh nylon seine measuring 2m x 30 m long with a mid-section seine bag measuring 2m x 2m across the opening.

Trawling - semi balloon trawl with the following dimensions:
4-seam semi balloon trawl with a 6.1 m head rope and 7.6 m foot rope. A Atickler chain@ attached to the foot rope. Body and wings - 3.7 cm stretch mesh 100 meshes deep. Intermediate section - 3.2 cm stretch mesh 66 meshes deep. Cod end, outer bag - 2.9 cm stretch mesh 889 meshes deep. Cod end, inner bag - 1.8 cm stretch mesh 200 meshes deep. Trawl doors - 0.53 m. V-shaped bridle with 18.3 m legs. All trawling done at low tide. Tow with the current for 5 minutes.

Fyke Net - aluminum frame measures 1.8 m x 1.8 m. Four panel net of

	0.95 cm stretch mesh netting, tapering from the mouth to a 10.2 cm diameter opening at the cod end. A PVC sleeve attaches the cod end of the net to a nylon sleeve on a 61 cm x 91 cm live box covered with 0.64 cm woven mesh nylon. A wooden frame supports the fyke net in a vertical position. Fyke net samples are collected by placing the fyke nets in the wooden frames at high slack tide. The nets fish until the channel is drained at low tide.
Data Management	Relational Database (Microsoft Access/SAS). GIS according to TCWRC specifications.
Related Monitoring Programs	Fish Monitoring (Rivers) Tidal Wetlands Assessments Submerged Aquatic Vegetation Surveys
Anticipated Cost	$25,000/year

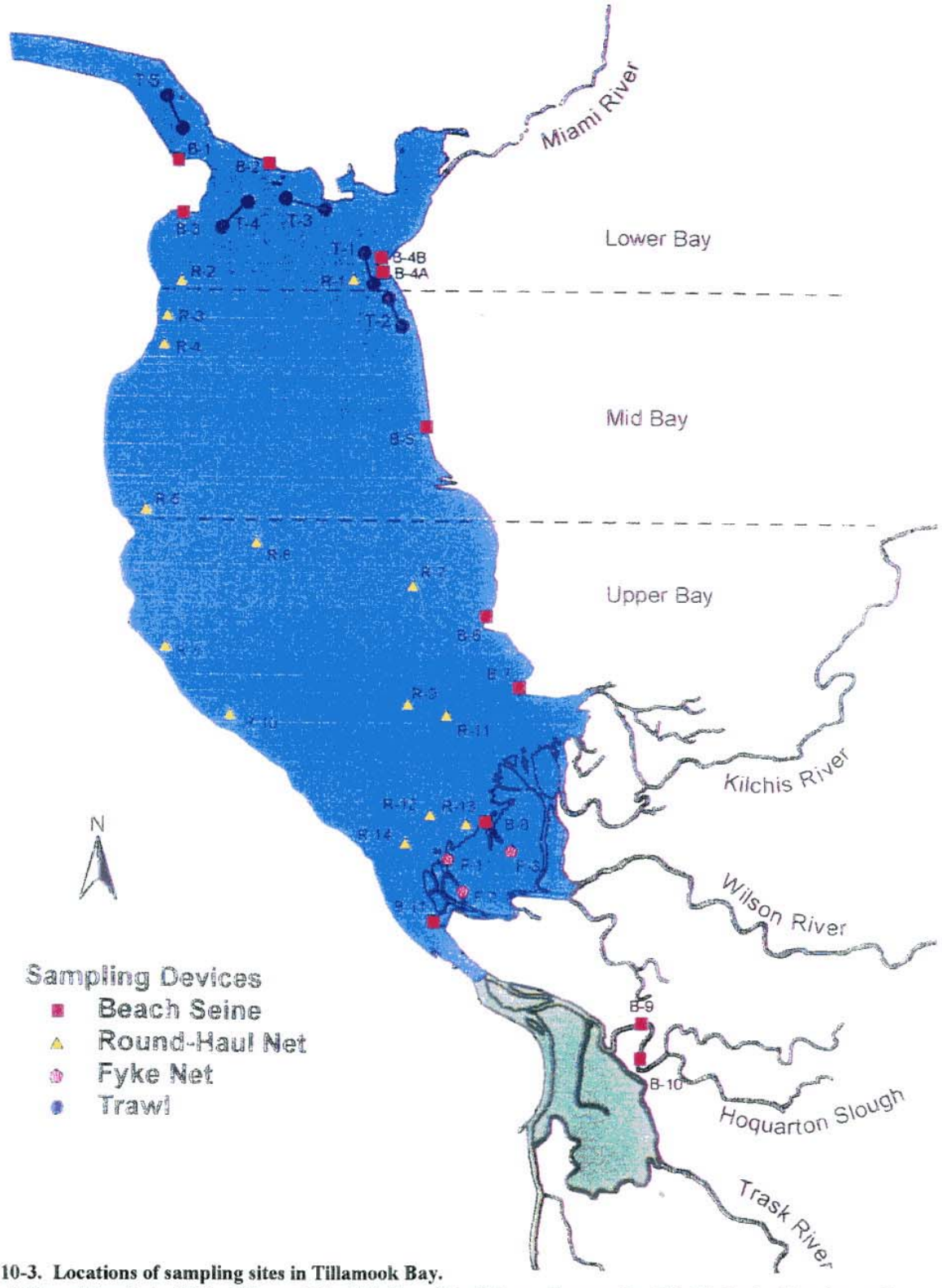


Figure 10-3. Locations of sampling sites in Tillamook Bay.
Source: Ellis and TeraStat. 1998. Tillamook Bay Fish Use of the Estuary. Prepared by Ellis Ecological Services and TeraStat Consulting Group (draft) for the Tillamook Bay National Estuary Project, Garibaldi, OR.

BENTHIC INVERTEBRATE INVENTORY (BAY)

Program Objective (Research)	To quantify changes in the abundance and distribution of dominant benthic macroinvertebrates in Tillamook Bay.
Monitoring Question(s)	Are the density or extent of dominant benthic macroinvertebrates in Tillamook Bay changing over the time scale of years to decades?
CCMP Objective	Research Need: Collect information to manage the shellfish industry, monitor burrowing shrimp populations, identify non-native species, and develop estuarine bioindicators.
Program Description	The ODFW surveyed Tillamook Bay in the summer of 1996 (Golden *et al.*) to inventory the Bay's benthic invertebrates. The survey emphasis was to estimate clam density and biomass in selected areas and habitats. Data were also gathered on burrowing shrimp, algae, eelgrass, habitat, and benthic infauna from grab samples. This study identified conspicuous absences of important prey species for juvenile salmonids and changes in clam community structure compared with past studies.
Date Initiated	1996.
Coordinating Agency	ODFW.
Funding Agency	ODFW.
Monitoring Parameters	Clam species Clam length Clam recruitment Clam density Clam biomass Benthic identification, count, biomass (calculate richness, diversity, and dominance indices) Substrate type Shrimp spp. Eelgrass density Depth
Stations	Garibaldi Flats and in one subtidal area associated with 1996 clam surveys.
Frequency	Every 5 years.

Sample Collection	As described in "Biological Inventory of Benthic Invertebrates in Tillamook Bay" prepared by ODFW, 1998.
Data Management	Relational Database (Microsoft Access/SAS).
Related Monitoring Programs	Submerged Aquatic Vegetation Survey Ecological Interaction Among Eelgrass, Oysters, and Burrowing Shrimp ODFW Shellfish Harvest Management
Anticipated Cost	$50,000/survey

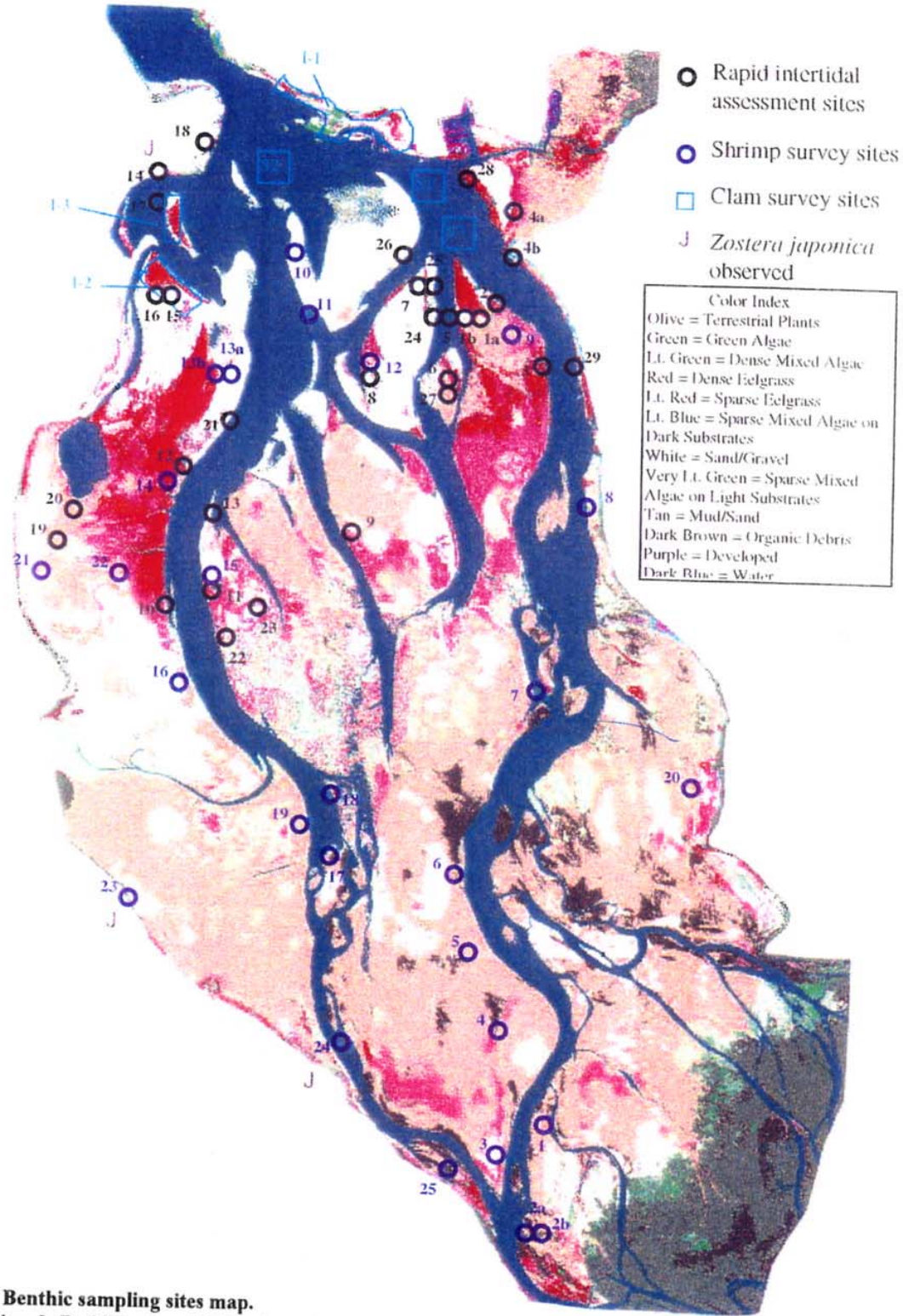


Figure 10-4. Benthic sampling sites map.
Source: Golden, J., D. Gillingham, V. Krutzikowsky, D. Fox, J. Johnson., R. Sardiña, and S. Hammond. 1998. *A Biological Inventory of Benthic Invertebrates in Tilamook Bay*. Oregon Department of Fish and Wildlife. Prepared for the TBNEP, Garibaldi, OR.

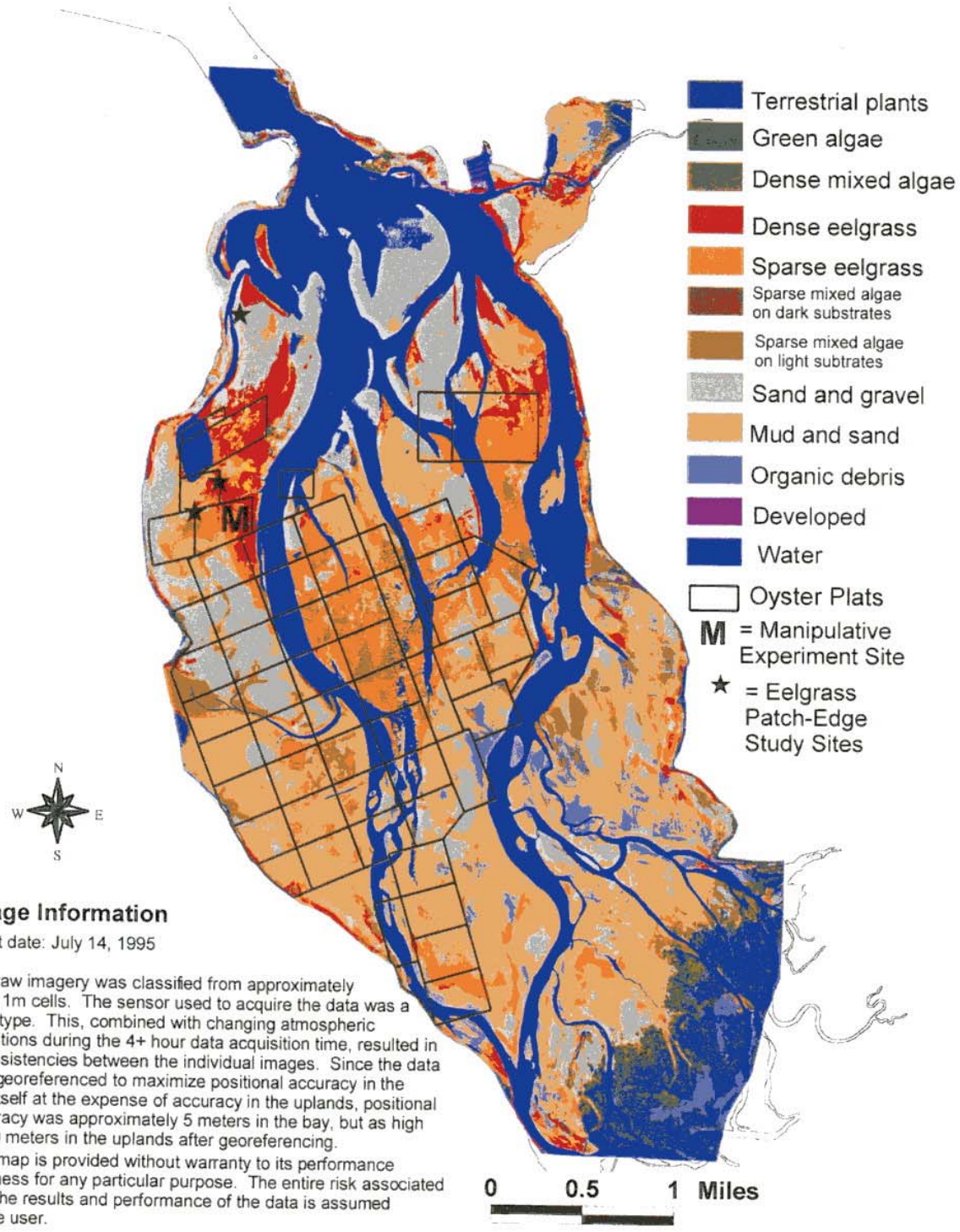


Figure 10-5. Multispectral habitat map of Tillamook Bay (modified from Earth Design Consultants (1996) showing the locations of three eelgrass patch-edge study sites and manipulative experiment site.
Source: by Shreffler, D., R. Thom, and A. Borde (Battelle Marine Sciences Laboratory) and K. Griffin (TBNEP). 1999. *Ecological Interactions Among Eelgrass, Oysters, and Burrowing Shrimp in Tillamook Bay, Oregon: Year 1 (1998) Final Report.* Prepared for TBNEP, Garibaldi, OR.

ECOLOGICAL INTERACTIONS AMONG EELGRASS, OYSTERS, AND BURROWING SHRIMP

Program Objective (Research)

Identify and characterize the major forcing factors affecting the temporal and spatial variability in eelgrass distribution in Tillamook Bay. Evaluate whether current oyster ground culture practices have long-term effects on eelgrass distribution in the Bay.

Monitoring Question(s)

What are the major forcing factors that may explain the spatial and temporal variability in the distribution and densities of eelgrass "patches" in the Bay?

What are some of the specific ecological interactions among eelgrass, oysters, and burrowing shrimp that, if better understood, could be used to improve management decisions?

Objective

Collect information to develop cost-effective, long term ecological monitoring and mapping strategies for the Bay and to support the development of estuarine bioindicators.

Program Description

Historically, Tillamook Bay was one of Oregon's top oyster-producing Bays. While some oyster culture methods may negatively impact eelgrass meadows, oyster culture also can provide habitat for aquatic species. Burrowing shrimp will inhabit an established eelgrass bed that has been stressed in some way. In 1998, the TBNEP initiated a project to conduct an eelgrass patch-edge study to evaluate interspecific interactions among eelgrass, oysters, and burrowing shrimp. We started a series of manipulative studies to evaluate whether oyster culture practices have long term effects on eelgrass distribution, and patch edge studies to identify and characterize the major forcing factors that affect eelgrass distribution. These studies will be continued over the course of an oyster harvest cycle.

Date Initiated

1998.

Coordinating Agency

TBNEP/TCPP/USFWS.

Funding Agency

TBNEP/TCPP/USFWS

Monitoring Parameters

- Percent cover
- Eelgrass density
- Burrow density
- Oyster density
- Photo station at Strata C site
- Multispectral surveys
- Dissolved oxygen
- Salinity
- pH
- Aerial photographs
- Temperature

Stations

See Fig. 10-6. Three eelgrass patch-edge sites (Schweizer lease, Crab Harbor, South Channel). Manipulative experiments - Strata A, B, C, and D of Pacific Oyster Lease. Water quality - five stations monitored by Schweizer in 1998. Three eelgrass patch-edge sites monitored by Griffin in 1998.

Frequency

Patch edge: three times per year (spring, summer, fall) for four more years (through 2002).
Manipulative experiments: three times per year (spring, summer, fall) for four more years (through 2002).
Water quality: preferably weekly, but at a minimum bi-weekly (through 2002).
Aerial photographs: once per year.
Multispectral surveys: every five years (next one in 2001, then every five years thereafter).

Sample Collection

For detailed sampling and analysis protocols, see "Ecological Interactions Among Eelgrass, Oysters, and Burrowing Shrimp in Tillamook Bay, Oregon: Year 1 Final Report," prepared by Battelle Marine Sciences Laboratory, 1999.

Patch edge study: Five parallel 30 m transects that extend from approximately 10 m outside of the eelgrass patch to the interior of the patch. Record data at low tide (eelgrass percent cover, eelgrass shoot density, shrimp burrow density, and oyster density). Data recorded within 1 m^2 quadrants placed at 5 m intervals.

Manipulative study: 10 controlled removal and transplant experiments (See Table 4.2 in "Ecological Interactions Among Eelgrass, Oysters, and Burrowing Shrimp in Tillamook Bay, Oregon: Year 1 Final Report").

Aerial photographs with photo-interpretation to map habitat changes (scale 1:200 shot at low tide).

Multispectral surveys with subsequent ground-truthing (see Submerged Aquatic Vegetation Surveys).

Data Management

Relational Database (Microsoft Access/SAS).
GIS according to TCWRC specifications.

Related Monitoring Programs

Submerged Aquatic Vegetation Survey
Fish Use of the Estuary
Benthic Invertebrate Inventory (Bay)

Anticipated Cost

$25,000/year

NUTRIENT MONITORING

Program Objective (Research)	To quantify changes in the total annual loading of nitrogen and phosphorus from the Wilson and Trask River watersheds to Tillamook Bay.
Monitoring Question(s)	Is the total nutrient loading (N, P) to Tillamook Bay from the Trask and Wilson Rivers increasing or decreasing (and by how much) over time scales of years to decades?
CCMP Objective	To meet water quality standards in the rivers and Bay.
Program Description	Based on TBNEP sampling conducted from 1996 to 1998, and DEQ monitoring conducted over the last two decades, the immediate risk of nutrient-caused degradation of the ecological integrity of the rivers and the estuary appears less than the risk of degradation caused by other issues, such as bacteria, sediment and temperature. However, because of the importance of eutrophication as a potential threat to any estuary, including Tillamook Bay, and evidence of site-specific nutrient water quality issues (sloughs, small tributaries, etc.), continued monitoring of nitrogen will continue, but at lower intensity than monitoring of other parameters. The largest loads of N and P occur in the Wilson and Trask Rivers, and these watersheds contain a variety of land uses, including forestry, agricultural, rural residential, and urban. The program will continue to collect samples for nutrient analysis for the Wilson and Trask Rivers during storm conditions to enable continued evaluation of nutrient loads during high-flow periods. It will continue to collect nutrient data during summer to enable detection of potential future indications regarding N and P limitation. This frequency of sampling will provide general information on most probable ranges of concentration. Nutrient monitoring will support OPSW workplans DEQ9S, DEQ11S, DEQ17S, DEQ19S, and ODA1.
Date Initiated	1996 TBNEP Monitoring.
Coordinating Agency	TBNEP/TCPP.
Funding Agency	TBNEP/TCPP.

Monitoring Parameters	TP TKN DOP NO_3^{2-} and NO_2^{2-} NH_4^+ and NH_3 Flow Precipitation
Stations	Primary lower sites on Wilson and Trask Rivers.
Frequency	Bi-monthly sampling with the winter-season sampling skewed toward high-discharge periods.
Sample Collection	Van Dorn sample collection at 0.5m depth.
Data Management	Relational database (Microsoft Access/SAS).
Related Monitoring Programs	Bacteria Monitoring OSU Water and Watersheds Monitoring
Anticipated Cost	Included in Storm Monitoring for bacteria

BENTHIC MACROINVERTEBRATE MONITORING (RIVERS)

Program Objective (Citizen)	To quantify changes in the abundance and distribution of dominant benthic macroinvertebrates in the Tillamook Watershed.
Monitoring Question(s)	Are the density, biomass, species richness, or diversity of benthic macro-invertebrates in the rivers changing over the time scale of years to decades?
Objective	Support DEQ water quality monitoring program, increase citizen involvement, and development of freshwater bioindicators.
Program Description	The DEQ recently collected benthic data using the Index of Biotic Conditions protocol in several tributaries in the Watershed and reported poor community structure in many of the streams surveyed. Using the same procedure, Oregon Trout started citizen-based benthic macroinvertebrate monitoring in the Kilchis subbasin in the fall of 1997. OSU began benthic macroinvertebrate monitoring in the Tillamook and Kilchis rivers as part of its Water and Watersheds Project in 1998.
Date Initiated	1997.
Coordinating Agency	DEQ.
Funding Agency	DEQ.
Monitoring Parameters	Species Biomass Density Abundance
Stations	10 locations on the Kilchis River.
Frequency	2/year.
Sample Collection	According to DEQ protocols .
Data Management	Relational Database (Microsoft Access/SAS).

Related Monitoring Programs	Benthic Invertebrate Inventory (Bay) Fish Use of the Estuary Tillamook Bay Shellfish Sanitation Program
Anticipated Cost	$10,000/year

PLANKTON MONITORING

Program Objective (Citizen)

To quantify changes in the abundance, distribution, and community structure of plankton in Tillamook Bay.

Monitoring Question(s)

Are plankton biovolumes changing over time scales of years to decades?

Objective

Support citizen involvement and development of estuarine bioindicators.

Program Description

The TBNEP initiated a plankton monitoring program in September 1997 to develop a multi-year data set of plankton species identification, biovolumes, and relative abundance. The Tillamook Bay plankton monitoring program was based on a similar monitoring program in Willapa Bay, Washington. A local oyster grower began collecting weekly samples at three stations in the Bay, each station representing different water column habitats. This effort will be continued as a tool for local resource managers to track subtle changes in the bay environment. Moreover, the Performance Partnership will collaborate with other regional coastal managers to develop standard monitoring protocols for Pacific Northwest estuaries. Monitoring of relative rates of primary production has been identified as a need in the OPSW.

Date Initiated

1997.

Coordinating Agency

TBNEP/TCPP.

Funding Agency

TBNEP/TCPP.

Monitoring Parameters

Zooplankton biovolume
Phytoplankton biovolume
Temperature
DO
Salinity
Secchi Depth
pH

Stations

Port of Garibaldi dock.
Larson Cove.
Memaloose Point Dock.

Frequency

Weekly samples March through September.

Sample Collection	Following methods developed by staff from Willapa Bay and detailed in *"A Citizen's Guide to Plankton Monitoring in Tillamook Bay"* prepared by K. Griffin, 1998. Horizontal tows and vertical lifts. Plankton biovolumes are settled and enumerated using Imhoff cones. Samples are fixed with formalin. Plankton are identified to lowest practical taxon using a compound microscope.
Data Management	Relational Database (Microsoft Access/SAS).
Related Monitoring	Fish Use of the Estuary Benthic Invertebrate Inventory (Bay)
Anticipated Cost	$5,000