FISH USE OF TILLAMOOK BAY

SYNTHESIS REPORT
FOR
MONITORING CONDUCTED 1999 THROUGH 2001

Prepared for:

Tillamook County Estuary Partnership
P.O. Box 493
613 Commercial
Garibaldi, OR 97118

Prepared by:

Robert H. Ellis, Ph.D.
Ellis Ecological Services, Inc.
20988 S. Springwater Rd.
Estacada, OR 97023

December 4, 2002

TABLE OF CONTENTS

FIGURES

Tables

Appendices

INTRODUCTION

The primary objectives of this study were to develop baseline information on fish use of Tillamook Bay estuary and to test and evaluate a sampling approach for long-term monitoring of fish abundance and distribution across major habitat types within the estuary. Long-term data sets are presently lacking for the Tillamook Bay estuary as well as for most other estuaries along the Pacific Northwest Coast of the United States. The sampling data presented in this report represent the first three years of a long-term fish monitoring program authorized under the Tillamook Bay Comprehensive Conservation and Management Plan (CCMP). The objective of the CCMP is "to protect and restore estuarine habitat for important fishery resources, particularly anadromous salmonids". The initial CCMP was completed in June 1999 and lays out a variety of management actions designed to achieve the goal of protecting and restoring habitat for fish. Baseline information on the present status of the estuary's fish community and periodic updating of the baseline information through monitoring were identified as essential components of the CCMP evaluation process.

The results presented herein represent a compilation and synthesis of three previous reports (Ellis 1999, 2002a and 2002b), which documented results for monitoring conducted in 1999, 2000, and 2001. The 1999 report (Ellis 1999) also provided results of some initial test sampling conducted during the summer and fall of 1998 and compared the results with fish survey data collected by Oregon Department of Fish and Wildlife (ODFW) during the mid 1970s (Forsberg et al. 1977 and Bottom and Forsberg 1978). An initial strategy for a long-term fish monitoring program was designed and tested during 1999 and then implemented with minor modifications in 2000 and 2001. The sampling design for the long-term monitoring program was structured to allow testing of hypotheses regarding use of three regions of the estuary (lower, mid, and upper), two major substrate types (fine-grained and coarse-grained) and the effect sampling time (months, within months, and years) for relatively abundant anadromous salmonid and non-salmonid species.

STUDY AREA

Tillamook Bay is a drowned river estuary. It averages only about 2.0 m (6.6 ft) depth over a total surface area of 33.7 square kilometers (13 square miles). Several deep channels wind through the intertidal mud and sand flats that rise above the water surface at low tide. The Bay receives freshwater input from the Miami, Kilchis, Wilson, Trask and Tillamook Rivers and exchanges ocean water through a single channel in the northwest corner. Despite large freshwater inflow, especially during the rainy winter months, heavy tidal fluxes dominate the system; extreme diurnal tides can reach 4.1 m (13.5 ft), with a mean tidal range of 1.7 m (5.6 ft) and diurnal range of 2.3 m (7.5 ft). The Bay experiences the full range of estuarine circulation patterns, from well-stratified to well-mixed, depending on the season and variations in discharge. During months of heavy rainfall, November through March, the system is periodically stratified, but during low precipitation summer months the Bay shifts to a well-mixed estuarine system (Camber 1997). Salinity ranges from around 32 parts per thousand (ppt) near the ocean entrance to about 15 ppt at the upper (southern) end of the Bay at high tide during the summer. The estuary typically maintains relatively high levels of dissolved oxygen (DO) throughout the year and ranges from about 6.0 milligrams per liter (mg/l) to 12.0 mg/l.

The Bay provides habitat for numerous fish, shellfish, crabs, birds, seals, and sea grasses. An Oregon Department of Fish and Wildlife (ODFW) fish survey conducted in the mid 1970s identified 56 species of fish in the Bay at various times of the year (Bottom and Forsberg 1978). The following five species of anadromous salmonids spawn in the watershed and use the estuary at some point in their life cycle:

- Chinook salmon (*Oncorhynchus tshawytscha*);
- Coho salmon (*Oncorhynchus kisutch*);
- Chum salmon (*Oncorhynchus keta*);
- Steelhead trout (*Oncorhynchus mykiss*); and
- Cutthroat trout (*Oncorhynchus clarki*).

With the exception of fall chinook salmon, most of the other salmonid species have exhibited substantial declines in abundance over the past two decades.

The major habitat categories in the Estuary include the following:

- Intertidal and Subtidal Mud/Sand flats;
- Eelgrass Beds (primarily *Zostera marina*);
- Salt Marsh;
- Rocky Intertidal;
- Subtidal Channels; and
- Tidal Portions of Rivers and Sloughs.

Mud flat habitat, consisting of a mixture of silt and fine sand, is the predominant habitat type in the upper two thirds of the estuary although some coarser sandy deposits are found in the extreme upper bay in and near the lower portions of the rivers. Sand flats occur primarily in the lower third of the estuary where tidal currents tend to be stronger and deposition of fine silts and mud are reduced. Eelgrass beds are found predominately in the lower half of the estuary but some scattered beds are found throughout the estuary, primarily along the deeper tidal channels. An extensive area of salt marsh has developed at the south end of the Bay at the mouths of the Kilchis, Wilson and Trask Rivers. A few small areas of salt marsh also occur along the eastern shoreline north of the Kilchis River mouth and at the mouth of the Miami River. Rocky intertidal habitat is largely restricted to the area of very strong tidal currents near the mouth of the estuary and along shorelines exposed to wind driven wave action on the east side of the Bay.

Tidal effects extend various distances up the rivers, ranging from 0.6 km (0.4 miles) for the Miami River, to 11 km (6.8 miles) for the Tillamook River (Komar 1997). A number of tidal

sloughs are located in the lowlands adjacent to and connected with the Kilchis, Wilson, Trask and Tillamook Rivers. Water quality problems (i.e., low dissolved oxygen and high coliform bacteria counts) have been identified in Hoquarton Slough (Newell 1998) and may occur in some of the other sloughs.
This study was limited to the saline portions of the Tillamook Bay estuary and did not address freshwater wetlands, riverine habitats or sloughs influenced by tidal exchange in the estuary.

METHODS

SAMPLING APPROACH

Information developed during the 1998 summer and fall sampling program was used to design a preliminary sampling strategy for long-term monitoring of fish (Ellis 1999). Because we anticipated that the salinity gradient across the estuary would likely influence species distribution, we divided the estuary into three broad regions (lower, mid, and upper regions), corresponding to areas of relatively high, intermediate, and low salinities. The dividing lines between upper, middle, and lower regions were the same as those used by ODFW for their surveys in the mid 1970s. We were also interested in comparing species distribution and abundance along shores with coarse-grained substrate (gravel, cobble and boulders) with shores with fine grained-substrate (sand and sand/silt). Beach seining was selected as the most appropriate sampling method for sampling the intertidal shoreline habitat.

A preliminary survey of suitable sites for beach seining was conducted during early April 1999 and the locations of potential sites were mapped. Potential beach seine sites were selected based on boat accessibility and suitability of shoreline conditions for seining at high tide. From the potential sites, six were randomly selected from the upper, six from the middle, and six from lower regions of the Bay for a total of 18 beach seining sites (Figure 1). No suitable beach seine sites were found along the south end of the Bay adjacent to the Three Capes Highway. Final selection of sites within each region was conducted by assigning numbers to all potential sites with coarse grain and fine grain shoreline conditions and then randomly selecting three sites from the coarse grain group and three from the fine grain group. The presence of eelgrass at or near to selected coarse or fine grain beach seine sites was recorded and used as an additional habitat criterion for potential comparison purposes. Figure 2 shows the distribution of coarse grain and fine grain substrate stations and those stations having eelgrass beds nearby. This random block design allowed statistical testing of effects of region and substrate.

Beach seine sampling was initiated in late April in 1999 and was conducted at twice-monthly intervals through June. In July 1999, only a single set of beach seine samples was collected. In 2000 and 2001, sampling was initiated in early May and continued at twice-monthly intervals through late July. Samples were collected within approximately ± 2 hours of high tide. Since high tide occurs about 40 minutes later in the upper bay than at the mouth of the Bay, it was possible to collect samples over about a 6-hour interval each day. Sampling was limited to daylight hours.

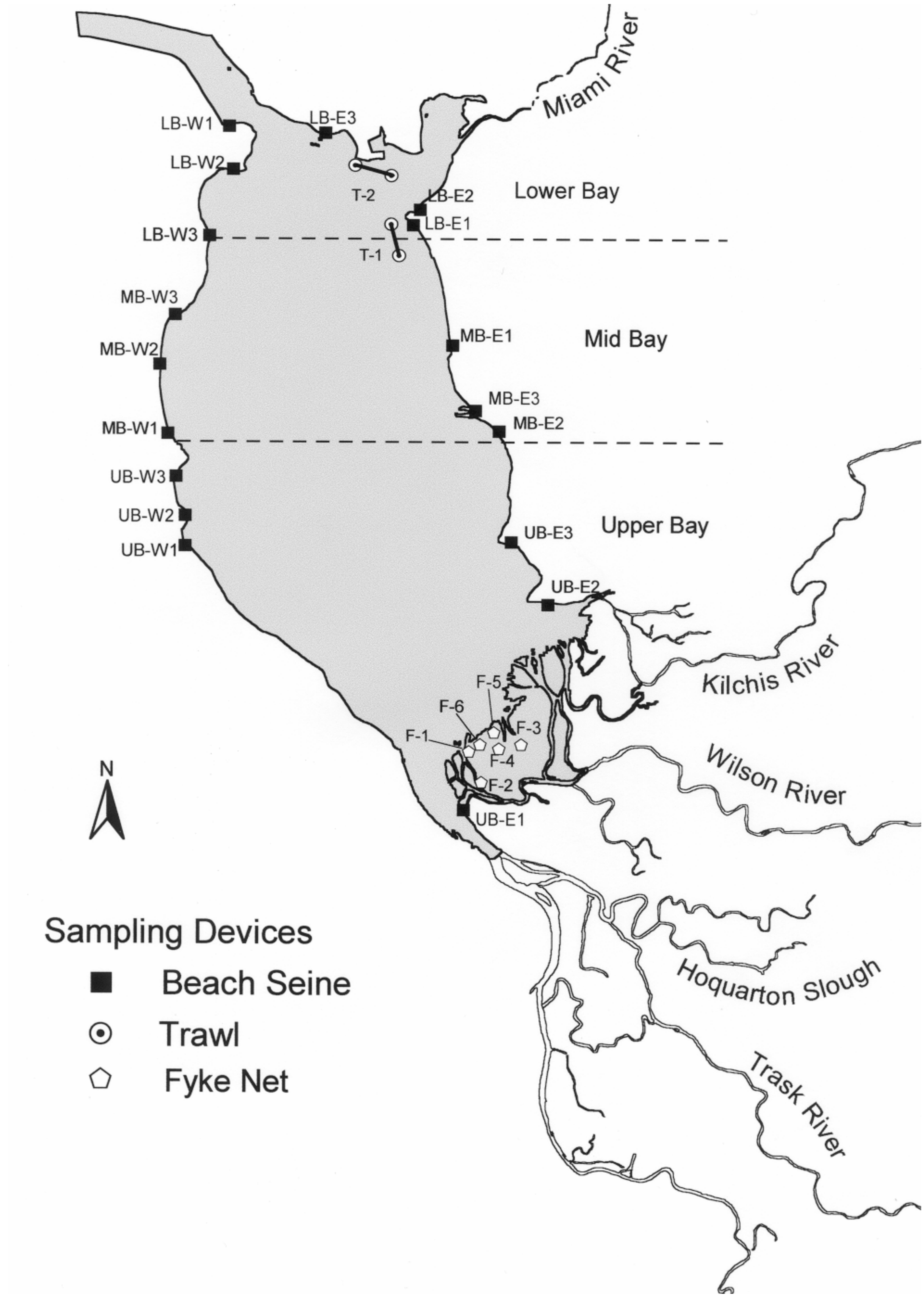
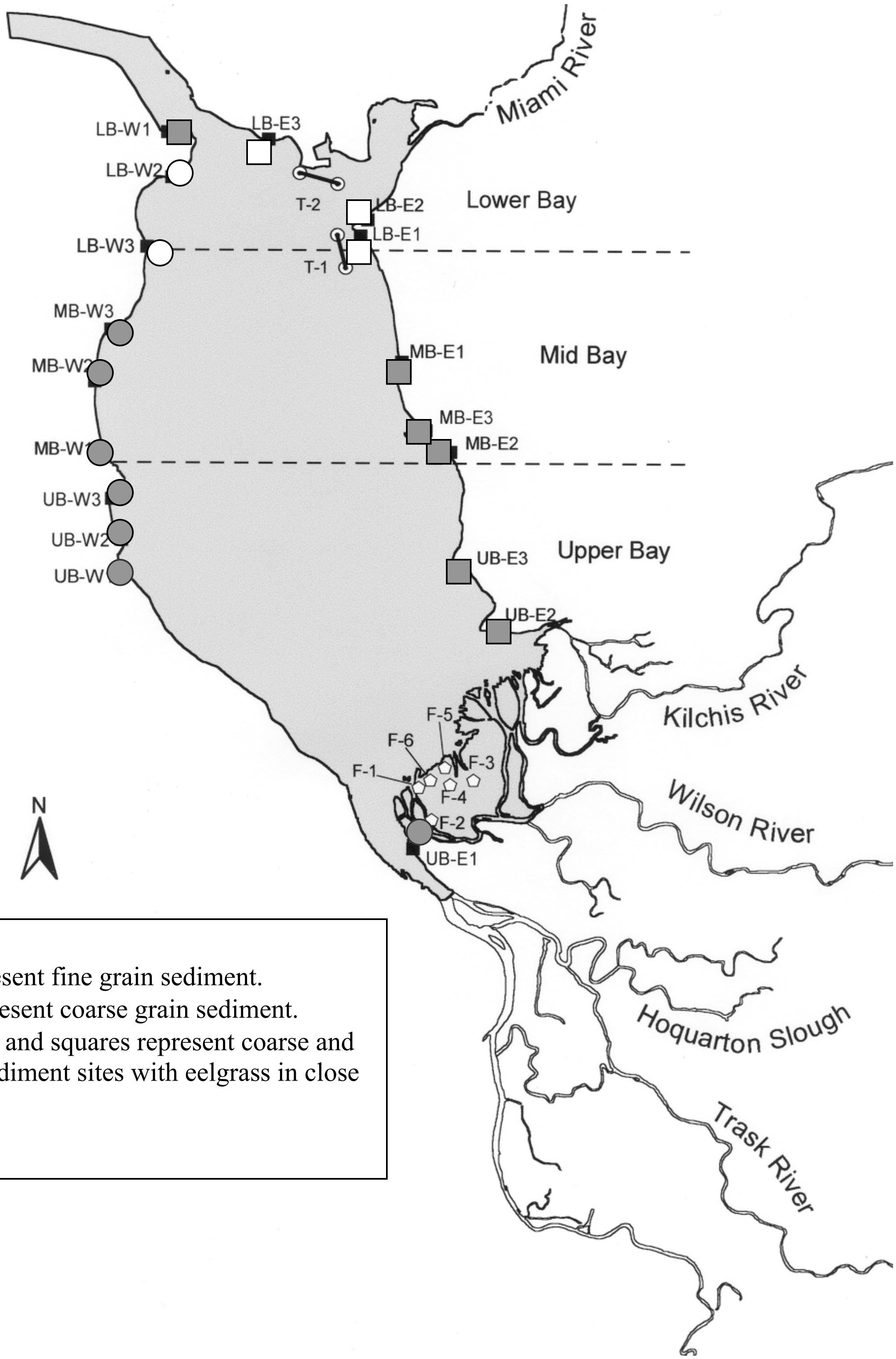


Figure 1. Location of sampling sites in Tillamook Bay for the fish monitoring program.



- Circles represent fine grain sediment.
- Squares represent coarse grain sediment.
- Open circles and squares represent coarse and fine grain sediment sites with eelgrass in close proximity.

Figure 2. Location of beach seine sites on fine-grained and coarse-grained substrate. Sampling sites where eelgrass beds were in close proximity to the sampling sites also are shown.

Bottom trawling was used to sample the subtidal channel habitat. Trawling was conducted at two channel locations in the lower Bay (Figure 1). These sites were selected based on results of the 1998 preliminary trawl surveys and represented the two areas with the highest catch per unit effort (CPE). Two replicate trawls were made at low tide at each of the two trawl sites. In 1999, sampling was conducted at approximately bi-weekly intervals from late April through June on the same schedule as the beach seine sampling. A late July sample also was collected to coincide with the timing of the beach seine samples. In 2000 and 2001, trawl sampling was conducted once a month at each station from May through July.

Salt marsh habitat was sampled with stationary fyke nets. In the spring of 1999, six fyke net sites were established to sample fish in salt marsh tidal channel habitat (Figure 1). The sampling sites provided treatment replication. All sites were located on either third or fourth order tidal channels. Sampling efficiency was estimated based on recapture of fin-clipped fish released upstream of the fyke nets at high tide. All fyke-net sampling was limited to daylight hours.

Water quality sampling was conducted concurrent with collection of all fish samples. The water quality parameters measured throughout the study were temperature and salinity. Measurements were taken with a YSI Model 85 multiprobe water quality probe.

During each of the sampling periods (i.e., 1999, 2000 and 2001), samples of juvenile chinook and chum salmon, Pacific staghorn sculpin, and English sole were collected and archived for future stomach content analysis. Approximately 50 fish of each species were collected during each of the sampling periods.

FIELD METHODS

Detailed descriptions of the field methods and sampling gear can be found in Ellis (1999, 2002a, and 2002b). All fish captured were identified to species and measured to the nearest millimeter. When over 25 fish of a given species was collected at a sampling site, the first 25 individuals were measured and counted; the remainder was only counted. Consistency in sampling methods from year to year was maintained through adherence to the long-term monitoring program guidelines and through use of the same field crew leader.

STATISTICAL ANALYSIS

A one-way Analysis of Variance (ANOVA) was use to determine whether mean numbers of species differed between beach seine stations with fine-grained and coarse-grained substrate. No transformation of the species data was required for the ANOVA.

Tests of hypotheses regarding effects of region of the Bay, substrate, and time (year, month and within month) were tested through the application of a generalized linear modeling procedure (GENMOD) available through the SAS Institute, Inc (SAS 1996). The GENMOD procedure fits generalized linear models. The class of linear models is an extension of traditional linear models that allows the mean of a population to depend on a linear predictor through a non-linear link function and allows the response probability distribution to be any member of an exponential family of distributions. We found that the *negative binomial* distribution with a *log* link function provided the best fit to the majority of the beach seine catch data for abundant species. The GENMOD procedure conducts tests for main effects and all interaction effects through a series of Chi Square analyses. All tests were considered significant at α values of 0.05.

Quality Control/Quality Assurance

One of the most important aspects of a long-term monitoring program is consistency through time in sampling techniques and procedures. To ensure that the sampling program is consistent from year to year, a monitoring plan document was prepared that provides details on the equipment to be used and the specific techniques for use of each type of sampling gear. The procedures described in the monitoring plan are closely adhered to so that comparable data are collected during each year of the program. Consistency in sampling the same locations through time is also important. Each site was located with GPS coordinates so that future sampling can be conducted at the same locations. For the sampling conducted to date, the same senior fisheries biologist has conducted all of the field work. This consistency in project staffing also has helped ensure that the data collected to date are comparable.

When species were collected that were not readily identifiable in the field, representative specimens were retained for identification in the laboratory. Standard keys to the identification of estuarine and marine fishes (e.g. Hart 1973) were used for these identifications.

Water temperature and salinity were measured throughout the study. The temperature sensor was calibrated against a laboratory thermometer. Salinity was checked against a reference standard. Measurements of temperature and salinity were made to the nearest 0.1 C and 0.1 ppt, respectively. Manufacturer's stated accuracy of the meter for temperature is $\pm$0.1 C and for salinity is $\pm$0.1 ppt.

Field data were recorded on standard field data forms as described in the long-term monitoring plan. At the end of each day's sampling the data forms were checked for completeness. Upon return to the office, all field data were transferred to computer spread sheets by a technician familiar with the taxonomic nomenclature, sampling sites, and expected size ranges of fish. All of the data was conducted following the data entry to identify entry errors.

Coordination with Other Programs

ODFW monitored downstream migration of juvenile anadromous salmonids at two screw-traps located on the Little North Fork Wilson River and the Little South Fork Kilchis River from 1999-2001. The ODFW out-migrant data were used to help interpret movements of juvenile salmonids into the estuary and to estimate the contribution of Little North Fork Wilson River to chum salmon fry in our estuarine beach seine catches.

RESULTS AND DISCUSSION

FRESHWATER INFLOW AND WATER QUALITY CONDITIONS

One of the factors that must be considered when comparing fish data collected in different years is the freshwater inflow conditions during the study period. Differences between years in freshwater input affect salinity and other water quality conditions that potentially could influence the distribution of fish in the Bay. Flow in the lower Wilson River is routinely monitored by the U.S. Geological Survey (stream gage # 14301500) and was used as an index to freshwater input to the Bay. Weekly mean stream flow data for the period May through July are compared for the three years of study in Figure 3.

Between the first week in May and the middle of June, flows in the Wilson River were variable in all three years due to typical seasonal variability in precipitation. From late May through July, flow conditions were similar in 1999 and 2001 with a gradual steady decline in flow. Heavy precipitation in mid June 2000 resulted in a substantial increase in fresh water input compared with either 1999 or 2001 (Figure 3). After the precipitation event in mid June 2000, flow declined but remained slightly higher than in either 1999 or 2001.

Salinity in the Bay, as measured at beach seine sites, generally increased as the fresh water input decreased over the three-month study period in all three years (Figure 4). The exception was in mid June 2000 when relatively high inflows of fresh water diluted the marine water and reduced salinity. The influx of fresh water in mid June 2000 resulted in a decrease in salinity throughout the Bay (Figure 4). As will be discussed below, this temporary reduction in salinity may have temporarily affected the distribution of certain fish species.

Salinity in salt marsh habitat at the south end of the Bay was measured twice-monthly in 1999 and monthly in 2000 and 2001. All measurements were made at high tide. Mean salinity values recorded at the fyke net sites ranged from 0.4 ppt to 1.4 ppt during May, from 0.3 ppt to 9.3 ppt in June and from 4.7 ppt to 10.4 ppt in late July (Table 1). The mean salinity in the marsh was usually substantially lower than mean salinity measured at beach seine sites in the upper region of the open Bay. This probably reflects input to the marsh from the Wilson River, which flows along most of the east side of the salt marsh. The substantial increase in marsh habitat salinity in July reflects the relatively low flow conditions prevailing in the Wilson River during July.

Surface water temperature in the three regions of the Bay was measured twice-monthly in conjunction with beach seining (Figure 5). Mean water temperature generally varied over a wider range in the upper bay than in the mid and lower regions of the bay due to the shallow nature of the upper bay and the greater influence of freshwater input. The maximum

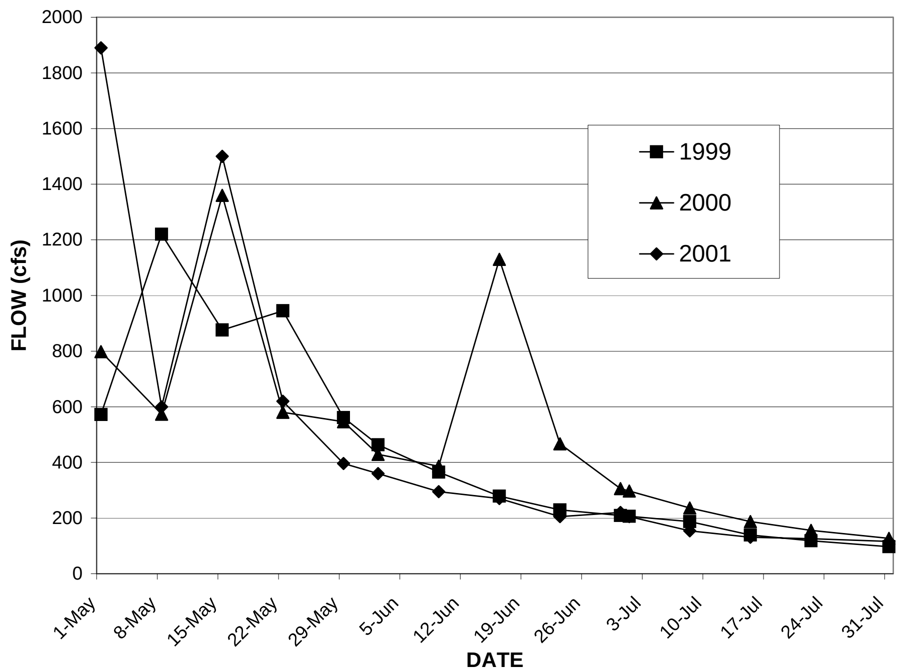


Figure 3. Mean stream flow of the Wilson River for the period May-June 2001 compared to May-June 1999 and 2000 (U.S.G.S. gauge no. 14301500).

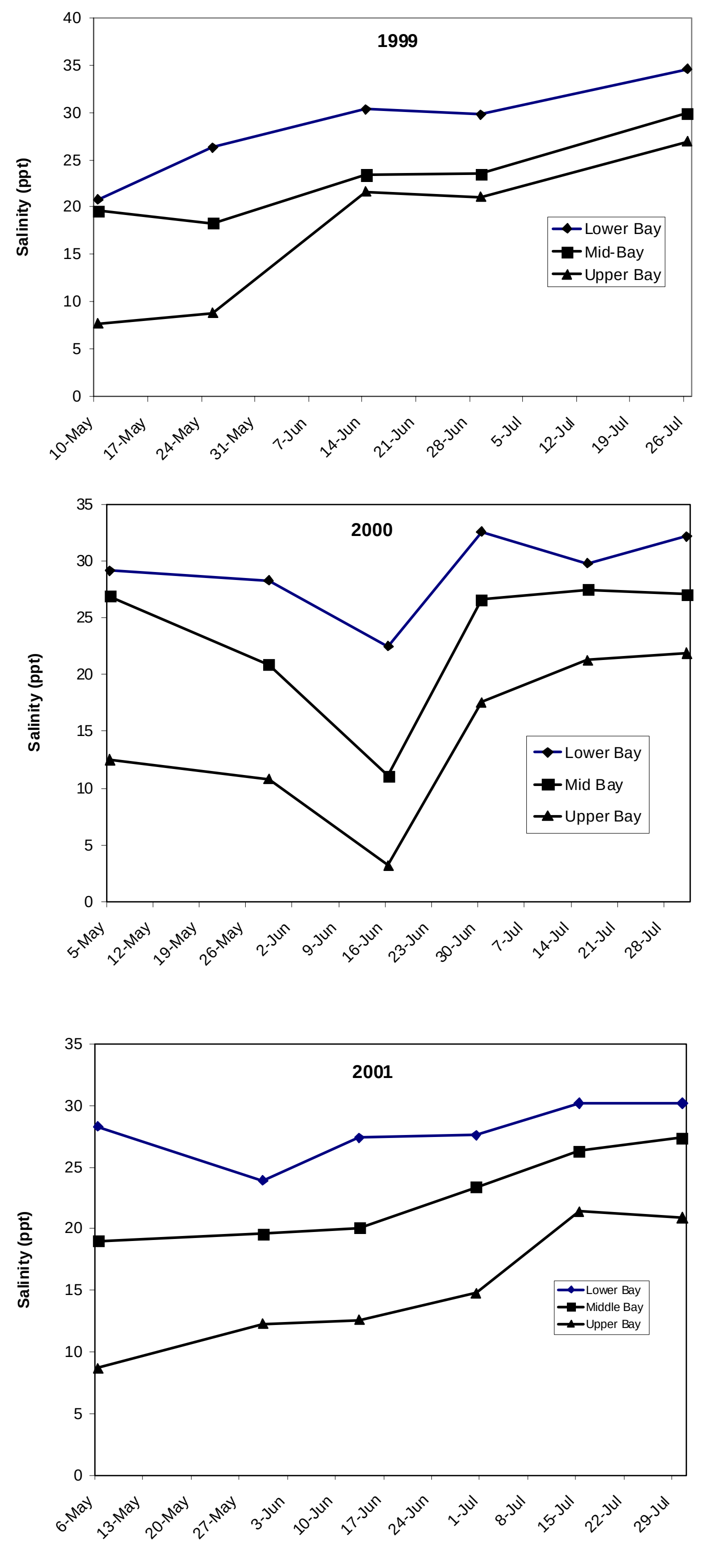


Figure 4. Mean salinity at beach seine sites in the lower, mid, and upper regions of Tillamook Bay in 1999, 2000, and 2001.

Table 1. Mean salinity (ppt) in salt marsh habitat measured at fyke net sampling sites in 1999, 2000, and 2001.

Sample Date	1999	2000	2001
Early May	0.4	1.4	0.6
Late May	0.7	---	---
Mid June	9.3	0.3	0.6
Late June	5.0	---	---
Late July	10.4	4.7	8.7

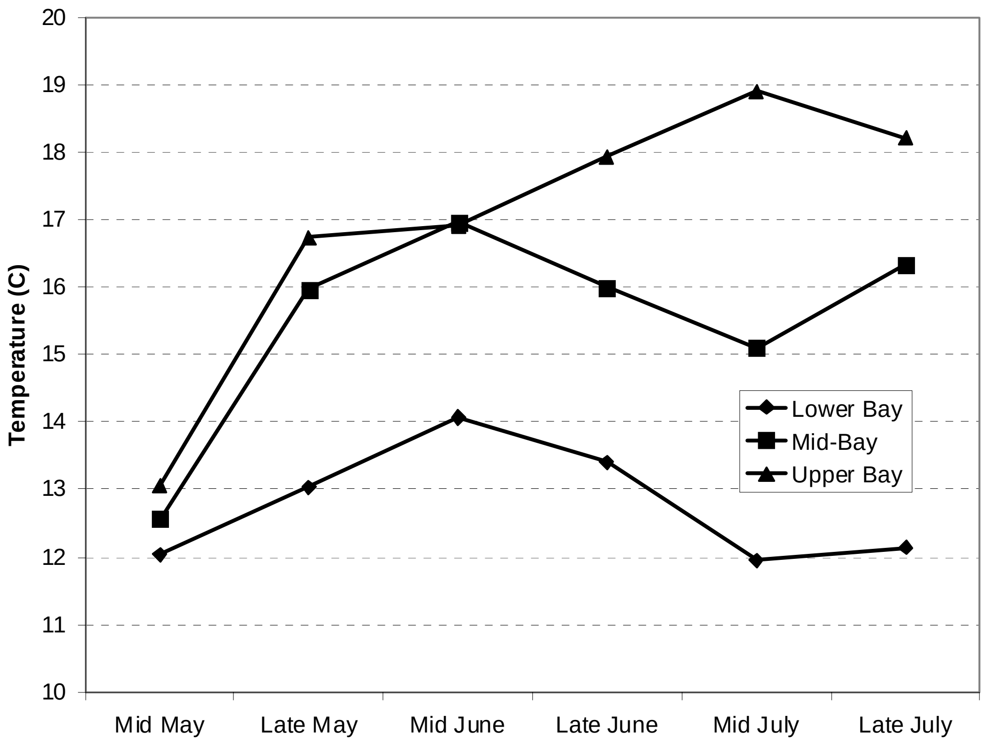


Figure 5. Mean water temperature in the upper, mid, and lower regions of Tillamook Bay for the period May through July, 1999-2001.

Table 2. Mean water temperature (˚C) in salt marsh habitat measured at fyke net sampling sites in 1999, 2000 and 2001.

Sample Date	1999	2000	2001
Early May	9.0	13.2	14.8
Late May	16.5	---	---
Mid June	18.3	17.3	11.0
Late June	19.7	---	---
Late July	18.5	NA	17.4

temperature measured at a beach seine site was 23.8˚C and occurred in the mid-region of the Bay. Temperatures over 20.0˚C were common from late May through July in the upper region of the Bay. Mean temperatures in the lower bay were relatively constant, ranging from about 12 to 14˚C. Note that the mean water temperature in the lower bay decreased by about 2.0˚C between mid June and late July. This decline in temperature was due to the effects of nearshore upwelling of cool oceanic waters. Persistent northwest winds were largely responsible for the upwelling conditions.

Mean water temperatures for the six fyke net sites in salt marsh channel habitat are shown in Table 2. Water temperature in the marsh appeared to follow a pattern similar to that of the temperature in the open portion of the upper bay. Maximum temperatures recorded at individual sites in the marsh ranged from 17.9˚C in 2001 to 21.8˚C in 1999.

SPECIES COMPOSITION

From 1998 through 2001, 48 species of fish were collected by the various sampling techniques (Table 3). This compares with 56 species identified during the 2.5-year study conducted by ODFW in the mid 1970s (Bottom and Forsberg 1978). Species missing from the recent sampling efforts probably can be attributed largely to differences in sampling techniques and seasonal (recent study) versus year-round sampling (ODFW study). Species found in this study but not previously reported for Tillamook Bay included night smelt, slimy snail fish, bay goby, rock prickleback, rockweed gunnel and speckled sandab. Species known to presently occur in Tillamook Bay but not collected in the 1998-2001 samples include white and green sturgeon (ODFW annual gill net records for Tillamook Bay) and Pacific lamprey. Many of the species found in Tillamook Bay also have been found in other Oregon estuaries such as Yaquina Bay (Percy and Myers 1974), the Umpqua estuary (Johnson et al. 1986), and Coos Bay (Cummings and Schwartz 1971).

Previous studies indicate that species diversity in Oregon estuaries peaks during the summer months (Bottom and Forsberg 1978, Johnson et al. 1986). This is due largely to the intrusion of saline marine waters during the low flow period of the year. Marine species with low tolerance to brackish water conditions are able to invade the lower ends of

Table 3. Scientific and common names of fish species collected from Tillamook Bay during the mid-1970s (all seasons) compared to those fish species collected during the 1998-99, 2000, and 2001 sampling seasons.

Family, Genus, and Species	Common Name	Present During 1974-76	Present During 1998-99	Present During 2000	Present During 2001
Petromyzontidae					
Entosphenus tridentatus	Pacific Lamprey	X	---	---	---
Rajidae					
Raja binoculata	Big Skate	X	---	---	---
Raja rhina	Longnose Skate	X	---	---	---
Acipenseridae					
Acipenser medirostris	Green Sturgeon	X	---	---	---
Clupeidae					
Alosa sapidissima	American Shad	X	X	X	X
Clupea harengus pallasi	Pacific Herring	X	X	X	X
Engraulidae					
Engraulis mordax	Northern Anchovy	X	X	X	X
Salmonidae					
Oncorhynchus tshawytscha	Chinook Salmon	X	X	X	X
Oncorhynchus clarki	Cutthroat Trout	X	X	X	X
Oncorhynchus kisutch	Coho Salmon	X	X	X	X
Oncorhynchus keta	Chum Salmon	X	X	X	X
Oncorhynchus mykiss	Steelhead Trout	X	X	X	---
Osmeridae					
Hypomesus pretiosus	Surf Smelt	X	X	X	X
Spirinchus thaleichthys	Longfin Smelt	X	---	X	---
Spirinchus starksi	Night Smelt	---	---	---	X
Gadidae					
Microgadus proximus	Pacific Tomcod	X	X	X	X
Zoarcidae					
Lycodes sp.	Eelpout (small juvenile)	---	X	---	---
Atherinidae					
Atherinops affinis	Top Smelt	X	X	X	X
Aulorhynchidae					
Aulorhynchus flavidus	Tubesnout	X	X	X	X
Gasterosteidae					
Gasterosteus aculeatus	Threespine Stickleback	X	X	X	X
Syngnathidae					
Syngnathus griseolineatus	Bay Pipefish	X	X	X	X
Embiotocidae					
Amphistichus rhododterus	Redtail Surfperch	X	---	---	---
Phanerodon furcatus	White Seaperch	X	X	---	---
Embiotoca lateralis	Striped Seaperch	X	X	X	X
Rhacochilus vacca	Pile Perch	X	X	X	X
Cymatogaster aggregata	Shiner Perch	X	X	X	X
Hyperporsopon argenteum	Walleye Surfperch	X	---	---	---
Hyperprosopon ellipticum	Silver Surfperch	X	---	---	---
Stichaeidae					
Lumpenus sagitta	Snake Prickleback	X	X	X	X
Xiphister mucosus	Rock Prickleback	---	X	---	---
Anoplarchus purpurescens	High cockscomb	X	---	---	---

Family, Genus, and Species	Common Name	Present During 1974-76	Present During 1998-99	Present During 2000	Present During 2001
Pholidae					
Pholis ornata	Saddleback Gunnel	X	X	X	X
Xererpes fucorum	Rockweed Gunnel	---	X	X	X
Pholis schultzi	Red Gunnel	X	---	---	---
Apodichthys flavidus	Penpoint Gunnel	X	---	---	---
Anarhichadidae					
Anarrhichthys ocellatus	Wolf-eel	X	---	---	---
Ammodtidae					
Ammodytes hexapterus	Pacific Sandlance	X	X	X	X
Gobiidae					
Clevelandia ios	Arrow Goby	X	X	X	---
Lepidogobius lepidus	Bay Goby	---	---	X	X
Scorpaenidae					
Sebastes sp.	Rockfish sp.	X	X	X	X
Anoplopomatidae					
Anoplopoma fimbria	Sablefish	X	---	---	---
Hexagrammidae					
Hexarammos sp.	Greenling sp.	X	X	X	X
Ophodon elongatus	Lingcod	X	X	X	X
Cottidae					
Cottus asper	Prickley Sculpin	X	X	X	X
Leptocottus armatus	Pacific Staghorn	X	X	X	X
Oligocottus maculosus	Sculpin	X	X	X	X
Artedius fenestralis	Tidepool Sculpin	X	X	X	X
Artedius lateralis	Padded Sculpin	X	---	---	---
Hemilepidotus hemilepidotus	Smoothhead Sculpin	X	X	X	X
Enophrys bison	Red Irish Lord	X	X	X	X
Scorpaenichthys	Buffalo Sculpin	X	X	X	X
marmoratus	Cabezon	X	---	---	X
Blepsias cirrhosus	Silverspotted Sculpin	X	---	---	---
Hemilepidotus hemilepidotus	Brown Irish Lord	X	---	X	X
Clinocottus acuticeps	Sharpnose Sculpin				
Agonidae					
Occella verrucosa	Warty Poacher	X	---	---	---
Pallasina barbata	Tubenose Poacher	X	---	---	---
Stellerina xyosterna	Pricklebreast Poacher	X	---	---	---
Cyclopteridae					
Liparis fucensis	Slipskin Snailfish	X	---	X	---
Liparis rutteri	Ringtail Snailfish	X	---	---	X
Liparis mucosus	Slimy Snailfish	---	---	---	X
Bothidae					
Citharichthys sordidus	Pacific Sanddab	X	X	---	X
Citharichthys stigmaeus	Speckled Sanddab	---	X	---	---
Pleuronectidae					
Parophrys vetulus	English Sole	X	X	X	X
Platichthys stellatus	Starry Flounder	X	X	X	X
Psettichthys melanostictus	Sand Sole	X	X	X	X
Isopsetta isolepis	Butter Sole	X	---	---	---
Unidentified sp. 1 (juvenile)	unknown	---	---	X	X

estuaries during these periods, which results in an increase in species diversity. The majority of these relatively stenohaline marine species occur in low numbers. In this study, the total numbers of species collected during each of the three sampling periods were very similar with 40 collected in 1998-99, 40 in 2000 and, 41 in 2001. With the exception of a few rare species, the same species were collected in all three years. The list of species presented in Table 3 probably represents the approximate annual peak in species diversity for the Bay.

For each year of the study, we used a one-way ANOVA to test for differences in the mean number of species collected at beach seine sites with coarse-grained and sites with fine-grained substrate. In all three years, significantly more species were collected on the coarse-grained substrate than on the fine-grained substrate.

Relative Abundance of Species

The combined beach seine, trawl, and fyke net catch for May through July is presented for the three sampling periods in Table 4. Pacific staghorn sculpin, shiner perch, surf smelt, Pacific sand lance, and English sole comprised the majority of the catch. Of these abundant species, Pacific staghorn sculpin, shiner perch, and surf smelt were found throughout the estuary. Pacific sand lance and English sole were found primarily in the lower and mid regions of the Bay. The relatively high abundance of Pacific sand lance in the 2000 catch was largely due to a few large beach seine catches. Pacific sand lance is a schooling species. Chance encounters with a large school may have determined the relative position of this species in the overall catch for a given year. Juvenile English sole were primarily caught by beach seine and were about equally abundant in all three years, with the total catch ranging from 1,002 in 2000 to 1,551 in 1998-99.

Juvenile chum salmon, chinook salmon, coho salmon, cutthroat trout, and steelhead trout represented the anadromous salmonid component of the catch. The majority of juvenile salmonids were collected by beach seine along the shores of the Bay. Over the study period, chum salmon was usually the most abundant of the salmonid species, followed by chinook salmon, cutthroat trout, steelhead trout and coho salmon, respectively.

A number of the species found in Tillamook Bay are known to be important food resources for anadromous salmonids. They include the Pacific sand lance, Pacific herring, northern anchovy, and surf smelt. All of these species are plankton feeders and depend heavily on zooplankton as a food resource. 1999 was the first year of the shift in oceanic conditions from one dominated by El Niño conditions to one dominated by cooler offshore waters and strong summer upwelling conditions. In 1999 there was a dramatic shift in the zooplankton species composition in the nearshore oceanic waters from a community that was dominated (between 1992-98) by a mixture of warm water and boreal coastal species to a community that contained only species that are subarctic in origin (Peterson and McKinnell 2000). During the period 1992 through 1998, Pacific herring and northern anchovy were in relatively low abundance along the entire Oregon coast, while Pacific sardine increased in abundance. It has been speculated that the return of cool waters and the shift in the zooplankton community could lead to one in which northern anchovy are once again a dominant component of the pelagic fish population (ibid).

Table 4. Relative abundance of fish species captured during the 2001, 2000, and 1998-99 sampling seasons (combined catch).

2001 Combined Catch			**2000 Combined Catch**			**1998-99 Combined Catch***		
Species	Number	Percent	Species	Number	Percent	Species	Number	Percent
Pacific Staghorn Sculpin	4859	29.81%	Pacific Sand Lance	5181	25.68%	Pacific Staghorn Sculpin	2910	21.06%
Shiner Perch	4067	24.95%	Pacific Staghorn Sculpin	4510	22.36%	Surf Smelt	2736	19.80%
Surf Smelt	2571	15.77%	Surf Smelt	4162	20.63%	Shiner Perch	2700	19.54%
Pacific Sand Lance	1103	6.77%	Shiner Perch	2726	13.53%	English Sole	1551	11.23%
English Sole	1038	6.37%	English Sole	1002	4.97%	Pacific Herring	1513	10.95%
Threespine Stickleback	874	5.36%	Threespine Stickleback	938	4.65%	Chum Salmon	713	5.16%
Chum Salmon	602	3.70%	Chinook Salmon	378	1.87%	Chinook Salmon	283	2.05%
Top Smelt	206	1.26%	Chum Salmon	219	1.09%	Pacific Sanddab	272	1.97%
Chinook Salmon	193	1.20%	Top Smelt	207	1.03%	Starry Flounder	259	1.87%
Saddleback Gunnel	143	0.88%	Pacific Herring	162	0.80%	Pacific Sand Lance	214	1.55%
Tidepool Sculpin	138	0.85%	Starry Flounder	123	0.61%	Threespine Stickleback	151	1.09%
Northern Anchovy	83	0.51%	Tidepool Sculpin	111	0.54%	Coho Salmon	97	0.70%
Starry Flounder	65	0.40%	Lingcod	88	0.44%	Lingcod	82	0.59%
Pacific Herring	51	0.31%	Buffalo Sculpin	71	0.35%	Tidepool Sculpin	79	0.57%
Bay Pipefish	40	0.25%	Saddleback Gunnel	54	0.27%	Prickley Sculpin	75	0.54%
Greenling sp.	36	0.22%	Cutthroat Trout	28	0.14%	Cutthroat Trout	38	0.28%
Prickly Sculpin	30	0.18%	Northern Anchovy	25	0.12%	Topsmelt	29	0.21%
Buffalo Sculpin	26	0.16%	Pile Perch	24	0.12%	Saddleback Gunnel	18	0.13%
Lingcod	21	0.13%	Snake Prickleback	20	0.10%	Buffalo Sculpin	15	0.11%
Padded Sculpin	15	0.09%	Greenling sp.	20	0.10%	Arrow Goby	12	0.09%
Pacific Sanddab	15	0.09%	Striped Sea Perch	19	0.09%	Striped Sea Perch	12	0.09%
Snake Prickleback	14	0.09%	Prickley Sculpin	19	0.09%	Greenling sp.	11	0.08%
Sharpnose Sculpin	14	0.09%	Padded Sculpin	16	0.08%	Steelhead Trout	7	0.05%
Striped Sea Perch	13	0.08%	Cabezon	10	0.05%	Bay Pipefish	5	0.04%
Cabezon	11	0.07%	Steelhead Trout	9	0.04%	Northern Anchovy	5	0.04%
Red Irish Lord	10	0.06%	Red Irish Lord	8	0.04%	Sand Sole	4	0.03%
Pile Perch	9	0.05%	Pacific Tomcod	8	0.04%	Padded Sculpin	4	0.03%
American Shad	8	0.05%	Bay Pipefish	5	0.03%	Speckled Sanddab	3	0.02%
Night Smelt	7	0.04%	Tubesnout	5	0.03%	American Shad	3	0.02%

2001 Combined Catch			2000 Combined Catch			1998-99 Combined Catch*		
Species	Number	Percent	Species	Number	Percent	Species	Number	Percent
Bay Goby	6	0.04%	Arrow Goby	4	0.02%	Cabezon	2	0.01%
Cutthroat Trout	6	0.04%	Rockweed Gunnel	4	0.02%	Rockweed Gunnel	2	0.01%
Pacific Tomcod	5	0.03%	Sharpnose Sculpin	4	0.02%	Snake Prickleback	2	0.01%
Sand Sole	3	0.02%	Unidentified sp. 1	4	0.02%	Pile Perch	2	0.01%
Tubesnout	3	0.02%	American Shad	3	0.01%	Red Irish Lord	2	0.01%
Rockfish sp. (juvenile)	3	0.02%	Sand Sole	2	0.01%	Rockweed Gunnel	1	0.01%
Coho Salmon	2	0.01%	Coho Salmon	2	0.01%	Pacific Tomcod	1	0.01%
Rockweed Gunnel	1	0.01%	Rockfish sp. (juvenile)	1	0.005%	Eel Pout	1	0.01%
Ringtail Snailfish	1	0.01%	Slipskin Snailfish	1	0.005%	Tubesnout	1	0.01%
Silver Spotted Sculpin	1	0.01%	Bay Goby	1	0.005%	White Seaperch	1	0.01%
Slimy Snailfish	1	0.01%	Longfin Smelt	1		Rock Prickleback	1	0.01%
Unidentified sp. 1	1	0.01%	**Total**	**20,175**		**Total**	**13,817**	
Total	**16,297**							

*1998 data set used in this comparison includes only the results of the estuary-wide survey conducted between July 14 and August 8, 1998.

Our sampling in the Bay indicated that juvenile surf smelt and Pacific sand lance were abundant throughout the study and apparently use the estuary for juvenile rearing. Pacific herring ranked fifth in abundance in the 1998-99 combined catch but dropped to 10^{th} and 14^{th} in 2000 and 2001, respectively. Northern anchovy showed a small but steady increase in abundance over the study period but were not a large component of the catch in any of the sampling periods. Both Pacific herring and northern anchovy tend to occur in schools in the Bay and their abundance in the catch depends largely on chance encounters with these schools. Also Pacific herring and northern anchovy use of the estuary may vary dramatically from year to year. For example, in the mid 1970s, northern anchovy were a major component of ODFW's combined beach seine and otter trawl catch (Bottom and Forsberg 1978). However, most of the northern anchovy were collected in a few large beach seine hauls in 1975. Bottom and Forsberg (1978) concluded that there is probably tremendous year-to-year variability in the use of the estuary by northern anchovy. This variability could explain why we did not see greater numbers northern anchovy and perhaps, Pacific herring in our catch.

When we compared the catch data compiled by ODFW in the mid 1970's with our data, we noted a large differences in the abundance of juvenile rockfish (*Sebastes spp*). Juvenile rockfish, probably blue (*S. mystinus*) or black rockfish (*S. melanops*), were relatively abundant in the ODFW study, with 1,267 juveniles collected during the period May through July 1974-1976. Most of these fish were captured by beach seine in the lower region of the Bay. We sampled similar areas with beach seine during our study but only captured four juveniles. These results indicate that juvenile rockfish abundance in the Bay probably has declined since the mid 1970s. Recent assessments of commercial and recreational catch along the Oregon coast indicate that populations of several species of rockfish, including black rockfish, have declined dramatically over the past decade (Bodenmiller 2001).

REGIONAL DISTRIBUTION OF FISH WITHIN THE ESTUARY

The beach seine CPE data were used to provide a general description of fish distribution within the lower, mid, and upper regions of the estuary. Beach seine sites were located around the perimeter of the Bay and were equally replicated within the lower, mid, and upper regions. The three regions of the Bay differ with respect to salinity and temperature conditions, depth, and to some extent, substrate conditions. The total beach seine catch for the period 1999 through 2001 was 39,128 fish. Total beach seine catch by year for the period 1999 through 2001, was 10,233 fish; 16,835 fish, 12,060 fish, respectively. Year-to-year differences in the total catch largely reflected differences in the abundance of one or two of the relatively abundant species. For example, the relatively large total catch in 2000 was due primarily to a few large catches of Pacific sand lance.

Mean beach seine CPE and standard errors of the means for all species combined are compared across the three regions of the Bay in Table 5. The lower region of the Bay generally had the highest CPE and also had the highest standard error, indicating higher

Table 5. Mean CPE and standard error for all species combined for beach seine samples collected in the lower, middle and upper regions of the Bay in 1999, 2000 and 2001.

Region of Bay	1999	2000	2001
Lower	112 ± 24	275 ± 144	149 ± 35
Middle	65 ± 10	90 ± 22	67 ± 10
Upper	117 ± 34	102 ± 16	116 ± 18

variability among samples. The lower bay typically has larger numbers of schooling fish such as Pacific sand lance and surf smelt. Capture of a few large schools increased the average CPE but also increased the sample variance. The mid region of the Bay consistently had the lowest CPE of the three regions. The mean total CPE in the upper region of the Bay was relatively constant over the three-year period, ranging from a low of 102 fish in 2000 to a high of 117 fish in 1999.

Table 6 compares beach seine CPE for the eight most abundant species collected in each region of the Bay over the 1999-2001 sampling period. In all three regions, the eight most abundant species comprised over 90 percent of the total catch. Surf smelt and Pacific sand lance were by far the most abundant components of the beach seine catch in the lower region of the Bay. Both of these species occur in large schools in the lower region of the Bay and when caught contribute relatively large numbers of fish to the catch. Juvenile English sole were over twice as abundant in the beach seine catch in the lower region of the Bay than in the mid region. Note that English sole were not among the eight most abundant species in the upper region of the Bay. English sole appear to prefer areas of moderate to high salinity and were rarely found in the upper region of the Bay.

In the mid region of the Bay, Pacific staghorn sculpin and shiner perch were the most abundant species in the beach seine catch. The majority of the Pacific staghorn sculpin captured in this region were juveniles. Concentrations of adult shiner perch were found along the eastern shoreline in the mid and upper regions of the Bay during late May and early June. Juveniles produced by these spawning aggregations in late June and July were largely responsible for the relatively high CPE in the mid and upper regions of the Bay.

Shiner perch, Pacific staghorn sculpin, and surf smelt were the most abundant species in the beach seine catch in the upper region of the Bay. The majority of the surf smelt were captured along the western shoreline. Note that CPE in this region of the bay declined sharply below the three most abundant species (Table 6).

Chum and chinook salmon juveniles were listed among the eight most abundant species in all three regions of the Bay. CPE of chum salmon was highest in the lower region of the Bay. Little difference in the CPE of chum salmon was found between the upper and mid regions of the Bay. CPE of juvenile chinook salmon was about the same in the lower and upper regions of the Bay. Fewer chinook salmon were caught in the mid region.

Table 6. Catch-per-unit-effort (CPE) for the eight most abundant species caught by beach seine in the lower, mid, and upper regions of the Bay 1999-2001.

Lower Bay		Mid-Bay		Upper Bay	
Species	**CPE**	**Species**	**CPE**	**Species**	**CPE**
Surf Smelt	172.2	P. Staghorn Sculpin	100.7	Shiner Perch	118.0
Pacific Sand Lance	168.8	Shiner Perch	61.6	P. Staghorn Sculpin	82.4
English Sole	49.9	English Sole	22.5	Surf Smelt	71.4
P. Staghorn Sculpin	36.5	Surf Smelt	15.3	P. Herring	9.2
Pacific Herring	26.1	Chum Salmon	7.8	Chum Salmon	8.6
Chum Salmon	23.1	Top Smelt	6.6	Chinook Salmon	8.4
Shiner Perch	15.1	Starry Flounder	5.1	3-spine Stickleback	7.3
Chinook Salmon	9.3	Chinook Salmon	2.1	Topsmelt	5.0

*one beach seine = one unit of effort

SPECIES COMPOSITION AND RELATIVE ABUNDANCE IN SUBTIDAL HABITAT

Trawl sampling was conducted at two locations in the lower region of the Bay to obtain samples of fish from subtidal habitat. Trawling was conducted at low tide, which probably concentrated some of the intertidal species into subtidal channel habitat. In 1999, trawl sampling was conducted on a twice-monthly schedule from May through July; in 2000 and 2001 trawl sampling was conducted on a monthly schedule. The mean trawl CPE data are compared across years for the ten most abundant species in Table 7.

With the exception of Pacific herring, shiner perch, and surf smelt, most of the fish caught in the trawl were bottom-dwelling species. Also, many of the species collected in the trawl were marine species with relatively low tolerance to salinity fluctuations. These differences were largely responsible for the differences in species composition between the trawl and beach seine samples.

Shiner perch was by far the most numerous component in the trawl catch in 2000 and 2001 and ranked third in abundance in 1999. The majority of shiner perch caught in the trawl were adults. Many of the adults caught in May and early June were in spawning coloration. Pacific herring was relatively abundant in 1999 and 2000 but was not among the top ten species in the 2001 trawl catch. The occurrence of Pacific herring in the bottom trawl catch was somewhat surprising since herring are usually considered a pelagic species. However, in the ocean, Pacific herring are known to undertake daily vertical migrations (Lassuy 1989). During the day they have been found near the bottom

Table 7. Catch-per-unit-effort of the ten most abundant species caught by trawl during May, June and July 1999-2001.

2001 Trawl Species	2001 CPE	2000 Trawl Species	2000 CPE	1999 Trawl Species	1999 CPE
Shiner Perch	38.5	Shiner Perch	32.9	P. Herring	13.9
English Sole	9.3	P. Staghorn Sculpin	27.1	Shiner Perch	7.3
P. Sandlance	9.1	P. Herring	7.9	English Sole	2.6
Buffalo Sculpin	2.2	Ling Cod	7.3	Ling Cod	2.3
Ling Cod	1.8	English Sole	6.5	Pacific Sandab	2.0
Pacific Sandab	1.3	Buffalo Sculpin	5.9	P. Staghorn Sculpin	1.9
Snake Prickelback	1.2	Tidepool Sculpin	1.8	Greenling sp.	0.4
P. Staghorn Sculpin	1.1	Snake Prickelback	1.7	Saddleback Gunnel	0.3
Northern Anchovy	0.8	Greenling sp.	1.4	Surf Smelt	0.3
Pile Perch	0.8	Tom Cod/ Pile Perch	0.7	Buffalo Sculpin	0.2

One trawl = one unit of effort.

or in mid-water schools. Their relatively high CPE in the bottom trawl was probably related to this diurnal movement pattern. Pacific staghorn sculpin abundance in the trawl catch varied substantially from year to year. Most of the Pacific staghorn sculpin collected in the trawl samples were relatively large adults. Greenling, ling cod, and buffalo sculpin, which were common components of the trawl catch were rarely caught in the beach seine and probably represent species associated with the deeper tidal channel habitat. All of the ling cod captured were juveniles. Several rare species such as cabezon, eelpout, tom cod, sand sole and rock prickleback were only captured in the trawl. Most of the representatives of these relatively rare species were juveniles.

SPECIES COMPOSITION AND RELATIVE ABUNDANCE IN SALT MARSH HABITAT

Several previous studies indicate that salt marsh habitat and associated tidal channels in the upper regions of Pacific Coast estuaries function as nursery areas for post larval and juvenile fish (e.g., Allen 1982, Bottom et al. 1987). Salt marshes, both natural and restored, also have been identified as rearing habitat for coho, chum, and chinook salmon juveniles prior to entering the ocean (e.g., Sadro 1999, Levy and Northcote 1982, Shreffler et al. 1990, Miller and Simenstad 1997). Tillamook Bay has an extensive area of salt marsh at the southern end of the Bay, part of which is dissected by tidal channels. The majority of the marsh is dominated by the sedge *Carex lyngbyei.*

We conducted fyke net sampling at six locations in the salt marsh to determine fish use of the marsh during the 1999 through 2001 study periods. To our knowledge, no previous studies of fish use of the marsh have been conducted.

In this study, fyke nets placed across tidal channels were used to sample fish leaving the tidal channels on outgoing tides. The nets were set at high tide and allowed to fish until the channels drained dry on the outgoing tide. Test sampling was initiated in the summer of 1998 with three fyke nets. In 1999, six fyke net sites were established and the same six sites were sampled during the 2000 and 2001 sampling periods. In 1999, sampling was initiated in late March and continued through July on a twice-monthly schedule. In 2000 and 2001 sampling occurred once a month from May through July. For a more detailed account of the fyke net sampling program see Ellis (1999). Results of the 1999 through 2001 fyke net sampling are shown in Table 8.

A total of seven species, including chum and chinook salmon juveniles were collected in the salt marsh. Pacific staghorn sculpin, threespine stickleback, and shiner perch were the most abundant species. A few prickly sculpin were also collected. Most of the Pacific staghorn sculpin were juveniles; whereas most of the threespine stickleback were mature adults in spawning condition. Shiner perch was represented predominately by young-of-the-year. Over the study period, only one juvenile chinook salmon and one juvenile coho salmon were collected from the salt marsh. Use of the salt marsh by these two species appears to be minimal, during the months sampled.

Table 8. Relative abundance (% of total) of fish species collected by fyke net during May-July 2001 compared with relative abundance of fish species collected by fyke net during same time period in 1999 and 2000.

SPECIES	2001		2000		1999*	
	Number	Percent	Number	Percent	Number	Percent
Pacific Staghorn Sculpin	2084	61.3	1228	56.38	959	36.38
Threespine Stickleback	768	22.6	805	36.96	1188	45.09
Shiner Perch	537	15.8	133	6.11	117	4.44
Chum Salmon	8	0.2	0	0	368	13.97
Chinook Salmon	1	<0.01	0	0	0	0
Coho Salmon	0	0	0	0	1	0.04
Prickly Sculpin	0	0	12	0.55	2	0.08
Total	3398	100	2178	100	2635	100

*sampling started in late March 1999

A total of 376 chum salmon fry were collected from the salt marsh. All but eight of the chum salmon fry were collected in 1999 between late March and late April. The remaining eight chum salmon fry were collected in early May 2001. No chum salmon were collected from the marsh between mid May and late July. Based on screw trap sampling conducted by ODFW in the Little North Fork Wilson River, chum salmon out migration generally begins in March and peaks in mid to late April (Dalton pers. com. 1999). Our sampling results suggest that chum salmon fry use of the salt marsh habitat occurs primarily in March and April. The largest catch of chum salmon fry occurred in late March when the marsh was essentially devoid of vegetative cover.

Threespine stickleback appear to use the salt marsh for spawning and rearing. Adults in spawning condition were most abundant from late May through June. Beginning in mid June through July, we observed large numbers of very small threespine stickleback in residual ponded water at low tide. These juveniles were too small to be retained by our fyke nets. Apparently, many of the small juveniles are able to find refuge in the salt marsh even during low tide conditions.

Pacific staghorn sculpin appear to use the salt marsh habitat primarily as a rearing area for juveniles. On several occasions, we observed juvenile Pacific staghorn sculpin moving in with the leading edge of the incoming tide. It appears that many juveniles move considerable distances across the mud flats on each tidal cycle to reach the salt marsh. The salt marsh channels appear to be areas of concentration, probably for feeding. For example, on several occasions, several hundred juveniles were caught in a single fyke net set and on one occasion over 1000 juveniles were caught.

In summary, species diversity in the salt marsh was low compared to other areas of the estuary, with only seven species found in this study. The salt marsh appears to be an important rearing area for Pacific staghorn sculpin, threespine stickleback and to a lesser extent juvenile shiner perch. Some use of the salt marsh by chum salmon fry occurs early in the spring but from May through July anadromous salmonid use of the salt marsh appears to be very limited. It should be noted that sampling only occurred during daylight hours and that it is possible more use of the salt marsh by juvenile salmonids occurs at night. During spring and summer most of the highest tides occur at night, which could improve access to the salt marsh habitat.

USE OF ESTUARY BY ANADROMOUS SALMONIDS

All five of the anadromous salmonid species known to inhabit the Tillamook Bay watershed use the estuary to some extent on their way to the ocean. Chum salmon fry and subyearling chinook salmon spend extended periods of time in the estuary where they feed and grow before entering the ocean. Yearling chinook salmon, coho salmon smolts, and steelhead smolts appear to use the estuary primarily as a migratory corridor and acclimation area for life in salt water. Based on their infrequent occurrence in the beach seine catch, it appears that estuarine residency for these fish is of relatively short duration. Cutthroat trout probably use the estuary for both juvenile and adult rearing.

The data sets for chum salmon and chinook salmon were relatively large compared to the other three salmonid species. We used the GENMOD procedure to test for significant differences in mean beach seine catch between years, months, regions of the Bay (group effect), and substrate (treatment effect) for the chum and chinook salmon data sets. Tables showing Chi Squares and probabilities of larger Chi Square values (i.e., p values) for primary effects and interaction effects in the GENMOD analyses for chum and chinook salmon are presented in Appendix A. Comparisons of the means for each possible main effect and interaction are presented in Appendix B. Graphic representations of the catch data by block, treatment, year and month are presented in Appendix C to aid in interpretation of the statistical analysis. Results and interpretation of the statistical analyses for chum and chinook salmon as well as interpretation of the data collected for coho salmon and steelhead and cutthroat trout are summarized below.

Chum Salmon

Tillamook Bay presently supports much smaller runs of chum salmon than it did historically and index counts of adult spawners indicate that interannual variability in run size is large (ODFW spawning count data 1977). The lower reaches and lower tributaries of the Miami, Kilchis, and Wilson Rivers are the primary spawning areas for chum salmon in the Tillamook Bay watershed.

Previous studies of estuarine residency of chum salmon fry in other estuarine environments indicate that the fry typically disperse several kilometers from the river mouth upon entry into the estuary, favoring the shoreline and eelgrass beds (Healey 1982). The first habitat occupied includes creeks and sloughs high in the delta area, but other intertidal areas are quickly colonized. The fry have been observed to congregate in the upper intertidal at the fringe of marshes and to penetrate deep into the marshes along tidal creeks. At low tide, the fry retreat into tidal creeks and delta channels.

During this study, juvenile chum salmon were abundant in the beach seine catch only during the month of May (Figure 6). Previous studies of estuarine residency for chum salmon fry suggest that the majority spend less than 30 days in the estuarine environment (Simenstad and Salo 1982). Since peak downstream migration from the spawning grounds in the Tillamook watershed generally occurs in April (Dalton pers. com. 1999), a 30-day residency period would be consistent with the observed pattern of abundance in this study. In 2000, a few individuals were collected in June and July, indicating that in some years a small percentage of the outmigrants may remain in the Bay for an extended period of time. The individuals collected in July were relatively large (80-100 mm fork length), indicating substantial estuarine growth.

Mean beach seine CPE of chum salmon fry was nearly the same in 1999 and 2000 but appeared to be considerably higher in 2001 (Figure 6). However, no statistically significant difference was found between years (Appendix A). The majority of the fry collected in 2001 were collected at one location (LB-W3) on one sampling date, resulting in high sample variability. We did not expect CPE in 2001 to be higher than the previous years because many adults were unable to reach preferred spawning grounds due to prolonged low flow conditions during the previous spawning season.

A plot of beach seine sites where chum salmon fry were frequently captured (i.e. $\geq$50 percent) during May (Figure 7) indicates that fry were widely distributed around the perimeter of the Bay. It is likely that the fry move to the edges of the Bay during high tide to forage and seek refuge in the shallow edge habitat. These findings are consistent with previous studies in other estuaries (e.g., Healey 1982).

Larger numbers of chum salmon fry were collected in the lower region of the Bay. Of the total beach seine catch (1,526 fry), 938 were collected in the lower bay, 281 in the mid-bay and 308 in the upper bay during the 1999-2001 study period. These differences were statistically highly significant ($p < 0.001$). The concentration of fry in the lower bay could reflect sample timing rather than a preference for the lower bay. By May, it is likely that the majority of the fry had moved to the lower bay in preparation for emigration to the ocean.

No statistically significant difference was found in the abundance of chum salmon fry on coarse or fine grained substrates. This finding is not too surprising in that the fry appear to follow the edges of the Bay during their out-migration and would be expected to pass over both fine-grained and coarse-grained substrates on their way to the mouth of the Bay.

Based on data collected at several fyke net sites in March 1999, chum salmon fry enter the estuary at lengths ranging from about 40 to 45 mm fork length. In 2001, the mode of the length frequency distribution was 50 to 55 mm fork length. This was about 10 mm

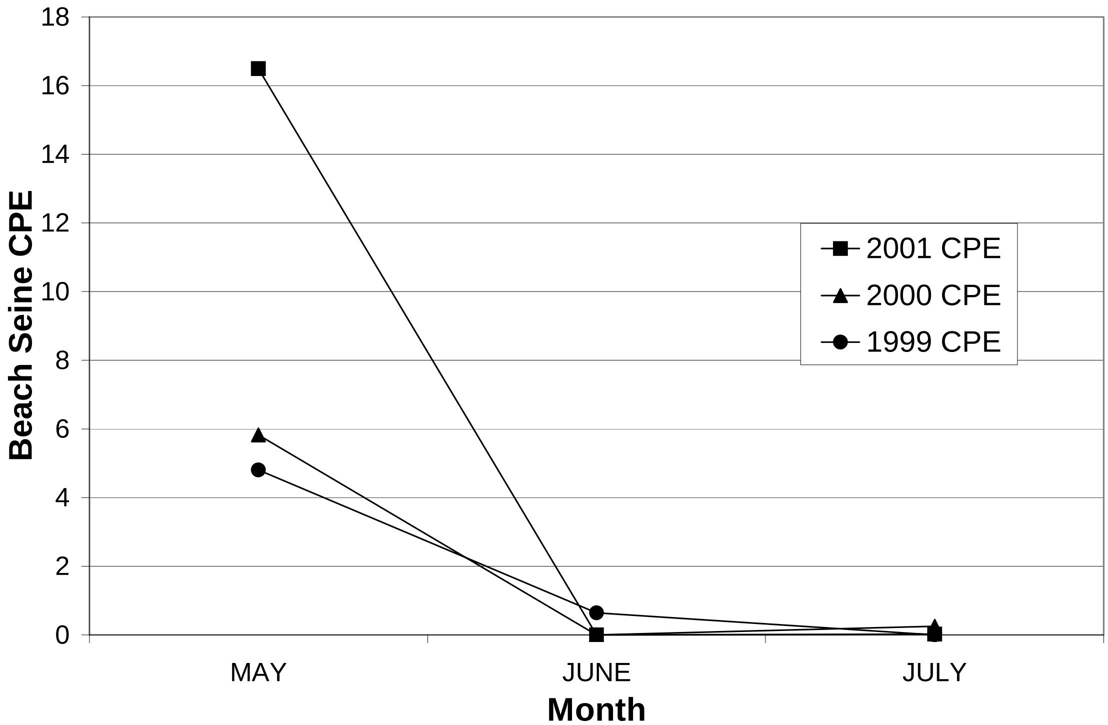


Figure 6. Monthly mean beach seine catch-per-unit-effort (CPE) for chum salmon fry caught during May, June and July 2001 compared with the monthly mean beach seine CPE for chum salmon fry caught during the same time period during 1999 and 2000.

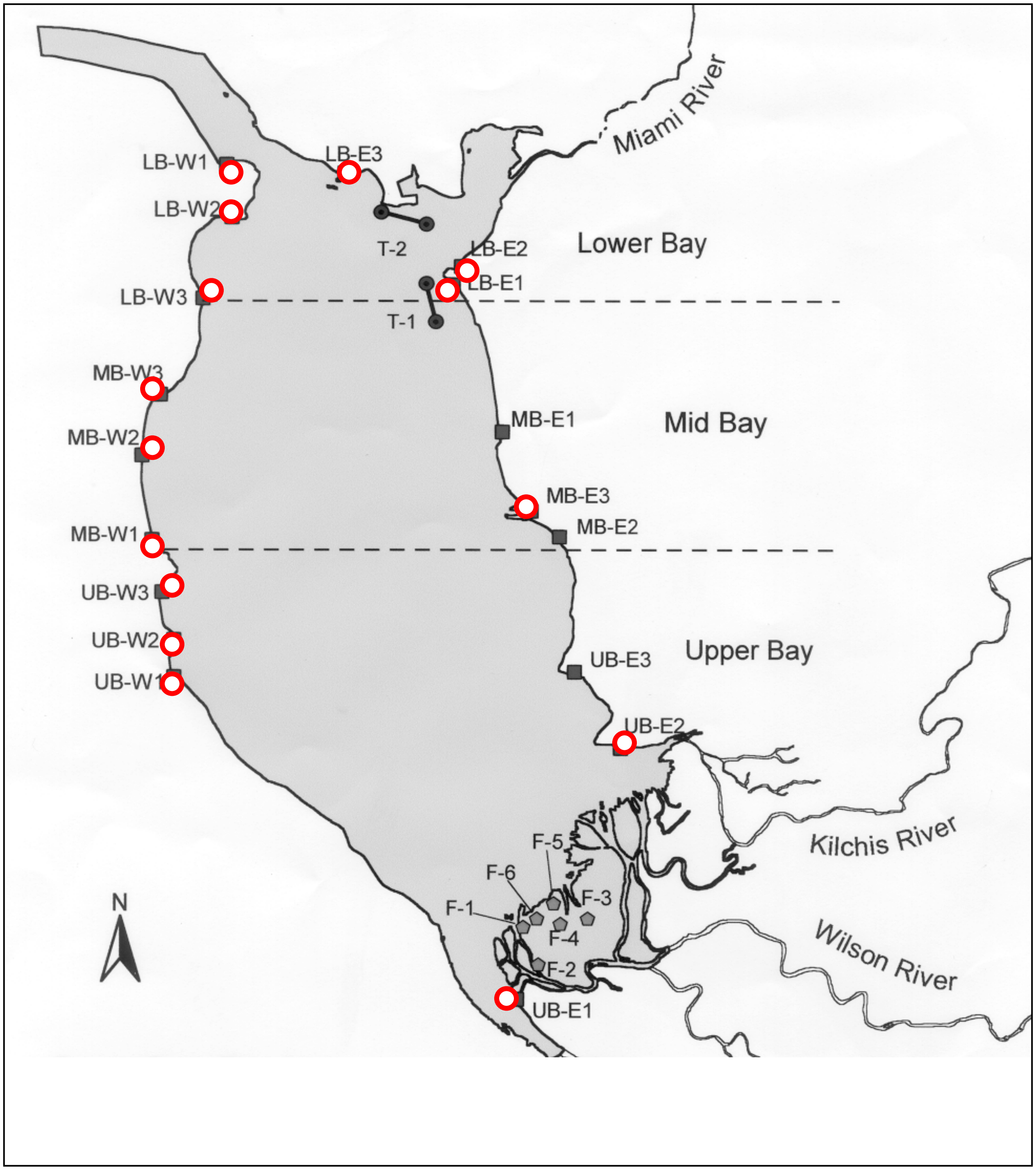


Figure 7. Beach seine sites (circles) where chum salmon fry were collected in 50 percent or more of the samples in May 1999-2001.

less than the modal length for the 2000 beach seine catch. This difference may indicate that growing conditions in the Bay were more favorable in 2000 or that the fry had been in the estuary longer prior to capture in 2000. A comparison of mean fork length of fish collected in 2001 from the lower bay (55.0 mm) and upper bay (51.8 mm) indicates that the lower bay fish were slightly larger than the upper Bay fish.

One of the most interesting findings with regard to chum salmon fry was the apparent importance of the Little North Fork Wilson River in the production of the fry that were present in the Bay. During 1999 and 2000, a small percentage of chum salmon fry captured at the screw trap on the Little North Fork Wilson River was marked with an upper caudal fin clip by ODFW biologists. In both years, marking began in March and continued through April. The marked fish were released upstream of the screw trap. The ratio of marked to unmarked fish in the screw trap catch was used to estimate the trapping efficiency for out-migrant population estimates. All of the marked fish were allowed to continue their migration to the estuary and ocean. We examined all juvenile salmonids collected by beach seine in 1999 and 2000 for fin clips. In 1999, we found five chum salmon fry with upper caudal fin clips in our late April samples and in 2000 we found four in our May samples. All of the recaptured juvenile chum salmon were collected in the lower region of the Bay and therefore, should have been well mixed with fry from other spawning areas within the watershed.

We used the ratio of fin clipped fry in our late April 1999 and our May 2000 catch with ODFW's screw trap data to estimate the contribution of the Little North Fork Wilson River to the total population of fry in the Bay in late April 1999 and in May 2000. For this estimate we assumed that mortality on fin-clipped and non-fin clipped fish was equal. We believe this is a reasonable assumption. For details of ODFW's fry population estimation procedures see Ellis (1999). Based on weekly estimates of the number of outmigrating fry, ODFW calculated that in 1999 approximately 64 percent of the outmigration occurred prior to April 18 and in 2000 over 99 percent of the outmigration had passed the screw trap by the last week in April. We estimated that travel time between the trap (located 9.1 river miles form the mouth of the Wilson River) to the lower estuary was approximately 10 days. Therefore, the fin-clipped fish captured in our beach seine would have been marked at the trap between early March and April 18 in 1999 and early March and April 30 in 2000. In 1999, ODFW estimated that 38,220 fry passed the screw trap by April 18. Of those, 760 fry were marked with an upper caudal clip. In 2000, 27,722 fry passed the trap by the end of April and 804 fry were marked with upper caudal clips.

We used the ODFW data and our beach seine catch and recapture data to estimate the total number of Little North Fork Wilson River fry expected in our May beach seine catch. The estimate was based on the formula

$$N = PRM^{-1}$$

Where:

> N = Number of Little North Fork Wilson River chum fry in the beach seine catch
> P = Estimated number of chum fry passing the screw trap by April 30
> R = Number of fin-clipped chum fry recovered in the April beach seining
> M = Number of chum fry marked at the screw trap by April 30

In 1999, the resulting estimate for the number of Little North Fork Wilson River chum fry in the beach seine catch was 251 fry or about 54 percent of the total late April beach seine catch. In 2000, the resulting estimate was 138 fish or about 66 percent of the 210 fry collected in May by beach seine. Due to the small number of recaptures, the confidence limits around the estimates were quite large. However, the similarity in the estimates between years suggests that the Little North Fork Wilson River may play a disproportionately large role in the production of chum salmon fry in the Tillamook Bay watershed.

We had planned to conduct a coordinated mark and recapture study with ODFW in the spring of 2001 to focus on the role of the Little North Fork Wilson River. However, poor escapement of adult chum salmon to the Little North Fork Wilson River in the winter of 2000/2001 resulted in very few chum salmon fry at ODFW's screw trap in the spring of 2001. Therefore, insufficient fry were marked in 2001 to attempt an estimation of the contribution of the Little North Fork Wilson River for 2001.

Chinook Salmon

Both spring and fall races of chinook salmon are present in the Tillamook Bay watershed. Mature chinook (two to six years of age) return to all five of the major sub-basins from early September through mid-February. Peak entry into the rivers usually occurs in mid-October. Fall chinook spawn from October to January and spring chinook spawn from early September to early October. Although hatchery fish contribute to the fall runs, it is believed that most fall chinook are produced from naturally spawning fish (Nicholas and Hankin 1988). Spring chinook salmon runs are heavily supplemented by hatchery fish. The fall chinook runs have remained healthy and strong over the past 25 years. The spring runs are considered to be depressed compared to historic levels but have remained relatively stable (Nicholas and Hankin 1988).

Other studies have shown that some chinook migrate to the estuarine environment as fry (Healey 1982). These fish have been observed in other estuaries to colonize the estuary in much the same way as chum salmon fry, first occupying tidal creeks high in the marsh area and later the outer estuary. Unlike chum, chinook salmon fry do not appear to occupy high salinity nursery areas. Most fall chinook juveniles in Oregon estuaries appear to enter as subyearling smolts in May and June (Reimers 1973). Bottom and Forsberg (1978) and Forsberg et al (1977) reported juvenile chinook salmon present in Tillamook Bay from June through November with a few collected in January through March and in May. Yearling chinook (mostly from the spring run) are thought to move directly into the neritic habitat without much utilization of salt marsh or other shallow habitat (Simenstad and Salo 1982).

In this study, juvenile chinook salmon were collected primarily by beach seine around the edges of the estuary. The total beach seine catches in 1999, 2000, and 2001 were 204, 378, and 193 chinook, respectively. The differences in mean beach seine catch between years were statistically highly significant. Subyearling fall chinook salmon were the predominant component of the catch. A few yearling spring chinook or overwintering fall chinook were captured during May in 2000 and 2001. None of these larger fish were fin clipped, indicating that they were probably wild fish.

The monthly pattern of chinook salmon abundance in the beach seine catch varied from year to year (Figure 8). In 1999, there was a sharp increase in abundance of juveniles from late June through July. In 2000, abundance gradually increased from May through July. Then in 2001, the numbers of juveniles captured remained low from May through July with little change from month to month. The increase in abundance from May to July for 1999 and 2000 was sufficiently large to result in a highly significant month effect. This same pattern was observed in ODFW's study in the mid 1970s with juvenile chinook salmon abundance being substantially higher in July than in May or June (Bottom and Forsberg 1998). A build up of numbers from May through July would be expected since subyearling fall chinook salmon usually spend an extended period of time in the estuary (up to several months) and also move into the estuary from May into July.

When the mean July beach seine CPE for chinook salmon subyearlings was plotted for the three-year study (Figure 9), a steady decline in abundance was indicated. This decline represents either a reduction in recruitment of juveniles to the estuary or a change in the expected residency pattern.

ODFW downstream migrant monitoring results in 1999 indicated that peak downstream migration of juvenile fall chinook salmon occurred in mid to late April. Since we did not find many downstream migrants in the estuary until mid June 1999, it appears that in 1999 the downstream migrants must have held up somewhere between the trapping site and the estuary during May and early June. During reconnaissance surveys conducted in 1998, we noticed substantial concentrations of juvenile salmonids in the lower sections of several brackish water tidal sloughs (e.g., Hoquarton Slough and Dougherty Slough) at the south end of the Bay. Beach seining in Hoquarton Slough confirmed that juvenile chinook were present. These protected brackish-water sloughs may offer food, refuge, and a transition zone between the stream and the open bay environments. It is possible that year-to-year differences in juvenile abundance in the open estuary could be explained by differences in the length of time juveniles spend in these sloughs. However, no studies have been conducted in the sloughs to evaluate their role in the rearing of outmigrant chinook salmon.

The juvenile chinook captured by beach seine were widely distributed throughout the estuary and at least a few individuals were collected from most of the sampling sites. The three lower bay sites on the east and north end of the Bay (i.e., LB-E1, LB-E2, and

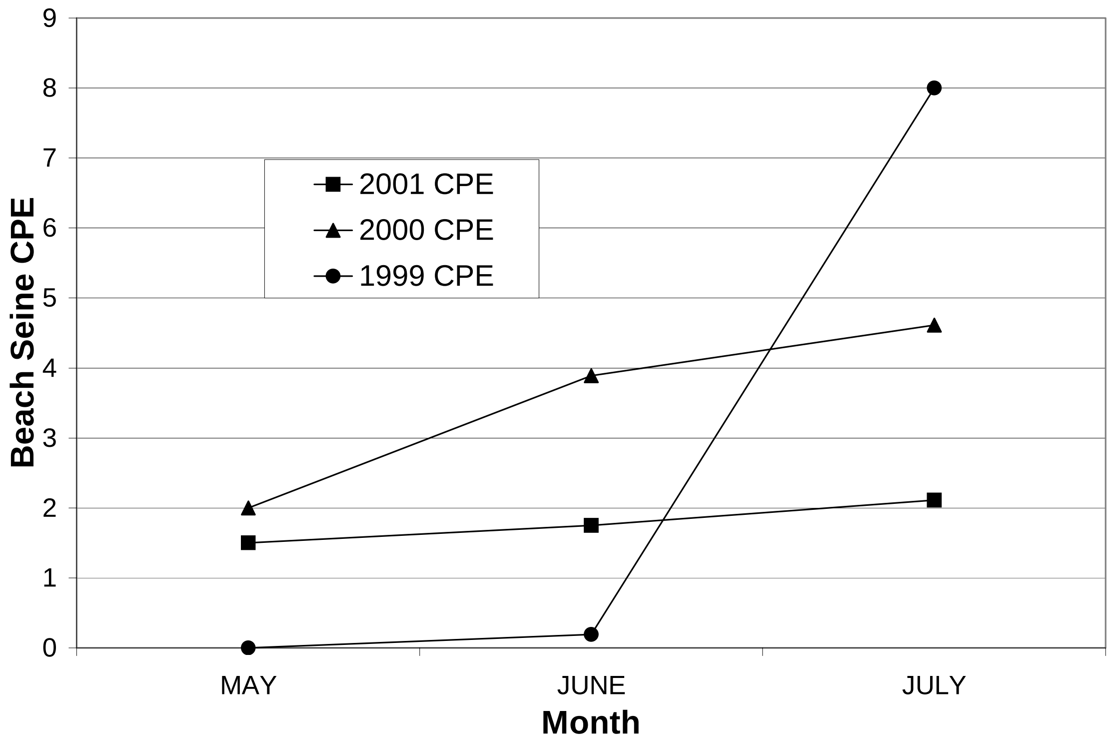


Figure 8. Beach seine CPE for chinook salmon fry caught during May, June and July in 1999, 2000 and 2001.

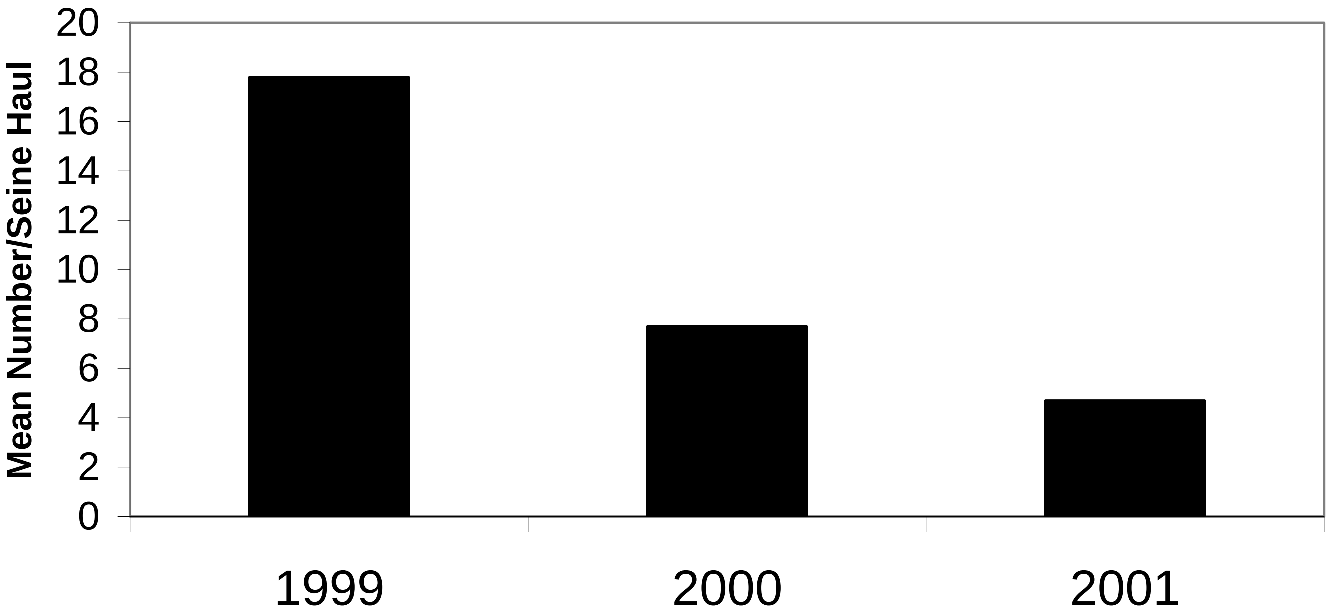


Figure 9. Mean number of juvenile chinook salmon per beach seine haul in July 1999-2001.

LB-E3) were consistent producers of juvenile chinook. All of these sites had eelgrass beds just off shore from the sampling sites. The largest individual beach seine catches generally occurred at upper bay sites UB-E1 and UB-E2, which are located near the mouths of the Wilson and Kilchis Rivers, respectively. Overall, the majority of juveniles were collected in the lower and upper regions of the Bay. Statistical analysis of the region effect (block) indicated that the upper and lower regions were not significantly different from each other but both were significantly larger than the mean for the mid-region of the Bay (Appendix B).

More juvenile chinook salmon were caught on the east side of the Bay than on the west side. They were also caught more frequently on the east side of the Bay as demonstrated in Figure 10. The majority of the sampling sites on the east side of the Bay were located on coarse-grained substrate (i.e., gravel, cobble and boulders). Analysis of the catch data with the GENMOD procedure indicated that the treatment effect (substrate) was statistically highly significant. It is difficult, however, in this case to know whether the abundance on the coarse grain substrate represented a true preference for coarse substrate or was simply an artifact of the proximity of the east side sites to the mouths of the juvenile's natal streams, all of which enter on the east side of the Bay. In any case, it appears from the results that the east side of the Bay is used more heavily by juvenile chinook than the west side.

In May 2000 and 2001, there were at least two size groups of juvenile chinook in the beach seine catch. The smaller size group with a modal length of 60-65 mm represented subyearlings while the larger-size juveniles (i.e. > 120 mm fork length) represented age

1+ fish. As suggested previously, juvenile chinook in this larger size group were either yearling spring chinook or fall chinook that had remained in the estuary over the winter. A few of the larger size group were present in the June catch; very few were found in July.

Juvenile chinook grew at a moderate rate during the study period. Most of the juveniles enter the open Bay in the 50 to 60 mm size range and by mid July average about 85 mm. Typical monthly length frequency distributions for juvenile chinook are presented in (Figure 11).

Coho Salmon

Adult coho salmon enter Tillamook Bay from October through December. The adults may hold in the upper tidal portion of the Bay until autumn freshets increase flow in tributary streams and rivers. Spawning occurs in all five sub-basins. Most spawning occurs in small to medium-size tributaries in areas with low to moderate gradient. Peak spawning occurs in November. Juveniles generally spend a year in fresh water before migrating to the ocean, although out-migration of fry to the estuary has been documented in Tillamook Bay (Dalton pers com. October 1999). Most of the yearling smolts appear to move quickly through the estuarine environment to the ocean. Very little is known about coho fry use of the estuarine environment. Recent studies in the South Slough of Coos Bay, Oregon (Sadro 1999) and the Salmon River, Oregon estuary (D. Bottom pers. com. July 1999) indicate that coho fry in those systems utilize marsh and channel habitat where salinities can occasionally exceed 20 ppt. Sadro (1999) suggested that sufficient growth may occur in the estuarine environment that some of the subyearling fish could become large enough to enter the ocean with yearling smolts.

During our 1999 sampling, a total of 75 juvenile coho were collected in the estuary from May through mid-June. The majority of these fish were caught at the upper bay sampling sites UB-E1, UB-E2 and UB-E3 near the mouths of the Kilchis, Wilson, and Trask Rivers. All but one of the coho juveniles caught in the lower bay were captured at Hobsonville Point near the entrance of the Miami River. Also in 1999, one small coho fry was captured at fyke net site F-3 in the marsh at the sough end of the Bay. Salinities at time of capture ranged from 9.3 ppt to 18.2 ppt in the lower bay and from 0.0 ppt to 5.4 ppt in the upper bay.

In 2000, only one juvenile coho salmon was captured and in 2001 only two were (probably age 1+) were captured. From these results, it appears that the occurrence of yearling coho smolts in nearshore habitat is very limited, at least during the daytime sampling conducted in this study. It is likely, based on these findings and the literature,

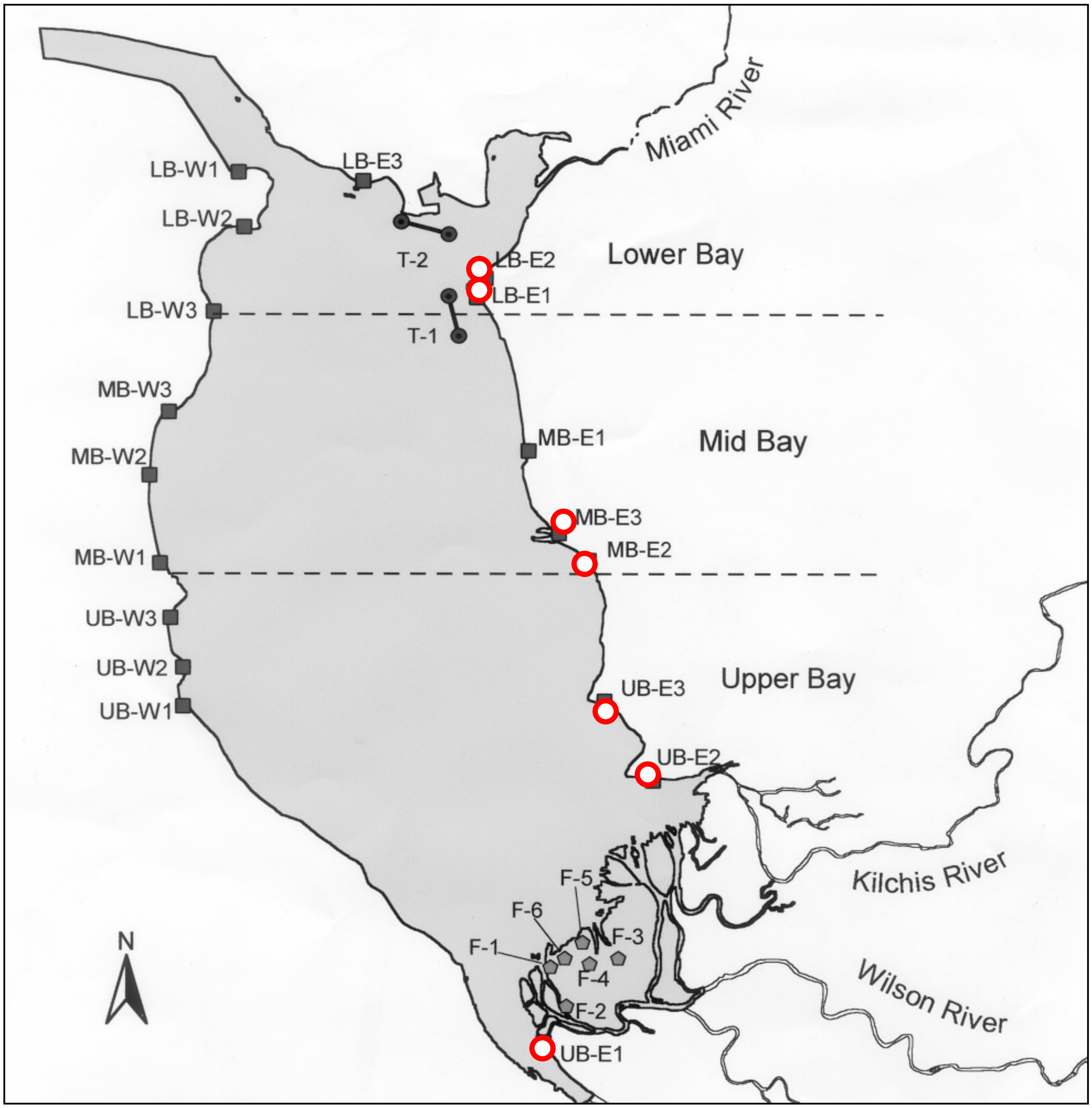


Figure 10. Beach seine sites (circles) where chinook salmon juveniles were collected in 50 percent or more of the samples during the period 1999-2001.

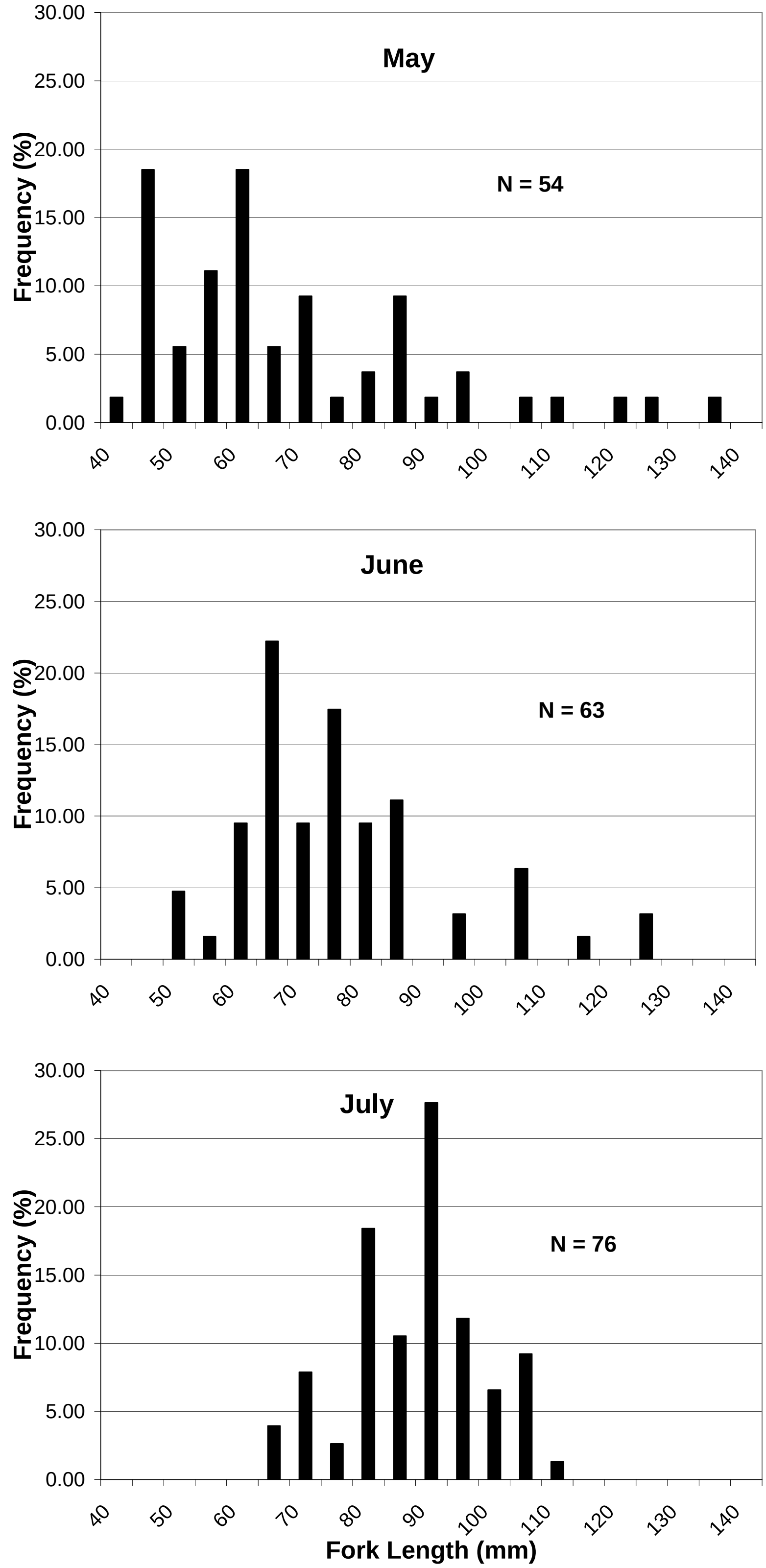


Figure 11. Length frequency histograms for juvenile chinook salmon captured by beach seine during May, June, and July 2001.

that coho smolts move quickly through the estuary and do not spend much time in the nearshore areas during their outmigration. In some years, such as in 1999, there may be some limited use of the estuary by subyearling coho, particularly in areas of low salinity.

Steelhead Trout

Two races of steelhead trout ("summer" and "winter") live in the Tillamook Bay watershed. Winter steelhead are native to Tillamook Bay streams and are widely distributed throughout the basin. Summer steelhead were introduced to the basin in the early 1960s and have been supported entirely by hatchery production (K. Braun pers. com. 1997). The summer steelhead occur primarily in the Wilson and Trask Rivers. Summer steelhead generally move through the estuary and into the rivers from April through July. Winter steelhead generally enter streams from November through March and spawn soon after entering. We caught one adult steelhead during the study in a May 26, 1999 beach seine haul. It had spawned and was returning to the ocean.

Steelhead trout smolts appear to spend little time in estuaries and move quickly into the ocean environment after migrating downstream in March, April and May. Data on juvenile steelhead outmigration at two screw trap sites in the Tillamook Bay watershed have been collected for several years by ODFW. ODFW segregates steelhead outmigrants into four size groups: 1) smolts $\geq$ 120 mm, 2) large parr between 90-119 mm, 3) small parr between 60-89 mm, and 4) fry under 60 mm. Smolts moved downstream over an extended period between early March and late May with a peak generally near the end of April and beginning of May. The downstream migration of the 90-119 mm size group extended from early March into late June with the peak in late April through May. The downstream migration of the 60-89 mm size group extended from early March into July with peaks in late March and late April through May. Trout fry were caught from mid-March through early July with a peak in April.

In this study, four juvenile steelhead were collected in 1999, eight were collected in 2000, and none were collected in 2001. All of the steelhead that were captured were large juveniles, ranging from 180 to 378 mm fork length. Nearly all of these fish were captured at Hobsonville Point in the lower bay. These relatively large juveniles may represent fish that either had over-wintered in the estuary or returned to the estuary after spending some time in the ocean. The general absence of typical smolt-size steelhead between 120-160 mm fork length as seen at the ODFW screw traps supports the general belief that ocean-bound smolts spend little time in the estuary. Also the absence of parr and fry in the catch indicates that these downstream migrants probably hold in freshwater rather than entering the saline portions of the estuarine environment.

Sea-run Cutthroat Trout

Adult sea-run cutthroat trout are most abundant in Pacific Northwest estuaries during late summer and early fall before moving upstream to spawning grounds. Spawning occurs in small headwater streams during late winter and early spring. The majority of smolts are two to four years of age and enter the estuarine environment during April and May

(Nicholas and Hankin 1988). ODFW catch results for outmigrant traps in the Tillamook watershed indicate that cutthroat trout smolts migrate downstream from early March through mid June with a peak in May through June.

Little is known about the estuarine residency of sea-run cutthroat trout. Juveniles have been captured in off-shore waters from May through August (Pearcy et al. 1990), suggesting that at least some move relatively quickly into the ocean after moving downstream from fresh water.

We collected 37 sea-run cutthroat trout in 1999, 28 in 2000 and 6 in 2001. All were captured by beach seine. In 1999, about half of the fish were caught at Hobsonville Point; the remainder were caught near the mouth of the Kilchis River in the upper bay. In 2000, fourteen juveniles were caught at Hobsonville Point, two were collected at mid-bay sites, and twelve were collected at upper bay sites. In 2001, five of the six fish caught were collected at upper bay sites on the east side of the Bay; the remaining fish was caught at a mid bay site on the west side.

Most of the fish captured were at least age 1+ and most were likely age 2+ or older. The size range for the fish captured was 45 mm to over 400 mm with the majority of fish in the 140 to 350 mm size range. Juveniles and immature adults were captured during May, June, and July during the study, indicating that some use of the estuary occurs during these months.

USE OF THE ESTUARY BY NON-SALMONID SPECIES

The catch of non-salmonid fish was dominated by a few euryhaline marine fishes. Pacific staghorn sculpin, shiner perch, and surf smelt were the most abundant species in the overall catch and were widely distributed throughout the estuary. In the remainder of this section, eight of the relatively abundant non-salmon species will be examined with regard to their use of the estuary and their abundance during the study. The mean monthly beach seine CPE values for the eight species are compared across the three years of study in Figure 12 to provide an initial overview of the catch results for the abundant non-salmonid species. As for chum and chinook salmon, we used the GENMOD procedure to test for significant differences between mean beach seine catch and years, months, region of the Bay (group effect), and substrate (treatment effect) for several of the more abundant non-salmonid species. Tables showing Chi Squares and probabilities of larger Chi Square values (i.e., p values) for primary effects and interaction effects Appendix A. Comparisons of the means for each possible main effect and interaction are presented in Appendix B. Graphic representations of the catch data by block, treatment, year and month are presented in Appendix C to aid in interpretation of the statistical analysis.

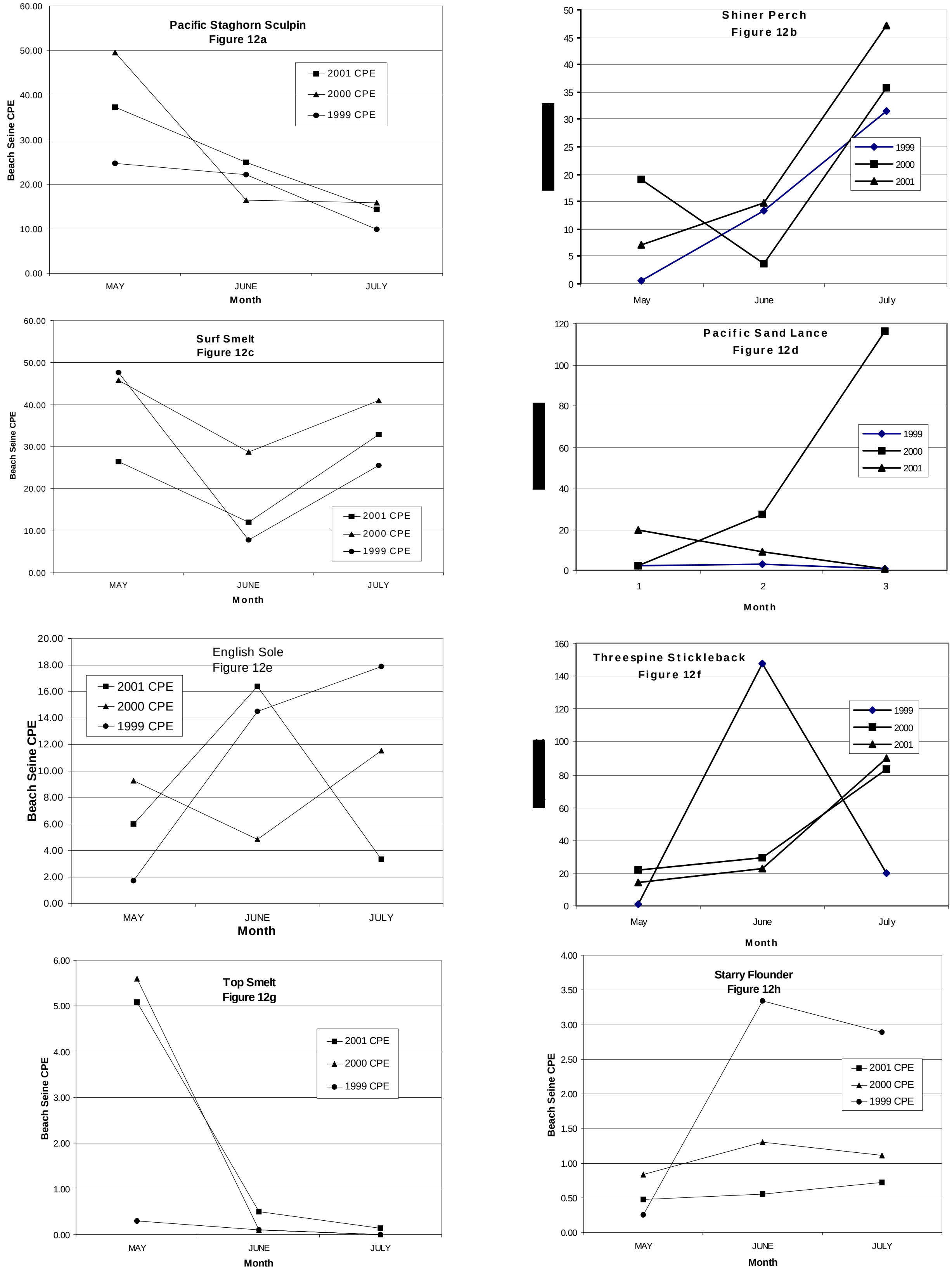


Figure 12. Catch-per-unit-effort for seven relatively abundant non-salmonid species captured by beach seine and for threespine stickleback captured by fyke net in 1999, 2000, and 2001.

Pacific Staghorn Sculpin

Pacific staghorn sculpin is an euryhaline marine species that uses the estuary for spawning, rearing and feeding. Spawning of Pacific staghorn sculpin probably occurs over an extended period of time. Forsberg et al. (1977) suggested that spawning in Tillamook Bay probably begins in late fall since the first juveniles appeared in December at a length of 20 to 45 mm. We found substantial numbers of 20-40 mm juveniles in April and May. The eggs of Pacific staghorn sculpin are demersal and adhesive. Larvae are planktonic (marine and estuarine), and juveniles and adults are demersal (Emmett et al. 1991). Pacific staghorn sculpin have no economic value but are an important predator on ghost shrimp, *Callianassa californiensis, (*Posey 1986*)* and are eaten by various fishes, birds, and mammals.

Beach seine CPE was highest in May in all three years of the study. The mean catch for May was significantly larger ($p = 0.0309$) than the mean for June and highly significantly larger ($p < 0.001$) than the mean for July (Appendix B). The May catch in all three years was dominated by sub-yearlings. The relatively large differences in beach seine catch in May between the three years resulted in a statistically significant result for year effect, with the mean for 2001 significantly smaller than the mean for 1999 (Appendix B). Pacific staghorn sculpin spawn during the winter and early spring, which accounts for the abundance of subyearlings in May. In all three years the mean CPE declined steadily from May through July. By July, the CPE was similar in all three years. This indicates that carrying capacity in terms of numbers of individuals at the beach seine sites was reached in July and that annual differences in mortality of young-of-the-year Pacific staghorn sculpin was probably the primary mechanism for the adjustment in numbers.

Although Pacific staghorn sculpin were widely distributed throughout the estuary (Figure 13), the largest numbers were collected in the mid and upper regions of the Bay. These observed differences were supported by a statistically highly significant block effect (region) in the GENMOD output. The differences between the mean catches in the mid and upper regions of the Bay were not significantly different. Beach seine sites on the west side of the Bay generally had the highest densities of Pacific staghorn sculpin. These sites are dominated by fine grained substrate. Statistical analysis indicated that the abundance on the fine-graine substrate was significantly greater than on the coarse-grain substrate.

The mean size of Pacific staghorn sculpin in the beach seine catch was larger in the lower bay than in either the mid or upper bay regions throughout the study. This same pattern in size distribution was noted by Bottom and Forsberg (1978) in their mid 1970s study of fish distribution and abundance in Tillamook Bay. It appears that Pacific staghorn sculpin use the mid and upper regions of the Bay as juvenile rearing sites with movement toward the lower bay occurring as the fish become larger. We also found that juveniles were abundant components of the tidal channels in salt marsh habitat in the upper region of the Bay. For length frequency distributions of Pacific staghorn sculpin from May through July, see Ellis (1999, 2002a and 2002b).

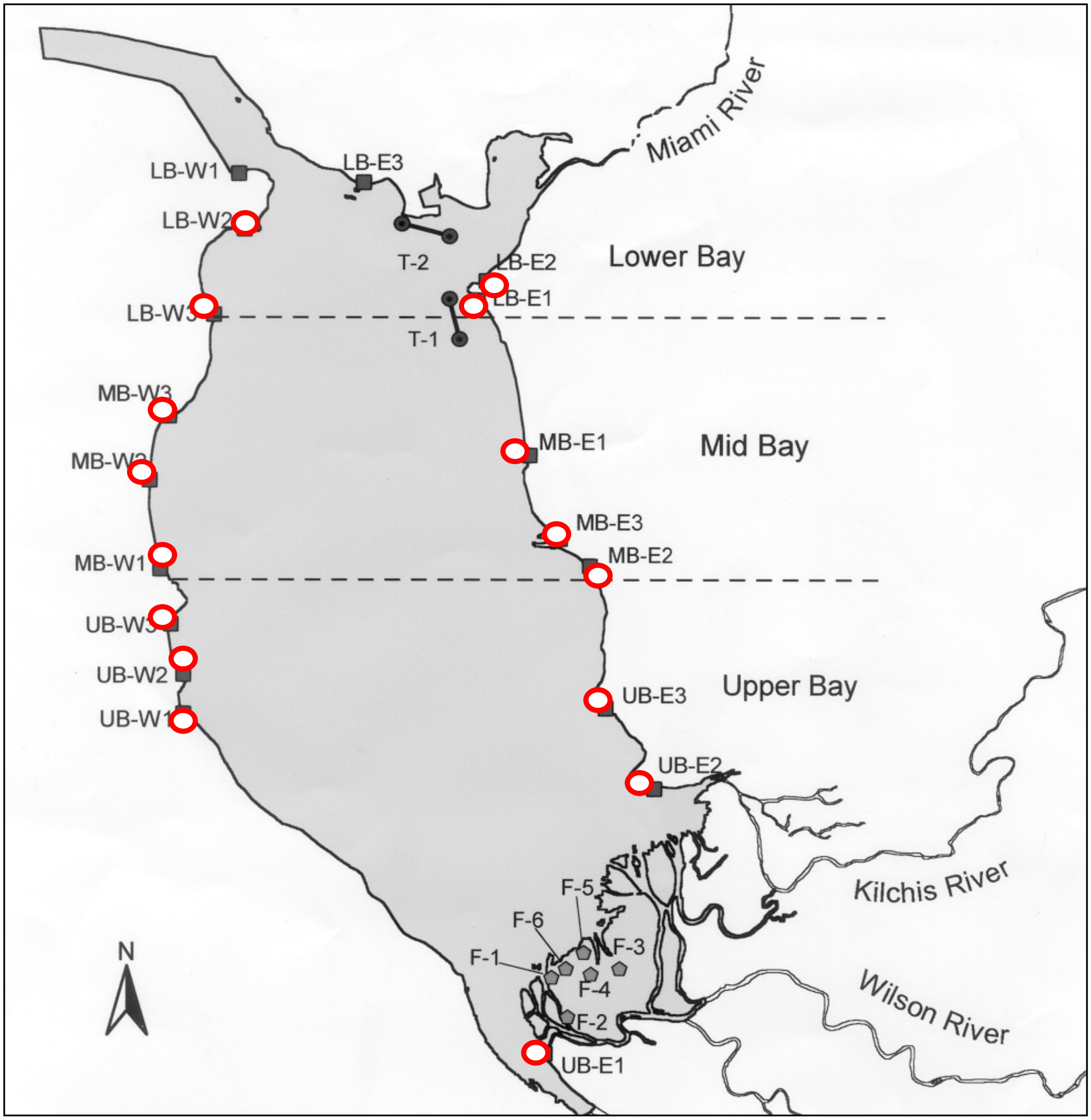


Figure 13. Beach seine sites where Pacific staghorn sculpin were collected in 50 percent or more of samples collected during the period 1999-2001.

Shiner Perch

This species occurs primarily in near-shore shallow marine, bay, and estuarine habitats. It is a live-bearer; eggs are retained within the female and juveniles are born fully developed. Juveniles and adults are primarily neritic and pelagic (Garrison and Miller 1982). The shiner perch is a small, yet abundant species in many estuaries and bays and is preyed upon by numerous birds, mammals and fishes (Wydoski and Whitney 1979).

Shiner perch was one of the most abundant components of the beach seine and trawl catches during the three-year study period. The general distribution of shiner perch in the Bay is reflected in their frequency of occurrence at beach seine sites (Figure 14). Mean beach seine CPE was relatively low in May and June and then increased substantially in July (Figure 12b). The large increase in numbers in July reflects the addition of the annual cohort of juvenile shiner perch (See Ellis 1999, 2002a and 2002b for monthly length frequency distributions). The beach seine mean CPE values for 1999, 2000, and 2001 were 15.2, 20.4 and 28.4, respectively. The larger mean CPE values for 2000 and 2001 were significantly different from the relatively low CPE value for 1999 (Appendix B). As expected by the large increase in numerical abundance in July, GENMOD output also showed a significant month effect.

Shiner perch spawned primarily in late June and July. These fish are live-bearers and females in the process of expelling their offspring were captured at a number of sites. Relatively large concentrations of spawning fish were found at mid bay station MB-E2 and upper bay station UB-E2. By the end of July, young-of-the-year shiner perch were widely distributed throughout the estuary.

The numerical distribution of shiner perch within the Bay increased from the lower bay to the upper bay, primarily due the presence of greater numbers of juveniles in the mid and upper regions. This distribution pattern resulted in a highly significant block (region) effect in the GENMOD analysis. Also, significantly more shiner perch were found at sites with coarse grain substrate than those with fine grain substrate.

Surf Smelt

Surf smelt is considered a nearshore coastal species, which does not typically spawn in estuaries but uses them for feeding and rearing. Spawning populations of surf smelt can be found nearly year-round along the Pacific coast (Emmett et al. 1991). The eggs are benthic. Larvae, juveniles, and adults are pelagic but remain principally inshore (Emmett et al. 1991). Surf smelt are not commercially important but are preyed upon by numerous birds, mammals and fishes (Emmett et al. 1991).

Surf smelt ranked second in the 1999 combined catch and third in 2000 and 2001 combined catches. The largest number of surf smelt was collected in 2000. Statistical analysis of the beach seine catch data indicated that the differences in mean CPE between

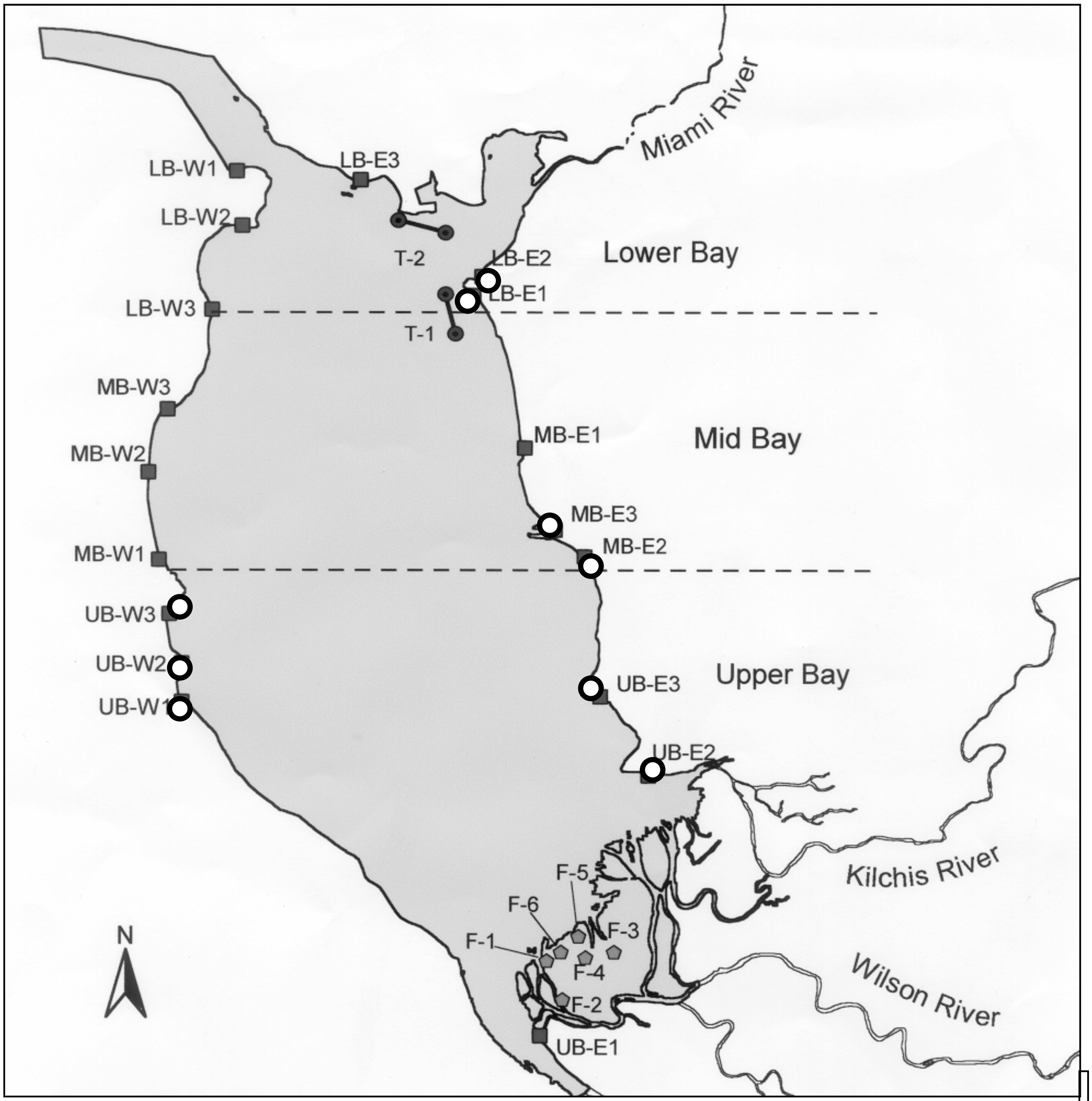


Figure 14. Beach seine sites (circles) where shiner perch were captured in 50 percent or more samples collected during the period 1999-2001.

years were not significant. Variability in the catch of surf smelt between stations was relatively high compared with Pacific staghorn sculpin and shiner perch. Surf smelt generally occurred in schools, which resulted in relatively large numbers being collected in a few beach seine hauls.

In all three years of the study, the catch of surf smelt declined from May to June and then increased in July (Figure 12c). These month-to-month differences were statistically significant. This pattern of abundance may reflect immigration patterns of different cohorts of surf smelt from the ocean. In May the population in the Bay was dominated by juveniles (35-75 mm fork length) whereas in July there was a mix of both juveniles and adults (81-155 mm fork length).

The general distribution of surf smelt at beach seine sites can be seen from a plot of sites where they occurred at least 50 percent of the time during the study (Figure 15). Although surf smelt were found in all regions of the Bay, the largest catches were generally from the lower region of the Bay. The larger mean catch in the lower bay was found to be significantly different from the smaller mean catches in the mid and upper regions of the Bay (Appendix B). No significant difference was found between the mid and upper regions of the Bay. In addition, no significant difference in abundance on fine grain or coarse grain substrate (treatment effect) was found for this species.

Pacific Sand Lance

Pacific sand lance is a very elongate fish that reaches a length of about 20 cm. This species leads a varied life, sometimes offshore, sometimes in large schools stemming tidal currents in estuarine channels, at other burying themselves more or less completely in beach sand. These fish occur as larvae up to 25 mm, post-larvae 25 to 75 mm, and adults. They feed mainly on copepods, their eggs and nauplii, but also on a wide variety of other foods. Sand lance are frequently taken as food by chinook and coho salmon, lingcod, halibut, and many other marine vertebrates (Hart 1973).

Because Pacific sand lance is a schooling species, its occurrence at beach seine sites was highly variable. The rather large differences in between-year CPE apparent in Figure 12d did not result in statistically significant year-to-year differences when the data were analyzed by the GENMOD procedure.

In 2001 the CPE ranged from a high of about 20 fish in May to a low of about 0.8 fish in July (Figure 12d). These values were similar to those reported for the 1999 sampling period. Catch-per-unit-effort in 2000 showed a substantially different pattern with a low in May and a large increase in July. The large increase in catch-per-unit-effort in July 2000 was due primarily to one very large beach seine haul that collected several thousand Pacific sand lance. Statistical analysis of the monthly data indicated that statistically significant monthly differences were present for the 1999 through 2001 sampling period (Appendix B). As pointed out above, high variability in the distribution of schools of Pacific sand lance could be responsible for the observed differences in the monthly patterns of abundance from year-to-year.

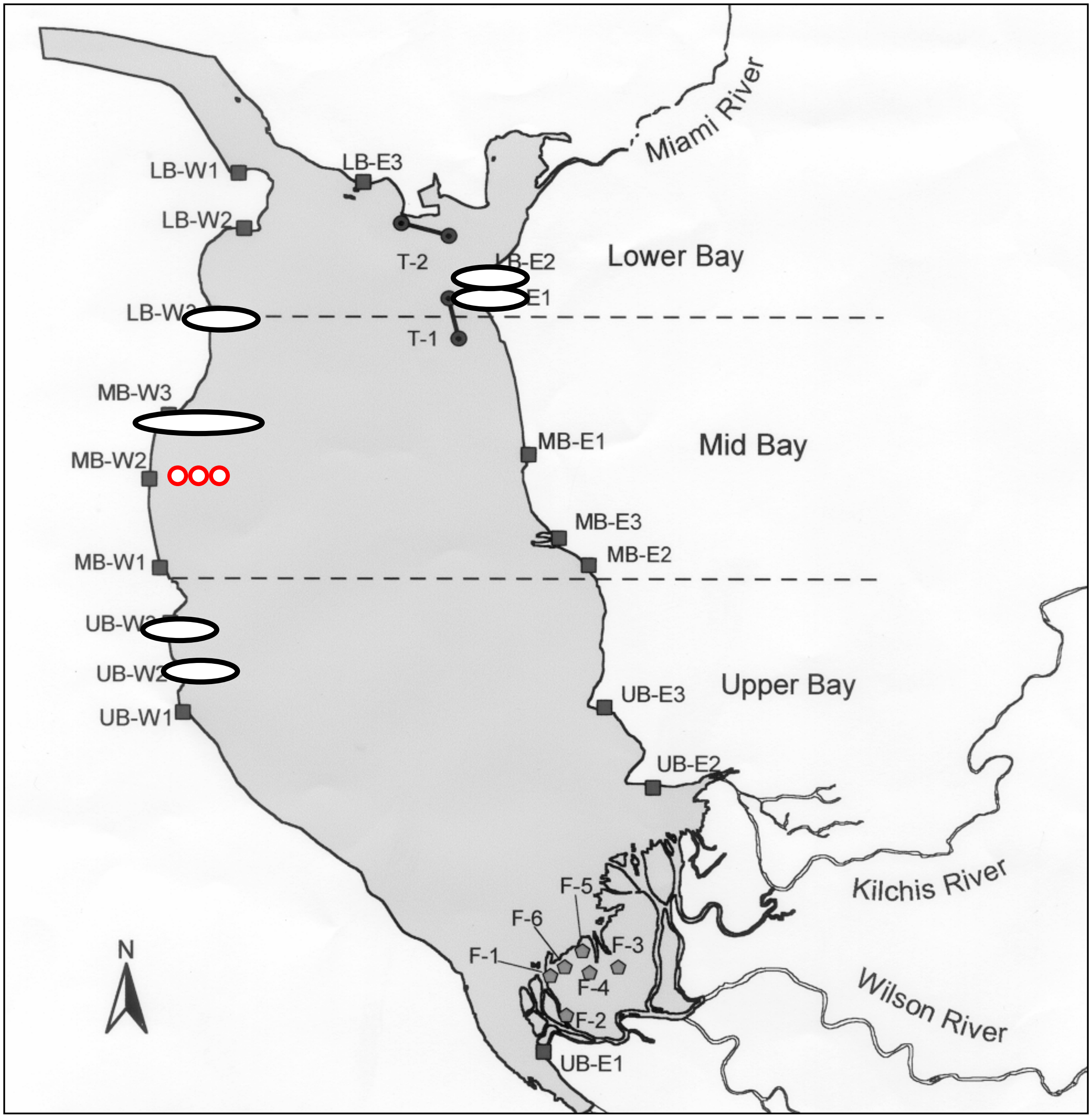


Figure15. Beach seine sites (circles) where surf smelt were collected in 50% or more of the samples during the period 1999-2001.

Significant differences in the regional differences in abundance of Pacific sand lance were found. The lower region of the Bay was by far the most important relative to the catch of this species. Very few Pacific sand lance were collected from the mid and upper regions of the Bay. The general distribution of Pacific sand lance at beach seine sites can be seen in Figure 16, which plots stations where Pacific sand lance were caught most often.

The majority of the Pacific sand lance collected in 2001and in previous years were a combination of post larvae (55-75 mm) and adults. The length frequency histograms (See Ellis 2002a and 2002b) for Pacific sand lance caught by beach seine in May, June, and July indicate that recruitment of post larvae occurred largely in June and July.

English Sole

English sole spawn in the ocean during September-April off Oregon (Kruse and Tyler 1983). The early larvae are pelagic, but later in their development they move to the benthos in both coastal and estuarine areas, and assume a demersal existence for the remainder of their life (Stevens and Armstrong 1984, Krygier and Pearcy 1986). Juvenile English sole use estuaries almost exclusively for rearing. Most juvenile English sole emigrate from estuaries and complete their life cycle in the offshore coastal waters. Emigration begins when they reach a length of 75-80 mm (Gunderson et al. 1990). Juvenile English sole are preyed on by variety of birds, mammals and fish; the adults are a commercially valuable food fish.

Juvenile English sole were present throughout the May through July sampling period in all three years (Figure 12e). Significantly more juvenile English sole were collected in the lower and mid regions of the Bay than in the upper bay. However, individuals were frequently caught at a few upper bay sites as well (Figure 17).

In early May, juvenile English sole were collected almost exclusively at lower bay beach seine sites in all three years. By the end of May, the juveniles were distributed farther up the Bay with representatives taken at three mid bay stations, primarily those on the west side of the Bay. Juveniles appeared at upper bay stations only from mid June through July. The gradual up-bay movement was probably related salinity preference. Salinity in the mid and upper regions of the Bay gradually increased with the seasonal decrease in fresh water input to the estuary. Juvenile English sole were rarely collected at sites where the salinity was less than 25 ppt.

The effect of salinity on the distribution of juvenile English sole also was apparent in mid June 2000, when salinity declined throughout the estuary due to a temporary increase in freshwater input. The beach seine catch of English sole, which increased from May through June in both 1999 and 2001, declined in June 2000. The drop in salinity probably forced juveniles to move to deeper water in the lower end of the Bay where they were less susceptible to capture by beach seine.

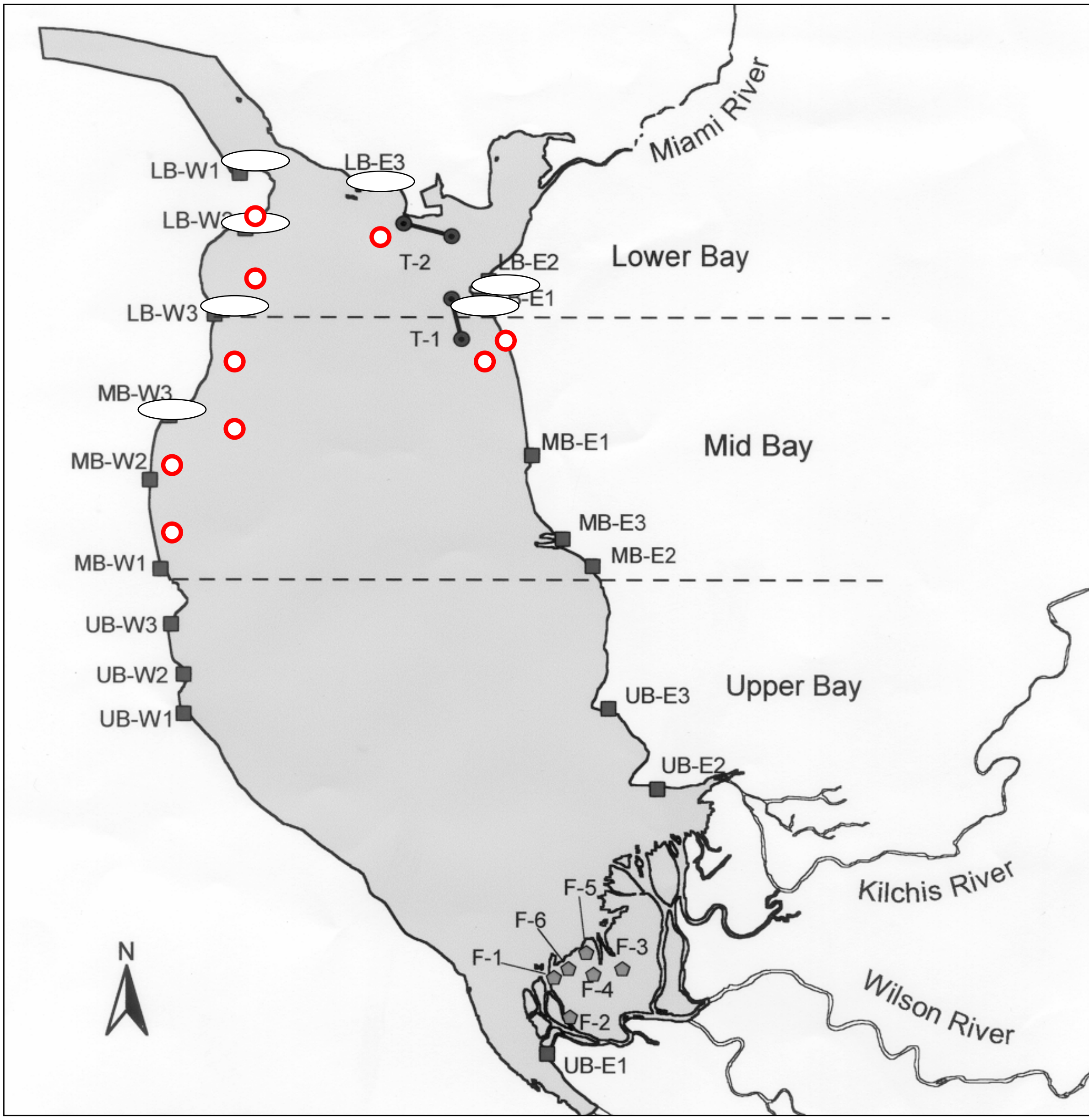


Figure 16. Beach seine sites where Pacific sand lance was captured in 50% or more samples during the period 1999-2001.

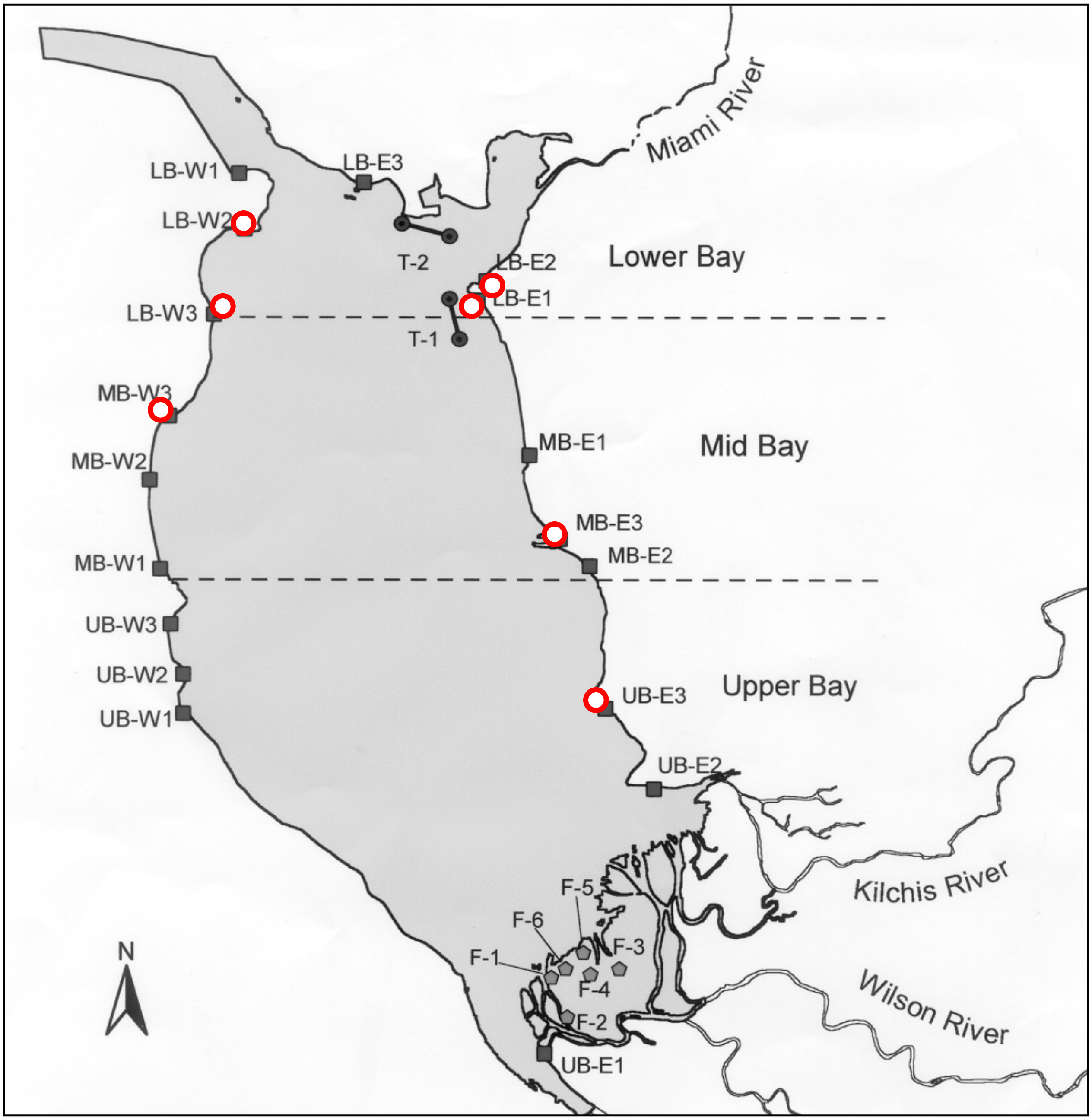


Figure 17. Beach seine sites where English sole were captured in 50 percent or more of samples collected in the period 1999-2001.

No significant difference in year-to-year abundance of English sole was found. As indicated in Figure 12e, month-to-month variability in the beach seine catch was quite high. Statistical analysis of the monthly catch data for the three years indicated a significant difference between June and July (Appendix B). However, this result may have been influenced by the short-term decrease in salinity in June 2000. Relatively high month-to-month variability in juvenile abundance might be expected for English sole due to the likely variability from year-to-year in timing of immigration of small (30-45mm) juveniles from the ocean, emigration of individuals larger than 75 mm from the estuary, and settlement of new larvae. The length frequency histograms for English sole (See Ellis 1999, 2002a and 2002b) indicated the presence of a mixture of length classes in the range 35 to 80 mm during May and June.

Significantly more juvenile English sole were collected at beach seine sites with fine grain substrate than at sites with coarse grain substrate. The GENMOD analysis also indicated a highly significant treatment/block interaction (Appendix A). The interaction between region of the Bay and substrate was probably related to the distribution pattern of the juveniles. In the lower bay where juveniles were relatively highly abundant, large catches were often made on sandy (fine grain) substrate. As numbers of juveniles declined further up the bay, more variability in the distribution of the catch on sandy and rocky substrates was found.

Starry Flounder

Starry flounder is widely distributed in the eastern Pacific Ocean from Santa Ynez River, California, north through the Bering and Chukchi Seas to Bathurst Inlet in Artic Canada. The starry flounder does not migrate extensively (Pedersen and DiDonato 1982). However, tagging studies have shown that there is some movement along the coast (Westerheim 1955). Spawning occurs near river mouths and sloughs in shallow water (Garison and Miller 1982). Spawning takes place primarily from February to April in Puget Sound and British Columbia (Hart 1973). Eggs and larvae are pelagic, while juveniles and adults are demersal (Garrison and Miller 1982). Juveniles commonly invade far up rivers (Moyle 1976), but appear to be estuarine-dependent. The starry flounder is a moderately important flatfish species landed by the Pacific coast trawl fishery. It also is important recreationally in some areas. It is prey for marine mammals and piscivorous birds.

Starry flounder ranked ninth in the combined catch in 1999, eleventh in 2000 and thirteenth in 2001. The monthly mean beach seine CPE for the three years is shown in Figure 12 h. In 1999, the catch of starry flounder was dominated by young-of-the-year, ranging in length from about 40 mm to 75 mm. In 2000, there was a mix of sub-adult (age 1+), adult, and juvenile fish present in the catch. In 2001 the catch was dominated by sub-adults and adults with only a few juveniles collected. This pattern in the size distribution is typical of populations that exhibit strong and weak year classes. Reproduction in 1999 appears to have been relatively good for starry flounder. That year class is probably responsible for the majority of the adult fish present in the population in

2001. Maturity in starry flounder is typically reached at age two when the fish are about 300 mm in length (Hart 1973).

Although the total beach seine catch steadily declined from 1999 through 2001, no statistically significant year-to-year difference in abundance was found. This was probably due to the variability in catch of starry flounder between stations and within stations through time.

Starry flounder were captured frequently at only a few beach seine sampling locations (Figure 18). Most of the juveniles were collected at UB-E1 near the mouths of the Wilson and Trask Rivers and on the west side of the Bay at MB-W1. The majority of the sub-adult and adult flounder were collected on the east side of the Bay at mid-bay sites MB-E2 and MB-E3. Because few starry flounder were captured in the lower bay, the statistical analysis showed a highly significant region (block) effect (Appendix A).

The majority of juvenile starry flounder were captured at sites with fine grain substrate, whereas sub-adults and adults occurred at both fine grained and coarse grained sites. Statistical analysis indicated that there were significantly more starry flounder on the fine grain substrate.

Threespine Stickleback

The threespine stickleback is a small (maximum length about 3.8 inches) fish that occurs in both freshwater and salt water. It is one of the most widespread fishes in the world and is found in North America, Europe and Asia. Threespine stickleback live only one or two years with most dying after the first spawning (Wydoski and Whitney 1979). In fresh water and estuarine bays, threespine stickleback are usually found closely associated with aquatic vegetation. Breeding occurs from May through July and sometimes into August in Washington (ibid. 1979). Food consists largely of zooplankton and aquatic insects. Threespine stickleback are preyed on by a variety of fish and birds and are an important component of the diet of coastal cutthroat trout in estuaries (ibid. 1979).

Threespine stickleback ranked sixth in the overall catches in 2000 and 2001 but were not among the ten most abundant species collected by beach seine in 1999-2001. Threespine stickleback were occasionally collected by beach seine but the majority were collected by fyke net in the salt marsh habitat at the southern end of the Bay. The pattern of abundance over the study interval in 2001 was nearly identical to the pattern observed in 2000 (Figure 12f). By far the majority of the threespine stickleback caught in the fyke nets were adults. Peak abundance in the fyke nets occurred in July in 2000 and 2001 but

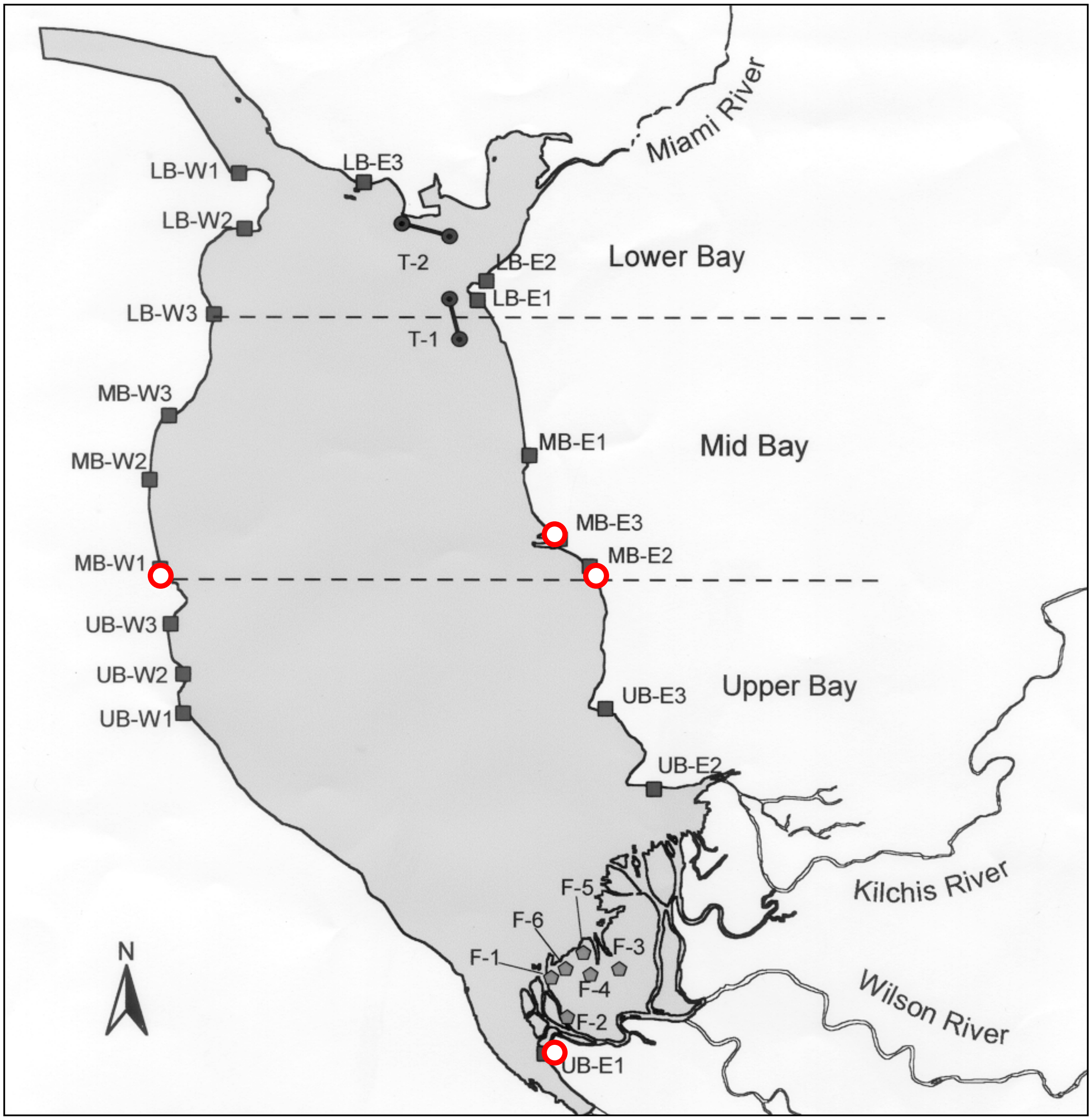


Figure 18. Beach seine sites where starry flounder were captured in 50 percent or more of the samples collected during the period 1999-2001.

in June in 1999. Those present in June and July were in spawning condition and it appears that the marsh habitat is used for spawning and early rearing. Apparently small residual pools in the salt marsh and salt marsh channels are used for nest construction and incubation of eggs. We noted large numbers of very small threespine stickleback in such habitat during July. These early juveniles were too small to be collected in the fyke nets.

Topsmelt

Topsmelt occur along the Pacific coast from Monterey, California to Southern British Columbia. Top smelt may live to six or seven years of age. Spawning of top smelt has been studied in Coos Bay, Oregon and occurs from May through early July. In Coos Bay, the eggs are attached to eelgrass just below low water (Hart 1973). Topsmelt are not a commercially important fish but are probably used as a forage species by anadromous salmonids and a variety of the marine fish, mammals and birds.

Top smelt ranked eighth in the combined catch for 2001 and ninth in the combined catch for 2000. In 1999, it was less abundant, ranking seventeenth in the combined catch. Most of the topsmelt were captured by beach seine, although some were taken by trawl. The pattern in CPE was similar in both 2001 and 2002, with peak abundance occurring in May (Figure 12g). In 1999, there was no May peak in abundance. Beach seine CPE was less that 0.6 fish per seine haul in June and July in all three years. This pattern of abundance was probably related to spawning activity of adults. The majority of topsmelt collected in May were adults based on the length frequency distribution of the catch. Most of the catch occurred over mud flats in the mid and upper regions of the Bay. Eelgrass occurs on the west side of Tillamook Bay in the vicinity of beach seine site UB-W2 where most of the topsmelt were collected. Therefore, it is likely that the adults collected in May were in the Bay to spawn.

EVALUATION OF THE SAMPLING DESIGN FOR LONG-TERM MONITORING

One of the objectives of this study was to evaluate the results of the first three years of sampling and determine whether the sampling design provides the kind of information needed to evaluate changes in species composition within the estuary and the abundance and distribution of species among major habitat types through time. We believe the results for the first three years are encouraging with respect to these goals.

With regard to species, there was very little variability in the total number of species collected from year-to-year. This indicates that the sampling effort provided consistent results with regard to species composition at the sites sampled. The year-to-year differences in species composition that were found were due to the presence or absence of a few relatively rare species. We were also able through ANOVA, to determine that significantly more species were present on coarse-grained substrate than on fine-grained substrate. The consistent species composition of the fyke net samples from marsh habitat also indicates that this habitat type was adequately sampled.

Relative abundance of species was evaluated in terms of CPE for the various gear types. Although there were year-to-year differences in the relative abundance of individual species, there was general consistency in the list of relatively abundant species. In any study of fish relative abundance, the results are biased by differences in gear sampling efficiency. Therefore, it is not possible to know how well the relative abundance data reflects actual relative abundance in the estuary. This is not a critical problem for monitoring since consistency in sampling effort with a specific gear type and adequate sample size are the primary concerns.

The nested randomized bock sampling design employed for the beach seine sampling program allowed statistical testing of key variables on a species by species basis. The three years of beach seine data provided a relatively large data set (108 samples) collected in a consistent manner through time. Through the use of the GENMOD procedure, we were able to show statistically significant differences between years, months, regions of the Bay, and major substrate types for several of the abundant salmonid and non-salmonid species. In most cases the results of the statistical analyses were consistent with what graphical analysis of the data seemed to indicate. The GENMOD procedure is a very flexible method for fitting generalized linear modes to various types of data sets. For the count data collected in this study, we found that the negative binomial distribution with a *log* link function provided a reasonably good fit to the data for most of the abundant species. It is likely that refinements could be made in our use of the GENMOD procedure, which would improve the power of the statistical testing for some of the species whose distributions may not be described adequately by the negative binomial.

The finding of significant year-to-year differences in abundance of several of the more abundant species, including juvenile chinook salmon, emphasizes the importance of collecting data over more than one year. Based on the results of this study, we believe that at least a three-year period of data collection is needed to allow valid comparisons of abundance estimates through time.

In summary, the results of the first three years seem to meet the general criteria that the CCMP outlined for the fish monitoring program. Future monitoring, using the same experimental design should allow valid comparisons to be made between the baseline conditions described in this study and conditions in the future.

SUMMARY

FRESH WATER INPUT, SALINITY AND TEMPERATURE CONDITIONS

- Input of freshwater to the estuary during the 1999-2001 study period was most variable in May. In June and July input was nearly the same in 1999 and 2001. A heavy precipitation event in mid June 2000 resulted in a substantial temporary increase in fresh water input from mid to late June.

- Mean monthly salinity measured at beach seine stations indicated that salinity conditions in the three regions of the Bay were similar across years except during mid June 2000 when salinity throughout the Bay declined with increased fresh water input. The salinity measurements also indicated that salinity consistently followed the regional division of the Bay with highest salinities in lower bay and lowest salinities in the upper bay.

- Water temperatures were cooler and more stable in the lower region of the Bay. Temperatures in excess of 20ºC were common in the mid and upper bay from late May through July.

SPECIES COMPOSITION

- A total of 48 fish species were collected during the study. The species composition of the fish community in Tillamook Bay is similar to what one would expect in other unpolluted estuaries along the Oregon Coast during the period May through July.

- Most of the species captured in this study also were collected in the mid 1970s during ODFW's comprehensive survey of the fish community of the Bay. This indicates that the species composition has remained relatively stable over the last 25 years.

- Significantly more ($p < 0.05$) species were collected by beach seine at intertidal shoreline sites with coarse-grain (gravel, cobble, boulder) substrate than at sites with fine-grain (sand and sand/silt) substrates.

RELATIVE ABUNDANCE OF SPECIES

- The total number of fish caught varied substantially from year-to-year within the study period. Total catches were as follows:

    - 1998-99 13,817
    - 2000 20,174
    - 2001 16,297

  Most of the differences between years were attributed to differences in the abundance of a few species.

- The numerical abundance of fish in the Bay is dominated by a few relatively abundant species. The following species accounted for over 90 percent of the total combined catch during this study: Pacific staghorn sculpin, shiner perch, Pacific sand lance, surf smelt, English sole, threespine stickleback, chum salmon, and chinook salmon. Pacific herring were relatively abundant in 1999.

- Year-to-year differences in relative abundance among the most abundant species were found. Some of these differences may have been related to sampling error since one or two large catches of a schooling fish such as Pacific sand lance had a large influence on relative abundance.

- Very few juvenile rockfish were collected during this study. In the mid-1970s juvenile rockfish were a relatively abundant component of ODFW's May-July catch. These results indicate that there may have been a significant reduction in use of the Bay by juvenile rockfish.

Regional Distribution of Fish Within the Estuary

- Overall abundance of fish was highest in the lower region of the Bay, lowest in the mid region, and intermediate in the upper region.

- Statistical analyses of the beach seine data indicated statistically significant differences in abundance for most of the relatively abundant across the three regions of the Bay. English sole, Pacific sand lance, and surf smelt appeared to prefer the lower region of the Bay where salinities were relatively high. Juvenile starry flounder and juvenile shiner perch were most abundant in the upper region of the Bay where salinities were relatively low.

Species Composition and Relative Abundance in Subtidal Habitat

- Greenling, ling cod, and buffalo sculpin were common components of the trawl catch but were rarely caught in the beach seine. These species appear to be restricted largely to the deeper subtidal channel habitat. All of the ling cod captured were juveniles. Several rare species such as cabezon, eelpout, tom cod, sand sole and rock prickleback were only captured in subtidal habitat. Most of the representatives of these relatively rare species also were juveniles.

- Relatively large percentages of the trawl catches consisted of species such as shiner perch and Pacific herring, which were commonly found at intertidal beach seine sites.

Species Composition and Relative Abundance in Salt Marsh Habitat

- Salt marsh channel habitat was sampled by fyke net. The species diversity in the fyke net catch was low compared with the open regions of the Bay.

- The species captured in the salt marsh included: Pacific staghorn sculpin, threespine stickleback, shiner perch, prickley sculpin, juvenile chum salmon and juvenile Chinook salmon. Only Pacific staghorn sculpin and threespine stickleback were consistently abundant in the catch.

- Anadromous salmonid use of salt marsh habitat was limited primarily to chum salmon fry, which were found in a few samples collected during March and April. Very little use by anadromous salmonids was found from May through July.

USE OF THE ESTUARY BY ANADROMOUS SALMONIDS

- Only juvenile chum salmon, subyearling chinook and searun cutthroat trout appear to use the estuary extensively for rearing. Juvenile coho salmon, yearling chinook salmon, and steelhead trout smolts were infrequent components of the catch and the majority of juveniles appear to move quickly through the estuary.

- Based on the recapture of a limited number of fin clipped chum salmon in 1999 and 2000, we estimated that the Little North Fork of the Wilson River may be responsible for a disproportionately large percentage of the production of chum salmon fry present in the estuary during our study.

- The beach seine sites located at Hobsonville Point (LB-E1 and LB-E2) were consistently productive sites for the capture of juvenile salmonids. Both of these sites are located on rocky substrate and are located adjacent to eelgrass beds.

- Use of the estuary by juvenile chum and chinook salmon was studied in more detail through through graphic and statistical analysis of the beach seine catch data. The beach seine sampling program was designed to allow statistical analysis of the effects of year, month, substrate, and regional use of the Bay. The results of these analyses are summarized in Table 9.

USE OF THE ESTUARY BY NON-SALMONID SPECIES

- Use of the estuary by non-salmonid species was studied in detail through the use of graphical and statistical analyses. Results of these analyses are summarized in Table 10.

EVAUATION OF SAMPLING DESIGN

- After evaluating the sensitivity of the sampling design in detecting effects of time (years and months), region of the Bay, and major habitat types on the numbers of species, relative abundance of species, and abundance of individual species, we conclude that the sampling design is adequate to meet the needs of the CCMP.

Table 9. Summary of findings relative to use of the estuary by chum and chinook salmon collected during the 1999-2001 study period.

Species	**Year-to-Year Differences in Abundance**	**Monthly Patterns of Abundance**	**Use of Fine and Coarse Substrate**	**Regional Use of the Bay**	**Use of Salt Marsh Habitat**
Chum Salmon	No significant difference detected	Use in May significantly greater than June or July	No significant difference detected	Significantly more use of lower and mid regions	Some use during March and April; little in May-July
Chinook Salmon	Significantly more juveniles present in 1999	Significantly more juveniles present in July	Significantly more juveniles found at coarse grain sites	Significantly more juveniles found in the lower and upper regions	Only one juvenile chinook collected from marsh habitat

Table 10. Summary of findings relative to use of the estuary by relatively abundant non-salmonid fish species collected during the 1999-2001 study period.

Species	Year-to-Year Differences in Abundance	Monthly Patterns of Abundance	Use of Fine and Coarse Substrate	Regional Use of the Bay	Use of Salt Marsh Habitat
Pacific Staghorn Sculpin	Significantly more present in 1999 than in 2001	Significantly more present in May	Significantly more found on fine grain substrate	Significantly more sculpins in upper and middle regions	Heavily used by juvenile sculpin
Shiner Perch	Significantly more fish present in 2000 & 2001 than in 1999	Significantly More fish present in July due to age)+ fish entering the catch	Significantly more at coarse grain sites	Significantly more present in the mid and upper regions	Some use in late June and July by juveniles
Surf Smelt	No significant difference detected	Significantly more present in May and July	No significant difference detected	Significantly more present in the lower bay	None collected in marsh habitat
English Sole	No significant difference detected	Significantly more in July than in June	Significantly more at fine grain sites	Significantly more juveniles present in the lower and mid bay	None collected in marsh habitat
Starry Flounder	No significant difference detected	No significant difference detected	Significantly more at fine grain sites	Significantly more in the mid and upper regions	None collected in marsh habitat
Threespine Stickleback	No statistical tests conducted for year effect	More present in June and July	Not able to evaluate	More in the upper region	Heavy use for spawning and juvenile rearing
Top Smelt	No statistical tests conducted or year effect	Most collected in May	Most collected over mud flat habitat	Most collected in upper bay	None collected in marsh habitat

ACKNOWLEDGMENTS

I want to especially thank Charles Wooldridge, Robert Reese, Helen Hill, Peter Kaczynski, Scott Sloane and Joseph Krieter for the long hours of work on intertidal mud flats that were required to obtain the data summarized in this report. I also would like to thank Derek Sowers and the staff at the Tillamook Estuaries Partnership for their support and assistance in both the field research and production of the report. This work would not have been possible without the funding provided by the Oregon Watershed Enhancement Board under contract #______.

LITERATURE CITED

Allen, L.G. 1982. Seasonal abundance, composition, and productivity of the littoral fish assemblages in upper Newport Bay, CA. Fishery Bulletin. 80:769-790.

Bodenmiller D. 2001. Oregon marine recreational fishery study. Marine resources program. Oregon Department of Fish and Wildlife, Contract F-128-15.

Bottom, D. 1999. Oregon Department of Fish and Wildlife Research Biologist. Personal Communication. July 1999.

Bottom, D., and B. Forsberg. 1978. The Fishes of Tillamook Bay. Oregon Department of Fish and Wildlife, Project No. F-100-R. 56 pp.

Bottom, D.L., K.K. Jones, and J.D. Rogers. 1987. Fish community structure, standing crop and production in upper South Slough (Coos Bay, Oregon). South Slough National Estuarine Research Reserve Technical Report Series. No. SOS 1-88.

Braun, K. 1997. Fisheries Biologist for the Oregon Department of Fish and Wildlife, Tillamook, Oregon. Personal Communication. February 1997.

Camber, P. 1997. Sediment Accumulation in Tillamook Bay, Oregon, a Large Drowned-River Estuary. Report to TBNEP, Garibaldi, OR.

Cummings, T.E. and E. Schwartz. 1971. Fish in Coos Bay, Oregon, with comments on distribution, temperature, and salinity of the estuary. Fish Comm. Oregon. Coastal Rivers Invest. Inf. Rep. 70-11. 22 pp.

Dalton, T. 1999. ODFW Fisheries Biologist, Tillamook region. Personal Conversation October 1999.

Ellis, R. H. 1999. Fish Use of the Estuary. 1999 Monitoring Report, Tillamook Bay. Report prepared for Tillamook Bay National Estuary Project and Tillamook County Performance Partnership, Garibaldi, Oregon.

Ellis, R. H. 2002a. Fish Use of the Estuary. 2000 Monitoring Report, Tillamook Bay. Report prepared for Tillamook Bay National Estuary Project and Tillamook County Performance Partnership, Garibaldi, Oregon.

Ellis, R. H. 2002b. Fish Use of the Estuary. 2001 Monitoring Report, Tillamook Bay. Report prepared for Tillamook Bay National Estuary Project and Tillamook County Performance Partnership, Garibaldi, Oregon.

Emmitt, R.L., S.A. Hinton, S.L. Stone, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volume II: Species life history summaries.

Forsberg, B., J. Johnson, and S. Klug. 1977. Identification, distribution and notes on food habits of fish and shellfish in Tillamook Bay, Oregon. Research Section, Oregon Department of Fish and Wildlife, Federal aid progress report, Fisheries. 117 pp.

Garrison, K.J. and B.S. Miller. 1982. Review of the early life history of Puget Sound fishes. Fish. Res. Inst., Univ. Wash., Seattle, Washington. 729 pp. (FRI-UW-8216)

Gunderson, D.R., D.A. Armstrong, S. Yun-Bing, R.A. McConnaughey. 1990. Patterns of estuarine use by juvenile English sole (*Parophrys vetulus*) and Dungeness Crab (*Cancer magister*). Estuaries. 13:59-71.

Hart, J.L. 1973. Pacific Fishes of Canada. Fisheries Research Board of Canada. Bull. 80. Ottawa, Canada. 740 pp.

Healey, M. 1982. Juvenile Pacific salmon in estuaries, the life support system. As cited in V.S. Kennedy, ed., Estuaries comparisons. Academic Press, Inc., New York, NY.

Johnson, J.A., DIP. Liscia and D.M. Anderson. 1986. The seasonal occurrence and distribution of fish in the Umpqua estuary, April 1977 through January 1986. Umpqua District, ODFW. Roseburg, OR. 10 pp.

Komar, P. 1997. Sediment Accumulation in Tillamook Bay, Oregon, A Large Drowned-River Estuary. Tillamook Bay National Estuary Project. Garibaldi, OR.

Kruse, G.H. and A.V. Tyler. 1983. Simulation of temperance and upwelling effects on the English sole (Parophrys vetulus) spawning season. Can J. Fish. Aquatic Sci. 40:230-237.

Krygier, E.E. and W.G. Pearcy. 1986. The role of estuarine and offshore nursery areas for young English sole, Parophrys vetulus, off Oregon. Fish Bull. U.S. 84:119-132.

Lassuy, D. R. 1989. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest) ---Pacific Herring. U. S. Fish and

Wildlife Service and U. S. Army Corps of Engineers Biological Report 82(11.1260). 19 pp.

Levy, D.A. and T.G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Franser River Estuary. Can. J. Fish. Aquatic Science 39: 270-276.

Miller, J.A. and C.A. Simenstad. 1997. A comparative assessment of a natural and created estuarine slough as rearing habitat for juvenile chinook and coho salmon. Estuaries. 20: 792-806.

Moyle, P.B. 1976. Inland fishes of California. Univ. Calif. Press, Berkeley, CA. 405 pp.

Newell, A. 1998. Chapter 4: Water Quality. In Tillamook Bay Environmental Characterization, A Scientific and Technical Summary. Ed. R. Hinzman and S. Nelson. Tillamook Bay National Estuary Project.

Nicholas, J. and D. Hankin. 1988. Chinook salmon populations in Oregon coastal river basins: Description of the life histories and assessment of recent trends in run strengths. ODFW Information Report. 88-1. 359 pp.

Oregon Department of Fish and Wildlife (ODFW) 1977. ODFW 1977 spawning count data. ODFW Tillamook office. Tillamook, OR.

Oregon Department of Fish and Wildlife (ODFW) 2000. ODFW 2000 screw trap data. ODFW Tillamook office, Tillamook, OR.

Oregon Department of Fish and Wildlife (ODFW) 1999-2000. ODFW annual gill net records for Tillamook Bay 1999-2000. ODFW Tillamook office, Tillamook, OR.

Pearcy, W.G., and Joseph P. Fisher. 1990. Distribution and abundance of juvenile salmonids off Oregon and Washington, 1981-1985**.** U.S. Dept. of Commerce, National Marine Fisheries Service, Seattle, WA.

Pearcy, W.G. and S.S. Myers. 1974. Larval fishes of Yaquina Bay, Oregon: a nursery ground for marine fishes? Fishery Bull. 72:201-213.

Pedersen, M., and G. DiDonato. 1982. Groundfish management plan for Washington's inside waters. Prog. Report. No. 170, Wash. Dept. Fish. Olympia, WA. 123 pp.

Peterson, William T. and Stewart M. McKinnell, 2000. Ocean ecology of juvenile salmonids along the North American coast. As reported in the National Pacific Marine Science Organization newsletter. pp. 25-28.

Posey, M.H. 1986. Predation on burrowing shrimp: distribution and community consequences. J. Exp. Mar. Biol. Ecol. 103:143-161.

Reimers, P.E. 1973. The length of residence of juvenile fall chinook salmon in the Sixes River, Oregon. P. 1-43 in R.T. Gunsolous (ed.) Research Reports of the fisheries commission of Oregon, Portland, OR 4:2.

Sadro, S. 1999. Winchester Tidelands Monitoring Report. South Slough National Estuarine Research Reserve, Charleston, OR.

SAS Institute Inc. 1996. The GENMOD Procedure, Chapter 29. SAS OnlineDoc™: Version 8.

Shreffler, D.K., C.A. Simenstad, and R.M. Thom. 1990. Temporary residence by juvenile salmon in a restored estuarine wetland. Can. J. Fish Aquatic Sci. 47:2079-2084.

Simenstad C. D., and E. Salo. 1982. Foraging success as a determinant of estuarine and nearshore carrying capacity of juvenile chum salmon, *Oncorhynchus keta*, in Hood Canal, Washington. As cited in: B.R. Miteff and R. A. Neve, *ed*., Proc. North Pacific Aquaculture Symposium Report 82-2. Alaska Sea Grant Program, University of Alaska, Fairbanks AK.

Stevens, B. and D.A. Armstrong. 1984. Distribution, abundance, and growth of juvenile Dungeness Crabs (*Cancer magister*) in Grays Harbor estuary, WA. Fish. Bull. U.S. 82:469-483.

Westerheim, S.J. 1955. Size composition, growth, and seasonal abundance of juvenile English sole (Parophrys vetulus) in Yaquina Bay. Research Brief, Fish Comm. Oreg., 7:4-9.

Wydoski, R.S. and R.R. Whitney. 1979. *Inland Fishes of Washington.* University of Washington Press. 220 pp.

APPENDIX A

Tests Of Significance For Main Effects And Selected Interactions For Selected Species Caught By Beach Seine In Tillamook Bay 1999-2001.

Appendix A. GENMOD procedure Type 3 output. Tests of significance for main effects and selected interactions for selected species caught by beach seine in Tillamook Bay 1999-2001.

Species	Source	Degrees of Freedom	Chi Square	Probability of a Larger Chi Square
Chinook Salmon	Block	2	33.23	0.0000
Chinook Salmon	Treatment	1	44.11	0.0000
Chinook Salmon	Year	2	22.67	0.0000
Chinook Salmon	month	2	19.82	0.0000
Chinook Salmon	period(month)	3	12.88	0.0049
Chinook Salmon	Block*Treatment	2	5.05	0.0801
Chinook Salmon	Block*Year	4	14.57	0.0057
Chinook Salmon	Block*month	4	21.30	0.0003
Chinook Salmon	Treatment*Year	2	1.69	0.4286
Chinook Salmon	Treatment*month	2	1.56	0.4593
Chum_Salmon	Block	2	22.31	0.0000
Chum_Salmon	Treatment	1	0.53	0.4663
Chum_Salmon	Year	2	2.49	0.2874
Chum_Salmon	month	2	123.87	0.0000
Chum_Salmon	period(month)	3	10.83	0.0127
Chum_Salmon	Block*Treatment	2	2.84	0.2412
Chum_Salmon	Block*Year	4	7.05	0.1335
Chum_Salmon	Block*month	4	3.50	0.4772
Chum_Salmon	Treatment*Year	2	1.72	0.4229
Chum_Salmon	Treatment*month	2	13.40	0.0012
English_Sole	Block	2	53.59	0.0000
English_Sole	Treatment	1	5.17	0.0229
English_Sole	Year	2	0.41	0.8134
English_Sole	month	2	6.97	0.0307
English_Sole	period(month)	3	1.52	0.6767
English_Sole	Block*Treatment	2	37.47	0.0000
English_Sole	Block*Year	4	1.39	0.8466
English_Sole	Block*month	4	1.69	0.7929
English_Sole	Treatment*Year	2	3.43	0.1803
English_Sole	Treatment*month	2	0.38	0.8261
Pacific_Sand_Lance	Block	2	58.23	0.0000
Pacific_Sand_Lance	Treatment	1	0.00	1.0000
Pacific_Sand_Lance	Year	2	0.00	1.0000
Pacific_Sand_Lance	month	2	0.00	1.0000
Pacific_Sand_Lance	period(month)	3	2.17	0.5380
Pacific_Sand_Lance	Block*Treatment	2	0.04	0.9784
Pacific_Sand_Lance	Block*Year	4	2.18	0.7025
Pacific_Sand_Lance	Block*month	4	1.31	0.8603
Pacific_Sand_Lance	Treatment*Year	2	1.65	0.4386
Pacific_Sand_Lance	Treatment*month	2	1.35	0.5082
Pacific_Staghorn_Sculpin	Block	2	33.97	0.0000
Pacific_Staghorn_Sculpin	Treatment	1	61.61	0.0000
Pacific_Staghorn_Sculpin	Year	2	13.38	0.0012
Pacific_Staghorn_Sculpin	month	2	20.13	0.0000
Pacific_Staghorn_Sculpin	period(month)	3	8.98	0.0296

Pacific_Staghorn_Sculpin	Block*Treatment	2	10.89	0.0043
Pacific_Staghorn_Sculpin	Block*Year	4	2.99	0.5603
Pacific_Staghorn_Sculpin	Block*month	4	10.19	0.0374
Pacific_Staghorn_Sculpin	Treatment*Year	2	8.62	0.0134
Pacific_Staghorn_Sculpin	Treatment*month	2	0.07	0.9668
Shiner_Perch	Block	2	72.65	0.0000
Shiner_Perch	Treatment	1	81.67	0.0000
Shiner_Perch	Year	2	12.22	0.0022
Shiner_Perch	month	2	55.47	0.0000
Shiner_Perch	period(month)	3	44.16	0.0000
Shiner_Perch	Block*Treatment	2	47.72	0.0000
Shiner_Perch	Block*Year	4	12.71	0.0128
Shiner_Perch	Block*month	4	7.88	0.0962
Shiner_Perch	Treatment*Year	2	5.01	0.0817
Shiner_Perch	Treatment*month	2	6.62	0.0366
Starry_Flounder	Block	2	26.25	0.0000
Starry_Flounder	Treatment	1	22.96	0.0000
Starry_Flounder	Year	2	0.67	0.7171
Starry_Flounder	month	2	1.89	0.3891
Starry_Flounder	period(month)	3	2.65	0.4484
Starry_Flounder	Block*Treatment	2	14.70	0.0006
Starry_Flounder	Block*Year	4	6.59	0.1591
Starry_Flounder	Block*month	4	8.39	0.0784
Starry_Flounder	Treatment*Year	2	4.48	0.1065
Starry_Flounder	Treatment*month	2	4.45	0.1078
Surf_Smelt	Block	2	60.78	0.0000
Surf_Smelt	Treatment	1	1.09	0.2956
Surf_Smelt	Year	2	1.22	0.5438
Surf_Smelt	month	2	35.06	0.0000
Surf_Smelt	period(month)	3	1.33	0.7220
Surf_Smelt	Block*Treatment	2	4.10	0.1289
Surf_Smelt	Block*Year	4	4.23	0.3762
Surf_Smelt	Block*month	4	40.16	0.0000
Surf_Smelt	Treatment*Year	2	9.02	0.0110
Surf_Smelt	Treatment*month	2	8.13	0.0171

APPENDIX B

Comparisons Of Differences Between Individual Means For Main Effects And Interactions In Beach Seine Data For Selected Species.

Appendix B. GENMOD output. Comparisons of differences between individual means for main effects and interactions in beach seine data for selected species.

Effect	Block	Treatment	Year	Month	period	_Block	_Treatment	_Year	_Month	_period	Estimate	StdErr	exp(est)	DF	ChiSq	ProbChiSq
Block	1					2					1.730	0.439	5.6	1	15.54	0.0001
Block	1					3					-0.539	0.333	0.6	1	2.62	0.1052
Block	2					3					-2.269	0.434	0.1	1	27.33	0.0000
Treatment		1					2				2.089	0.340	8.1	1	37.82	0.0000
Year			1999					2000			-1.748	0.391	0.2	1	20.02	0.0000
Year			1999					2001			-1.601	0.415	0.2	1	14.91	0.0001
Year			2000					2001			0.146	0.317	1.2	1	0.21	0.6445
Month				1_May					2_June		-1.220	0.385	0.3	1	10.03	0.0015
Month				1_May					3_July		-1.691	0.411	0.2	1	16.92	0.0000
Month				2_June					3_July		-0.470	0.329	0.6	1	2.04	0.1531
period(Month)				1_May	early				1_May	late	-0.707	0.532	0.5	1	1.77	0.1834
period(Month)				1_May	early				2_June	early	-0.962	0.565	0.4	1	2.90	0.0887
period(Month)				1_May	early				2_June	late	-2.186	0.565	0.1	1	14.97	0.0001
period(Month)				1_May	early				3_July	early	-1.549	0.578	0.2	1	7.19	0.0073
period(Month)				1_May	early				3_July	late	-2.540	0.574	0.1	1	19.54	0.0000
period(Month)				1_May	late				2_June	early	-0.255	0.474	0.8	1	0.29	0.5901
period(Month)				1_May	late				2_June	late	-1.479	0.472	0.2	1	9.82	0.0017
period(Month)				1_May	late				3_July	early	-0.842	0.504	0.4	1	2.79	0.0950
period(Month)				1_May	late				3_July	late	-1.832	0.494	0.2	1	13.77	0.0002
period(Month)				2_June	early				2_June	late	-1.223	0.457	0.3	1	7.16	0.0075
period(Month)				2_June	early				3_July	early	-0.586	0.475	0.6	1	1.52	0.2169
period(Month)				2_June	early				3_July	late	-1.577	0.470	0.2	1	11.26	0.0008
period(Month)				2_June	late				3_July	early	0.637	0.466	1.9	1	1.87	0.1720
period(Month)				2_June	late				3_July	late	-0.354	0.426	0.7	1	0.69	0.4059
period(Month)				3_July	early				3_July	late	-0.991	0.451	0.4	1	4.84	0.0279
Block*Treatment	1	1				1	2				1.946	0.487	7.0	1	15.99	0.0001
Block*Treatment	1	1				2	1				1.174	0.400	3.2	1	8.60	0.0034
Block*Treatment	1	1				2	2				4.232	0.734	68.9	1	33.22	0.0000
Block*Treatment	1	1				3	1				-0.197	0.391	0.8	1	0.25	0.6137

Block*Treatment	1	1				3	2				1.066	0.433	2.9	1	6.05	0.0139
Block*Treatment	1	2				2	1				-0.773	0.499	0.5	1	2.40	0.1215
Block*Treatment	1	2				2	2				2.286	0.766	9.8	1	8.91	0.0028
Block*Treatment	1	2				3	1				-2.143	0.503	0.1	1	18.14	0.0000
Block*Treatment	1	2				3	2				-0.881	0.534	0.4	1	2.71	0.0994
Block*Treatment	2	1				2	2				3.058	0.726	21.3	1	17.73	0.0000
Block*Treatment	2	1				3	1				-1.371	0.405	0.3	1	11.46	0.0007
Block*Treatment	2	1				3	2				-0.108	0.445	0.9	1	0.06	0.8080
Block*Treatment	2	2				3	1				-4.429	0.747	0.0	1	35.18	0.0000
Block*Treatment	2	2				3	2				-3.167	0.749	0.0	1	17.87	0.0000
Block*Treatment	3	1				3	2				1.263	0.447	3.5	1	7.99	0.0047
Block*Year	1		1999			1		2000			-0.799	0.515	0.4	1	2.40	0.1213
Block*Year	1		1999			1		2001			0.152	0.564	1.2	1	0.07	0.7870
Block*Year	1		1999			2		1999			2.914	0.811	18.4	1	12.91	0.0003
Block*Year	1		1999			2		2000			1.105	0.662	3.0	1	2.79	0.0950
Block*Year	1		1999			2		2001			0.524	0.595	1.7	1	0.78	0.3779
Block*Year	1		1999			3		1999			0.980	0.590	2.7	1	2.76	0.0965
Block*Year	1		1999			3		2000			-1.656	0.538	0.2	1	9.48	0.0021
Block*Year	1		1999			3		2001			-1.587	0.558	0.2	1	8.11	0.0044
Block*Year	1		2000			1		2001			0.951	0.516	2.6	1	3.39	0.0654
Block*Year	1		2000			2		1999			3.712	0.804	40.9	1	21.32	0.0000
Block*Year	1		2000			2		2000			1.903	0.615	6.7	1	9.58	0.0020
Block*Year	1		2000			2		2001			1.323	0.550	3.8	1	5.79	0.0161
Block*Year	1		2000			3		1999			1.779	0.585	5.9	1	9.25	0.0024
Block*Year	1		2000			3		2000			-0.857	0.486	0.4	1	3.11	0.0779
Block*Year	1		2000			3		2001			-0.789	0.491	0.5	1	2.58	0.1084
Block*Year	1		2001			2		1999			2.761	0.839	15.8	1	10.83	0.0010
Block*Year	1		2001			2		2000			0.952	0.657	2.6	1	2.10	0.1469
Block*Year	1		2001			2		2001			0.372	0.582	1.5	1	0.41	0.5227
Block*Year	1		2001			3		1999			0.828	0.626	2.3	1	1.75	0.1861
Block*Year	1		2001			3		2000			-1.808	0.523	0.2	1	11.95	0.0005
Block*Year	1		2001			3		2001			-1.740	0.532	0.2	1	10.69	0.0011

Block*Year	2		1999			2		2000			-1.809	0.764	0.2	1	5.60	0.0180
Block*Year	2		1999			2		2001			-2.389	0.810	0.1	1	8.70	0.0032
Block*Year	2		1999			3		1999			-1.934	0.809	0.1	1	5.72	0.0168
Block*Year	2		1999			3		2000			-4.570	0.808	0.0	1	31.95	0.0000
Block*Year	2		1999			3		2001			-4.501	0.811	0.0	1	30.78	0.0000
Block*Year	2		2000			2		2001			-0.580	0.654	0.6	1	0.79	0.3750
Block*Year	2		2000			3		1999			-0.125	0.696	0.9	1	0.03	0.8581
Block*Year	2		2000			3		2000			-2.761	0.617	0.1	1	20.00	0.0000
Block*Year	2		2000			3		2001			-2.692	0.619	0.1	1	18.89	0.0000
Block*Year	2		2001			3		1999			0.456	0.640	1.6	1	0.51	0.4765
Block*Year	2		2001			3		2000			-2.180	0.547	0.1	1	15.90	0.0001
Block*Year	2		2001			3		2001			-2.112	0.557	0.1	1	14.37	0.0002
Block*Year	3		1999			3		2000			-2.636	0.570	0.1	1	21.41	0.0000
Block*Year	3		1999			3		2001			-2.567	0.581	0.1	1	19.55	0.0000
Block*Year	3		2000			3		2001			0.069	0.457	1.1	1	0.02	0.8807
Block*Month	1			1_May		1			2_June		-1.366	0.645	0.3	1	4.48	0.0343
Block*Month	1			1_May		1			3_July		-3.377	0.629	0.0	1	28.86	0.0000
Block*Month	1			1_May		2			1_May		1.224	0.843	3.4	1	2.11	0.1462
Block*Month	1			1_May		2			2_June		-0.327	0.727	0.7	1	0.20	0.6527
Block*Month	1			1_May		2			3_July		-0.451	0.723	0.6	1	0.39	0.5325
Block*Month	1			1_May		3			1_May		-1.865	0.653	0.2	1	8.16	0.0043
Block*Month	1			1_May		3			2_June		-2.609	0.630	0.1	1	17.17	0.0000
Block*Month	1			1_May		3			3_July		-1.885	0.677	0.2	1	7.74	0.0054
Block*Month	1			2_June		1			3_July		-2.011	0.507	0.1	1	15.71	0.0001
Block*Month	1			2_June		2			1_May		2.590	0.830	13.3	1	9.75	0.0018
Block*Month	1			2_June		2			2_June		1.039	0.597	2.8	1	3.03	0.0817
Block*Month	1			2_June		2			3_July		0.915	0.619	2.5	1	2.18	0.1396
Block*Month	1			2_June		3			1_May		-0.499	0.523	0.6	1	0.91	0.3399
Block*Month	1			2_June		3			2_June		-1.243	0.521	0.3	1	5.69	0.0171
Block*Month	1			2_June		3			3_July		-0.519	0.564	0.6	1	0.85	0.3579
Block*Month	1			3_July		2			1_May		4.601	0.795	99.6	1	33.51	0.0000
Block*Month	1			3_July		2			2_June		3.050	0.573	21.1	1	28.30	0.0000

Block*Month	1			3_July		2			3_July		2.926	0.571	18.6	1	26.23	0.0000
Block*Month	1			3_July		3			1_May		1.511	0.479	4.5	1	9.95	0.0016
Block*Month	1			3_July		3			2_June		0.767	0.460	2.2	1	2.79	0.0950
Block*Month	1			3_July		3			3_July		1.492	0.505	4.4	1	8.73	0.0031
Block*Month	2			1_May		2			2_June		-1.551	0.771	0.2	1	4.05	0.0441
Block*Month	2			1_May		2			3_July		-1.675	0.830	0.2	1	4.08	0.0434
Block*Month	2			1_May		3			1_May		-3.090	0.823	0.0	1	14.09	0.0002
Block*Month	2			1_May		3			2_June		-3.834	0.805	0.0	1	22.68	0.0000
Block*Month	2			1_May		3			3_July		-3.109	0.847	0.0	1	13.46	0.0002
Block*Month	2			2_June		2			3_July		-0.124	0.626	0.9	1	0.04	0.8428
Block*Month	2			2_June		3			1_May		-1.539	0.588	0.2	1	6.85	0.0089
Block*Month	2			2_June		3			2_June		-2.282	0.581	0.1	1	15.41	0.0001
Block*Month	2			2_June		3			3_July		-1.558	0.630	0.2	1	6.11	0.0134
Block*Month	2			3_July		3			1_May		-1.414	0.585	0.2	1	5.84	0.0156
Block*Month	2			3_July		3			2_June		-2.158	0.569	0.1	1	14.40	0.0001
Block*Month	2			3_July		3			3_July		-1.434	0.596	0.2	1	5.79	0.0162
Block*Month	3			1_May		3			2_June		-0.744	0.475	0.5	1	2.45	0.1176
Block*Month	3			1_May		3			3_July		-0.019	0.534	1.0	1	0.00	0.9712
Block*Month	3			2_June		3			3_July		0.725	0.515	2.1	1	1.98	0.1595
Treatment*Year		1	1999				1	2000			-1.359	0.413	0.3	1	10.83	0.0010
Treatment*Year		1	1999				1	2001			-1.141	0.454	0.3	1	6.31	0.0120
Treatment*Year		1	1999				2	1999			2.655	0.630	14.2	1	17.78	0.0000
Treatment*Year		1	1999				2	2000			0.519	0.502	1.7	1	1.07	0.3009
Treatment*Year		1	1999				2	2001			0.593	0.496	1.8	1	1.43	0.2324
Treatment*Year		1	2000				1	2001			0.219	0.400	1.2	1	0.30	0.5844
Treatment*Year		1	2000				2	1999			4.015	0.629	55.4	1	40.73	0.0000
Treatment*Year		1	2000				2	2000			1.879	0.451	6.5	1	17.32	0.0000
Treatment*Year		1	2000				2	2001			1.952	0.446	7.0	1	19.15	0.0000
Treatment*Year		1	2001				2	1999			3.796	0.668	44.5	1	32.30	0.0000
Treatment*Year		1	2001				2	2000			1.660	0.496	5.3	1	11.21	0.0008
Treatment*Year		1	2001				2	2001			1.733	0.479	5.7	1	13.09	0.0003
Treatment*Year		2	1999				2	2000			-2.136	0.627	0.1	1	11.62	0.0007

Treatment*Year		2	1999				2	2001			-2.062	0.645	0.1	1	10.24	0.0014
Treatment*Year		2	2000				2	2001			0.074	0.481	1.1	1	0.02	0.8778
Treatment*Month		1		1_May			1		2_June		-1.158	0.414	0.3	1	7.84	0.0051
Treatment*Month		1		1_May			1		3_July		-1.283	0.430	0.3	1	8.89	0.0029
Treatment*Month		1		1_May			2		1_May		2.402	0.674	11.0	1	12.71	0.0004
Treatment*Month		1		1_May			2		2_June		1.120	0.501	3.1	1	4.99	0.0255
Treatment*Month		1		1_May			2		3_July		0.304	0.489	1.4	1	0.39	0.5341
Treatment*Month		1		2_June			1		3_July		-0.124	0.384	0.9	1	0.10	0.7461
Treatment*Month		1		2_June			2		1_May		3.561	0.653	35.2	1	29.73	0.0000
Treatment*Month		1		2_June			2		2_June		2.278	0.477	9.8	1	22.84	0.0000
Treatment*Month		1		2_June			2		3_July		1.462	0.455	4.3	1	10.35	0.0013
Treatment*Month		1		3_July			2		1_May		3.685	0.672	39.9	1	30.10	0.0000
Treatment*Month		1		3_July			2		2_June		2.403	0.495	11.1	1	23.59	0.0000
Treatment*Month		1		3_July			2		3_July		1.587	0.465	4.9	1	11.65	0.0006
Treatment*Month		2		1_May			2		2_June		-1.283	0.653	0.3	1	3.86	0.0495
Treatment*Month		2		1_May			2		3_July		-2.098	0.686	0.1	1	9.36	0.0022
Treatment*Month		2		2_June			2		3_July		-0.816	0.527	0.4	1	2.40	0.1215
Block	1					2					11.852	585.400	140355.4	1	0.00	0.9838
Block	1					3					1.578	0.645	4.8	1	5.99	0.0144
Block	2					3					-10.274	585.401	0.0	1	0.00	0.9860
Treatment		1					2				3.858	167.838	47.4	1	0.00	0.9817
Year			1999					2000			0.880	0.548	2.4	1	2.57	0.1086
Year			1999					2001			0.317	0.599	1.4	1	0.28	0.5968
Year			2000					2001			-0.563	0.622	0.6	1	0.82	0.3659
Month				1_May					2_June		15.358	385.817	######	1	0.00	0.9682
Month				1_May					3_July		16.813	629.967	######	1	0.00	0.9787
Month				2_June					3_July		1.455	738.725	4.3	1	0.00	0.9984
period(Month)				1_May	early				1_May	late	1.238	0.576	3.4	1	4.62	0.0316
period(Month)				1_May	early				2_June	early	16.124	385.818	######	1	0.00	0.9667
period(Month)				1_May	early				2_June	late	15.829	385.818	######	1	0.00	0.9673
period(Month)				1_May	early				3_July	early	25.022	903.203	######	1	0.00	0.9779
period(Month)				1_May	early				3_July	late	9.841	507.169	18790.9	1	0.00	0.9845

period(Month)				1_May	late				2_June	early	14.886	385.818	######	1	0.00	0.9692
period(Month)				1_May	late				2_June	late	14.592	385.818	######	1	0.00	0.9698
period(Month)				1_May	late				3_July	early	23.784	903.203	######	1	0.00	0.9790
period(Month)				1_May	late				3_July	late	8.603	507.169	5450.3	1	0.00	0.9865
period(Month)				2_June	early				2_June	late	-0.294	0.993	0.7	1	0.09	0.7671
period(Month)				2_June	early				3_July	early	8.898	982.157	7318.7	1	0.00	0.9928
period(Month)				2_June	early				3_July	late	-6.282	637.240	0.0	1	0.00	0.9921
period(Month)				2_June	late				3_July	early	9.192	982.157	9821.5	1	0.00	0.9925
period(Month)				2_June	late				3_July	late	-5.988	637.240	0.0	1	0.00	0.9925
period(Month)				3_July	early				3_July	late	-15.181	747.367	0.0	1	0.00	0.9838
Block*Treatment	1	1				1	2				4.182	167.838	65.5	1	0.00	0.9801
Block*Treatment	1	1				2	1				12.607	585.401	298507.7	1	0.00	0.9828
Block*Treatment	1	1				2	2				15.279	608.985	4321212.2	1	0.00	0.9800
Block*Treatment	1	1				3	1				1.308	0.771	3.7	1	2.88	0.0896
Block*Treatment	1	1				3	2				6.029	167.840	415.2	1	0.00	0.9713
Block*Treatment	1	2				2	1				8.425	608.986	4558.8	1	0.00	0.9890
Block*Treatment	1	2				2	2				11.097	585.401	65993.7	1	0.00	0.9849
Block*Treatment	1	2				3	1				-2.873	167.839	0.1	1	0.00	0.9863
Block*Treatment	1	2				3	2				1.847	0.958	6.3	1	3.72	0.0538
Block*Treatment	2	1				2	2				2.672	167.841	14.5	1	0.00	0.9873
Block*Treatment	2	1				3	1				-11.298	585.401	0.0	1	0.00	0.9846
Block*Treatment	2	1				3	2				-6.578	608.986	0.0	1	0.00	0.9914
Block*Treatment	2	2				3	1				-13.971	608.986	0.0	1	0.00	0.9817
Block*Treatment	2	2				3	2				-9.250	585.401	0.0	1	0.00	0.9874
Block*Treatment	3	1				3	2				4.720	167.840	112.2	1	0.00	0.9776
Block*Year	1		1999			1		2000			-0.476	0.880	0.6	1	0.29	0.5890
Block*Year	1		1999			1		2001			0.840	0.936	2.3	1	0.81	0.3691
Block*Year	1		1999			2		1999			11.544	585.401	103201.3	1	0.00	0.9843
Block*Year	1		1999			2		2000			13.117	585.401	497438.0	1	0.00	0.9821
Block*Year	1		1999			2		2001			11.259	585.401	77570.6	1	0.00	0.9847
Block*Year	1		1999			3		1999			1.053	0.961	2.9	1	1.20	0.2733
Block*Year	1		1999			3		2000			2.595	0.965	13.4	1	7.24	0.0071

Block*Year	1		1999			3		2001			1.449	1.014	4.3	1	2.05	0.1527
Block*Year	1		2000			1		2001			1.316	0.904	3.7	1	2.12	0.1453
Block*Year	1		2000			2		1999			12.020	585.401	166055.7	1	0.00	0.9836
Block*Year	1		2000			2		2000			13.593	585.401	800400.5	1	0.00	0.9815
Block*Year	1		2000			2		2001			11.735	585.401	124814.6	1	0.00	0.9840
Block*Year	1		2000			3		1999			1.529	0.909	4.6	1	2.83	0.0926
Block*Year	1		2000			3		2000			3.071	0.985	21.6	1	9.73	0.0018
Block*Year	1		2000			3		2001			1.925	1.023	6.9	1	3.54	0.0599
Block*Year	1		2001			2		1999			10.704	585.401	44533.1	1	0.00	0.9854
Block*Year	1		2001			2		2000			12.277	585.401	214652.8	1	0.00	0.9833
Block*Year	1		2001			2		2001			10.418	585.401	33473.0	1	0.00	0.9858
Block*Year	1		2001			3		1999			0.213	0.986	1.2	1	0.05	0.8291
Block*Year	1		2001			3		2000			1.755	1.030	5.8	1	2.90	0.0886
Block*Year	1		2001			3		2001			0.609	0.995	1.8	1	0.37	0.5404
Block*Year	2		1999			2		2000			1.573	1.162	4.8	1	1.83	0.1759
Block*Year	2		1999			2		2001			-0.285	1.000	0.8	1	0.08	0.7753
Block*Year	2		1999			3		1999			-10.491	585.401	0.0	1	0.00	0.9857
Block*Year	2		1999			3		2000			-8.949	585.401	0.0	1	0.00	0.9878
Block*Year	2		1999			3		2001			-10.095	585.401	0.0	1	0.00	0.9862
Block*Year	2		2000			2		2001			-1.858	1.194	0.2	1	2.42	0.1197
Block*Year	2		2000			3		1999			-12.064	585.401	0.0	1	0.00	0.9836
Block*Year	2		2000			3		2000			-10.522	585.401	0.0	1	0.00	0.9857
Block*Year	2		2000			3		2001			-11.668	585.402	0.0	1	0.00	0.9841
Block*Year	2		2001			3		1999			-10.206	585.401	0.0	1	0.00	0.9861
Block*Year	2		2001			3		2000			-8.664	585.401	0.0	1	0.00	0.9882
Block*Year	2		2001			3		2001			-9.810	585.401	0.0	1	0.00	0.9866
Block*Year	3		1999			3		2000			1.542	0.878	4.7	1	3.08	0.0790
Block*Year	3		1999			3		2001			0.396	0.995	1.5	1	0.16	0.6906
Block*Year	3		2000			3		2001			-1.146	0.882	0.3	1	1.69	0.1939
Block*Month	1			1_May		1			2_June		10.330	251.756	30629.8	1	0.00	0.9673
Block*Month	1			1_May		1			3_July		11.652	373.684	114962.4	1	0.00	0.9751
Block*Month	1			1_May		2			1_May		2.521	0.636	12.4	1	15.72	0.0001

Block*Month	1			1_May		2			2_June		26.050	912.495	######	1	0.00	0.9772
Block*Month	1			1_May		2			3_July		28.967	1566.721	######	1	0.00	0.9852
Block*Month	1			1_May		3			1_May		0.720	0.601	2.1	1	1.43	0.2313
Block*Month	1			1_May		3			2_June		12.935	251.759	414619.5	1	0.00	0.9590
Block*Month	1			1_May		3			3_July		13.060	373.685	469869.9	1	0.00	0.9721
Block*Month	1			2_June		1			3_July		1.323	450.578	3.8	1	0.00	0.9977
Block*Month	1			2_June		2			1_May		-7.808	251.756	0.0	1	0.00	0.9753
Block*Month	1			2_June		2			2_June		15.720	877.078	######	1	0.00	0.9857
Block*Month	1			2_June		2			3_July		18.637	1586.820	######	1	0.00	0.9906
Block*Month	1			2_June		3			1_May		-9.610	251.756	0.0	1	0.00	0.9696
Block*Month	1			2_June		3			2_June		2.605	1.337	13.5	1	3.80	0.0514
Block*Month	1			2_June		3			3_July		2.730	450.579	15.3	1	0.00	0.9952
Block*Month	1			3_July		2			1_May		-9.131	373.684	0.0	1	0.00	0.9805
Block*Month	1			3_July		2			2_June		14.397	986.045	######	1	0.00	0.9884
Block*Month	1			3_July		2			3_July		17.314	1521.505	######	1	0.00	0.9909
Block*Month	1			3_July		3			1_May		-10.932	373.684	0.0	1	0.00	0.9767
Block*Month	1			3_July		3			2_June		1.283	450.579	3.6	1	0.00	0.9977
Block*Month	1			3_July		3			3_July		1.408	1.464	4.1	1	0.92	0.3363
Block*Month	2			1_May		2			2_June		23.528	912.495	######	1	0.00	0.9794
Block*Month	2			1_May		2			3_July		26.445	1566.721	######	1	0.00	0.9865
Block*Month	2			1_May		3			1_May		-1.802	0.586	0.2	1	9.44	0.0021
Block*Month	2			1_May		3			2_June		10.414	251.759	33310.2	1	0.00	0.9670
Block*Month	2			1_May		3			3_July		10.539	373.685	37749.0	1	0.00	0.9775
Block*Month	2			2_June		2			3_July		2.917	1813.081	18.5	1	0.00	0.9987
Block*Month	2			2_June		3			1_May		-25.330	912.495	0.0	1	0.00	0.9779
Block*Month	2			2_June		3			2_June		-13.115	877.078	0.0	1	0.00	0.9881
Block*Month	2			2_June		3			3_July		-12.989	986.046	0.0	1	0.00	0.9895
Block*Month	2			3_July		3			1_May		-28.247	1566.721	0.0	1	0.00	0.9856
Block*Month	2			3_July		3			2_June		-16.032	1586.820	0.0	1	0.00	0.9919
Block*Month	2			3_July		3			3_July		-15.907	1521.505	0.0	1	0.00	0.9917
Block*Month	3			1_May		3			2_June		12.215	251.759	201831.0	1	0.00	0.9613
Block*Month	3			1_May		3			3_July		12.340	373.685	228726.1	1	0.00	0.9737

Block*Month	3			2_June		3			3_July		0.125	450.581	1.1	1	0.00	0.9998
Treatment*Year		1	1999				1	2000			1.102	0.841	3.0	1	1.72	0.1903
Treatment*Year		1	1999				1	2001			1.035	0.834	2.8	1	1.54	0.2147
Treatment*Year		1	1999				2	1999			4.485	167.840	88.7	1	0.00	0.9787
Treatment*Year		1	1999				2	2000			5.143	167.839	171.2	1	0.00	0.9756
Treatment*Year		1	1999				2	2001			4.084	167.840	59.4	1	0.00	0.9806
Treatment*Year		1	2000				1	2001			-0.067	0.780	0.9	1	0.01	0.9318
Treatment*Year		1	2000				2	1999			3.383	167.840	29.5	1	0.00	0.9839
Treatment*Year		1	2000				2	2000			4.041	167.839	56.9	1	0.00	0.9808
Treatment*Year		1	2000				2	2001			2.982	167.840	19.7	1	0.00	0.9858
Treatment*Year		1	2001				2	1999			3.450	167.840	31.5	1	0.00	0.9836
Treatment*Year		1	2001				2	2000			4.108	167.839	60.8	1	0.00	0.9805
Treatment*Year		1	2001				2	2001			3.049	167.840	21.1	1	0.00	0.9855
Treatment*Year		2	1999				2	2000			0.658	0.768	1.9	1	0.73	0.3917
Treatment*Year		2	1999				2	2001			-0.401	0.819	0.7	1	0.24	0.6244
Treatment*Year		2	2000				2	2001			-1.059	0.869	0.3	1	1.49	0.2229
Treatment*Month		1		1_May			1		2_June		7.228	292.360	1377.4	1	0.00	0.9803
Treatment*Month		1		1_May			1		3_July		17.165	629.968	######	1	0.00	0.9783
Treatment*Month		1		1_May			2		1_May		-1.327	0.519	0.3	1	6.52	0.0107
Treatment*Month		1		1_May			2		2_June		22.161	582.236	######	1	0.00	0.9696
Treatment*Month		1		1_May			2		3_July		15.133	629.967	######	1	0.00	0.9808
Treatment*Month		1		2_June			1		3_July		9.937	694.503	20687.7	1	0.00	0.9886
Treatment*Month		1		2_June			2		1_May		-8.554	292.360	0.0	1	0.00	0.9767
Treatment*Month		1		2_June			2		2_June		14.933	503.512	######	1	0.00	0.9763
Treatment*Month		1		2_June			2		3_July		7.906	694.502	2712.2	1	0.00	0.9909
Treatment*Month		1		3_July			2		1_May		-18.492	629.968	0.0	1	0.00	0.9766
Treatment*Month		1		3_July			2		2_June		4.996	857.822	147.8	1	0.00	0.9954
Treatment*Month		1		3_July			2		3_July		-2.032	1.485	0.1	1	1.87	0.1713
Treatment*Month		2		1_May			2		2_June		23.487	582.236	######	1	0.00	0.9678
Treatment*Month		2		1_May			2		3_July		16.460	629.967	######	1	0.00	0.9792
Treatment*Month		2		2_June			2		3_July		-7.027	857.821	0.0	1	0.00	0.9935
Block	1					2					-0.230	0.365	0.8	1	0.40	0.5291

Block	1					3					3.242	0.463	25.6	1	48.95	0.0000
Block	2					3					3.471	0.464	32.2	1	56.06	0.0000
Treatment		1					2				-0.843	0.357	0.4	1	5.58	0.0181
Year			1999					2000			-0.010	0.447	1.0	1	0.00	0.9818
Year			1999					2001			-0.252	0.445	0.8	1	0.32	0.5702
Year			2000					2001			-0.242	0.449	0.8	1	0.29	0.5894
Month				1_May					2_June		-0.638	0.438	0.5	1	2.12	0.1452
Month				1_May					3_July		0.487	0.455	1.6	1	1.14	0.2853
Month				2_June					3_July		1.125	0.423	3.1	1	7.06	0.0079
period(Month)				1_May	early				1_May	late	-0.202	0.580	0.8	1	0.12	0.7279
period(Month)				1_May	early				2_June	early	-0.834	0.575	0.4	1	2.11	0.1467
period(Month)				1_May	early				2_June	late	-0.645	0.595	0.5	1	1.17	0.2789
period(Month)				1_May	early				3_July	early	0.717	0.612	2.0	1	1.37	0.2410
period(Month)				1_May	early				3_July	late	0.054	0.615	1.1	1	0.01	0.9298
period(Month)				1_May	late				2_June	early	-0.632	0.613	0.5	1	1.06	0.3024
period(Month)				1_May	late				2_June	late	-0.443	0.629	0.6	1	0.50	0.4811
period(Month)				1_May	late				3_July	early	0.919	0.624	2.5	1	2.17	0.1407
period(Month)				1_May	late				3_July	late	0.256	0.618	1.3	1	0.17	0.6790
period(Month)				2_June	early				2_June	late	0.189	0.593	1.2	1	0.10	0.7496
period(Month)				2_June	early				3_July	early	1.551	0.589	4.7	1	6.94	0.0084
period(Month)				2_June	early				3_July	late	0.888	0.596	2.4	1	2.22	0.1360
period(Month)				2_June	late				3_July	early	1.362	0.630	3.9	1	4.67	0.0306
period(Month)				2_June	late				3_July	late	0.699	0.573	2.0	1	1.49	0.2226
period(Month)				3_July	early				3_July	late	-0.663	0.599	0.5	1	1.23	0.2679
Block*Treatment	1	1				1	2				-3.711	0.514	0.0	1	52.07	0.0000
Block*Treatment	1	1				2	1				-1.618	0.550	0.2	1	8.67	0.0032
Block*Treatment	1	1				2	2				-2.552	0.535	0.1	1	22.73	0.0000
Block*Treatment	1	1				3	1				0.328	0.563	1.4	1	0.34	0.5608
Block*Treatment	1	1				3	2				2.445	0.761	11.5	1	10.31	0.0013
Block*Treatment	1	2				2	1				2.093	0.510	8.1	1	16.87	0.0000
Block*Treatment	1	2				2	2				1.159	0.494	3.2	1	5.51	0.0189
Block*Treatment	1	2				3	1				4.038	0.533	56.7	1	57.32	0.0000

Block*Treatment	1	2				3	2				6.156	0.739	471.5	1	69.32	0.0000
Block*Treatment	2	1				2	2				-0.934	0.543	0.4	1	2.96	0.0855
Block*Treatment	2	1				3	1				1.946	0.576	7.0	1	11.40	0.0007
Block*Treatment	2	1				3	2				4.063	0.754	58.1	1	29.03	0.0000
Block*Treatment	2	2				3	1				2.880	0.548	17.8	1	27.57	0.0000
Block*Treatment	2	2				3	2				4.997	0.747	148.0	1	44.70	0.0000
Block*Treatment	3	1				3	2				2.117	0.778	8.3	1	7.41	0.0065
Block*Year	1		1999			1		2000			-0.072	0.624	0.9	1	0.01	0.9083
Block*Year	1		1999			1		2001			-0.462	0.628	0.6	1	0.54	0.4618
Block*Year	1		1999			2		1999			-0.006	0.659	1.0	1	0.00	0.9923
Block*Year	1		1999			2		2000			-0.496	0.640	0.6	1	0.60	0.4387
Block*Year	1		1999			2		2001			-0.720	0.634	0.5	1	1.29	0.2559
Block*Year	1		1999			3		1999			2.747	0.764	15.6	1	12.94	0.0003
Block*Year	1		1999			3		2000			3.278	0.834	26.5	1	15.46	0.0001
Block*Year	1		1999			3		2001			3.166	0.835	23.7	1	14.37	0.0002
Block*Year	1		2000			1		2001			-0.390	0.627	0.7	1	0.39	0.5339
Block*Year	1		2000			2		1999			0.065	0.696	1.1	1	0.01	0.9250
Block*Year	1		2000			2		2000			-0.424	0.638	0.7	1	0.44	0.5064
Block*Year	1		2000			2		2001			-0.648	0.627	0.5	1	1.07	0.3015
Block*Year	1		2000			3		1999			2.819	0.773	16.8	1	13.30	0.0003
Block*Year	1		2000			3		2000			3.350	0.841	28.5	1	15.85	0.0001
Block*Year	1		2000			3		2001			3.238	0.819	25.5	1	15.64	0.0001
Block*Year	1		2001			2		1999			0.455	0.641	1.6	1	0.50	0.4776
Block*Year	1		2001			2		2000			-0.034	0.612	1.0	1	0.00	0.9556
Block*Year	1		2001			2		2001			-0.258	0.593	0.8	1	0.19	0.6631
Block*Year	1		2001			3		1999			3.209	0.762	24.8	1	17.72	0.0000
Block*Year	1		2001			3		2000			3.740	0.820	42.1	1	20.81	0.0000
Block*Year	1		2001			3		2001			3.628	0.820	37.6	1	19.57	0.0000
Block*Year	2		1999			2		2000			-0.489	0.686	0.6	1	0.51	0.4758
Block*Year	2		1999			2		2001			-0.714	0.665	0.5	1	1.15	0.2834
Block*Year	2		1999			3		1999			2.754	0.775	15.7	1	12.64	0.0004
Block*Year	2		1999			3		2000			3.285	0.843	26.7	1	15.19	0.0001

Block*Year	2		1999			3		2001			3.172	0.876	23.9	1	13.11	0.0003
Block*Year	2		2000			2		2001			-0.224	0.617	0.8	1	0.13	0.7163
Block*Year	2		2000			3		1999			3.243	0.755	25.6	1	18.45	0.0000
Block*Year	2		2000			3		2000			3.774	0.835	43.6	1	20.42	0.0000
Block*Year	2		2000			3		2001			3.662	0.829	38.9	1	19.53	0.0000
Block*Year	2		2001			3		1999			3.468	0.781	32.1	1	19.69	0.0000
Block*Year	2		2001			3		2000			3.998	0.824	54.5	1	23.52	0.0000
Block*Year	2		2001			3		2001			3.886	0.822	48.7	1	22.34	0.0000
Block*Year	3		1999			3		2000			0.531	0.952	1.7	1	0.31	0.5770
Block*Year	3		1999			3		2001			0.418	0.889	1.5	1	0.22	0.6380
Block*Year	3		2000			3		2001			-0.112	1.036	0.9	1	0.01	0.9137
Block*Month	1			1_May		1			2_June		-1.040	0.628	0.4	1	2.74	0.0978
Block*Month	1			1_May		1			3_July		-0.258	0.631	0.8	1	0.17	0.6824
Block*Month	1			1_May		2			1_May		-0.624	0.624	0.5	1	1.00	0.3173
Block*Month	1			1_May		2			2_June		-1.182	0.659	0.3	1	3.22	0.0728
Block*Month	1			1_May		2			3_July		-0.181	0.632	0.8	1	0.08	0.7740
Block*Month	1			1_May		3			1_May		2.489	0.809	12.1	1	9.47	0.0021
Block*Month	1			1_May		3			2_June		2.172	0.748	8.8	1	8.44	0.0037
Block*Month	1			1_May		3			3_July		3.765	0.893	43.2	1	17.77	0.0000
Block*Month	1			2_June		1			3_July		0.782	0.641	2.2	1	1.49	0.2227
Block*Month	1			2_June		2			1_May		0.417	0.638	1.5	1	0.43	0.5135
Block*Month	1			2_June		2			2_June		-0.142	0.643	0.9	1	0.05	0.8257
Block*Month	1			2_June		2			3_July		0.859	0.620	2.4	1	1.92	0.1661
Block*Month	1			2_June		3			1_May		3.529	0.800	34.1	1	19.44	0.0000
Block*Month	1			2_June		3			2_June		3.213	0.751	24.8	1	18.30	0.0000
Block*Month	1			2_June		3			3_July		4.805	0.893	122.1	1	28.96	0.0000
Block*Month	1			3_July		2			1_May		-0.366	0.628	0.7	1	0.34	0.5607
Block*Month	1			3_July		2			2_June		-0.924	0.677	0.4	1	1.86	0.1723
Block*Month	1			3_July		2			3_July		0.077	0.659	1.1	1	0.01	0.9074
Block*Month	1			3_July		3			1_May		2.747	0.810	15.6	1	11.50	0.0007
Block*Month	1			3_July		3			2_June		2.431	0.744	11.4	1	10.66	0.0011
Block*Month	1			3_July		3			3_July		4.023	0.913	55.9	1	19.42	0.0000

Block*Month	2			1_May		2			2_June		-0.558	0.679	0.6	1	0.68	0.4113
Block*Month	2			1_May		2			3_July		0.442	0.641	1.6	1	0.48	0.4905
Block*Month	2			1_May		3			1_May		3.113	0.821	22.5	1	14.39	0.0001
Block*Month	2			1_May		3			2_June		2.796	0.747	16.4	1	14.02	0.0002
Block*Month	2			1_May		3			3_July		4.389	0.886	80.5	1	24.53	0.0000
Block*Month	2			2_June		2			3_July		1.000	0.663	2.7	1	2.27	0.1315
Block*Month	2			2_June		3			1_May		3.671	0.822	39.3	1	19.94	0.0000
Block*Month	2			2_June		3			2_June		3.354	0.803	28.6	1	17.46	0.0000
Block*Month	2			2_June		3			3_July		4.947	0.900	140.7	1	30.19	0.0000
Block*Month	2			3_July		3			1_May		2.671	0.809	14.5	1	10.90	0.0010
Block*Month	2			3_July		3			2_June		2.354	0.764	10.5	1	9.50	0.0021
Block*Month	2			3_July		3			3_July		3.947	0.885	51.8	1	19.90	0.0000
Block*Month	3			1_May		3			2_June		-0.317	0.968	0.7	1	0.11	0.7435
Block*Month	3			1_May		3			3_July		1.276	1.066	3.6	1	1.43	0.2314
Block*Month	3			2_June		3			3_July		1.593	0.920	4.9	1	3.00	0.0835
Treatment*Year		1	1999				1	2000			0.217	0.599	1.2	1	0.13	0.7175
Treatment*Year		1	1999				1	2001			-0.795	0.552	0.5	1	2.08	0.1495
Treatment*Year		1	1999				2	1999			-1.053	0.608	0.3	1	3.00	0.0833
Treatment*Year		1	1999				2	2000			-1.290	0.614	0.3	1	4.41	0.0356
Treatment*Year		1	1999				2	2001			-0.763	0.631	0.5	1	1.46	0.2269
Treatment*Year		1	2000				1	2001			-1.012	0.586	0.4	1	2.98	0.0843
Treatment*Year		1	2000				2	1999			-1.270	0.630	0.3	1	4.06	0.0439
Treatment*Year		1	2000				2	2000			-1.507	0.598	0.2	1	6.34	0.0118
Treatment*Year		1	2000				2	2001			-0.979	0.629	0.4	1	2.43	0.1194
Treatment*Year		1	2001				2	1999			-0.258	0.624	0.8	1	0.17	0.6793
Treatment*Year		1	2001				2	2000			-0.495	0.598	0.6	1	0.69	0.4075
Treatment*Year		1	2001				2	2001			0.032	0.600	1.0	1	0.00	0.9570
Treatment*Year		2	1999				2	2000			-0.237	0.629	0.8	1	0.14	0.7059
Treatment*Year		2	1999				2	2001			0.290	0.655	1.3	1	0.20	0.6576
Treatment*Year		2	2000				2	2001			0.528	0.654	1.7	1	0.65	0.4196
Treatment*Month		1		1_May			1		2_June		-0.562	0.600	0.6	1	0.88	0.3482
Treatment*Month		1		1_May			1		3_July		0.746	0.593	2.1	1	1.58	0.2082

Treatment*Month		1		1_May			2		1_May		-0.619	0.580	0.5	1	1.14	0.2865
Treatment*Month		1		1_May			2		2_June		-1.333	0.615	0.3	1	4.70	0.0302
Treatment*Month		1		1_May			2		3_July		-0.392	0.662	0.7	1	0.35	0.5537
Treatment*Month		1		2_June			1		3_July		1.309	0.586	3.7	1	4.99	0.0255
Treatment*Month		1		2_June			2		1_May		-0.056	0.594	0.9	1	0.01	0.9246
Treatment*Month		1		2_June			2		2_June		-0.771	0.624	0.5	1	1.53	0.2166
Treatment*Month		1		2_June			2		3_July		0.171	0.626	1.2	1	0.07	0.7851
Treatment*Month		1		3_July			2		1_May		-1.365	0.604	0.3	1	5.11	0.0238
Treatment*Month		1		3_July			2		2_June		-2.079	0.613	0.1	1	11.50	0.0007
Treatment*Month		1		3_July			2		3_July		-1.138	0.646	0.3	1	3.10	0.0782
Treatment*Month		2		1_May			2		2_June		-0.714	0.635	0.5	1	1.27	0.2603
Treatment*Month		2		1_May			2		3_July		0.227	0.656	1.3	1	0.12	0.7295
Treatment*Month		2		2_June			2		3_July		0.941	0.643	2.6	1	2.15	0.1430
Block	1					2					22.036	93.576	######	1	0.06	0.8138
Block	1					3					16.455	61.036	######	1	0.07	0.7875
Block	2					3					-5.581	111.728	0.0	1	0.00	0.9602
Treatment		1					2				-4.001	83.613	0.0	1	0.00	0.9618
Year			1999					2000			-2.716	86.548	0.1	1	0.00	0.9750
Year			1999					2001			-5.232	63.791	0.0	1	0.01	0.9346
Year			2000					2001			-2.516	68.870	0.1	1	0.00	0.9709
Month				1_May					2_June		0.526	81.024	1.7	1	0.00	0.9948
Month				1_May					3_July		-2.758	77.745	0.1	1	0.00	0.9717
Month				2_June					3_July		-3.284	61.775	0.0	1	0.00	0.9576
period(Month)				1_May	early				1_May	late	-3.095	5.995	0.0	1	0.27	0.6056
period(Month)				1_May	early				2_June	early	-0.237	81.165	0.8	1	0.00	0.9977
period(Month)				1_May	early				2_June	late	-1.807	81.144	0.2	1	0.00	0.9822
period(Month)				1_May	early				3_July	early	-3.128	77.877	0.0	1	0.00	0.9680
period(Month)				1_May	early				3_July	late	-5.484	77.870	0.0	1	0.00	0.9439
period(Month)				1_May	late				2_June	early	2.859	81.048	17.4	1	0.00	0.9719
period(Month)				1_May	late				2_June	late	1.288	81.015	3.6	1	0.00	0.9873
period(Month)				1_May	late				3_July	early	-0.033	77.746	1.0	1	0.00	0.9997
period(Month)				1_May	late				3_July	late	-2.389	77.740	0.1	1	0.00	0.9755

period(Month)				2_June	early				2_June	late	-1.570	2.934	0.2	1	0.29	0.5926
period(Month)				2_June	early				3_July	early	-2.891	61.830	0.1	1	0.00	0.9627
period(Month)				2_June	early				3_July	late	-5.247	61.820	0.0	1	0.01	0.9324
period(Month)				2_June	late				3_July	early	-1.321	61.781	0.3	1	0.00	0.9829
period(Month)				2_June	late				3_July	late	-3.677	61.768	0.0	1	0.00	0.9525
period(Month)				3_July	early				3_July	late	-2.356	1.883	0.1	1	1.57	0.2108
Block*Treatment	1	1				1	2				-2.916	2.226	0.1	1	1.72	0.1903
Block*Treatment	1	1				2	1				25.008	137.134	######	1	0.03	0.8553
Block*Treatment	1	1				2	2				16.148	73.628	######	1	0.05	0.8264
Block*Treatment	1	1				3	1				15.111	142.163	3651312.6	1	0.01	0.9154
Block*Treatment	1	1				3	2				14.884	109.470	######	1	0.02	0.8918
Block*Treatment	1	2				2	1				27.924	137.153	######	1	0.04	0.8387
Block*Treatment	1	2				2	2				19.064	73.609	######	1	0.07	0.7956
Block*Treatment	1	2				3	1				18.026	142.152	######	1	0.02	0.8991
Block*Treatment	1	2				3	2				17.800	109.429	######	1	0.03	0.8708
Block*Treatment	2	1				2	2				-8.861	115.869	0.0	1	0.01	0.9390
Block*Treatment	2	1				3	1				-9.898	197.536	0.0	1	0.00	0.9600
Block*Treatment	2	1				3	2				-10.124	175.482	0.0	1	0.00	0.9540
Block*Treatment	2	2				3	1				-1.037	160.071	0.4	1	0.00	0.9948
Block*Treatment	2	2				3	2				-1.264	131.873	0.3	1	0.00	0.9924
Block*Treatment	3	1				3	2				-0.227	222.417	0.8	1	0.00	0.9992
Block*Year	1		1999			1		2000			-4.576	2.406	0.0	1	3.62	0.0571
Block*Year	1		1999			1		2001			-1.868	1.518	0.2	1	1.51	0.2186
Block*Year	1		1999			2		1999			25.081	139.053	######	1	0.03	0.8569
Block*Year	1		1999			2		2000			22.356	134.681	######	1	0.03	0.8682
Block*Year	1		1999			2		2001			12.227	76.831	204229.0	1	0.03	0.8736
Block*Year	1		1999			3		1999			14.913	136.036	######	1	0.01	0.9127
Block*Year	1		1999			3		2000			14.068	112.446	######	1	0.02	0.9004
Block*Year	1		1999			3		2001			13.940	108.792	1132971.2	1	0.02	0.8980
Block*Year	1		2000			1		2001			2.709	1.986	15.0	1	1.86	0.1726
Block*Year	1		2000			2		1999			29.658	139.055	######	1	0.05	0.8311
Block*Year	1		2000			2		2000			26.932	134.700	######	1	0.04	0.8415

Block*Year	1		2000			2		2001			16.803	76.849	######	1	0.05	0.8269
Block*Year	1		2000			3		1999			19.489	136.023	######	1	0.02	0.8861
Block*Year	1		2000			3		2000			18.644	112.433	######	1	0.03	0.8683
Block*Year	1		2000			3		2001			18.517	108.784	######	1	0.03	0.8648
Block*Year	1		2001			2		1999			26.949	139.045	######	1	0.04	0.8463
Block*Year	1		2001			2		2000			24.223	134.675	######	1	0.03	0.8573
Block*Year	1		2001			2		2001			14.095	76.822	1321963.8	1	0.03	0.8544
Block*Year	1		2001			3		1999			16.781	136.029	######	1	0.02	0.9018
Block*Year	1		2001			3		2000			15.936	112.441	######	1	0.02	0.8873
Block*Year	1		2001			3		2001			15.808	108.787	######	1	0.02	0.8845
Block*Year	2		1999			2		2000			-2.726	160.161	0.1	1	0.00	0.9864
Block*Year	2		1999			2		2001			-12.854	115.891	0.0	1	0.01	0.9117
Block*Year	2		1999			3		1999			-10.168	194.506	0.0	1	0.00	0.9583
Block*Year	2		1999			3		2000			-11.013	178.817	0.0	1	0.00	0.9509
Block*Year	2		1999			3		2001			-11.141	176.541	0.0	1	0.00	0.9497
Block*Year	2		2000			2		2001			-10.129	110.610	0.0	1	0.01	0.9270
Block*Year	2		2000			3		1999			-7.443	191.427	0.0	1	0.00	0.9690
Block*Year	2		2000			3		2000			-8.288	175.460	0.0	1	0.00	0.9623
Block*Year	2		2000			3		2001			-8.415	173.132	0.0	1	0.00	0.9612
Block*Year	2		2001			3		1999			2.686	156.226	14.7	1	0.00	0.9863
Block*Year	2		2001			3		2000			1.841	136.183	6.3	1	0.00	0.9892
Block*Year	2		2001			3		2001			1.713	133.179	5.5	1	0.00	0.9897
Block*Year	3		1999			3		2000			-0.845	204.358	0.4	1	0.00	0.9967
Block*Year	3		1999			3		2001			-0.973	152.280	0.4	1	0.00	0.9949
Block*Year	3		2000			3		2001			-0.128	174.506	0.9	1	0.00	0.9994
Block*Month	1			1_May		1			2_June		1.139	1.556	3.1	1	0.54	0.4641
Block*Month	1			1_May		1			3_July		1.580	1.935	4.9	1	0.67	0.4143
Block*Month	1			1_May		2			1_May		25.092	125.442	######	1	0.04	0.8415
Block*Month	1			1_May		2			2_June		27.325	140.515	######	1	0.04	0.8458
Block*Month	1			1_May		2			3_July		16.409	78.762	######	1	0.04	0.8350
Block*Month	1			1_May		3			1_May		18.350	132.724	######	1	0.02	0.8900
Block*Month	1			1_May		3			2_June		16.556	110.940	######	1	0.02	0.8814

Block*Month	1			1_May		3			3_July		17.178	122.968	######	1	0.02	0.8889
Block*Month	1			2_June		1			3_July		0.441	2.150	1.6	1	0.04	0.8376
Block*Month	1			2_June		2			1_May		23.953	125.448	######	1	0.04	0.8486
Block*Month	1			2_June		2			2_June		26.186	140.513	######	1	0.03	0.8522
Block*Month	1			2_June		2			3_July		15.271	78.765	######	1	0.04	0.8463
Block*Month	1			2_June		3			1_May		17.211	132.715	######	1	0.02	0.8968
Block*Month	1			2_June		3			2_June		15.417	110.933	######	1	0.02	0.8895
Block*Month	1			2_June		3			3_July		16.039	122.967	######	1	0.02	0.8962
Block*Month	1			3_July		2			1_May		23.512	125.424	######	1	0.04	0.8513
Block*Month	1			3_July		2			2_June		25.745	140.498	######	1	0.03	0.8546
Block*Month	1			3_July		2			3_July		14.830	78.757	######	1	0.04	0.8506
Block*Month	1			3_July		3			1_May		16.770	132.733	######	1	0.02	0.8995
Block*Month	1			3_July		3			2_June		14.976	110.949	3191362.4	1	0.02	0.8926
Block*Month	1			3_July		3			3_July		15.598	122.987	######	1	0.02	0.8991
Block*Month	2			1_May		2			2_June		2.233	152.005	9.3	1	0.00	0.9883
Block*Month	2			1_May		2			3_July		-8.683	97.886	0.0	1	0.01	0.9293
Block*Month	2			1_May		3			1_May		-6.742	182.632	0.0	1	0.00	0.9706
Block*Month	2			1_May		3			2_June		-8.536	167.455	0.0	1	0.00	0.9593
Block*Month	2			1_May		3			3_July		-7.914	175.665	0.0	1	0.00	0.9641
Block*Month	2			2_June		2			3_July		-10.916	116.347	0.0	1	0.01	0.9253
Block*Month	2			2_June		3			1_May		-8.975	193.278	0.0	1	0.00	0.9630
Block*Month	2			2_June		3			2_June		-10.769	179.013	0.0	1	0.00	0.9520
Block*Month	2			2_June		3			3_July		-10.147	186.729	0.0	1	0.00	0.9567
Block*Month	2			3_July		3			1_May		1.941	154.326	7.0	1	0.00	0.9900
Block*Month	2			3_July		3			2_June		0.146	136.046	1.2	1	0.00	0.9991
Block*Month	2			3_July		3			3_July		0.769	146.022	2.2	1	0.00	0.9958
Block*Month	3			1_May		3			2_June		-1.794	189.679	0.2	1	0.00	0.9925
Block*Month	3			1_May		3			3_July		-1.172	211.709	0.3	1	0.00	0.9956
Block*Month	3			2_June		3			3_July		0.622	144.222	1.9	1	0.00	0.9966
Treatment*Year		1	1999				1	2000			-5.348	86.589	0.0	1	0.00	0.9508
Treatment*Year		1	1999				1	2001			-6.211	63.828	0.0	1	0.01	0.9225
Treatment*Year		1	1999				2	1999			-6.409	83.636	0.0	1	0.01	0.9389

Treatment*Year		1	1999				2	2000			-6.492	141.793	0.0	1	0.00	0.9635
Treatment*Year		1	1999				2	2001			-10.661	111.194	0.0	1	0.01	0.9236
Treatment*Year		1	2000				1	2001			-0.863	68.902	0.4	1	0.00	0.9900
Treatment*Year		1	2000				2	1999			-1.061	94.146	0.3	1	0.00	0.9910
Treatment*Year		1	2000				2	2000			-1.144	83.680	0.3	1	0.00	0.9891
Treatment*Year		1	2000				2	2001			-5.313	86.131	0.0	1	0.00	0.9508
Treatment*Year		1	2001				2	1999			-0.198	98.771	0.8	1	0.00	0.9984
Treatment*Year		1	2001				2	2000			-0.281	126.699	0.8	1	0.00	0.9982
Treatment*Year		1	2001				2	2001			-4.450	83.610	0.0	1	0.00	0.9576
Treatment*Year		2	1999				2	2000			-0.083	86.564	0.9	1	0.00	0.9992
Treatment*Year		2	1999				2	2001			-4.252	63.790	0.0	1	0.00	0.9469
Treatment*Year		2	2000				2	2001			-4.169	68.894	0.0	1	0.00	0.9517
Treatment*Month		1		1_May			1		2_June		3.035	81.041	20.8	1	0.00	0.9701
Treatment*Month		1		1_May			1		3_July		0.424	77.771	1.5	1	0.00	0.9957
Treatment*Month		1		1_May			2		1_May		-0.207	83.819	0.8	1	0.00	0.9980
Treatment*Month		1		1_May			2		2_June		-2.190	91.807	0.1	1	0.00	0.9810
Treatment*Month		1		1_May			2		3_July		-6.147	80.753	0.0	1	0.01	0.9393
Treatment*Month		1		2_June			1		3_July		-2.611	61.849	0.1	1	0.00	0.9663
Treatment*Month		1		2_June			2		1_May		-3.242	136.745	0.0	1	0.00	0.9811
Treatment*Month		1		2_June			2		2_June		-5.225	83.629	0.0	1	0.00	0.9502
Treatment*Month		1		2_June			2		3_July		-9.182	97.060	0.0	1	0.01	0.9246
Treatment*Month		1		3_July			2		1_May		-0.631	139.854	0.5	1	0.00	0.9964
Treatment*Month		1		3_July			2		2_June		-2.614	110.395	0.1	1	0.00	0.9811
Treatment*Month		1		3_July			2		3_July		-6.571	83.611	0.0	1	0.01	0.9374
Treatment*Month		2		1_May			2		2_June		-1.983	81.141	0.1	1	0.00	0.9805
Treatment*Month		2		1_May			2		3_July		-5.940	77.878	0.0	1	0.01	0.9392
Treatment*Month		2		2_June			2		3_July		-3.957	61.777	0.0	1	0.00	0.9489
Block	1					2					-1.032	0.195	0.4	1	28.09	0.0000
Block	1					3					-1.094	0.192	0.3	1	32.59	0.0000
Block	2					3					-0.062	0.188	0.9	1	0.11	0.7432
Treatment		1					2				-1.323	0.157	0.3	1	71.36	0.0000
Year			1999					2000			-0.366	0.201	0.7	1	3.31	0.0688

Year			1999					2001			-0.723	0.196	0.5	1	13.63	0.0002
Year			2000					2001			-0.357	0.195	0.7	1	3.36	0.0669
Month				1_May					2_June		0.416	0.193	1.5	1	4.66	0.0309
Month				1_May					3_July		0.881	0.192	2.4	1	21.14	0.0000
Month				2_June					3_July		0.465	0.191	1.6	1	5.90	0.0151
period(Month)				1_May	early				1_May	late	-0.184	0.277	0.8	1	0.44	0.5074
period(Month)				1_May	early				2_June	early	0.009	0.271	1.0	1	0.00	0.9725
period(Month)				1_May	early				2_June	late	0.640	0.282	1.9	1	5.14	0.0233
period(Month)				1_May	early				3_July	early	0.520	0.273	1.7	1	3.64	0.0565
period(Month)				1_May	early				3_July	late	1.059	0.282	2.9	1	14.14	0.0002
period(Month)				1_May	late				2_June	early	0.193	0.268	1.2	1	0.52	0.4714
period(Month)				1_May	late				2_June	late	0.823	0.274	2.3	1	9.03	0.0027
period(Month)				1_May	late				3_July	early	0.704	0.272	2.0	1	6.68	0.0098
period(Month)				1_May	late				3_July	late	1.243	0.277	3.5	1	20.19	0.0000
period(Month)				2_June	early				2_June	late	0.630	0.273	1.9	1	5.35	0.0207
period(Month)				2_June	early				3_July	early	0.511	0.271	1.7	1	3.55	0.0596
period(Month)				2_June	early				3_July	late	1.050	0.274	2.9	1	14.66	0.0001
period(Month)				2_June	late				3_July	early	-0.119	0.280	0.9	1	0.18	0.6692
period(Month)				2_June	late				3_July	late	0.419	0.273	1.5	1	2.36	0.1246
period(Month)				3_July	early				3_July	late	0.539	0.284	1.7	1	3.60	0.0578
Block*Treatment	1	1				1	2				-2.053	0.283	0.1	1	52.56	0.0000
Block*Treatment	1	1				2	1				-1.501	0.285	0.2	1	27.76	0.0000
Block*Treatment	1	1				2	2				-2.616	0.281	0.1	1	86.55	0.0000
Block*Treatment	1	1				3	1				-1.718	0.280	0.2	1	37.61	0.0000
Block*Treatment	1	1				3	2				-2.522	0.279	0.1	1	81.82	0.0000
Block*Treatment	1	2				2	1				0.551	0.270	1.7	1	4.17	0.0412
Block*Treatment	1	2				2	2				-0.563	0.268	0.6	1	4.41	0.0357
Block*Treatment	1	2				3	1				0.334	0.266	1.4	1	1.58	0.2089
Block*Treatment	1	2				3	2				-0.469	0.264	0.6	1	3.16	0.0752
Block*Treatment	2	1				2	2				-1.114	0.270	0.3	1	16.98	0.0000
Block*Treatment	2	1				3	1				-0.217	0.269	0.8	1	0.65	0.4204
Block*Treatment	2	1				3	2				-1.020	0.266	0.4	1	14.76	0.0001

Block*Treatment	2	2				3	1				0.897	0.266	2.5	1	11.38	0.0007
Block*Treatment	2	2				3	2				0.094	0.264	1.1	1	0.13	0.7223
Block*Treatment	3	1				3	2				-0.803	0.264	0.4	1	9.28	0.0023
Block*Year	1		1999			1		2000			-0.470	0.356	0.6	1	1.74	0.1872
Block*Year	1		1999			1		2001			-1.151	0.349	0.3	1	10.87	0.0010
Block*Year	1		1999			2		1999			-1.273	0.348	0.3	1	13.36	0.0003
Block*Year	1		1999			2		2000			-1.687	0.348	0.2	1	23.43	0.0000
Block*Year	1		1999			2		2001			-1.758	0.348	0.2	1	25.50	0.0000
Block*Year	1		1999			3		1999			-1.385	0.347	0.3	1	15.88	0.0001
Block*Year	1		1999			3		2000			-1.600	0.347	0.2	1	21.31	0.0000
Block*Year	1		1999			3		2001			-1.918	0.343	0.1	1	31.35	0.0000
Block*Year	1		2000			1		2001			-0.682	0.335	0.5	1	4.13	0.0420
Block*Year	1		2000			2		1999			-0.804	0.338	0.4	1	5.65	0.0175
Block*Year	1		2000			2		2000			-1.217	0.338	0.3	1	12.98	0.0003
Block*Year	1		2000			2		2001			-1.288	0.335	0.3	1	14.77	0.0001
Block*Year	1		2000			3		1999			-0.915	0.343	0.4	1	7.10	0.0077
Block*Year	1		2000			3		2000			-1.130	0.333	0.3	1	11.49	0.0007
Block*Year	1		2000			3		2001			-1.448	0.333	0.2	1	18.91	0.0000
Block*Year	1		2001			2		1999			-0.122	0.333	0.9	1	0.13	0.7140
Block*Year	1		2001			2		2000			-0.535	0.335	0.6	1	2.55	0.1103
Block*Year	1		2001			2		2001			-0.606	0.328	0.5	1	3.41	0.0647
Block*Year	1		2001			3		1999			-0.233	0.333	0.8	1	0.49	0.4837
Block*Year	1		2001			3		2000			-0.448	0.330	0.6	1	1.85	0.1741
Block*Year	1		2001			3		2001			-0.767	0.327	0.5	1	5.51	0.0189
Block*Year	2		1999			2		2000			-0.414	0.331	0.7	1	1.56	0.2113
Block*Year	2		1999			2		2001			-0.485	0.332	0.6	1	2.12	0.1449
Block*Year	2		1999			3		1999			-0.111	0.332	0.9	1	0.11	0.7380
Block*Year	2		1999			3		2000			-0.327	0.330	0.7	1	0.98	0.3223
Block*Year	2		1999			3		2001			-0.645	0.327	0.5	1	3.88	0.0488
Block*Year	2		2000			2		2001			-0.071	0.336	0.9	1	0.04	0.8324
Block*Year	2		2000			3		1999			0.302	0.339	1.4	1	0.79	0.3730
Block*Year	2		2000			3		2000			0.087	0.326	1.1	1	0.07	0.7896

Block*Year	2		2000			3		2001			-0.231	0.331	0.8	1	0.49	0.4840
Block*Year	2		2001			3		1999			0.373	0.332	1.5	1	1.27	0.2606
Block*Year	2		2001			3		2000			0.158	0.329	1.2	1	0.23	0.6307
Block*Year	2		2001			3		2001			-0.160	0.328	0.9	1	0.24	0.6248
Block*Year	3		1999			3		2000			-0.215	0.338	0.8	1	0.41	0.5243
Block*Year	3		1999			3		2001			-0.534	0.332	0.6	1	2.58	0.1080
Block*Year	3		2000			3		2001			-0.318	0.329	0.7	1	0.94	0.3329
Block*Month	1			1_May		1			2_June		-0.248	0.345	0.8	1	0.52	0.4709
Block*Month	1			1_May		1			3_July		0.427	0.343	1.5	1	1.55	0.2136
Block*Month	1			1_May		2			1_May		-1.807	0.343	0.2	1	27.75	0.0000
Block*Month	1			1_May		2			2_June		-0.555	0.340	0.6	1	2.67	0.1021
Block*Month	1			1_May		2			3_July		-0.556	0.336	0.6	1	2.74	0.0978
Block*Month	1			1_May		3			1_May		-1.438	0.332	0.2	1	18.77	0.0000
Block*Month	1			1_May		3			2_June		-1.193	0.334	0.3	1	12.78	0.0004
Block*Month	1			1_May		3			3_July		-0.472	0.339	0.6	1	1.94	0.1640
Block*Month	1			2_June		1			3_July		0.675	0.343	2.0	1	3.87	0.0491
Block*Month	1			2_June		2			1_May		-1.559	0.334	0.2	1	21.78	0.0000
Block*Month	1			2_June		2			2_June		-0.307	0.336	0.7	1	0.83	0.3611
Block*Month	1			2_June		2			3_July		-0.308	0.332	0.7	1	0.86	0.3537
Block*Month	1			2_June		3			1_May		-1.190	0.331	0.3	1	12.95	0.0003
Block*Month	1			2_June		3			2_June		-0.944	0.330	0.4	1	8.18	0.0042
Block*Month	1			2_June		3			3_July		-0.224	0.335	0.8	1	0.44	0.5050
Block*Month	1			3_July		2			1_May		-2.234	0.339	0.1	1	43.37	0.0000
Block*Month	1			3_July		2			2_June		-0.982	0.339	0.4	1	8.40	0.0038
Block*Month	1			3_July		2			3_July		-0.983	0.336	0.4	1	8.58	0.0034
Block*Month	1			3_July		3			1_May		-1.865	0.334	0.2	1	31.19	0.0000
Block*Month	1			3_July		3			2_June		-1.619	0.334	0.2	1	23.57	0.0000
Block*Month	1			3_July		3			3_July		-0.899	0.341	0.4	1	6.93	0.0085
Block*Month	2			1_May		2			2_June		1.252	0.334	3.5	1	14.05	0.0002
Block*Month	2			1_May		2			3_July		1.251	0.329	3.5	1	14.50	0.0001
Block*Month	2			1_May		3			1_May		0.369	0.328	1.4	1	1.27	0.2603
Block*Month	2			1_May		3			2_June		0.614	0.326	1.8	1	3.55	0.0596

Block*Month	2			1_May		3			3_July		1.335	0.330	3.8	1	16.35	0.0001
Block*Month	2			2_June		2			3_July		-0.001	0.329	1.0	1	0.00	0.9982
Block*Month	2			2_June		3			1_May		-0.883	0.330	0.4	1	7.14	0.0075
Block*Month	2			2_June		3			2_June		-0.637	0.327	0.5	1	3.81	0.0510
Block*Month	2			2_June		3			3_July		0.083	0.330	1.1	1	0.06	0.8007
Block*Month	2			3_July		3			1_May		-0.882	0.325	0.4	1	7.38	0.0066
Block*Month	2			3_July		3			2_June		-0.637	0.324	0.5	1	3.86	0.0493
Block*Month	2			3_July		3			3_July		0.084	0.330	1.1	1	0.07	0.7986
Block*Month	3			1_May		3			2_June		0.246	0.324	1.3	1	0.57	0.4489
Block*Month	3			1_May		3			3_July		0.966	0.330	2.6	1	8.56	0.0034
Block*Month	3			2_June		3			3_July		0.721	0.329	2.1	1	4.81	0.0282
Treatment*Year		1	1999				1	2000			-0.447	0.292	0.6	1	2.34	0.1260
Treatment*Year		1	1999				1	2001			-1.257	0.288	0.3	1	19.07	0.0000
Treatment*Year		1	1999				2	1999			-1.733	0.282	0.2	1	37.66	0.0000
Treatment*Year		1	1999				2	2000			-2.018	0.285	0.1	1	50.04	0.0000
Treatment*Year		1	1999				2	2001			-1.923	0.282	0.1	1	46.37	0.0000
Treatment*Year		1	2000				1	2001			-0.810	0.274	0.4	1	8.72	0.0032
Treatment*Year		1	2000				2	1999			-1.286	0.275	0.3	1	21.86	0.0000
Treatment*Year		1	2000				2	2000			-1.571	0.272	0.2	1	33.47	0.0000
Treatment*Year		1	2000				2	2001			-1.476	0.273	0.2	1	29.11	0.0000
Treatment*Year		1	2001				2	1999			-0.476	0.268	0.6	1	3.16	0.0754
Treatment*Year		1	2001				2	2000			-0.762	0.271	0.5	1	7.88	0.0050
Treatment*Year		1	2001				2	2001			-0.666	0.268	0.5	1	6.16	0.0131
Treatment*Year		2	1999				2	2000			-0.286	0.270	0.8	1	1.11	0.2911
Treatment*Year		2	1999				2	2001			-0.190	0.266	0.8	1	0.51	0.4761
Treatment*Year		2	2000				2	2001			0.096	0.272	1.1	1	0.12	0.7252
Treatment*Month		1		1_May			1		2_June		0.367	0.277	1.4	1	1.76	0.1845
Treatment*Month		1		1_May			1		3_July		0.864	0.279	2.4	1	9.62	0.0019
Treatment*Month		1		1_May			2		1_May		-1.368	0.272	0.3	1	25.37	0.0000
Treatment*Month		1		1_May			2		2_June		-0.902	0.274	0.4	1	10.84	0.0010
Treatment*Month		1		1_May			2		3_July		-0.469	0.270	0.6	1	3.02	0.0823
Treatment*Month		1		2_June			1		3_July		0.497	0.278	1.6	1	3.21	0.0731

Treatment*Month		1		2_June			2		1_May		-1.735	0.269	0.2	1	41.55	0.0000
Treatment*Month		1		2_June			2		2_June		-1.269	0.271	0.3	1	21.90	0.0000
Treatment*Month		1		2_June			2		3_July		-0.836	0.268	0.4	1	9.71	0.0018
Treatment*Month		1		3_July			2		1_May		-2.232	0.274	0.1	1	66.27	0.0000
Treatment*Month		1		3_July			2		2_June		-1.766	0.274	0.2	1	41.57	0.0000
Treatment*Month		1		3_July			2		3_July		-1.334	0.274	0.3	1	23.77	0.0000
Treatment*Month		2		1_May			2		2_June		0.466	0.268	1.6	1	3.01	0.0828
Treatment*Month		2		1_May			2		3_July		0.898	0.264	2.5	1	11.58	0.0007
Treatment*Month		2		2_June			2		3_July		0.433	0.266	1.5	1	2.64	0.1040
Block	1					2					-0.617	0.467	0.5	1	1.74	0.1869
Block	1					3					-3.156	0.421	0.0	1	56.27	0.0000
Block	2					3					-2.540	0.444	0.1	1	32.78	0.0000
Treatment		1					2				3.475	0.388	32.3	1	80.09	0.0000
Year			1999					2000			-1.479	0.444	0.2	1	11.10	0.0009
Year			1999					2001			-1.214	0.440	0.3	1	7.62	0.0058
Year			2000					2001			0.264	0.396	1.3	1	0.44	0.5048
Month				1_May					2_June		-0.620	0.444	0.5	1	1.95	0.1626
Month				1_May					3_July		-2.815	0.417	0.1	1	45.59	0.0000
Month				2_June					3_July		-2.194	0.390	0.1	1	31.65	0.0000
period(Month)				1_May	early				1_May	late	-2.983	0.557	0.1	1	28.64	0.0000
period(Month)				1_May	early				2_June	early	-0.890	0.645	0.4	1	1.91	0.1673
period(Month)				1_May	early				2_June	late	-3.334	0.580	0.0	1	33.08	0.0000
period(Month)				1_May	early				3_July	early	-3.876	0.587	0.0	1	43.58	0.0000
period(Month)				1_May	early				3_July	late	-4.736	0.604	0.0	1	61.58	0.0000
period(Month)				1_May	late				2_June	early	2.093	0.599	8.1	1	12.21	0.0005
period(Month)				1_May	late				2_June	late	-0.351	0.530	0.7	1	0.44	0.5084
period(Month)				1_May	late				3_July	early	-0.893	0.523	0.4	1	2.92	0.0876
period(Month)				1_May	late				3_July	late	-1.753	0.531	0.2	1	10.91	0.0010
period(Month)				2_June	early				2_June	late	-2.443	0.539	0.1	1	20.52	0.0000
period(Month)				2_June	early				3_July	early	-2.986	0.569	0.1	1	27.49	0.0000
period(Month)				2_June	early				3_July	late	-3.846	0.578	0.0	1	44.34	0.0000
period(Month)				2_June	late				3_July	early	-0.542	0.508	0.6	1	1.14	0.2855

period(Month)				2_June	late				3_July	late	-1.403	0.492	0.2	1	8.13	0.0044
period(Month)				3_July	early				3_July	late	-0.860	0.508	0.4	1	2.87	0.0904
Block*Treatment	1	1				1	2				3.853	0.698	47.1	1	30.46	0.0000
Block*Treatment	1	1				2	1				-1.765	0.445	0.2	1	15.76	0.0001
Block*Treatment	1	1				2	2				4.384	0.732	80.2	1	35.90	0.0000
Block*Treatment	1	1				3	1				-1.442	0.455	0.2	1	10.04	0.0015
Block*Treatment	1	1				3	2				-1.018	0.457	0.4	1	4.97	0.0258
Block*Treatment	1	2				2	1				-5.618	0.679	0.0	1	68.46	0.0000
Block*Treatment	1	2				2	2				0.531	0.842	1.7	1	0.40	0.5283
Block*Treatment	1	2				3	1				-5.295	0.713	0.0	1	55.21	0.0000
Block*Treatment	1	2				3	2				-4.871	0.700	0.0	1	48.46	0.0000
Block*Treatment	2	1				2	2				6.149	0.737	468.2	1	69.63	0.0000
Block*Treatment	2	1				3	1				0.323	0.457	1.4	1	0.50	0.4793
Block*Treatment	2	1				3	2				0.746	0.448	2.1	1	2.77	0.0959
Block*Treatment	2	2				3	1				-5.826	0.757	0.0	1	59.21	0.0000
Block*Treatment	2	2				3	2				-5.403	0.752	0.0	1	51.67	0.0000
Block*Treatment	3	1				3	2				0.423	0.466	1.5	1	0.82	0.3639
Block*Year	1		1999			1		2000			-3.063	0.874	0.0	1	12.29	0.0005
Block*Year	1		1999			1		2001			-1.699	0.792	0.2	1	4.61	0.0319
Block*Year	1		1999			2		1999			-1.782	0.847	0.2	1	4.42	0.0354
Block*Year	1		1999			2		2000			-2.764	0.815	0.1	1	11.51	0.0007
Block*Year	1		1999			2		2001			-2.064	0.913	0.1	1	5.12	0.0237
Block*Year	1		1999			3		1999			-4.059	0.781	0.0	1	27.03	0.0000
Block*Year	1		1999			3		2000			-4.451	0.803	0.0	1	30.72	0.0000
Block*Year	1		1999			3		2001			-5.721	0.802	0.0	1	50.94	0.0000
Block*Year	1		2000			1		2001			1.364	0.731	3.9	1	3.48	0.0623
Block*Year	1		2000			2		1999			1.280	0.755	3.6	1	2.87	0.0901
Block*Year	1		2000			2		2000			0.298	0.697	1.3	1	0.18	0.6687
Block*Year	1		2000			2		2001			0.998	0.757	2.7	1	1.74	0.1871
Block*Year	1		2000			3		1999			-0.996	0.655	0.4	1	2.32	0.1279
Block*Year	1		2000			3		2000			-1.388	0.608	0.2	1	5.22	0.0224
Block*Year	1		2000			3		2001			-2.659	0.637	0.1	1	17.44	0.0000

Block*Year	1		2001			2		1999			-0.084	0.758	0.9	1	0.01	0.9122
Block*Year	1		2001			2		2000			-1.066	0.731	0.3	1	2.12	0.1450
Block*Year	1		2001			2		2001			-0.366	0.714	0.7	1	0.26	0.6086
Block*Year	1		2001			3		1999			-2.360	0.686	0.1	1	11.82	0.0006
Block*Year	1		2001			3		2000			-2.752	0.688	0.1	1	15.99	0.0001
Block*Year	1		2001			3		2001			-4.022	0.734	0.0	1	30.07	0.0000
Block*Year	2		1999			2		2000			-0.982	0.725	0.4	1	1.83	0.1758
Block*Year	2		1999			2		2001			-0.282	0.752	0.8	1	0.14	0.7078
Block*Year	2		1999			3		1999			-2.277	0.692	0.1	1	10.81	0.0010
Block*Year	2		1999			3		2000			-2.668	0.718	0.1	1	13.80	0.0002
Block*Year	2		1999			3		2001			-3.939	0.722	0.0	1	29.77	0.0000
Block*Year	2		2000			2		2001			0.700	0.693	2.0	1	1.02	0.3125
Block*Year	2		2000			3		1999			-1.295	0.655	0.3	1	3.91	0.0481
Block*Year	2		2000			3		2000			-1.686	0.645	0.2	1	6.83	0.0090
Block*Year	2		2000			3		2001			-2.957	0.668	0.1	1	19.58	0.0000
Block*Year	2		2001			3		1999			-1.995	0.720	0.1	1	7.68	0.0056
Block*Year	2		2001			3		2000			-2.386	0.716	0.1	1	11.11	0.0009
Block*Year	2		2001			3		2001			-3.657	0.755	0.0	1	23.45	0.0000
Block*Year	3		1999			3		2000			-0.392	0.556	0.7	1	0.50	0.4814
Block*Year	3		1999			3		2001			-1.662	0.642	0.2	1	6.70	0.0097
Block*Year	3		2000			3		2001			-1.271	0.585	0.3	1	4.71	0.0300
Block*Month	1			1_May		1			2_June		-0.978	0.793	0.4	1	1.52	0.2175
Block*Month	1			1_May		1			3_July		-2.465	0.796	0.1	1	9.58	0.0020
Block*Month	1			1_May		2			1_May		-1.374	0.820	0.3	1	2.81	0.0936
Block*Month	1			1_May		2			2_June		-0.632	0.936	0.5	1	0.46	0.4997
Block*Month	1			1_May		2			3_July		-3.288	0.795	0.0	1	17.10	0.0000
Block*Month	1			1_May		3			1_May		-2.407	0.809	0.1	1	8.85	0.0029
Block*Month	1			1_May		3			2_June		-4.033	0.750	0.0	1	28.91	0.0000
Block*Month	1			1_May		3			3_July		-6.473	0.758	0.0	1	73.01	0.0000
Block*Month	1			2_June		1			3_July		-1.487	0.615	0.2	1	5.85	0.0156
Block*Month	1			2_June		2			1_May		-0.396	0.784	0.7	1	0.26	0.6132
Block*Month	1			2_June		2			2_June		0.347	0.766	1.4	1	0.20	0.6508

Block*Month	1			2_June		2			3_July		-2.309	0.662	0.1	1	12.18	0.0005
Block*Month	1			2_June		3			1_May		-1.429	0.677	0.2	1	4.46	0.0348
Block*Month	1			2_June		3			2_June		-3.055	0.655	0.0	1	21.77	0.0000
Block*Month	1			2_June		3			3_July		-5.494	0.651	0.0	1	71.14	0.0000
Block*Month	1			3_July		2			1_May		1.091	0.756	3.0	1	2.08	0.1491
Block*Month	1			3_July		2			2_June		1.834	0.793	6.3	1	5.35	0.0207
Block*Month	1			3_July		2			3_July		-0.822	0.633	0.4	1	1.69	0.1937
Block*Month	1			3_July		3			1_May		0.058	0.644	1.1	1	0.01	0.9283
Block*Month	1			3_July		3			2_June		-1.568	0.603	0.2	1	6.76	0.0093
Block*Month	1			3_July		3			3_July		-4.007	0.601	0.0	1	44.41	0.0000
Block*Month	2			1_May		2			2_June		0.743	0.827	2.1	1	0.81	0.3691
Block*Month	2			1_May		2			3_July		-1.913	0.711	0.1	1	7.24	0.0071
Block*Month	2			1_May		3			1_May		-1.033	0.773	0.4	1	1.79	0.1814
Block*Month	2			1_May		3			2_June		-2.659	0.713	0.1	1	13.91	0.0002
Block*Month	2			1_May		3			3_July		-5.098	0.724	0.0	1	49.60	0.0000
Block*Month	2			2_June		2			3_July		-2.656	0.789	0.1	1	11.34	0.0008
Block*Month	2			2_June		3			1_May		-1.776	0.794	0.2	1	5.01	0.0252
Block*Month	2			2_June		3			2_June		-3.402	0.793	0.0	1	18.41	0.0000
Block*Month	2			2_June		3			3_July		-5.841	0.799	0.0	1	53.44	0.0000
Block*Month	2			3_July		3			1_May		0.880	0.617	2.4	1	2.04	0.1536
Block*Month	2			3_July		3			2_June		-0.746	0.588	0.5	1	1.61	0.2049
Block*Month	2			3_July		3			3_July		-3.185	0.582	0.0	1	29.97	0.0000
Block*Month	3			1_May		3			2_June		-1.626	0.618	0.2	1	6.92	0.0085
Block*Month	3			1_May		3			3_July		-4.065	0.592	0.0	1	47.10	0.0000
Block*Month	3			2_June		3			3_July		-2.439	0.524	0.1	1	21.66	0.0000
Treatment*Year		1	1999				1	2000			-0.748	0.521	0.5	1	2.07	0.1506
Treatment*Year		1	1999				1	2001			-1.236	0.473	0.3	1	6.83	0.0090
Treatment*Year		1	1999				2	1999			3.947	0.664	51.8	1	35.37	0.0000
Treatment*Year		1	1999				2	2000			1.738	0.551	5.7	1	9.95	0.0016
Treatment*Year		1	1999				2	2001			2.755	0.665	15.7	1	17.15	0.0000
Treatment*Year		1	2000				1	2001			-0.488	0.465	0.6	1	1.10	0.2938
Treatment*Year		1	2000				2	1999			4.696	0.703	109.5	1	44.60	0.0000

Treatment*Year		1	2000				2	2000			2.487	0.524	12.0	1	22.56	0.0000
Treatment*Year		1	2000				2	2001			3.503	0.665	33.2	1	27.73	0.0000
Treatment*Year		1	2001				2	1999			5.184	0.647	178.4	1	64.12	0.0000
Treatment*Year		1	2001				2	2000			2.975	0.502	19.6	1	35.16	0.0000
Treatment*Year		1	2001				2	2001			3.991	0.668	54.1	1	35.71	0.0000
Treatment*Year		2	1999				2	2000			-2.209	0.659	0.1	1	11.25	0.0008
Treatment*Year		2	1999				2	2001			-1.192	0.758	0.3	1	2.47	0.1158
Treatment*Year		2	2000				2	2001			1.017	0.662	2.8	1	2.36	0.1244
Treatment*Month		1		1_May			1		2_June		-1.289	0.478	0.3	1	7.27	0.0070
Treatment*Month		1		1_May			1		3_July		-2.512	0.475	0.1	1	27.92	0.0000
Treatment*Month		1		1_May			2		1_May		3.231	0.722	25.3	1	20.00	0.0000
Treatment*Month		1		1_May			2		2_June		3.279	0.676	26.5	1	23.52	0.0000
Treatment*Month		1		1_May			2		3_July		0.114	0.524	1.1	1	0.05	0.8271
Treatment*Month		1		2_June			1		3_July		-1.224	0.435	0.3	1	7.91	0.0049
Treatment*Month		1		2_June			2		1_May		4.520	0.672	91.8	1	45.19	0.0000
Treatment*Month		1		2_June			2		2_June		4.568	0.655	96.3	1	48.63	0.0000
Treatment*Month		1		2_June			2		3_July		1.403	0.485	4.1	1	8.38	0.0038
Treatment*Month		1		3_July			2		1_May		5.743	0.682	312.1	1	70.99	0.0000
Treatment*Month		1		3_July			2		2_June		5.791	0.659	327.4	1	77.24	0.0000
Treatment*Month		1		3_July			2		3_July		2.627	0.483	13.8	1	29.61	0.0000
Treatment*Month		2		1_May			2		2_June		0.048	0.776	1.0	1	0.00	0.9508
Treatment*Month		2		1_May			2		3_July		-3.117	0.696	0.0	1	20.03	0.0000
Treatment*Month		2		2_June			2		3_July		-3.165	0.642	0.0	1	24.30	0.0000
Block	1					2					-2.149	0.451	0.1	1	22.69	0.0000
Block	1					3					-1.531	0.486	0.2	1	9.90	0.0017
Block	2					3					0.618	0.351	1.9	1	3.10	0.0781
Treatment		1					2				-1.584	0.345	0.2	1	21.06	0.0000
Year			1999					2000			-0.189	0.421	0.8	1	0.20	0.6539
Year			1999					2001			0.110	0.418	1.1	1	0.07	0.7927
Year			2000					2001			0.299	0.368	1.3	1	0.66	0.4167
Month				1_May					2_June		-0.482	0.365	0.6	1	1.74	0.1866
Month				1_May					3_July		-0.407	0.407	0.7	1	1.00	0.3171

Month				2_June					3_July		0.075	0.384	1.1	1	0.04	0.8463
period(Month)				1_May	early				1_May	late	-0.346	0.527	0.7	1	0.43	0.5112
period(Month)				1_May	early				2_June	early	-0.539	0.522	0.6	1	1.07	0.3013
period(Month)				1_May	early				2_June	late	-0.771	0.516	0.5	1	2.23	0.1355
period(Month)				1_May	early				3_July	early	-0.922	0.544	0.4	1	2.87	0.0900
period(Month)				1_May	early				3_July	late	-0.239	0.554	0.8	1	0.19	0.6667
period(Month)				1_May	late				2_June	early	-0.193	0.504	0.8	1	0.15	0.7020
period(Month)				1_May	late				2_June	late	-0.424	0.496	0.7	1	0.73	0.3922
period(Month)				1_May	late				3_July	early	-0.576	0.533	0.6	1	1.17	0.2796
period(Month)				1_May	late				3_July	late	0.108	0.538	1.1	1	0.04	0.8415
period(Month)				2_June	early				2_June	late	-0.231	0.479	0.8	1	0.23	0.6288
period(Month)				2_June	early				3_July	early	-0.383	0.512	0.7	1	0.56	0.4549
period(Month)				2_June	early				3_July	late	0.301	0.522	1.4	1	0.33	0.5646
period(Month)				2_June	late				3_July	early	-0.152	0.509	0.9	1	0.09	0.7661
period(Month)				2_June	late				3_July	late	0.532	0.511	1.7	1	1.08	0.2980
period(Month)				3_July	early				3_July	late	0.683	0.485	2.0	1	1.99	0.1588
Block*Treatment	1	1				1	2				-2.087	0.769	0.1	1	7.36	0.0067
Block*Treatment	1	1				2	1				-3.163	0.752	0.0	1	17.68	0.0000
Block*Treatment	1	1				2	2				-3.223	0.755	0.0	1	18.20	0.0000
Block*Treatment	1	1				3	1				-1.272	0.840	0.3	1	2.29	0.1300
Block*Treatment	1	1				3	2				-3.876	0.755	0.0	1	26.35	0.0000
Block*Treatment	1	2				2	1				-1.075	0.479	0.3	1	5.04	0.0248
Block*Treatment	1	2				2	2				-1.135	0.485	0.3	1	5.47	0.0193
Block*Treatment	1	2				3	1				0.815	0.586	2.3	1	1.94	0.1640
Block*Treatment	1	2				3	2				-1.789	0.462	0.2	1	14.97	0.0001
Block*Treatment	2	1				2	2				-0.060	0.442	0.9	1	0.02	0.8922
Block*Treatment	2	1				3	1				1.891	0.558	6.6	1	11.48	0.0007
Block*Treatment	2	1				3	2				-0.714	0.416	0.5	1	2.94	0.0864
Block*Treatment	2	2				3	1				1.951	0.563	7.0	1	12.01	0.0005
Block*Treatment	2	2				3	2				-0.654	0.426	0.5	1	2.35	0.1250
Block*Treatment	3	1				3	2				-2.604	0.543	0.1	1	23.03	0.0000
Block*Year	1		1999			1		2000			-1.131	0.885	0.3	1	1.63	0.2012

Block*Year	1		1999			1		2001			-1.101	0.897	0.3	1	1.51	0.2196
Block*Year	1		1999			2		1999			-2.856	0.851	0.1	1	11.27	0.0008
Block*Year	1		1999			2		2000			-2.968	0.843	0.1	1	12.40	0.0004
Block*Year	1		1999			2		2001			-2.854	0.847	0.1	1	11.35	0.0008
Block*Year	1		1999			3		1999			-2.976	0.859	0.1	1	12.02	0.0005
Block*Year	1		1999			3		2000			-2.300	0.912	0.1	1	6.36	0.0117
Block*Year	1		1999			3		2001			-1.548	0.920	0.2	1	2.83	0.0924
Block*Year	1		2000			1		2001			0.031	0.723	1.0	1	0.00	0.9663
Block*Year	1		2000			2		1999			-1.725	0.692	0.2	1	6.22	0.0126
Block*Year	1		2000			2		2000			-1.837	0.680	0.2	1	7.29	0.0069
Block*Year	1		2000			2		2001			-1.723	0.678	0.2	1	6.45	0.0111
Block*Year	1		2000			3		1999			-1.845	0.694	0.2	1	7.08	0.0078
Block*Year	1		2000			3		2000			-1.169	0.696	0.3	1	2.82	0.0931
Block*Year	1		2000			3		2001			-0.416	0.748	0.7	1	0.31	0.5780
Block*Year	1		2001			2		1999			-1.756	0.680	0.2	1	6.68	0.0098
Block*Year	1		2001			2		2000			-1.867	0.658	0.2	1	8.06	0.0045
Block*Year	1		2001			2		2001			-1.753	0.690	0.2	1	6.46	0.0110
Block*Year	1		2001			3		1999			-1.875	0.677	0.2	1	7.68	0.0056
Block*Year	1		2001			3		2000			-1.199	0.724	0.3	1	2.75	0.0975
Block*Year	1		2001			3		2001			-0.447	0.712	0.6	1	0.39	0.5302
Block*Year	2		1999			2		2000			-0.112	0.579	0.9	1	0.04	0.8471
Block*Year	2		1999			2		2001			0.002	0.601	1.0	1	0.00	0.9971
Block*Year	2		1999			3		1999			-0.120	0.571	0.9	1	0.04	0.8340
Block*Year	2		1999			3		2000			0.557	0.634	1.7	1	0.77	0.3796
Block*Year	2		1999			3		2001			1.309	0.634	3.7	1	4.26	0.0391
Block*Year	2		2000			2		2001			0.114	0.535	1.1	1	0.05	0.8316
Block*Year	2		2000			3		1999			-0.008	0.550	1.0	1	0.00	0.9882
Block*Year	2		2000			3		2000			0.668	0.601	2.0	1	1.24	0.2660
Block*Year	2		2000			3		2001			1.420	0.608	4.1	1	5.46	0.0194
Block*Year	2		2001			3		1999			-0.122	0.564	0.9	1	0.05	0.8289
Block*Year	2		2001			3		2000			0.554	0.608	1.7	1	0.83	0.3617
Block*Year	2		2001			3		2001			1.307	0.655	3.7	1	3.98	0.0461

Block*Year	3		1999			3		2000			0.676	0.607	2.0	1	1.24	0.2655
Block*Year	3		1999			3		2001			1.429	0.637	4.2	1	5.03	0.0249
Block*Year	3		2000			3		2001			0.752	0.643	2.1	1	1.37	0.2423
Block*Month	1			1_May		1			2_June		-0.430	0.750	0.7	1	0.33	0.5667
Block*Month	1			1_May		1			3_July		0.664	0.859	1.9	1	0.60	0.4397
Block*Month	1			1_May		2			1_May		-1.517	0.729	0.2	1	4.33	0.0375
Block*Month	1			1_May		2			2_June		-1.686	0.707	0.2	1	5.69	0.0171
Block*Month	1			1_May		2			3_July		-3.009	0.696	0.0	1	18.72	0.0000
Block*Month	1			1_May		3			1_May		-1.039	0.748	0.4	1	1.93	0.1650
Block*Month	1			1_May		3			2_June		-1.886	0.723	0.2	1	6.80	0.0091
Block*Month	1			1_May		3			3_July		-1.432	0.771	0.2	1	3.46	0.0630
Block*Month	1			2_June		1			3_July		1.093	0.815	3.0	1	1.80	0.1795
Block*Month	1			2_June		2			1_May		-1.088	0.667	0.3	1	2.66	0.1029
Block*Month	1			2_June		2			2_June		-1.256	0.661	0.3	1	3.61	0.0573
Block*Month	1			2_June		2			3_July		-2.580	0.651	0.1	1	15.68	0.0001
Block*Month	1			2_June		3			1_May		-0.609	0.722	0.5	1	0.71	0.3988
Block*Month	1			2_June		3			2_June		-1.457	0.674	0.2	1	4.66	0.0308
Block*Month	1			2_June		3			3_July		-1.003	0.721	0.4	1	1.94	0.1641
Block*Month	1			3_July		2			1_May		-2.181	0.792	0.1	1	7.59	0.0059
Block*Month	1			3_July		2			2_June		-2.350	0.786	0.1	1	8.93	0.0028
Block*Month	1			3_July		2			3_July		-3.673	0.789	0.0	1	21.69	0.0000
Block*Month	1			3_July		3			1_May		-1.702	0.851	0.2	1	4.01	0.0453
Block*Month	1			3_July		3			2_June		-2.550	0.809	0.1	1	9.94	0.0016
Block*Month	1			3_July		3			3_July		-2.096	0.813	0.1	1	6.64	0.0099
Block*Month	2			1_May		2			2_June		-0.168	0.539	0.8	1	0.10	0.7547
Block*Month	2			1_May		2			3_July		-1.492	0.558	0.2	1	7.14	0.0075
Block*Month	2			1_May		3			1_May		0.479	0.611	1.6	1	0.61	0.4331
Block*Month	2			1_May		3			2_June		-0.369	0.552	0.7	1	0.45	0.5038
Block*Month	2			1_May		3			3_July		0.085	0.603	1.1	1	0.02	0.8881
Block*Month	2			2_June		2			3_July		-1.324	0.539	0.3	1	6.04	0.0140
Block*Month	2			2_June		3			1_May		0.647	0.600	1.9	1	1.16	0.2806
Block*Month	2			2_June		3			2_June		-0.201	0.556	0.8	1	0.13	0.7186

Block*Month	2			2_June		3			3_July		0.253	0.594	1.3	1	0.18	0.6699
Block*Month	2			3_July		3			1_May		1.971	0.612	7.2	1	10.38	0.0013
Block*Month	2			3_July		3			2_June		1.123	0.553	3.1	1	4.12	0.0424
Block*Month	2			3_July		3			3_July		1.577	0.612	4.8	1	6.63	0.0100
Block*Month	3			1_May		3			2_June		-0.848	0.598	0.4	1	2.01	0.1565
Block*Month	3			1_May		3			3_July		-0.394	0.632	0.7	1	0.39	0.5330
Block*Month	3			2_June		3			3_July		0.454	0.601	1.6	1	0.57	0.4499
Treatment*Year		1	1999				1	2000			0.054	0.666	1.1	1	0.01	0.9351
Treatment*Year		1	1999				1	2001			-0.474	0.641	0.6	1	0.55	0.4593
Treatment*Year		1	1999				2	1999			-1.811	0.580	0.2	1	9.75	0.0018
Treatment*Year		1	1999				2	2000			-2.243	0.585	0.1	1	14.72	0.0001
Treatment*Year		1	1999				2	2001			-1.117	0.612	0.3	1	3.33	0.0681
Treatment*Year		1	2000				1	2001			-0.528	0.609	0.6	1	0.75	0.3853
Treatment*Year		1	2000				2	1999			-1.866	0.596	0.2	1	9.80	0.0017
Treatment*Year		1	2000				2	2000			-2.298	0.568	0.1	1	16.36	0.0001
Treatment*Year		1	2000				2	2001			-1.171	0.581	0.3	1	4.06	0.0438
Treatment*Year		1	2001				2	1999			-1.337	0.564	0.3	1	5.62	0.0178
Treatment*Year		1	2001				2	2000			-1.769	0.528	0.2	1	11.22	0.0008
Treatment*Year		1	2001				2	2001			-0.643	0.576	0.5	1	1.25	0.2641
Treatment*Year		2	1999				2	2000			-0.432	0.478	0.6	1	0.82	0.3660
Treatment*Year		2	1999				2	2001			0.694	0.514	2.0	1	1.82	0.1769
Treatment*Year		2	2000				2	2001			1.126	0.457	3.1	1	6.08	0.0136
Treatment*Month		1		1_May			1		2_June		-0.580	0.572	0.6	1	1.03	0.3109
Treatment*Month		1		1_May			1		3_July		0.253	0.656	1.3	1	0.15	0.6996
Treatment*Month		1		1_May			2		1_May		-1.209	0.574	0.3	1	4.44	0.0351
Treatment*Month		1		1_May			2		2_June		-1.593	0.548	0.2	1	8.44	0.0037
Treatment*Month		1		1_May			2		3_July		-2.277	0.564	0.1	1	16.27	0.0001
Treatment*Month		1		2_June			1		3_July		0.833	0.611	2.3	1	1.86	0.1730
Treatment*Month		1		2_June			2		1_May		-0.629	0.519	0.5	1	1.47	0.2256
Treatment*Month		1		2_June			2		2_June		-1.013	0.494	0.4	1	4.20	0.0404
Treatment*Month		1		2_June			2		3_July		-1.697	0.517	0.2	1	10.76	0.0010
Treatment*Month		1		3_July			2		1_May		-1.462	0.621	0.2	1	5.54	0.0186

Treatment*Month		1		3_July			2		2_June		-1.846	0.602	0.2	1	9.42	0.0021
Treatment*Month		1		3_July			2		3_July		-2.530	0.612	0.1	1	17.07	0.0000
Treatment*Month		2		1_May			2		2_June		-0.384	0.457	0.7	1	0.71	0.4005
Treatment*Month		2		1_May			2		3_July		-1.068	0.482	0.3	1	4.91	0.0268
Treatment*Month		2		2_June			2		3_July		-0.684	0.456	0.5	1	2.25	0.1335
Block	1					2					4.007	0.579	55.0	1	47.98	0.0000
Block	1					3					3.579	0.543	35.8	1	43.42	0.0000
Block	2					3					-0.429	0.553	0.7	1	0.60	0.4380
Treatment		1					2				0.473	0.447	1.6	1	1.12	0.2904
Year			1999					2000			-0.518	0.562	0.6	1	0.85	0.3562
Year			1999					2001			0.094	0.555	1.1	1	0.03	0.8653
Year			2000					2001			0.612	0.619	1.8	1	0.98	0.3221
Month				1_May					2_June		1.735	0.478	5.7	1	13.19	0.0003
Month				1_May					3_July		3.325	0.584	27.8	1	32.41	0.0000
Month				2_June					3_July		1.590	0.589	4.9	1	7.30	0.0069
period(Month)				1_May	early				1_May	late	0.985	0.988	2.7	1	0.99	0.3186
period(Month)				1_May	early				2_June	early	2.021	0.739	7.5	1	7.48	0.0062
period(Month)				1_May	early				2_June	late	2.434	0.769	11.4	1	10.03	0.0015
period(Month)				1_May	early				3_July	early	3.895	0.849	49.1	1	21.02	0.0000
period(Month)				1_May	early				3_July	late	3.740	0.912	42.1	1	16.83	0.0000
period(Month)				1_May	late				2_June	early	1.035	0.791	2.8	1	1.71	0.1906
period(Month)				1_May	late				2_June	late	1.449	0.855	4.3	1	2.88	0.0899
period(Month)				1_May	late				3_July	early	2.910	0.879	18.3	1	10.96	0.0009
period(Month)				1_May	late				3_July	late	2.755	0.909	15.7	1	9.18	0.0024
period(Month)				2_June	early				2_June	late	0.414	0.777	1.5	1	0.28	0.5945
period(Month)				2_June	early				3_July	early	1.874	0.771	6.5	1	5.91	0.0150
period(Month)				2_June	early				3_July	late	1.719	0.859	5.6	1	4.01	0.0454
period(Month)				2_June	late				3_July	early	1.460	0.794	4.3	1	3.38	0.0660
period(Month)				2_June	late				3_July	late	1.306	0.915	3.7	1	2.04	0.1537
period(Month)				3_July	early				3_July	late	-0.155	0.901	0.9	1	0.03	0.8637
Block*Treatment	1	1				1	2				0.568	0.650	1.8	1	0.76	0.3819
Block*Treatment	1	1				2	1				4.649	0.846	104.5	1	30.20	0.0000

Block*Treatment	1	1				2	2				3.934	0.736	51.1	1	28.55	0.0000
Block*Treatment	1	1				3	1				3.079	0.716	21.7	1	18.51	0.0000
Block*Treatment	1	1				3	2				4.646	0.774	104.2	1	36.00	0.0000
Block*Treatment	1	2				2	1				4.081	0.824	59.2	1	24.56	0.0000
Block*Treatment	1	2				2	2				3.366	0.742	29.0	1	20.60	0.0000
Block*Treatment	1	2				3	1				2.511	0.719	12.3	1	12.20	0.0005
Block*Treatment	1	2				3	2				4.078	0.763	59.0	1	28.59	0.0000
Block*Treatment	2	1				2	2				-0.716	0.851	0.5	1	0.71	0.4006
Block*Treatment	2	1				3	1				-1.570	0.799	0.2	1	3.86	0.0493
Block*Treatment	2	1				3	2				-0.003	0.896	1.0	1	0.00	0.9971
Block*Treatment	2	2				3	1				-0.854	0.714	0.4	1	1.43	0.2314
Block*Treatment	2	2				3	2				0.712	0.778	2.0	1	0.84	0.3601
Block*Treatment	3	1				3	2				1.567	0.780	4.8	1	4.03	0.0446
Block*Year	1		1999			1		2000			-0.082	0.895	0.9	1	0.01	0.9266
Block*Year	1		1999			1		2001			-0.550	0.819	0.6	1	0.45	0.5022
Block*Year	1		1999			2		1999			3.446	1.012	31.4	1	11.59	0.0007
Block*Year	1		1999			2		2000			3.026	0.920	20.6	1	10.81	0.0010
Block*Year	1		1999			2		2001			4.918	1.061	136.8	1	21.47	0.0000
Block*Year	1		1999			3		1999			3.932	1.005	51.0	1	15.31	0.0001
Block*Year	1		1999			3		2000			2.879	0.878	17.8	1	10.76	0.0010
Block*Year	1		1999			3		2001			3.292	0.934	26.9	1	12.43	0.0004
Block*Year	1		2000			1		2001			-0.467	0.922	0.6	1	0.26	0.6122
Block*Year	1		2000			2		1999			3.528	0.914	34.1	1	14.90	0.0001
Block*Year	1		2000			2		2000			3.109	0.850	22.4	1	13.38	0.0003
Block*Year	1		2000			2		2001			5.001	0.998	148.5	1	25.12	0.0000
Block*Year	1		2000			3		1999			4.015	0.972	55.4	1	17.05	0.0000
Block*Year	1		2000			3		2000			2.962	0.863	19.3	1	11.77	0.0006
Block*Year	1		2000			3		2001			3.374	0.937	29.2	1	12.97	0.0003
Block*Year	1		2001			2		1999			3.995	1.004	54.3	1	15.84	0.0001
Block*Year	1		2001			2		2000			3.576	0.902	35.7	1	15.71	0.0001
Block*Year	1		2001			2		2001			5.468	1.039	237.0	1	27.68	0.0000
Block*Year	1		2001			3		1999			4.482	0.996	88.4	1	20.25	0.0000

Block*Year	1		2001			3		2000			3.429	0.926	30.8	1	13.70	0.0002
Block*Year	1		2001			3		2001			3.841	0.918	46.6	1	17.53	0.0000
Block*Year	2		1999			2		2000			-0.420	0.979	0.7	1	0.18	0.6681
Block*Year	2		1999			2		2001			1.473	1.005	4.4	1	2.15	0.1429
Block*Year	2		1999			3		1999			0.487	0.991	1.6	1	0.24	0.6235
Block*Year	2		1999			3		2000			-0.566	0.975	0.6	1	0.34	0.5612
Block*Year	2		1999			3		2001			-0.154	0.957	0.9	1	0.03	0.8721
Block*Year	2		2000			2		2001			1.892	1.073	6.6	1	3.11	0.0778
Block*Year	2		2000			3		1999			0.906	1.011	2.5	1	0.80	0.3700
Block*Year	2		2000			3		2000			-0.147	0.915	0.9	1	0.03	0.8726
Block*Year	2		2000			3		2001			0.266	1.017	1.3	1	0.07	0.7939
Block*Year	2		2001			3		1999			-0.986	1.054	0.4	1	0.88	0.3495
Block*Year	2		2001			3		2000			-2.039	1.017	0.1	1	4.02	0.0449
Block*Year	2		2001			3		2001			-1.627	0.960	0.2	1	2.87	0.0903
Block*Year	3		1999			3		2000			-1.053	1.016	0.3	1	1.07	0.2999
Block*Year	3		1999			3		2001			-0.641	0.963	0.5	1	0.44	0.5058
Block*Year	3		2000			3		2001			0.412	0.989	1.5	1	0.17	0.6767
Block*Month	1			1_May		1			2_June		0.458	0.872	1.6	1	0.28	0.5997
Block*Month	1			1_May		1			3_July		-0.067	0.908	0.9	1	0.01	0.9415
Block*Month	1			1_May		2			1_May		2.999	0.935	20.1	1	10.29	0.0013
Block*Month	1			1_May		2			2_June		2.402	0.861	11.0	1	7.78	0.0053
Block*Month	1			1_May		2			3_July		7.012	1.259	1109.8	1	31.03	0.0000
Block*Month	1			1_May		3			1_May		-0.082	1.042	0.9	1	0.01	0.9374
Block*Month	1			1_May		3			2_June		5.262	0.980	192.9	1	28.84	0.0000
Block*Month	1			1_May		3			3_July		5.947	1.042	382.4	1	32.56	0.0000
Block*Month	1			2_June		1			3_July		-0.524	0.858	0.6	1	0.37	0.5409
Block*Month	1			2_June		2			1_May		2.542	0.794	12.7	1	10.25	0.0014
Block*Month	1			2_June		2			2_June		1.944	0.824	7.0	1	5.56	0.0183
Block*Month	1			2_June		2			3_July		6.554	1.201	702.2	1	29.77	0.0000
Block*Month	1			2_June		3			1_May		-0.540	0.812	0.6	1	0.44	0.5063
Block*Month	1			2_June		3			2_June		4.804	0.952	122.0	1	25.47	0.0000
Block*Month	1			2_June		3			3_July		5.489	0.953	242.0	1	33.18	0.0000

Block*Month	1			3_July		2			1_May		3.066	0.843	21.5	1	13.22	0.0003
Block*Month	1			3_July		2			2_June		2.469	0.777	11.8	1	10.09	0.0015
Block*Month	1			3_July		2			3_July		7.079	1.243	1186.2	1	32.43	0.0000
Block*Month	1			3_July		3			1_May		-0.015	0.895	1.0	1	0.00	0.9864
Block*Month	1			3_July		3			2_June		5.329	0.909	206.2	1	34.36	0.0000
Block*Month	1			3_July		3			3_July		6.013	0.926	408.7	1	42.19	0.0000
Block*Month	2			1_May		2			2_June		-0.597	0.814	0.6	1	0.54	0.4630
Block*Month	2			1_May		2			3_July		4.013	1.182	55.3	1	11.52	0.0007
Block*Month	2			1_May		3			1_May		-3.081	0.818	0.0	1	14.17	0.0002
Block*Month	2			1_May		3			2_June		2.263	0.925	9.6	1	5.99	0.0144
Block*Month	2			1_May		3			3_July		2.947	0.933	19.1	1	9.98	0.0016
Block*Month	2			2_June		2			3_July		4.610	1.192	100.5	1	14.95	0.0001
Block*Month	2			2_June		3			1_May		-2.484	0.888	0.1	1	7.83	0.0051
Block*Month	2			2_June		3			2_June		2.860	0.889	17.5	1	10.34	0.0013
Block*Month	2			2_June		3			3_July		3.544	0.920	34.6	1	14.85	0.0001
Block*Month	2			3_July		3			1_May		-7.094	1.195	0.0	1	35.23	0.0000
Block*Month	2			3_July		3			2_June		-1.750	1.238	0.2	1	2.00	0.1574
Block*Month	2			3_July		3			3_July		-1.065	1.251	0.3	1	0.73	0.3945
Block*Month	3			1_May		3			2_June		5.344	1.001	209.3	1	28.47	0.0000
Block*Month	3			1_May		3			3_July		6.028	0.982	415.0	1	37.65	0.0000
Block*Month	3			2_June		3			3_July		0.684	1.071	2.0	1	0.41	0.5228
Treatment*Year		1	1999				1	2000			-0.963	0.823	0.4	1	1.37	0.2417
Treatment*Year		1	1999				1	2001			-1.601	0.802	0.2	1	3.98	0.0460
Treatment*Year		1	1999				2	1999			-0.954	0.776	0.4	1	1.51	0.2193
Treatment*Year		1	1999				2	2000			-1.027	0.734	0.4	1	1.96	0.1619
Treatment*Year		1	1999				2	2001			0.836	0.811	2.3	1	1.06	0.3028
Treatment*Year		1	2000				1	2001			-0.638	0.887	0.5	1	0.52	0.4718
Treatment*Year		1	2000				2	1999			0.009	0.808	1.0	1	0.00	0.9907
Treatment*Year		1	2000				2	2000			-0.064	0.797	0.9	1	0.01	0.9359
Treatment*Year		1	2000				2	2001			1.799	0.849	6.0	1	4.49	0.0340
Treatment*Year		1	2001				2	1999			0.648	0.817	1.9	1	0.63	0.4280
Treatment*Year		1	2001				2	2000			0.574	0.811	1.8	1	0.50	0.4793

Treatment*Year		1	2001				2	2001			2.437	0.854	11.4	1	8.15	0.0043
Treatment*Year		2	1999				2	2000			-0.074	0.795	0.9	1	0.01	0.9262
Treatment*Year		2	1999				2	2001			1.789	0.770	6.0	1	5.40	0.0202
Treatment*Year		2	2000				2	2001			1.863	0.855	6.4	1	4.75	0.0293
Treatment*Month		1		1_May			1		2_June		1.112	0.678	3.0	1	2.69	0.1009
Treatment*Month		1		1_May			1		3_July		4.537	0.934	93.4	1	23.62	0.0000
Treatment*Month		1		1_May			2		1_May		0.866	0.689	2.4	1	1.58	0.2092
Treatment*Month		1		1_May			2		2_June		3.224	0.754	25.1	1	18.28	0.0000
Treatment*Month		1		1_May			2		3_July		2.979	0.756	19.7	1	15.53	0.0001
Treatment*Month		1		2_June			1		3_July		3.425	0.948	30.7	1	13.04	0.0003
Treatment*Month		1		2_June			2		1_May		-0.246	0.693	0.8	1	0.13	0.7226
Treatment*Month		1		2_June			2		2_June		2.112	0.792	8.3	1	7.10	0.0077
Treatment*Month		1		2_June			2		3_July		1.867	0.746	6.5	1	6.27	0.0123
Treatment*Month		1		3_July			2		1_May		-3.671	0.874	0.0	1	17.66	0.0000
Treatment*Month		1		3_July			2		2_June		-1.313	0.917	0.3	1	2.05	0.1520
Treatment*Month		1		3_July			2		3_July		-1.558	0.996	0.2	1	2.45	0.1177
Treatment*Month		2		1_May			2		2_June		2.358	0.712	10.6	1	10.96	0.0009
Treatment*Month		2		1_May			2		3_July		2.113	0.791	8.3	1	7.13	0.0076
Treatment*Month		2		2_June			2		3_July		-0.245	0.843	0.8	1	0.08	0.7713

APPENDIX C

Genmod Output.
Graphical Distributions Of
Beach Seine Catch Data

Figure 1—a: Number of Fish (Count) with random jiggle[0,.2]

Species=Chinook Salmon

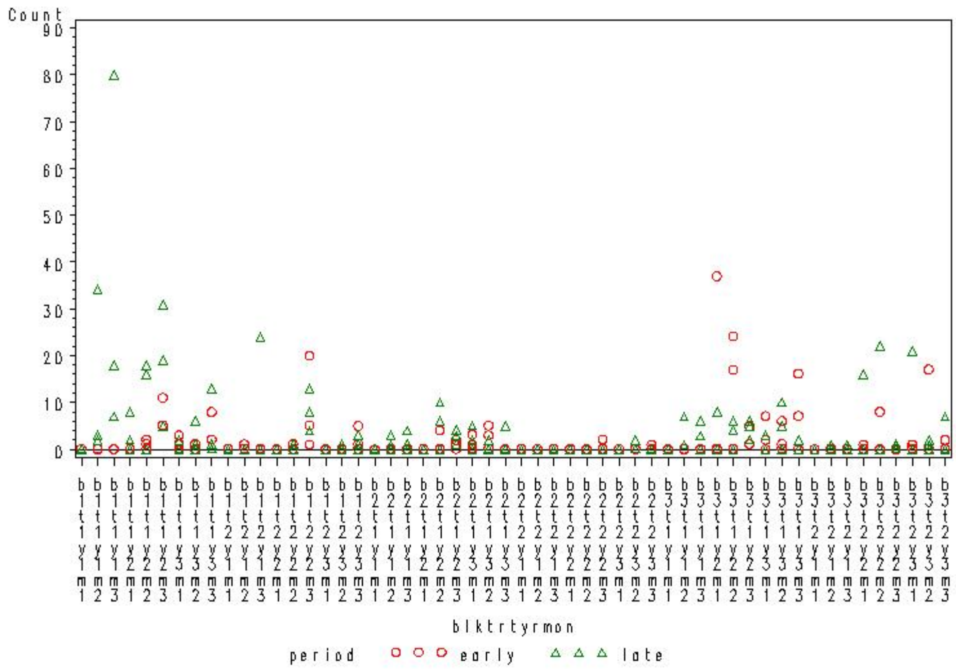


Figure 1—a: Number of Fish (Count) with random jiggle[0,2]

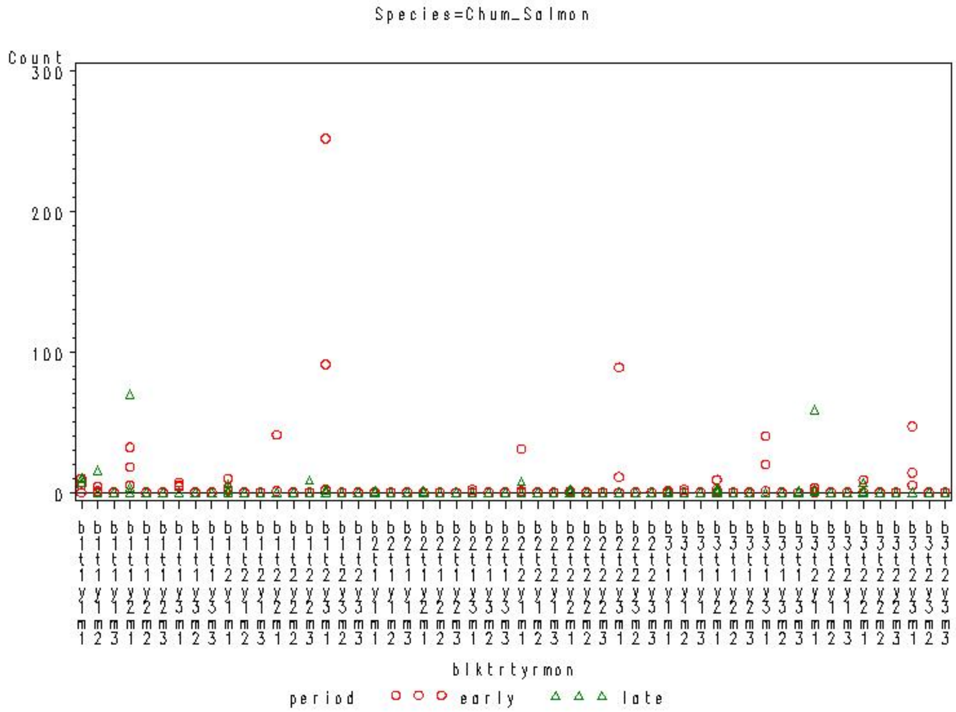


Figure 1—a: Number of Fish (Count) with random jiggle[0,.2]

Species=English_Sole

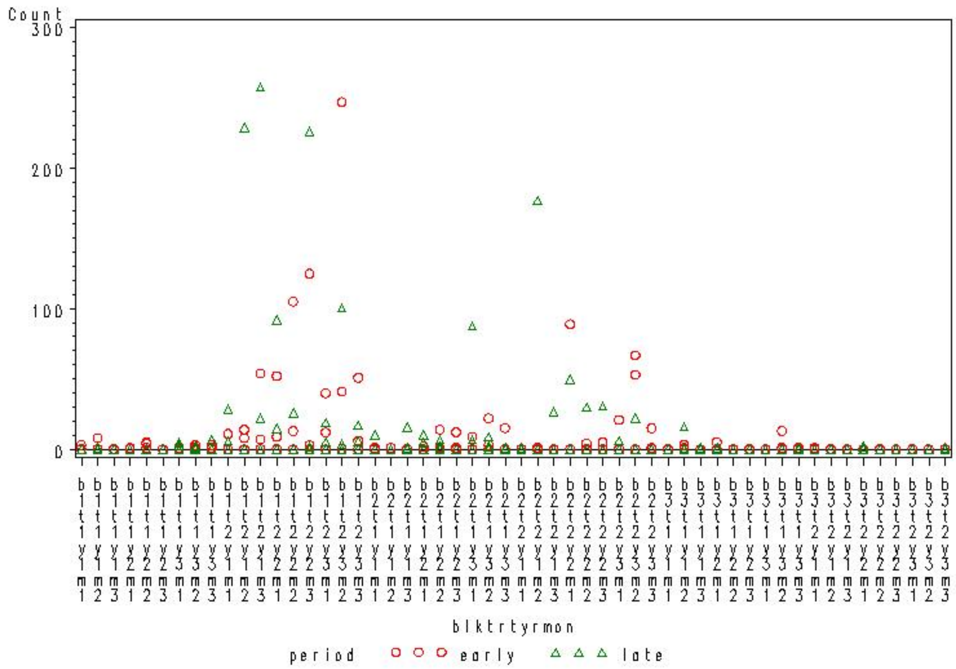


Figure 1—a: Number of Fish (Count) with random jiggle[0,.2]

Species=Pacific_Sand_Lance

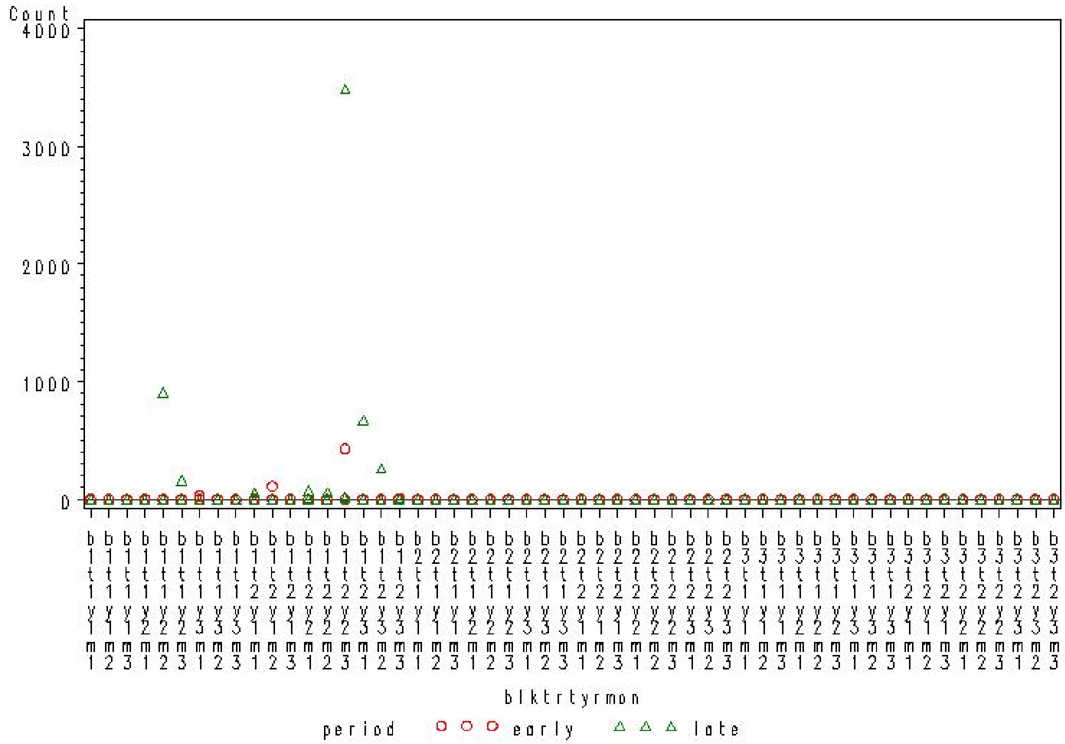


Figure 1—a: Number of Fish (Count) with random jiggle[0,.2]

Species=Pacific_Staghorn_Sculpin

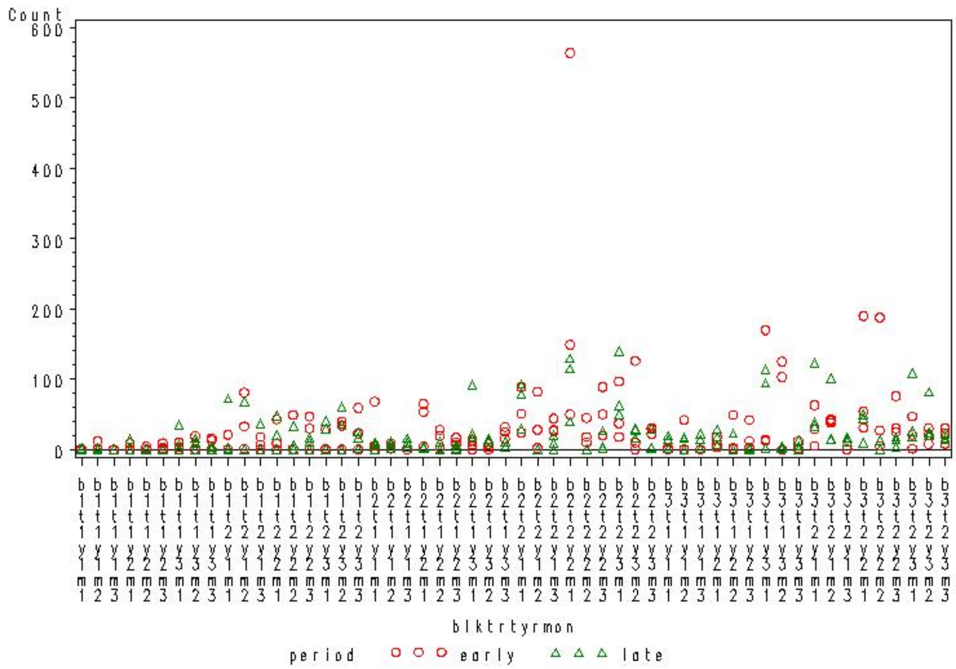


Figure 1—a: Number of Fish (Count) with random jiggle[0,.2]

Species=Starry_Flounder

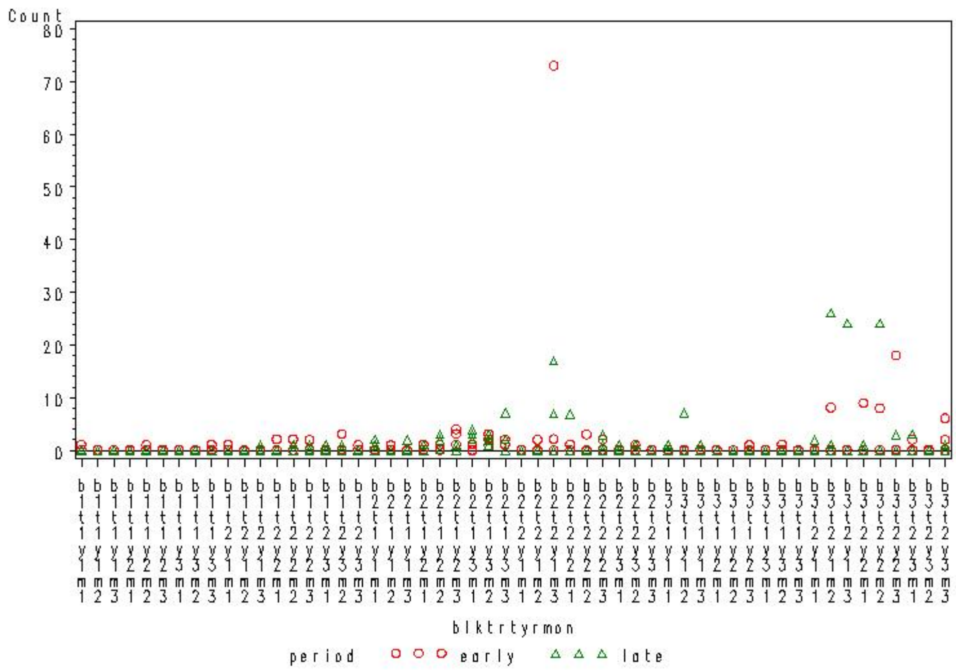


Figure 1—a: Number of Fish (Count) with random jiggle[0,.2]

Species=Surf_Smelt

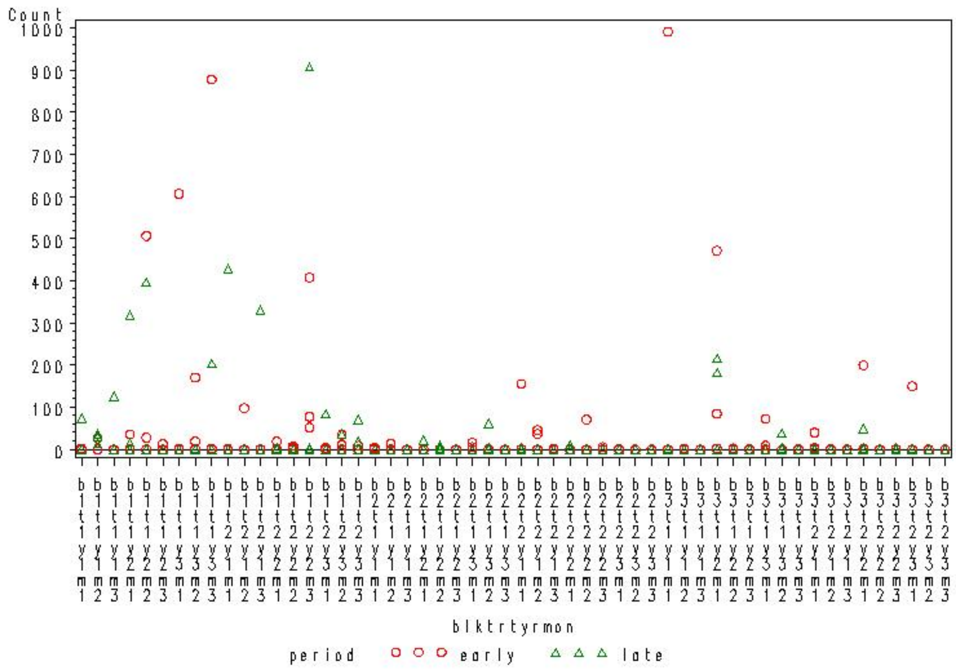


Figure 1—a: Number of Fish (Count) with random jiggle[0,2]

Species=Shiner_Perch