FISHERIES ASSESSMENT FOR BOLINAS LAGOON TRIBUTARIES WITHIN THE GOLDEN GATE NATIONAL RECREATION AREA, 1995-2000

Darren Fong
Aquatic Ecologist
Golden Gate National Recreation Area
Building 1061, Fort Cronkhite
Sausalito, CA 94965
(415) 331-8716

February 2002

Prepared for the
National Park Service
Golden Gate National Recreation Area
Division of Natural Resource Management and Research

GENERAL SUMMARY

Tributaries on the east-side of Bolinas Lagoon run off from the steep slopes of the Bolinas Ridge. Flows in these small tributary streams may often be perennial until they enter the alluvial flats near the lagoon. During the late summer, surface flows near the lagoon may be absent, although isolated pools may be present. With the exception of some limited data from Easkoot Creek, no information had been available regarding the distribution of fish within these streams. Stream aquatic invertebrates were collected in 1995. Habitat and fish surveys were conducted from between 1997 and 2000. Streamflow and water quality data collection were initiated in 1999.

Habitat conditions in all streams reflected disturbed conditions. Exotic riparian vegetation was found in the alluvial flats of surveyed streams near Highway One. Non-riparian plants such as french broom are common on the disturbed berms. These areas also had the lowest amount of woody materials. The disturbed reaches (e.g., lower Easkoot Creek and Stinson Gulch) were also dominated by shallow-water habitats. Field observations indicate the lingering effects of debris flows caused by the 1982 floods and subsequent channel cleaning activities by the Park and others. Map of stream segments from GPS equipment show channels that have shifted from the alignments illustrated on earlier USGS topographic maps. Much of the material excavated from the channels have been sidecast in berms that line the creek. This is most evident along the lower portion of Easkoot and Stinson Gulch.

All surveyed streams had small populations of anadramous and resident fish such as steelhead and sculpin. However, redd surveys indicate very low numbers of spawning adults. Interviews with local residents indicate that adults were much more abundant, even as recent as the 1970’s. Changes that may have impacted steelhead since then include increased water appropriation, instream flood control activities that have simplified habitats, loss of freshwater embayment, and loss of riparian habitat.

Recent efforts to improve habitat conditions have shown that simple measures such as boulder and rootwad placement to be successful in increasing the carrying capacity of steelhead. Fish surveys have shown highest concentrations of steelhead to be present in pools which also harbor several year-classes of steelhead.

Several actions can be taken to protect and improve fishery resources. These include protection of instream flows, cooperation with local residents in protecting riparian and channel habitats, initiation of mitigation for channel disturbing activities, and control of non-native riparian plants.

TABLE OF CONTENTS

INTRODUCTION

The Natural Resources Management Guideline (NPS-77) and the National Park Service's (NPS) Management Policies provide a broad directive "to restore, maintain, or enhance the quality of all surface and groundwater within the parks consistent with the Clean Water Act and other applicable federal, state, and local laws and regulations" (NPS-77, page 50). However, baseline information on existing conditions is needed to assist efforts to restore, maintain or enhance wetland and aquatic sites. NPS Management Policies reflect this need and require NPS to assemble baseline inventory data describing natural resources under its stewardship.

Objectives

Much of the east and south draining tributaries to Bolinas Lagoon, Marin Co., California are under the management of resource conservation landowners including Audubon Canyon Ranch, Mt. Tamalpais State Park, and the Golden Gate National Recreation Area (Figure 1). Little information was available

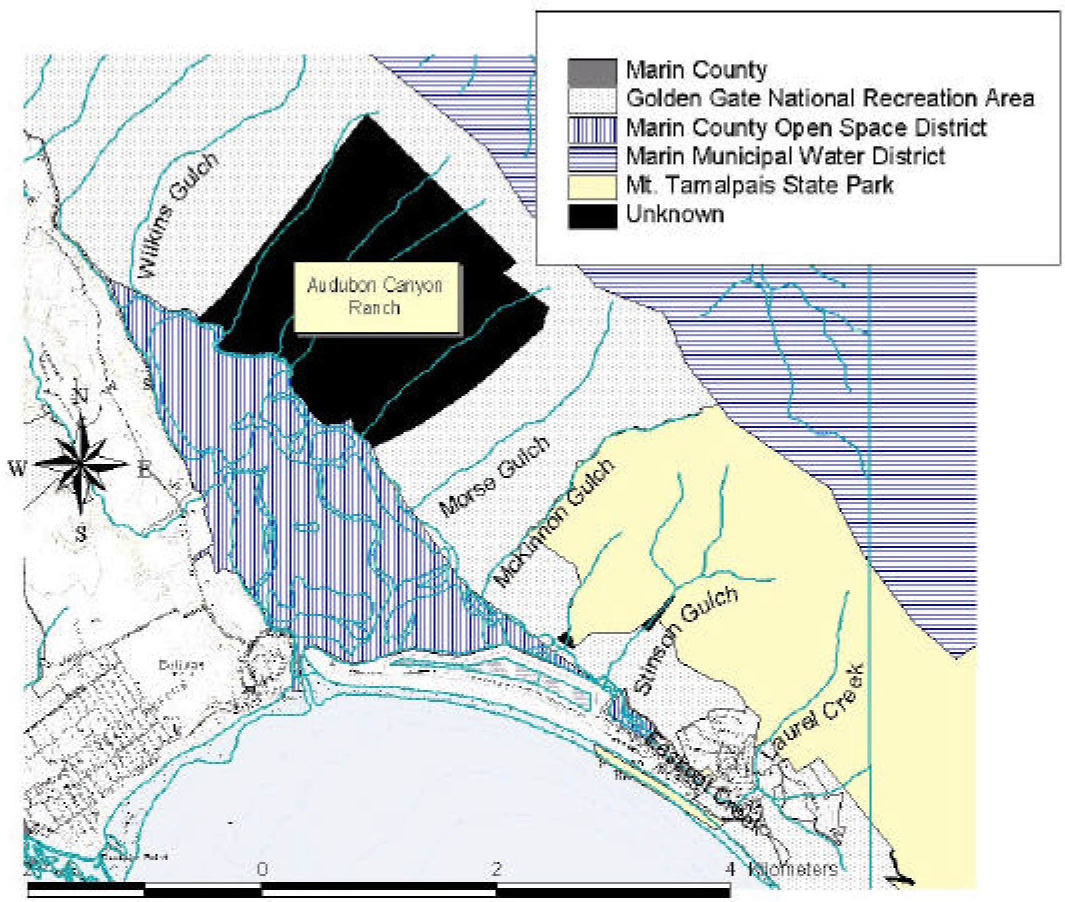


Figure 1: Watershed landowners along the east side of Bolinas Lagoon, Marin Co., CA

regarding aquatic biological resources and stream habitat conditions. Also, local residents expressed concerns that the numbers of steelhead trout present in these tributaries were being affected by poor habitat conditions. To better understand juvenile rearing habitat conditions, an inventory was undertaken to describe habitat conditions pertinent to aquatic life, to describe the stream macroinvertebrate community, and to estimate the abundance of fish by species within Stinson Gulch and Easkoot Creek. In addition, we reviewed historic information available through aerial photos, maps, and interviews to describe events that may have resulted in current fisheries conditions. In addition to this assessment effort, the Park is working on a restoration project to improve riparian and stream functioning in Easkoot Creek. This report will serve to document past fishery protection and improvement activities that the Park has been involved in.

Project Area

The project streams drain the east end of the Bolinas Lagoon watershed. The tributaries draining Bolinas Lagoon descend rapidly from Bolinas Ridge and flatten onto a plain before entering the lagoon. The hillslopes are dominated by either mixed conifer forest or coastal scrub communities. In the lower reaches of the Easkoot drainage, urban development is present.

With the exception of Easkoot Creek, the streams are very similar in size and characteristics. The mainstem portions of the creeks are all short, between 2 and 4 km (Table 1). The flows are intermittent in the lower reaches with small, but perennial flows in the bedrock upper reaches. Unimpaired flows were measured by the U.S. Geological Survey in 1967-1969 in Morse Creek, near the confluence with Bolinas Lagoon (USGS 2000). Currently, streamflows are only being measured at Easkoot Creek. Table 1 provides a summary of the general stream and watershed features.

For the purposes of comparison, we compared fish and habitat data with a Park stream in San Mateo Co (West Union Creek), a second-order tributary of San Francisquito Creek in San Mateo Co. draining the San Francisco Bay (Figure 2). The watershed area and flow regime are similar to the Bolinas tributaries.

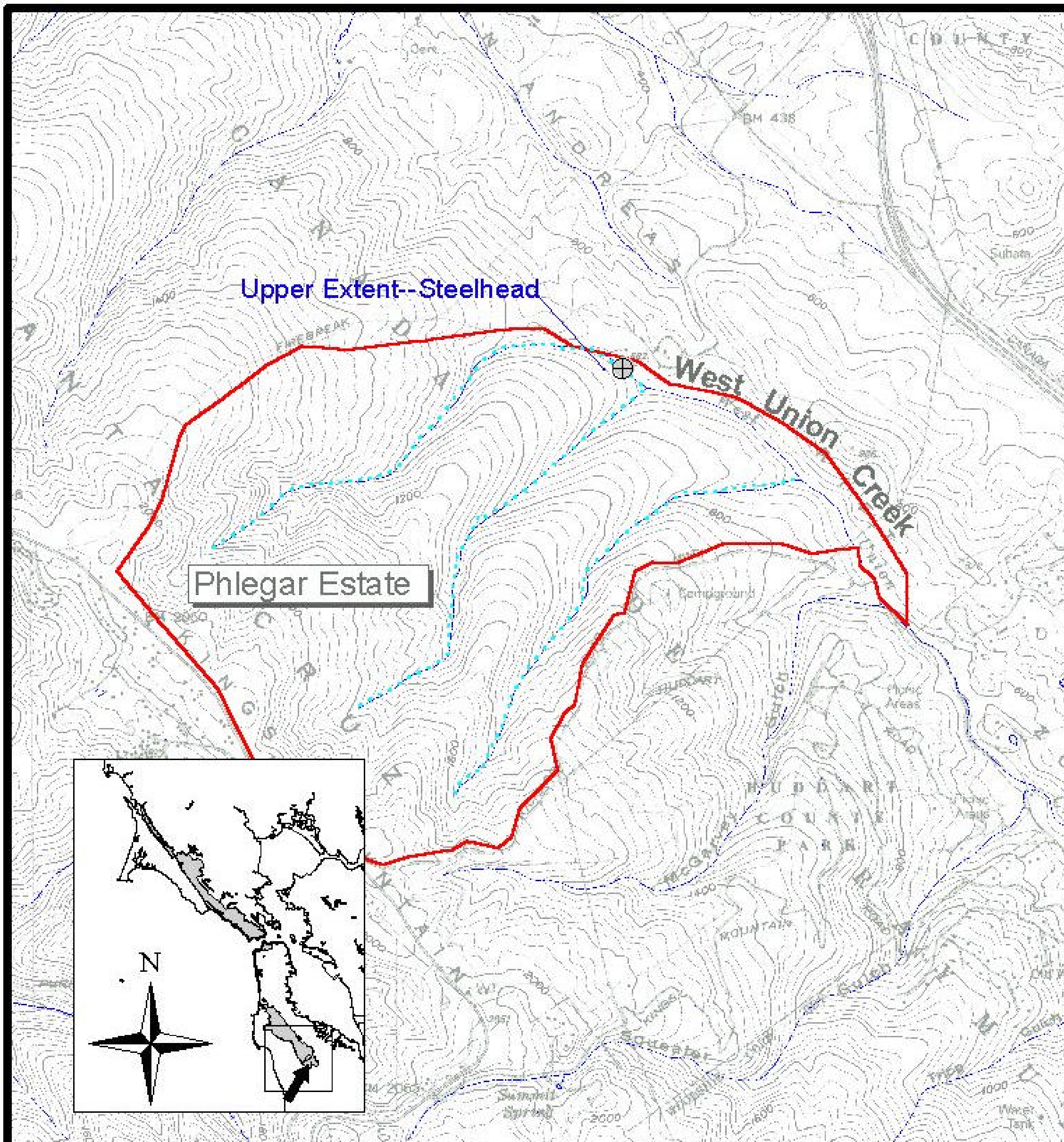


Figure 3 - Steelhead Trout (Oncorhynchus mykiss) Distribution in GGNRA, San Mateo Co.

Along Tributaries
Along West Union Creek
GGNRA Management Boundary

500 0 500 1000 1500 2000 2500 Meters

* Upper limit distribution unknown

Table 1: General watershed characteristics for five Bolinas Lagoon subwatersheds, Marin County and a San Mateo County reference subwatershed.

Name	Watershed Area (a)	Stream Order	Mainstem Channel Length (km)	Mainstem Channel Slope[1]	Elev. Range (m)	Ownership
Wilkins Gulch	447	1	3.00	0.12	1-503	NPS
Morses Gulch	433	1	2.67	0.15	1-512	NPS
McKinnon Gulch	442	1	2.67	0.17	1-562	NPS, Mt. Tam SP
Stinson Gulch	633	2	2.33	0.20	1-591	NPS, SBCWD, Mt. Tam SP
Easkoot Creek	1062	2	3.33	0.15	1-630	NPS, Private, SBCWD, Mt. Tam SP
West Union Creek	1856	2	2.0	0.6	180-628	NPS, Huddart Co. Park, Private

[1]Gregory and Walling (1973)

Past Work

Local residents are exceptionally interested in restoring and protecting fish and habitat and have undertaken several actions. In 1993, an ad hoc Easkoot Creek Advisory Committee was formed by the Stinson Beach Village Association (local community "government") and funded a restoration plan to harmonize flood control with fishery, scenic, educational, and cultural values. The plan also represented the first fisheries assessment along Easkoot Creek (Rich 1992). Later, a non-profit organization was formed; they initiated and completed a project in 1998 to improve adult steelhead fish passage.

Habitat and fisheries data have recently been gathered in nearby Audubon Canyon Ranch streams (Szychowski 1999). The U.S. Army Corps of Engineers are currently conducting a watershed assessment for the Bolinas Lagoon Restoration Project.

METHODS

Stream surveys at Wilkins, Morses, McKinnon, and Stinson Gulches were all initiated at the confluence with Bolinas Lagoon. They terminated at locations where we believed that either upstream barriers to fish were present or when habitat became unsuitable for steelhead. For Easkoot Creek, the survey reach was initiated in the tidally influenced portion near the Stinson Beach Fire Station at Seadrift Road in Stinson Beach. Survey activities extended for 1000 m to the Arenal Bridge crossing, just upstream of the Stinson Beach Park boundary. Sampling dates are provided below in Table 2.

Table 2. Field sampling dates for east-side Bolinas Lagoon tributaries, Marin Co.

Stream	Habitat Sampling Dates	Juvenile Fish Sampling Dates
Wilkins Gulch	Aug 12-17, 1998	
Morses Gulch	July 21-22, 1998	
McKinnon Gulch	July 28 -Aug 4, 1998	
Stinson Gulch	July 9-10, 1997	July 10, 1997
Easkoot Creek	August 7, 1997	July 29 & 31, 1998; Aug 4-5, 1999; Aug 3-4, 2000

Stream Inventory Data

We collected data on stream habitat features which we felt described habitat suitability for aquatic life and hydrologic functionality (Table 3). Much of the inventory was based on standard protocol from CDFG (1994), Dollof *et al.* (1993), Pfankuch (1975), and Overton *et al*. (1994, 1993). Data was collected both continuously along the surveyed reaches as well as at systematically spaced stations (every 100 m). These surveyed areas are indicated in Figures 3-5.

We used a simple habitat classification system. Stream habitat classification systems have received much criticism because of the inherent observer variability and the ephemeral nature of habitat units both seasonally and annually. However, no other cost-effective system has been recommended to inventory over large distances, stream habitat suitability for aquatic life. To minimize seasonal and observer variability, the habitat classification was based on just riffle, flatwater, pool (main channel {including step/plunge pools}, scour, and backwater) units rather than more detailed classification schemes. Habitat unit lengths were measured along the thalweg. Habitat unit widths and depths were estimated using a graduated wading rod.

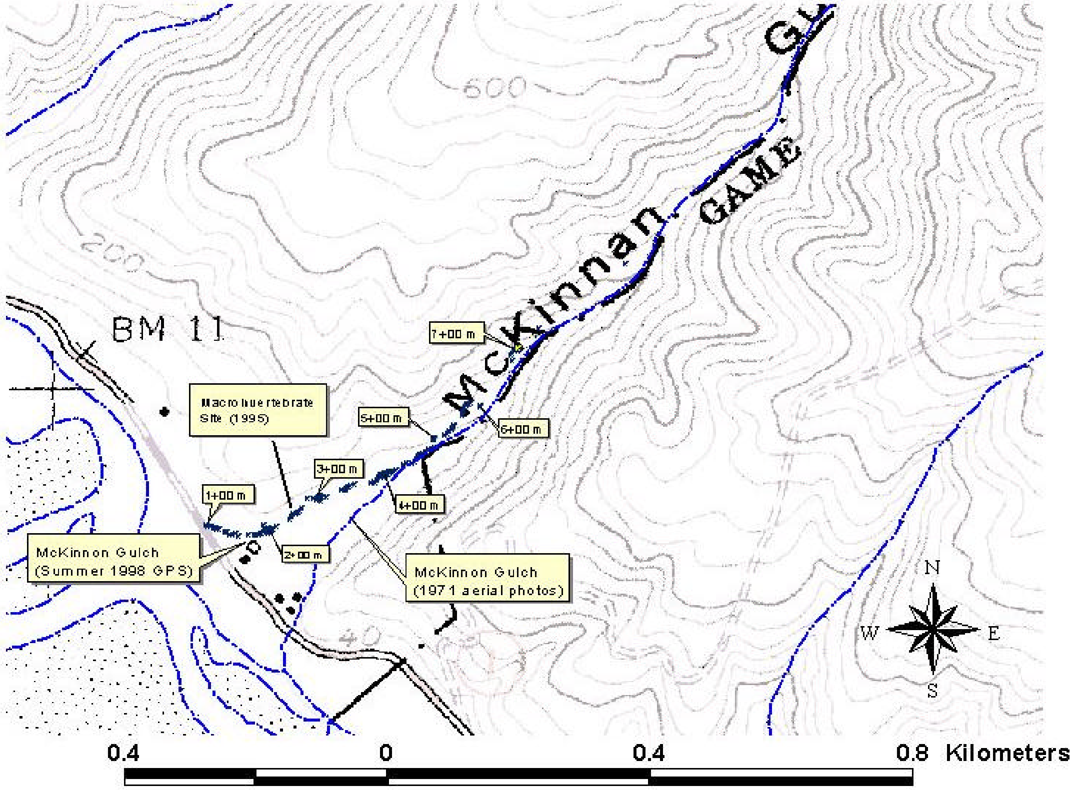


Figure 3: McKinnon Gulch Sampling Stations, Marin Co., CA

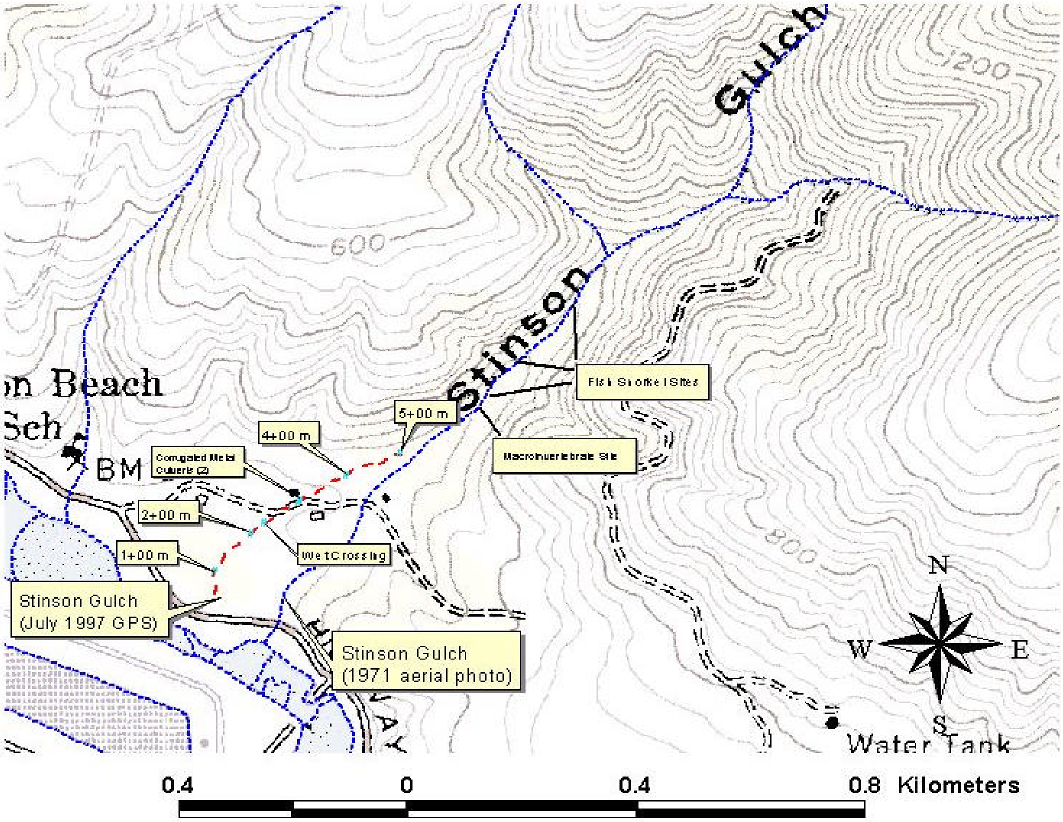


Figure 4: Stinson Gulch Sampling Stations, Marin Co., CA

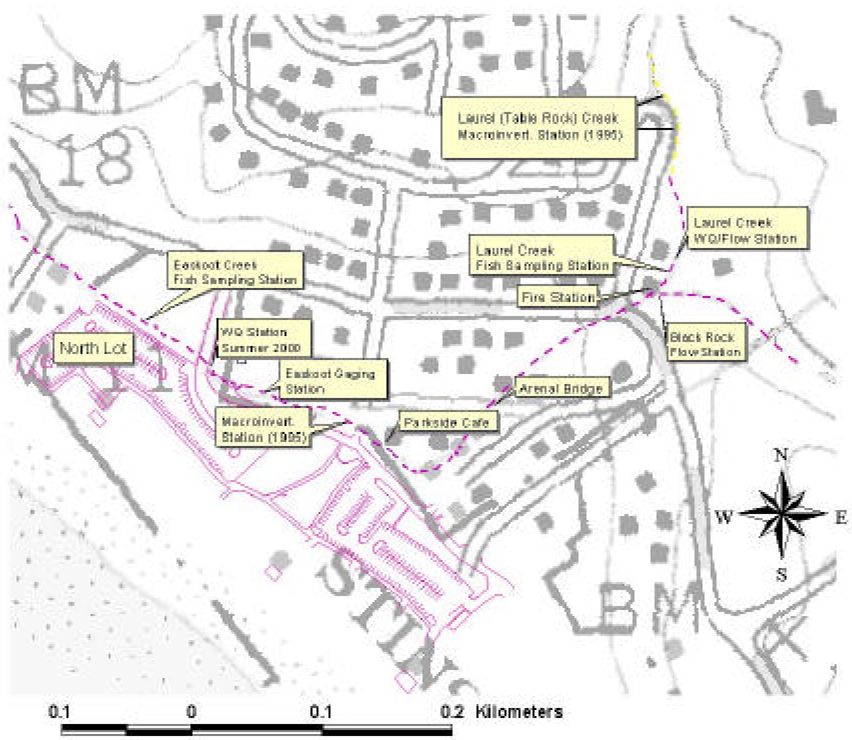


Figure 5: Easkoot and Laurel Creek Sampling Stations, Marin Co., CA

Within each 100 m section, we tallied all woody materials within the bankfull channel. To qualify, individual logs must be dead or dying and meet specific size requirements. Tallied logs were at least 2 m in length and were subdivided into the following diameter classes: 10-20 cm, 20-50 cm, and >50 cm. Diameter was measured at the mid-point of the log. Stumps or rootwads with their root structure intact and less than 2 m long were tallied separately. Rootwads are stable structures and provide excellent juvenile fish habitat. Accumulations of more than 10 individuals pieces of large woody materials constituted a large woody debris jam. Each jam was tallied separately. Small woody debris accumulations that were at least 2 m in length and 10 cm in diameter were also tallied.

Other important information were recorded as the observer waded upstream. Non-native vegetation seen from the channel, presence/not found data of juvenile steelhead and other organisms, and near-channel disturbances (e.g., slides) were recorded.

Table 3: Collected stream data for east-side Bolinas Lagoon tributaries, Marin Co.

Habitat type	Landform slope/mass wasting hazard
Habitat width (m)	Location of culverts, bank protection, slides
Habitat length (m)	Large woody material (>10 cm dia, 1 m length)
Maximum pool depth	Presence of non-native vegetation
Pool tail depth	Fish presence
Canopy Cover (using spherical densiometer)	Bankfull width/depth

Topographic Surveys

We conducted topographic surveys at Easkoot Creek using fiberglass tapes, laser level (Beacon Model 3900, Ser# 3920-28794), and fiberglass rod (Mound City 25ft-100th& 8th, Mod# 903041). Profile surveys were conducted along the thalweg of the low flow channel. Water surface and bed elevations were measured to the nearest 0.01 feet at topographic breaks in the channel. Notes were made regarding the specific type of stream habitat unit (pool {main channel, backwater, or scour}, riffle, and flatwater) and any features that could influence aquatic habitat (e.g., location of bank protection). For pools, we typically measured the elevations at the tail, mid-point, maximum depth, and head. Prior to field surveys, a peg test was conducted to assess instrument accuracy (over 250.0 ft distance). We determined instrument accuracy to be ±0.016 ft over 100 feet. No adjustments were made to laser level.

We surveyed into an existing National Geodetic Survey benchmark (PID# HT 1718, UTM 657470N 1811590E, established 1951) located on a bedrock outcrop on the west of Highway One at the street intersection with Calle del Pradero. The NAVD88 elevation of this benchmark is 20.7 ft (± 2 cm). We placed rebar monuments (with aluminum tags with location information) every 25 meters from the downstream boundary of Stinson Beach Park to the upstream boundary.

Streamflow

A stream gaging station was established in June 1999 by the Water Resources Division along lower Easkoot Creek within Stinson Beach Park (UTM 4914554 N 531586 E, Figure 5). The gaging station consists of an automatic rain gage, a pressure transducer (Druck PDCR 1830-8388, 0-5 psi pressure range), and datalogger (Campbell Scientific CR10x, Ser#18250). Discharge values were established from a low flow rating curve relating water surface elevation and field discharge measurements. Field discharge measurements were conducted in the field using a Swoffer Model 2100 (propeller-type) meter during winter high flows. Low flows were measured using a Gurley pygmy meter (Model 625). Meters were individually rated by U.S. Geological Survey's Hydrologic Instrumentation Facility in 2000 and rating equations were used to calculated velocity. The techniques used in taking discharge measurements and computing streamflow are described in Buchanan and Somers (1969). Several instruments were used to obtain measurements at low flows including a modified 3-inch Parshall flume, a custom-made flume, and a Gurly pygmy meter. It was determined that the pygmy meter provided the most accurate low-flow measurements.

We also established two sites upstream of the Park and downstream of existing water appropriation sites in Laurel and Black Rock Creeks in 1999. These sites were established to gage flows specifically to assess water appropriation activities. Flows were measured volumetrically by recording the amount of time needed to fill 5-gallon buckets. Location of sampling locations is provided in Figure 5 (UTM 4194649 N, 531894 E, NAD 83). Water diversion information was provided by the Stinson Beach County Water District.

Water Quality

Water quality data was deemed critical to determining instream flows needed to protect aquatic community health. In fact, water quality data was likely a more effective indicator of aquatic community well-being than fish for the streams near Stinson Beach. Water appropriation occurs in the headwaters of Stinson Gulch and Easkoot Creek, making control-treatment fishery assessments within these watersheds difficult, if not impossible In addition, the current fish population has been impaired by substantial physical habitat modifications as well as continued water appropriation.

No regulatory water quality objectives were available for any streams tributary to Bolinas Lagoon (RWQCB 1995). Therefore, we conducted a literature review to identify critical water quality parameters that would affect fish well-being and to identify any established water quality criteria. This information was used to identify appropriate "red flags" or parameters to monitor. Based on a literature review, we used sublethal dissolved oxygen threshold of 5 mg/l and water temperature of 20^{o}C as additional "red flags" (Table 4). Recent live cage studies using threespine stickleback and prickly sculpin at Rodeo Lake, Marin Co., by the U.S. Geological Survey (Biological Resources Division) found low mortality (<10%) when daily minimum dissolved oxygen exceeded 4.5 mg/l and high mortality below 3.8 mg/l (Martin and Saiki, unpublished data, 1998).

We were also interested in collecting specific conductance data at Laurel and lower Easkoot Creek stations. Several streets, businesses and residences (including the Park's parking lot at Stinson Beach) are adjacent and upstream of the lower Easkoot Creek project site. Specific conductance can provide a coarse index of pollutant loading into a waterbody. Specific conductance is a numerical expression of the ability of a solution to carry an electric current (APHA 1985). This ability depends on the presence of ions and temperature (APHA 1985). Work by Mike Rugg, California Department of Fish and Game's water quality specialist, found high conductivity in waters affected by livestock wastes.

Table 4: Summary of Water Quality Stressors on Juvenile Steelhead and Prickly Sculpin

SPECIES (life stage)	STRESSOR	RESPONSE PARAMETER	EFFECT	CITATION
STEELHEAD				
juvenile	Dissolved Oxygen	Acute lethality	<3 mg/l	Raleigh et al. (1984)
egg-fry	Temperature during incubation	Embryonic development	$T \leq 12$ and $\geq 7^{o}C$	Raleigh et al. (1984)
juvenile	Temperature	Preference	13-19^{o}C	Raleigh et al. (1984)
smolts	Temperature		$T > 4$ and $<13^{o}C$	Raleigh et al. (1984)
PRICKLY SCULPIN	Dissolved Oxygen	>60% mortality	<3.8 mg/l	Martin and Saiki, unpub.data, 1998

Summer stream temperature measurements were obtained during the summer of 1999 with ONSET Hobotemp and Stowaway units (3 hr interval). Accuracy of temperature measurements were assessed with a mercury thermometer and water bath. The units were installed just upstream and downstream from the Park entrance road bridge. In 2000, air and water temperature were obtained from thermistors located at the Park stream gage and were associated with the Campbell Scientific datalogger. From July to October 2000, the Park obtained dissolved oxygen, temperature, and specific conductance data at 30 minute intervals from two Hydrolab Datasonde 4 multi-parameter water quality dataloggers within Easkoot Creek. Dataloggers were downloaded and calibrated about once every three weeks.

Stream Macroinvertebrate Sampling

Areas within Easkoot Creek watershed, Stinson Gulch, and Morse Gulch were sampled with a D-frame dipnet (dipnet area approx 450 sq. cm, mesh size approx 0.5 mm) on November 8, 1995. Sampled areas included a representative riffle and pool habitat. Riffle habitats were sampled by kicking the substrate and by rubbing large rocks free of attached organisms and collected dislodged organisms with the dipnet. Pool habitats were sampled by pushing the net along the bottom of the pool and along any woody materials. The original intent of the sampling activities was to serve as a reconnaissance survey and to collect specimens for the Essig Museum of Entomology (U.C. Berkeley) and was not initially intended to serve as a bioassessment tool. Therefore, minimal quantitative habitat information was collected and short sample distance. However, equivalent sampling effort was spent at all sites.

In the lab, invertebrates were sorted from the debris and identified to the lowest practicable taxon under a dissecting scope. The taxa were grouped into abundance categories as described in EPA's rapid bioassessment procedures (Plafkin et al., 1989). The following taxanomic keys were used- Pennak (1989) and Merritt and Cummins (eds.) (1996).

The intent of the sampling was to provide a taxa list of stream macroinvertebrates and some index of relative abundance. The health of the stream macroinvertebrate community was also assessed using simple, commonly accepted metrics- taxa richness, number of mayfly/stonefly/caddisfly taxa, number of predatory taxa, unweighted family biotic index, and number of long-lived taxa (>1 year freshwater) (Karr and Chu 1999; Plafkin et al., 1989). These metrics were chosen to mirror impacts that we believe to be present in the system- namely, fluctuations in water quantity in summer, habitat simplification because of past stream practices, and questionable instream water quality adjacent to streamside roads, businesses, and residences. Generally, taxa richness increases with water quality, habitat diversity, and habitat suitability (Plafkin 1989). However, it should be noted that assessment of the health of the macroinvertebrate community may not necessarily reflect impairment that might be reflected on the organismal level (e.g., reduced growth), species level (e.g., abundance of species), or ecosystem processes (e.g., rate of detrital processing) (Carlisle 2000). The mayfly (Order Ephemeroptera), stonefly (Order Plecoptera), and caddisfly (Order Trichoptera) taxa are generally considered pollution sensitive and the number of "EPT" taxa generally increases with increasing water quality (Plfakin et al., 1989). The family biotic index was developed to summarize the water pollution tolerances of the benthic arthropod community into a single value (Plafkin et al. 1989). The index is generally weighted according to the abundance of collected taxa although unweighted index values are used in this report. To assess fluctuations in water quantity, the number of predatory taxa and long-lived taxa (semi- and merovoltine) were chosen as metrics. We assumed that long-lived taxa would be less common in streams that frequently went dry. For comparison purposes, we looked at sites within nearby Redwood Creek (Marin Co., Muir Woods National Monument) that were upstream of all diversions and known to be perennial.

Sample specimens have been preserved in 70% ethanol and are located within the Park's natural history museum collection currently located at Building 1061, Fort Cronkhite. Elmid specimens have also been archived at the Essig Museum of Entomology at U.C. Berkeley.

Juvenile Fish Sampling

Fish were sampled using both electrofishing and visual techniques. During stream habitat inventories, observers would note presence or not found status of juvenile steelhead within each 100 m reach. In certain instances, snorkel surveys were conducted at sites with known juveniles to determine their relative abundance. Snorkel surveys were conducted at Stinson Gulch. Because of the extreme shallowness of flatwater and riffle habitat units, sampling was confined to just pools. Snorkel site locations are indicated in Figure 4. During snorkel surveys, a single observer entered pools at the downstream end and carefully searched woody debris and undercuts with a divelight for fish. Most pools had minimal flows and suspended sediments made it impossible to make repeated snorkel surveys. Therefore, only single pass estimates are available. Observed fish were classified into 6 size classes and identified to species.

Snorkel surveys were not calibrated. We anticipated that the accuracy of the snorkel technique was high because of the simplified habitat conditions present in the creek, low numbers of fish (especially 1+ and older steelhead), and the small pool volumes. It should be noted that snorkel surveys in larger creeks (Pine Gulch, Redwood, and Olema Creeks) consistently underestimated juvenile 1+ and older steelhead when compared to electrofishing estimates (Fong, pers. obs., 2000).

The selected pools were sampled during the summer using multiple-pass electrofishing. Typically, two to four passes per pool were conducted with a programmable waveform backpack electrofishing unit (Smith-Root Model 12 B-POW). Fish were captured using either pulsed or straight direct current with the minimum voltage and frequency necessary for immobilization. Sampled habitat units were isolated with block nets unless there was no contiguous flows with adjacent areas. Collected fish were identified to species and measured to the nearest mm (fork length for steelhead, total length for sculpin and threespine stickleback). For steelhead juveniles, we weighed (nearest 0.1 g) (Ohaus Scout 400 g capacity) and collected scales from below the dorsal fin from individuals >90 mm for aging.

Abundance estimates for fish were calculated using the computer program, MICROFISH 3.0 (Van deventer and Platts 1988). Steelhead year-classes were estimated separately. Age classes were identified for juvenile steelhead trout by looking at length-frequency distributions and reading scales to identify annuli. A microfiche reader and hand lens were used to magnify scale images for viewing.

Juvenile condition was also assessed using the Fulton's condition factor and weight-length power function (Anderson and Gutreuter 1983). Fulton's condition factor (K) is represented by
$K = \frac{Weight(g)}{Length(mm)^3} x10,000$. The weight-length power function is represented by W = aL^b where w = wet weight (g), L= fork length (mm), and a and b are estimated parameters (Anderson and Gutreuter 1983). Typically, "plumper" fish have higher K and b values than "skinny" fish.

Standing vertebrate biomass was calculated by determining the mean weight per individual taxa per habitat unit and then extrapolating to the total weight per taxa per habitat unit based on the estimated total number of individuals. In 1998, only length data (no weight data available) was available for aquatic vertebrates. Standing biomass was estimated using length-weight relationships established in 1999 and 2000 datasets. We assumed that similar flow patterns for these years resulted in similar mean fish condition. This is consistent with the similarity in the growth coefficient 'b' between 1999 and 2000 (where $W=aL^b$) (Anderson and Gutreuter 1983). Growth coefficient 'b' was 2.988 (Summer 1999) and 2.987 (Summer 2000) for juvenile steelhead/rainbow trout.

Redd Surveys

The Park and local volunteers conducted redd surveys during the spring of 1999 and 2000. The survey areas were based on discussions with local residents and their recollection of the extent of steelhead spawning. Redd surveys were conducted on Easkoot Creek, Stinson Gulch, Morses Gulch, and McKinnon Gulch. During Spring 1999, repeated surveys were conducted. To prevent double counting of redds seen in prior surveys, redds were flagged and dated. In 2000, only a single survey was conducted.

Historic Fisheries and Habitat Information

Information regarding the historic distribution and abundance of fish along the east side Bolinas Lagoon was obtained by conducting phone or in-person conversations with long-term residents in the area. Current channel alignments were mapped in the field using GPS receivers. Changes in channel alignments and character were determined by comparing current locations with USGS topographic maps of various dates. The Map Room at the Geology Department in U.C. Berkeley was used to obtain maps. The Stinson Beach Historical Society assisted with the identification of old photos from the area. An extensive review of land-use maps and newsprint was conducted by Suzie van Kirk under contract to the consultant (Tetra Tech) that was preparing an environmental settings report on Bolinas Lagoon for the U.S. Army Corps of Engineers.

RESULTS AND DISCUSSION

General Habitat Observations.

With the exception of Easkoot Creek, all streams cross under State Highway One in box culverts. Sediments mobilized during winter storm events often are deposited near the low gradient portion of these culverts. Caltrans maintenance crews typically remove sediments on an annual basis. Other culverts observed were located on Stinson Gulch and Easkoot Creek.

Physical evidence of human modifications of channels were present on several creeks. Bank stabilization was present along all surveyed streams. Easkoot Creek had the dubious distinction of having the longest total length of bank stabilization as well as the most diverse types (Table 5). Other signs of human alteration were also present along Easkoot Creek. Grass trimmings were seen in the channel, sulfurous smells occurred instream, maintained yards went to the top of bank, and a variety of non-native plants.

Unstable bank conditions, based on surveyors' observations, were most prevalent along Wilkin's Gulch (Table 6). Unlike other streams, the area adjacent to the stream is being actively managed for horses and cattle. Stinson had significant areas above Highway One where past channel modifications created unstable bank conditions.

Table 5: Character and distance of bank stabilization along east-side Bolinas Lagoon tributaries, Marin Co.

Stream	Bank Stabilization Type	Bank Stabilization Distance (m)
Wilkins Gulch	Riprap	75
Morses Gulch	Riprap	10
McKinnon Gulch	Riprap	89
Stinson Gulch	Riprap	9
Easkoot Creek	Riprap	16
	Sandbag, Sacrete	20
	Gabion	22
	Retaining wall	108
Lower Easkoot Total	--	166

Table 6: Character of bank and landform along east-side Bolinas Lagoon tributaries, Marin Co.

Stream	Median Landform Slope Rating (Inner Gorge)[1]	Median Mass Wasting Hazard	Median Bank Soil Alteration*
Wilkins Gulch	4	3	3
Morses Gulch	3	2	1.25
McKinnon Gulch	4	2	2
Stinson Gulch	3	2	2
Lower Easkoot Creek	1	1	1

[1] (1)-<30% both banks, (2)- 30-40% one bank, (3) 40-60% one or both banks, (4) >60% either bank

[2] (1) excellent {none}, (2) good {slumps small and vegetated}, (3) fair, (4) poor

[3] (0)-stable banks, (1)-<25% receiving light stress; (2) <50% false, (3) broken/eroding; 50-75% false, broken/eroding; (4) >75% false, broken/eroding.

The lower portion of Stinson and McKinnon Gulches have been altered, and to a lesser extent, Morse Gulch. It appears that new channels for McKinnon and Stinson Gulches were created since 1952, the date of the aerial photography used for the U.S.G.S. 7.5 minute Bolinas quad map (Figures 3-4). It appears that creekbed materials have been excavated and spoiled along the banks, forming an artificial berm. Much of the spoiled materials are angular rather than rounded. Similar types of materials found on the banks of Easkoot Creek were from excavated debris flow materials from the early 1980's (Steve Zempsch, pers. comm., 2001). Plants typical of riparian areas are absent. Many of the plants growing along the lower section of Stinson Gulch include coyote brush and french broom. Caltrans routinely cleans the inlet and outlet of culverts underneath Highway One. Recent GPS surveys along the thalweg of Stinson and McKinnon Gulches show substantial realignment of the stream channels (Figures 3-4). At both streams, the channel has been displaced further north roughly 100 m over a 300-400 m distance (Figures 3-4).

McKinnon Gulch represents the most interesting habitat modification. There are several culverts draining the alluvial flats of McKinnon Gulch into Bolinas Lagoon. The largest culvert (@MP14.41) appears to be at a higher elevation than the other culverts and it also represents the outlet for the current alignment of the creek into Bolinas Lagoon. Unfortunately, the lower reach above this box culvert is dry for most of the year (isolated water during site visit of February 1, 2001). The southern culverts (@MP 14.31 and 14.37) nearer the historic alignment of the creek all had substantial amounts of flowing water entering into Bolinas Lagoon. However, these sites were not connected to the current main channel and the water came from an emergent wetland. The historic channel bisected the yards and residential structures (now since abandoned). It is possible that the channel was relocated north to protect these residential structures. In addition, two berms or dikes perpendicular to the existing channel are present. It is possible that these berms served to redirect flood flows away from the historic channel and low-lying areas to the reconstructed channel.

For the most part, very little canopy cover was present in the tidally influenced portions of the creeks (roughly first 100 m) where woody riparian species were naturally absent and halophytes such as saltgrass or pickleweed were common (Table 7). Generally, most of the surveyed streams had almost complete canopy cover except at sites in slide-prone, inner-gorge areas along the creek. Unfortunately, we did not collect complete instream canopy cover with a densiometer for all streams and stations. Our more subjective ocular estimates of canopy cover suggests that the lower 500 m of Stinson Gulch had less than 50% cover. Similarly, Easkoot Creek also has less than 50% within the lower 600 m.

Table 7: Instream canopy cover (%) at 100-m stations along east-side Bolinas Lagoon tributaries, 1997-1998.

	STATIONS													
Stream	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Median**
Wilkins Gulch	51	94	94	99	93	97	94	97	99	99	93	91	97	**94**
Morses Gulch	0			93	100	97	100	91	93	53	93			**93**
McKinnon Gulch	0	72	100	99	13	51	100	74	87	59	88	97	91	**87**
Stinson Gulch	ND													
Lower Easkoot Creek	ND													

ND-No data.

All streams had one or more non-native plants within the riparian corridor. Most of the non-native riparian plants were found in the low gradient portions nearest roads and urban development. Not surprisingly, Easkoot Creek, the most urbanized creek had the most exotic plant species found in our survey. We summarized the observed species below in Table 8. More extensive surveys and distribution maps of Cape ivy and pampas grass have been completed by the Park's vegetation program.

Table 8: Non-native plants found within near-stream riparian areas in east-side Bolinas Lagoon tributaries, 1997-1998.

Common Name	Scientific Name	Easkoot Creek	Stinson Gulch	McKinnon Gulch	Morse Gulch	Wilkins Gulch
Cape ivy	*Delairea odorata*	x				
English ivy	*Hedera helix*	x		x	x	
Eucalyptus	*Eucalyptus sp.*	x	x			
Fennel	*Foeniculum vulgare*	x				
French broom	*Genista monspessulana*		x			x

Common Name	Scientific Name	Easkoot Creek	Stinson Gulch	McKinnon Gulch	Morse Gulch	Wilkins Gulch
Fuschia	*Fuschia sp.*	x				
Himalayan blackberry	*Rubus discolor*	x			x	
Ice plant	*Mesembryanthemum sp.*	x				
Monterey pine	*Pinus radiata*	x				
Nasturtium	*Tropaeolum majus*	x				
Pampas grass	*Cortaderia jubata, C. selloana*	x	x	x		
Poison hemlock	*Conium maculatum*			x	x	x
Wild radish	*Raphanus sativum*				x	

Stream Habitat Types

All of the sampled stream reaches had dry reaches (Table 9). With the exception of Easkoot Creek, all of the dry reaches were in the reaches above the confluence Bolinas Lagoon. Stinson Gulch had the largest stretch of dry stream bed. Over 50% of the lower channel was dry during the summer sampling period. It is unclear whether human actions are causing this condition. Water diversions are present on Stinson Gulch. Two instream diversions withdraw water from the headwaters while a well (approx. 50 gpm) operates in the lower alluvial portion. However, substantial lengths of lower Morse and McKinnon Gulches were also dry despite the absence of any water diversions, although the dry reaches were in areas previously disturbed by human activity.

Certain areas within lower Easkoot Creek defied normal stream habitat classification. Around the Stinson Beach Park reach, much of the stream habitat consisted of shallow sheet flow across emergent and aquatic vegetation which we called "Marsh." Also, the relatively higher percentage of pool habitat in Easkoot Creek relative to other Bolinas streams is misleading (Table 9). Much of the lower Easkoot Creek (0-500 m) consisted of a tidally influenced slough which we considered as pool habitat, despite the fact that this pool type has a residual pool depth of zero. On low tides, very little water would be present in the channel.

Table 9: Summary of stream habitat units along east-side Bolinas Lagoon, Marin Co.

Stream Habitat Units	Wilkins Gulch	Morse Gulch	McKinnon Gulch	Stinson Gulch	Easkoot Creek
Pool	13.1	14.5	10.7	20.8	59.4
Dry	24.5	20.4	35.3	50.7	14.0
Riffle	62.4	55.1	53.5	23.9	12.6
Flatwater	-	8.9	-	4.6	9.6
Marsh	-	-	-	-	4.4
Cascade	-	1	<1	-	-

TOTAL (m)	1214	916	1206	1086	1005

Also, as stream gradient increased, step pools became increasingly common. Surveyors also noted the presence of nice cascades near the headwaters of Morse and McKinnon Gulches, which are an infrequent destination for hikers.

Pool Depths

Residual pool depth represents the mean depth of water for pools should surface flows drop to zero. We did not find any significant differences amongst the Bolinas tributary streams in their residual pool depths (single-factor ANOVA, Fischer's PLSD, Figure 6). However, West Union Creek (San Mateo Co.) had significantly deeper pools than any of the Bolinas tributary streams. (single factor ANOVA, Fisher's PLSD, $p<0.05$).

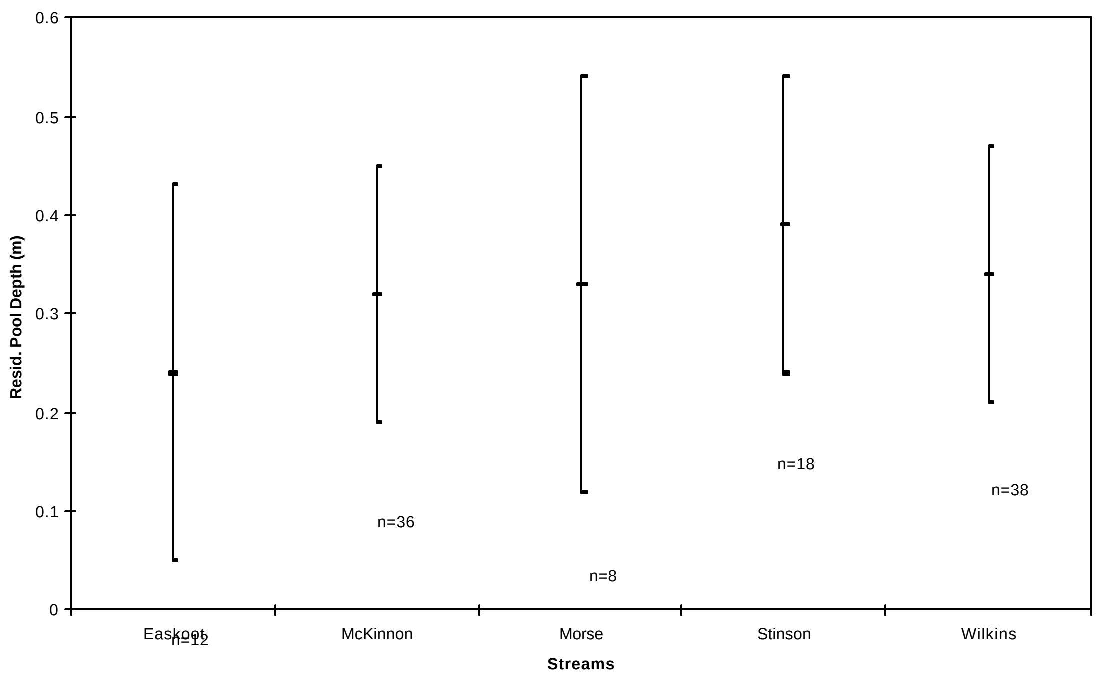


Figure 6: Mean residual pool depths and standard deviation for 5 streams draining Bolinas Lagoon (1997-1998)

Stream Profile

We only collected stream profile data for Easkoot Creek in 1999. Mean channel slope was 1.3 percent. The topographic profile and habitat classification data both indicate the scarcity of deep pool habitats within the Park boundaries, between Calle Pinos and the Arenal bridge. Topographic surveys in summer 1999 found just two shallow pools with mean depths of less than 0.5 m and representing less than 20% of project length (Figure 7). Slight depressions in the streambed indicate that a few pools could be present upstream of the Parkside Café if surface water is present.

The absence of deep pools reduces the total number of juvenile steelhead produced within Park waters as well as the size they can attain. Larger individuals have a higher likelihood of returning as adults (Ward and Slaney 1988).

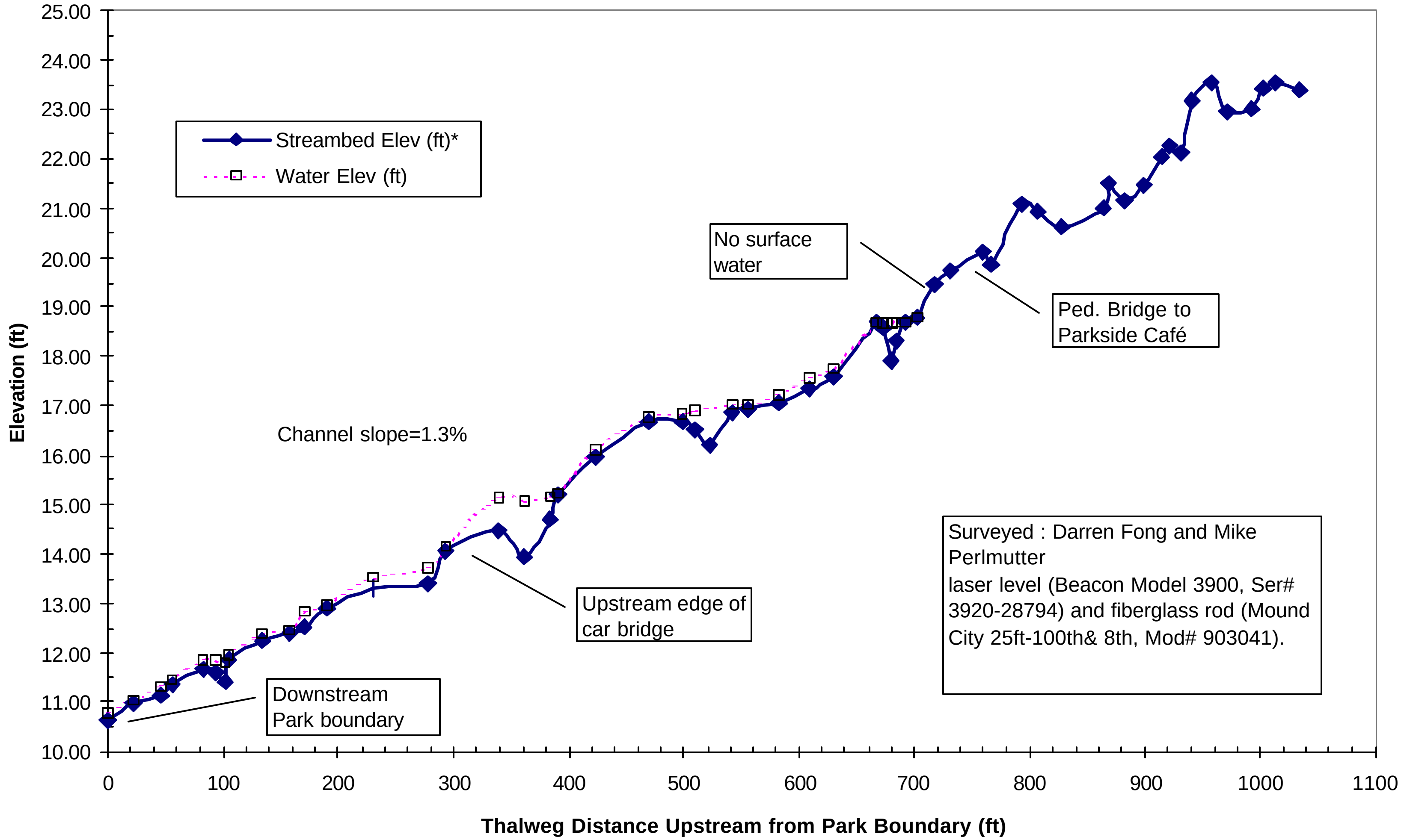


Figure 7: Lower Easkoot Creek Stream Thalweg Profile at Stinson Beach, Marin Co., August 1999

Woody Material

Historic accounts indicate that at least the northeastern half of the Bolinas Lagoon drainages had old-growth forest characteristics (van Kirk 2000). According to Munro-Fraser's "History of Marin County" (1880)

> "It is estimated that about fifteen million feet of lumber was cut in the immediate vicinity of Bolinas, and judging from the stumps which still remain, the redwoods of this grand old forest primeval must have been the peers of any of their congeners in the State, always excepting of course the "Big Trees of Calaveras." This forest extended from about midway of the bay on the eastern side northward to the summit between Bolinas and Olema. They grew much larger in the gulches where they were in a measure sheltered from the fierce winds of the ocean and also where the fog was the densest ."

Much of the old-growth douglas fir and redwoods have long been cut to supply the growing San Francisco metropolis. Trees in the Bolinas vicinity provided milled lumber and firewood to San Francisco (van Kirk 2000).

This removal of large riparian trees is reflected in the paucity of wood in the stream channels. Because of the low stream power and longevity of windblown douglas firs and redwoods in the channel, there should naturally be more large woody materials in the channel. Because all Bolinas stream drainages have been logged, we compared our data to frequency of woody materials within West Union Creek. Although this watershed was logged, large second growth redwoods are present in the riparian area. The average density of wood within the bankfull channel was 9.1 units per 100 m. Although information was not recorded, many of the woody debris in the creek tended to be downed redwoods.

WILKINS GULCH(Figure 8). This creek displayed the highest densities of woody materials of the sampled creeks. Mean densities of 5.8 units of wood were found per 100 m. Many of these pieces included long-term pool-forming rootwads and materials >50 cm in diameter.

MORSE GULCH (Figure 9). Low densities of woody materials were found in Morse Gulch. However, mean densities of 3.2 units per 100 m were higher than those reported for Easkoot Creek. Woody materials were present in almost all sections.

MCKINNON GULCH (Figure 10). As with Wilkins Gulch, McKinnon Gulch had the highest densities of woody materials of the sampled creeks (6.75 units per 100 m). Many of the downed trees were large California laurel (*Umbellularia californica*). In addition, this gulch had several debris jams (5).

STINSON GULCH (Figure 11). As with Easkoot Creek, very little wood was available in the lower portion of the channel above the lagoon. While the mean density of wood (2.2 units per 100 m) was higher than Easkoot Creek, 85% of the observed wood were within the last 200 m of the surveyed channel.

EASKOOT CREEK (Figure 12). The was little woody material within the channel. For the sampled 1000 m, a mean density of 0.6 units per 100 m was counted. No woody material was found within the first 600 m (Figure 12). This low density may partly be explained by the absence of large riparian trees in the lower section, particularly in the tidal slough portion (0-400 m). Above the tidally influenced areas, the local flood control district conducts an annual cleanup of the creek which includes the removal of large woody materials that could potentially be transported and lodged at bridge locations. In addition, almost all of the infrequently encountered woody materials are either downed alders or willows—species whose wood does not persist as long in the water as large conifers such as douglas fir. This removal prevents the establishment of main channel or scour pools that are formed by wood.

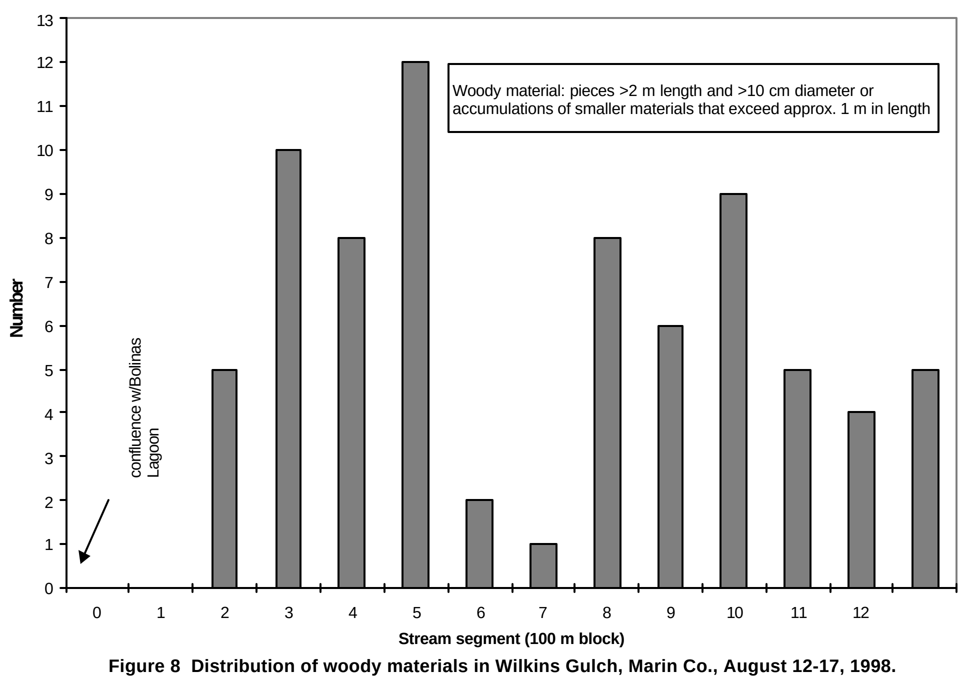


Figure 8 Distribution of woody materials in Wilkins Gulch, Marin Co., August 12-17, 1998.

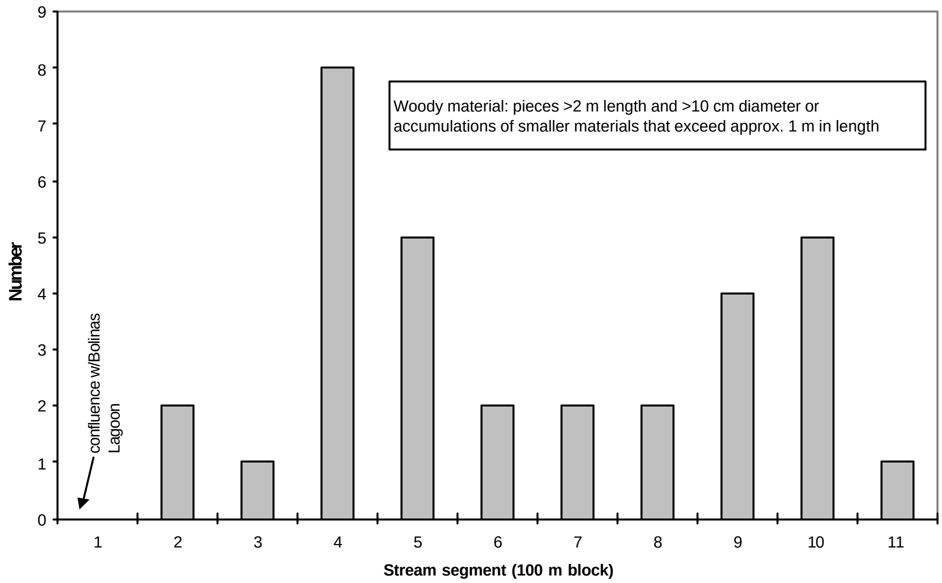


Figure 9: Distribution of woody materials in Morse Gulch, Marin Co., July 21-22, 1998.

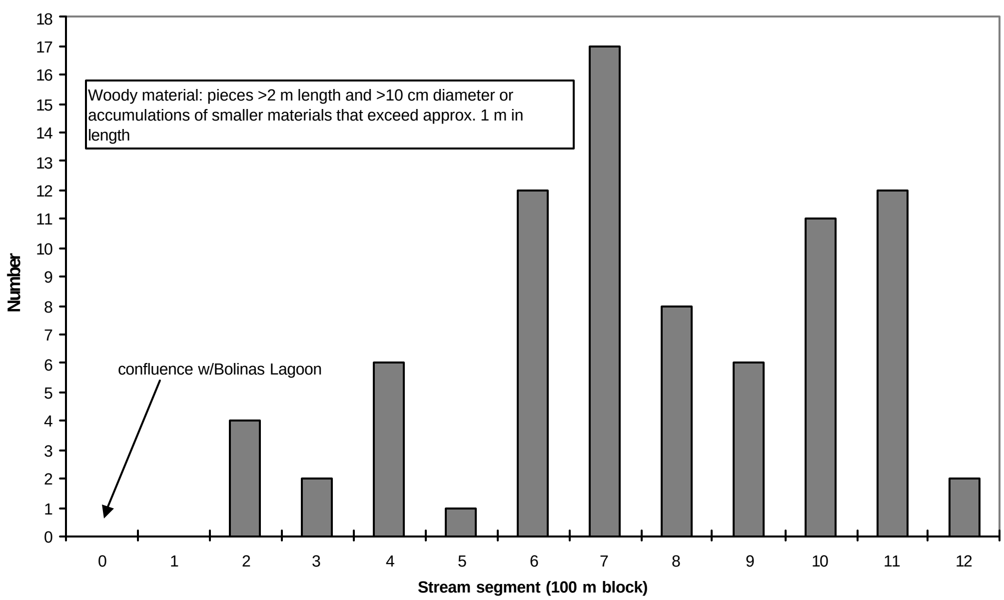


Figure 10: Distribution of woody materials in McKinnan Gulch, Marin Co., July 28-August 4, 1998.

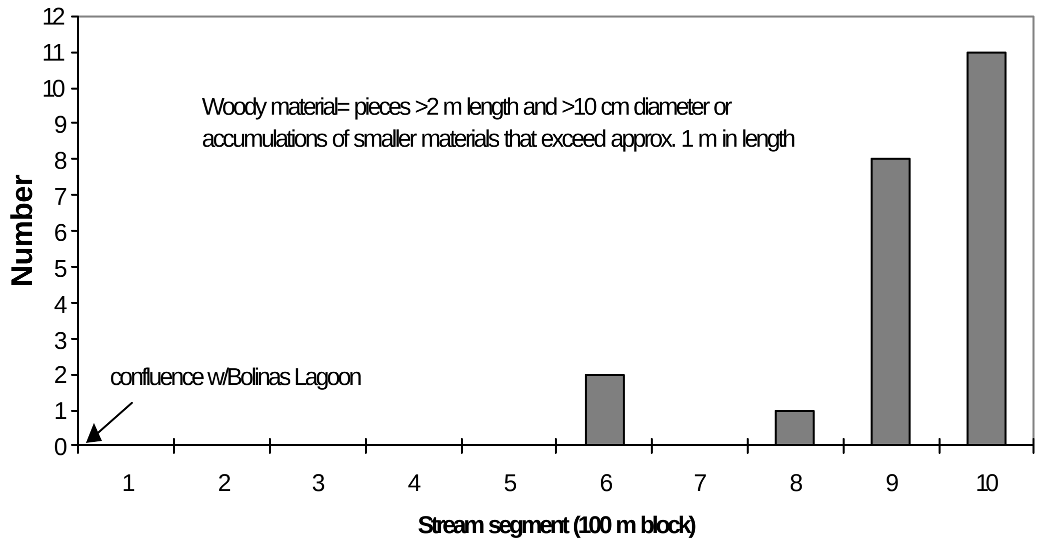


Figure 11: Distribution of woody debris in Stinson Gulch, Marin Co., July 9-10, 1997.

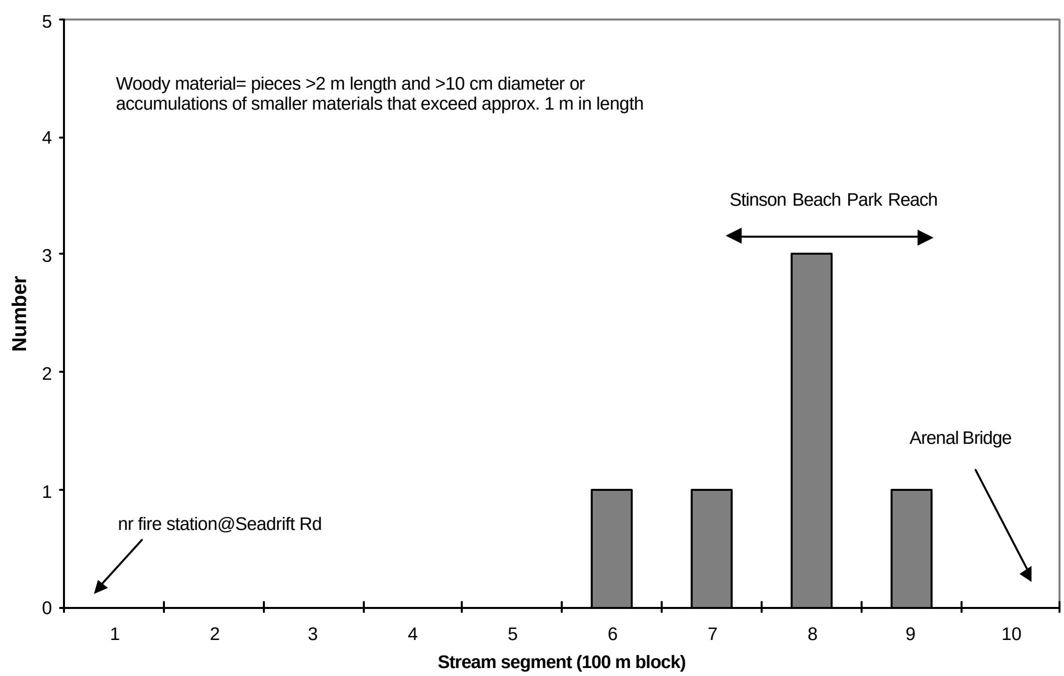


Figure 12: Distribution of instream woody material in lower Easkoot Creek (nr mouth to Arenal Bridge), Marin Co., August 7, 1997

Water Quality

DISSOLVED OXYGEN. Instream water quality data was obtained from July to October 2000. During this period, dissolved oxygen concentrations within the Laurel tributary were well above the minimum threshold for the growth and survival of juvenile steelhead. Dissolved oxygen concentrations from July through the end of October ranged from 10.36 to 8.36 mg/l. (Figures 13-16). The sampling station on the Laurel tributary was situated in a step pool where water was well-aerated by falling water. No days had minimum dissolved oxygen concentrations that fell below the 5 mg/l threshold.

However, dissolved oxygen concentrations within lower Easkoot Creek had periods of low dissolved oxygen throughout the sampled period. About 30% of the sampled days had dissolved minimum dissolved oxygen levels less than 5 mg/l (Table 11). Dissolved oxygen concentrations from July through the end of October ranged from to 8.1 to 2.4 mg/l (Figures 13-16).

Both sites exhibited seasonal trends and diel fluctuations in temperature, dissolved oxygen, and specific conductance. In general, dissolved oxygen concentrations declined at both sites from July through October coinciding with a general decrease in instream flows. The diel fluctuations are similar to studies elsewhere which found peaks in dissolved oxygen in the afternoon corresponding to peak photosynthesis and minimum levels during the early morning corresponding to net respiration. Dissolved oxygen concentrations at the Laurel station consistently reached minimum levels around 2000 HR (Pacific Standard Time) and maximum levels around 1000 HR (PST) (Figures 13-16).

Strong patterns in dissolved oxygen levels were less evident at the Easkoot station. Unlike the Laurel station, a single daily maximum or minimum were infrequent. While dissolved oxygen minimum and maximum levels were generally around the same times of day for the Laurel station, again, no such pattern was evident for the Easkoot station.

Of note, the Easkoot Creek station exhibited the largest swings in diel oxygen fluctuations. This station consistently had differences in maximum and minimum dissolved oxygen concentrations that were 3 times greater than the Laurel Creek station. Such difference might be explained by the amount of aquatic vegetation and algae facilitated by the open canopy within the Easkoot Creek station. The larger amount of plant life (and associated decaying vegetation) may explain the much lower dissolved oxygen levels during the early morning. Also, several residences and businesses are located along the creek just upstream of our Easkoot station.

Figure 13: Dissolved oxygen concentration at Laurel and Easkoot Creek Sampling Stations, Marin Co., July 2000

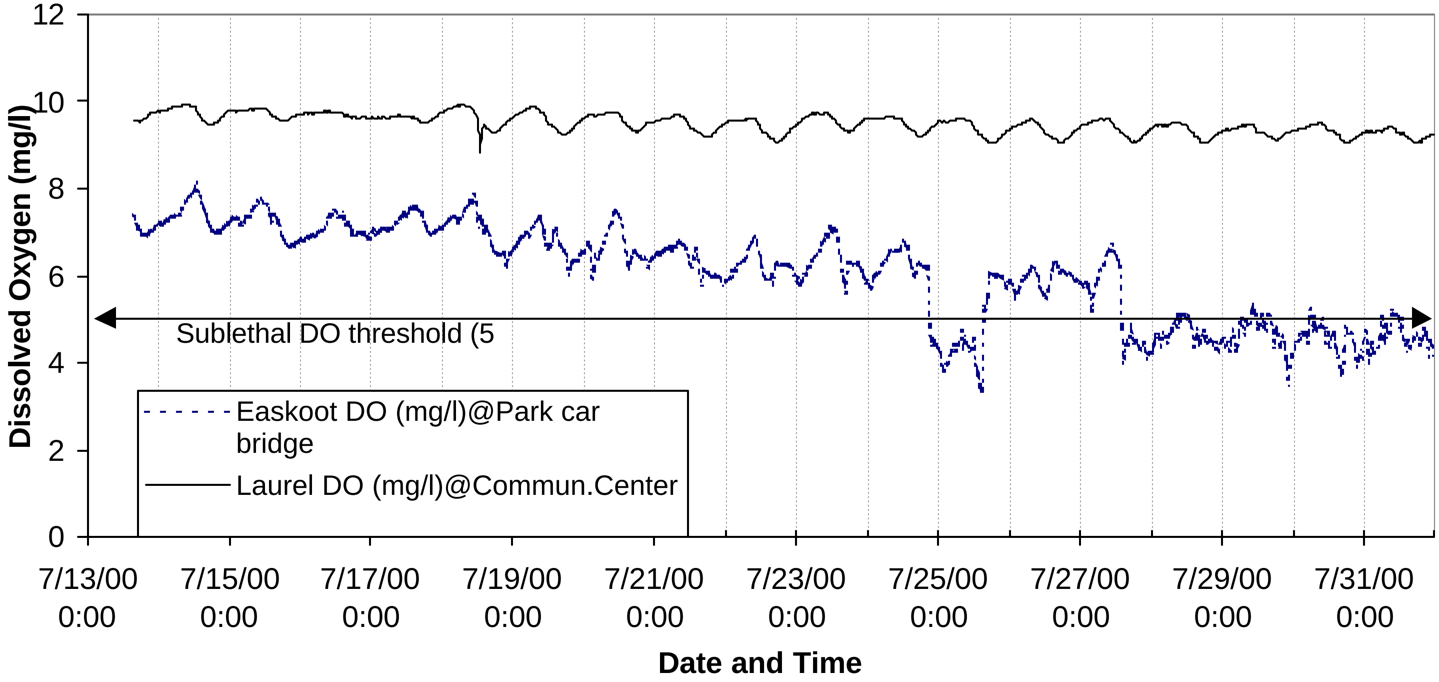


Figure 14: Dissolved oxygen conentration at Laurel and Easkoot Creek Sampling Stations, Marin Co., August 2000

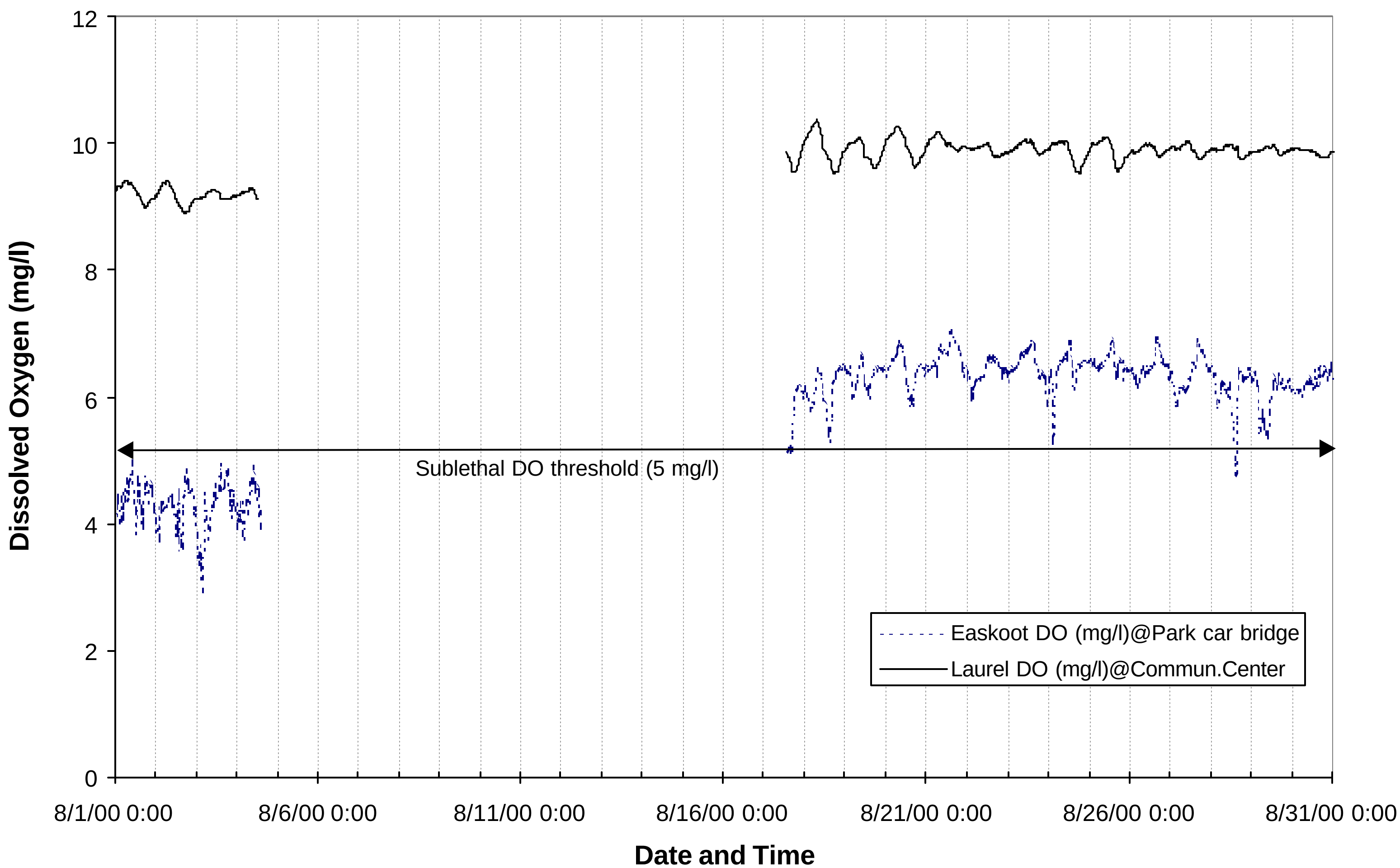


Figure 15: Dissolved oxygen concentration at Laurel and Easkoot Creek Sampling Stations, Marin Co., September 2000

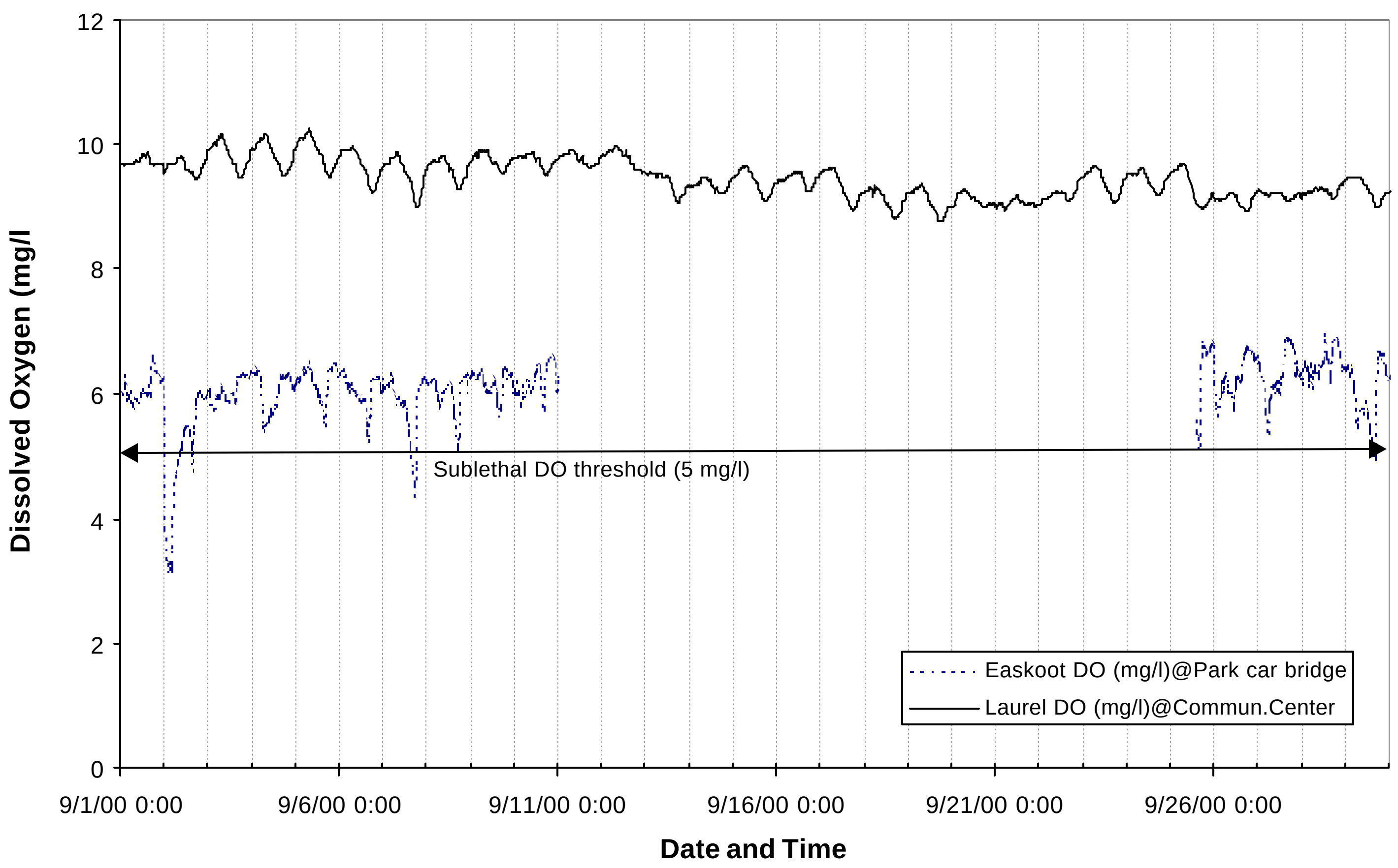


Figure 16: Dissolved oxygen concentration at Laurel and Easkoot Creek Sampling Stations, Marin Co., October 2000

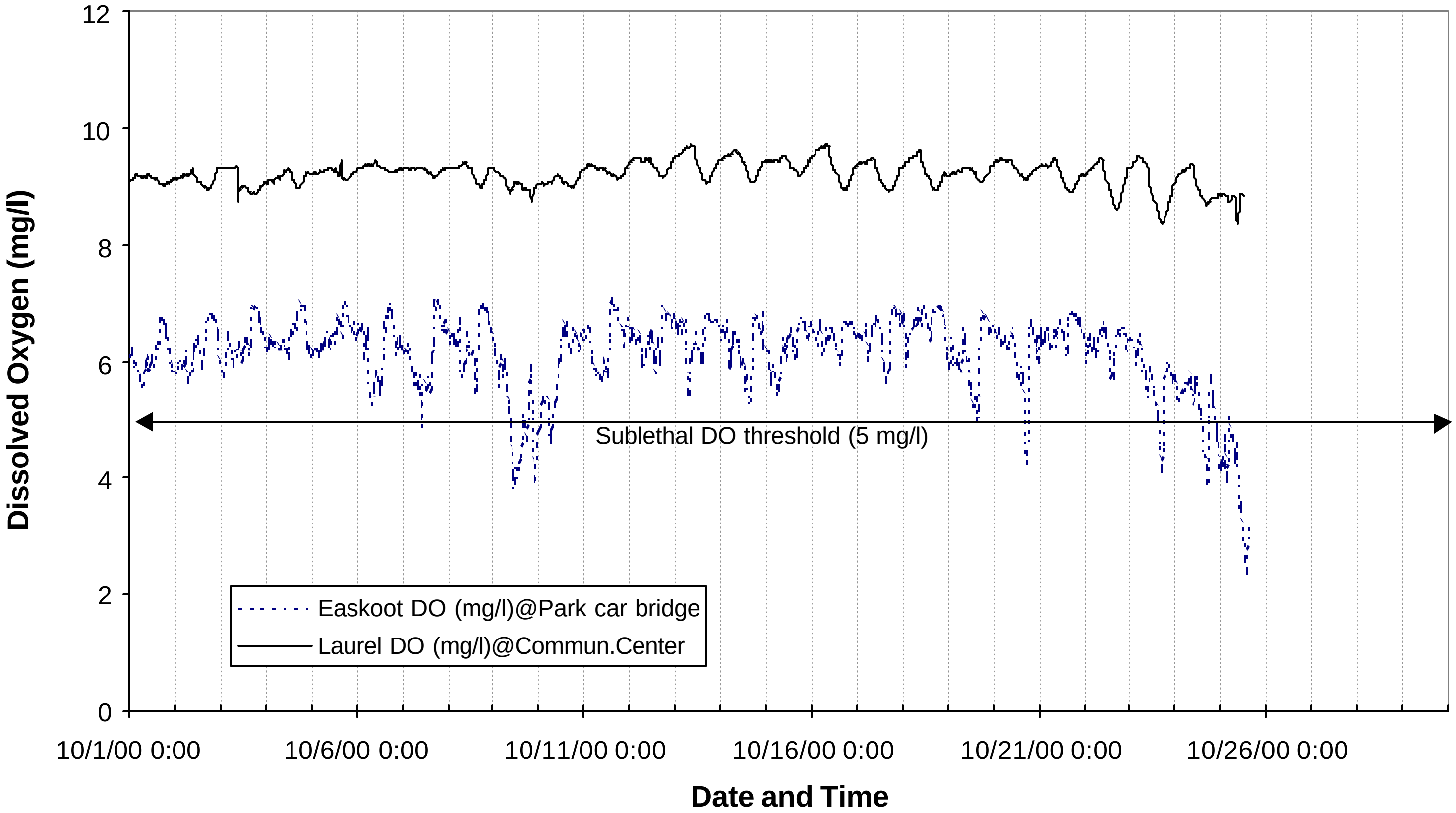


FIGURE 17a: LOWER EASKOOT CREEK AIR AND WATER TEMPERATURES, GOLDEN GATE NATIONAL RECREATION AREA, MARIN CO., JUNE-JULY 1999

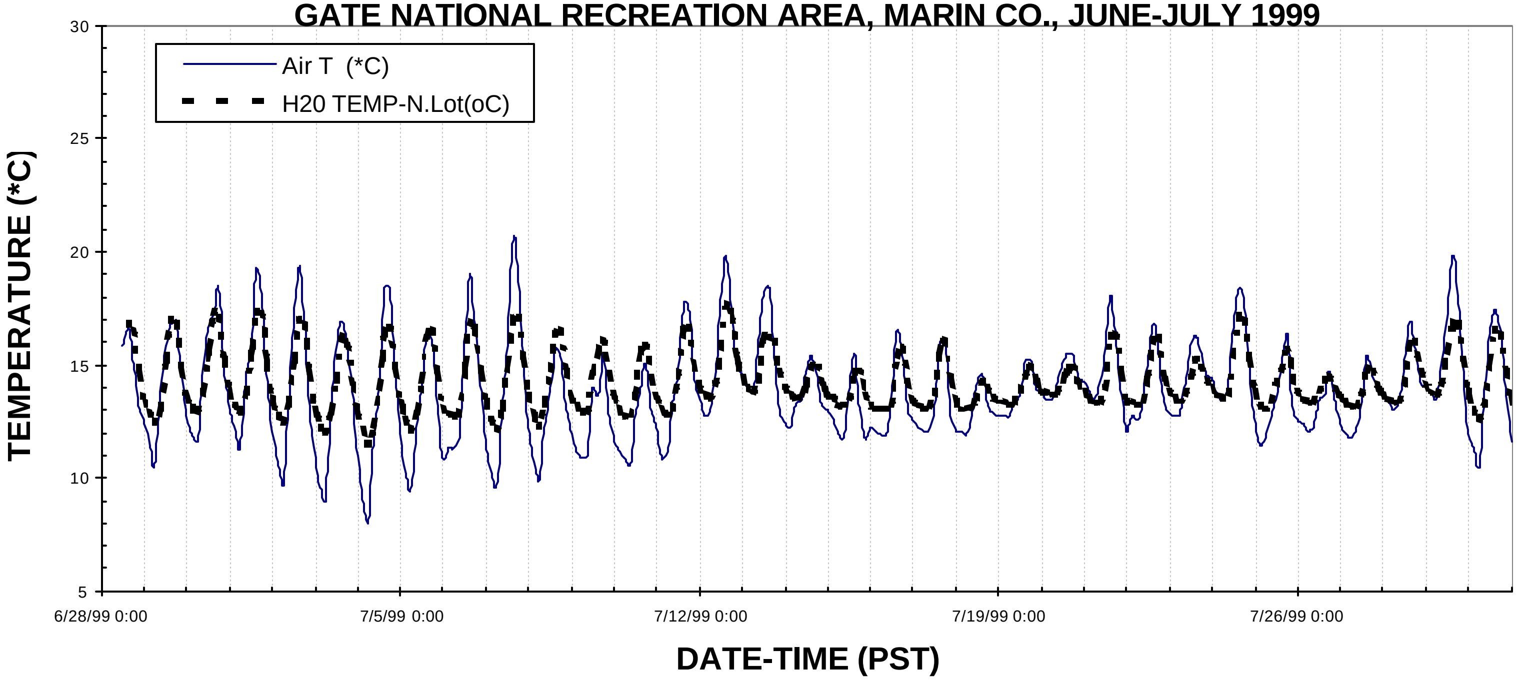


FIGURE 17b: LOWER EASKOOT CREEK AIR AND WATER TEMPERATURES, GOLDEN GATE NATIONAL RECREATION AREA, MARIN CO., AUGUST 1999

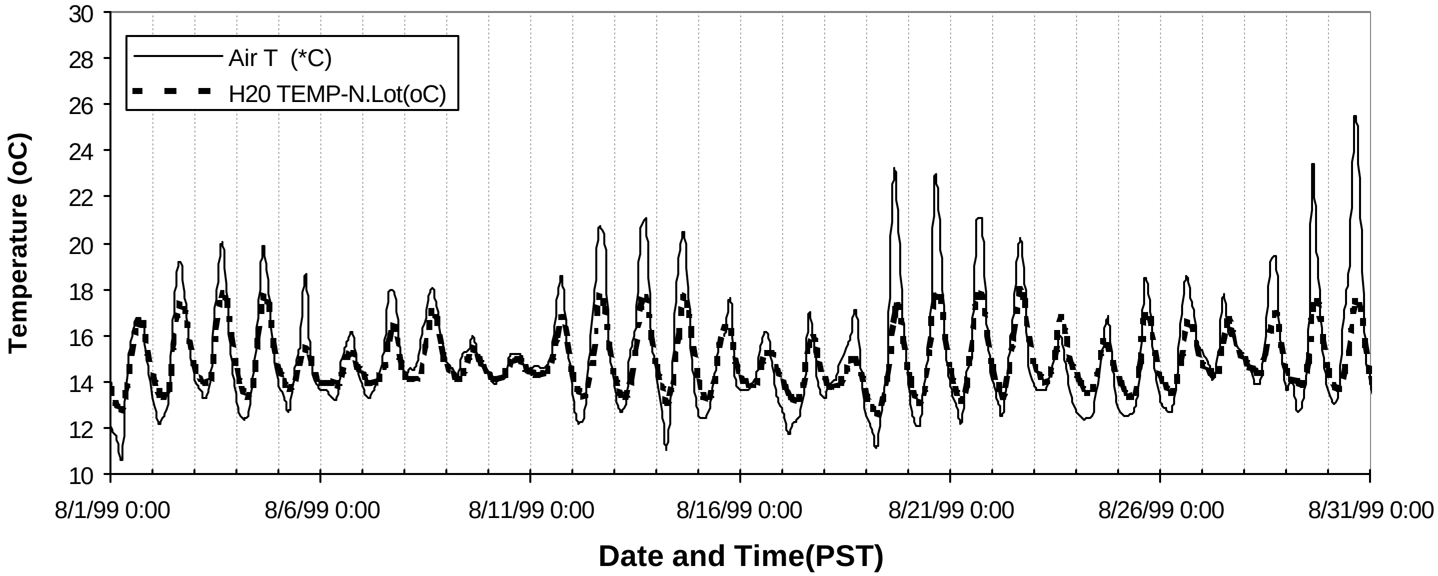


FIGURE 17c: LOWER EASKOOT CREEK AIR AND WATER TEMPERATURES, GOLDEN GATE NATIONAL RECREATION AREA, MARIN CO., September 1999

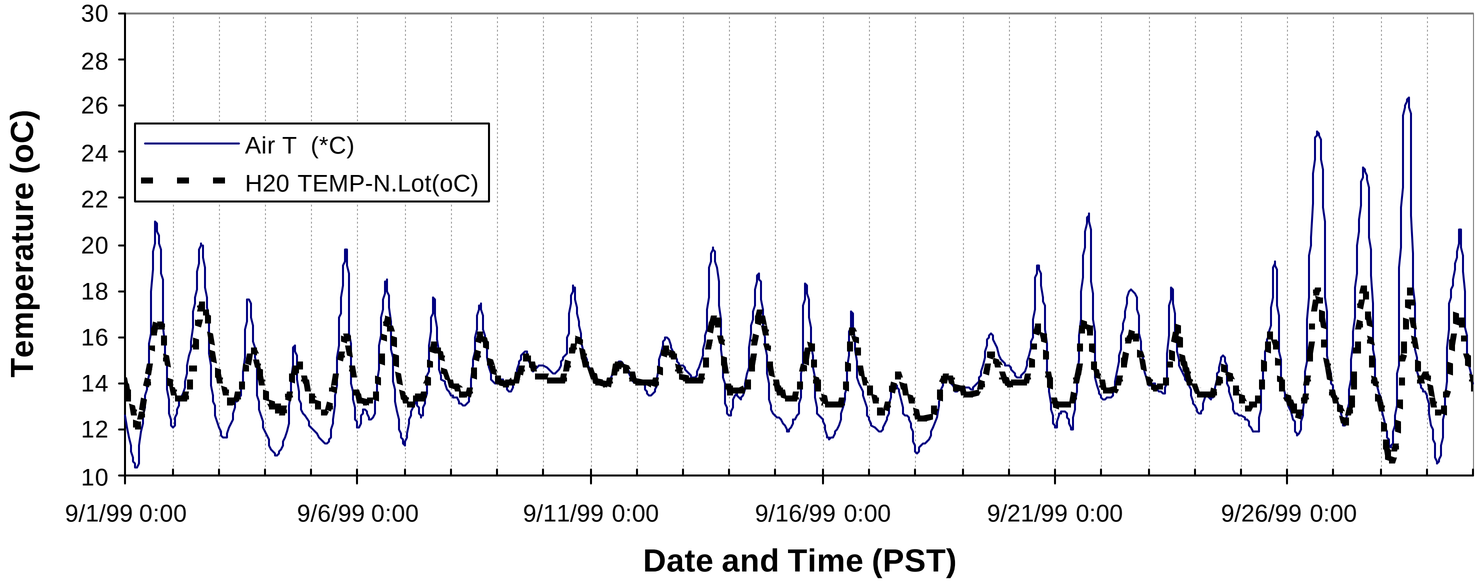


FIGURE 17d: LOWER EASKOOT CREEK AIR AND WATER TEMPERATURES, GOLDEN GATE NATIONAL RECREATION AREA, MARIN CO., OCTOBER 1999

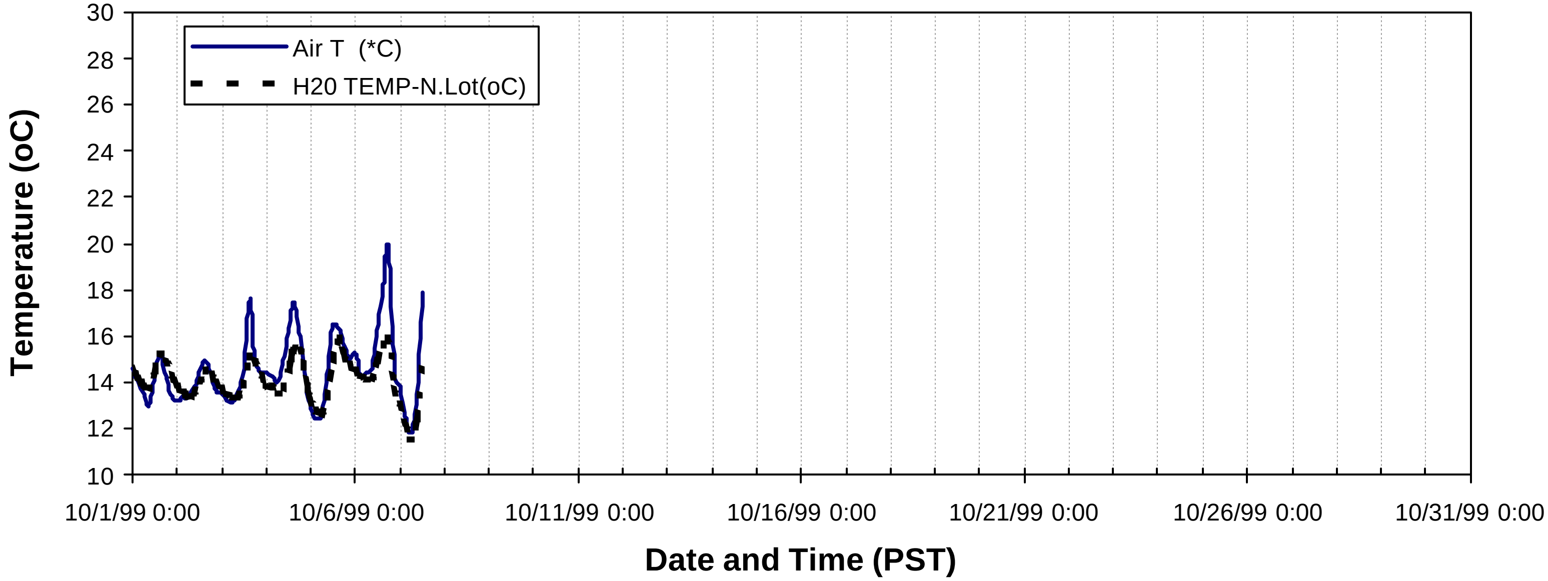


Figure 18a: Instream water temperature at Laurel and Easkoot Creek Sampling Stations, Marin Co., July 2000

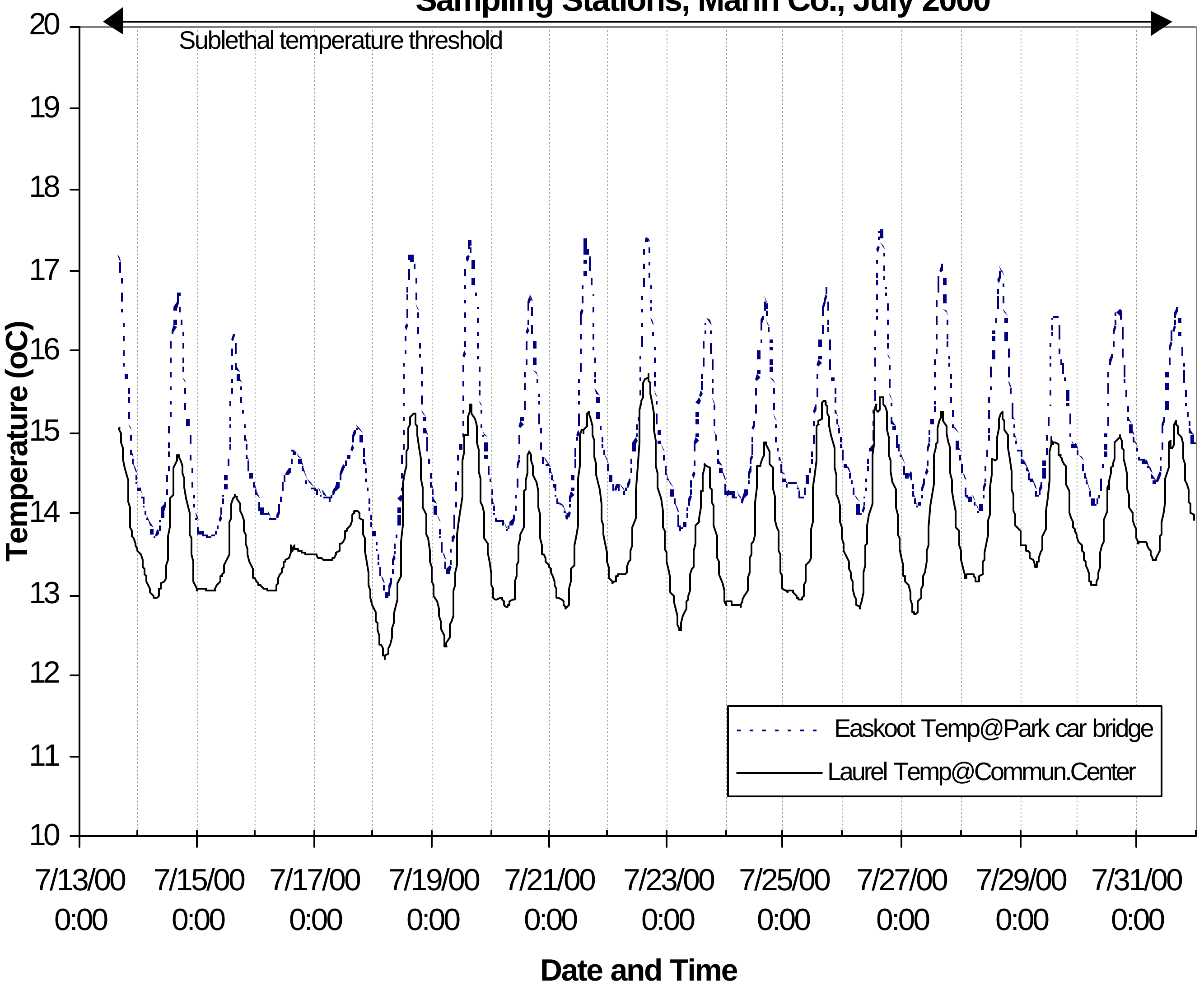


Figure 18b: Instream water temperature at Laurel and Easkoot Creek Sampling Stations, Marin Co., August 2000

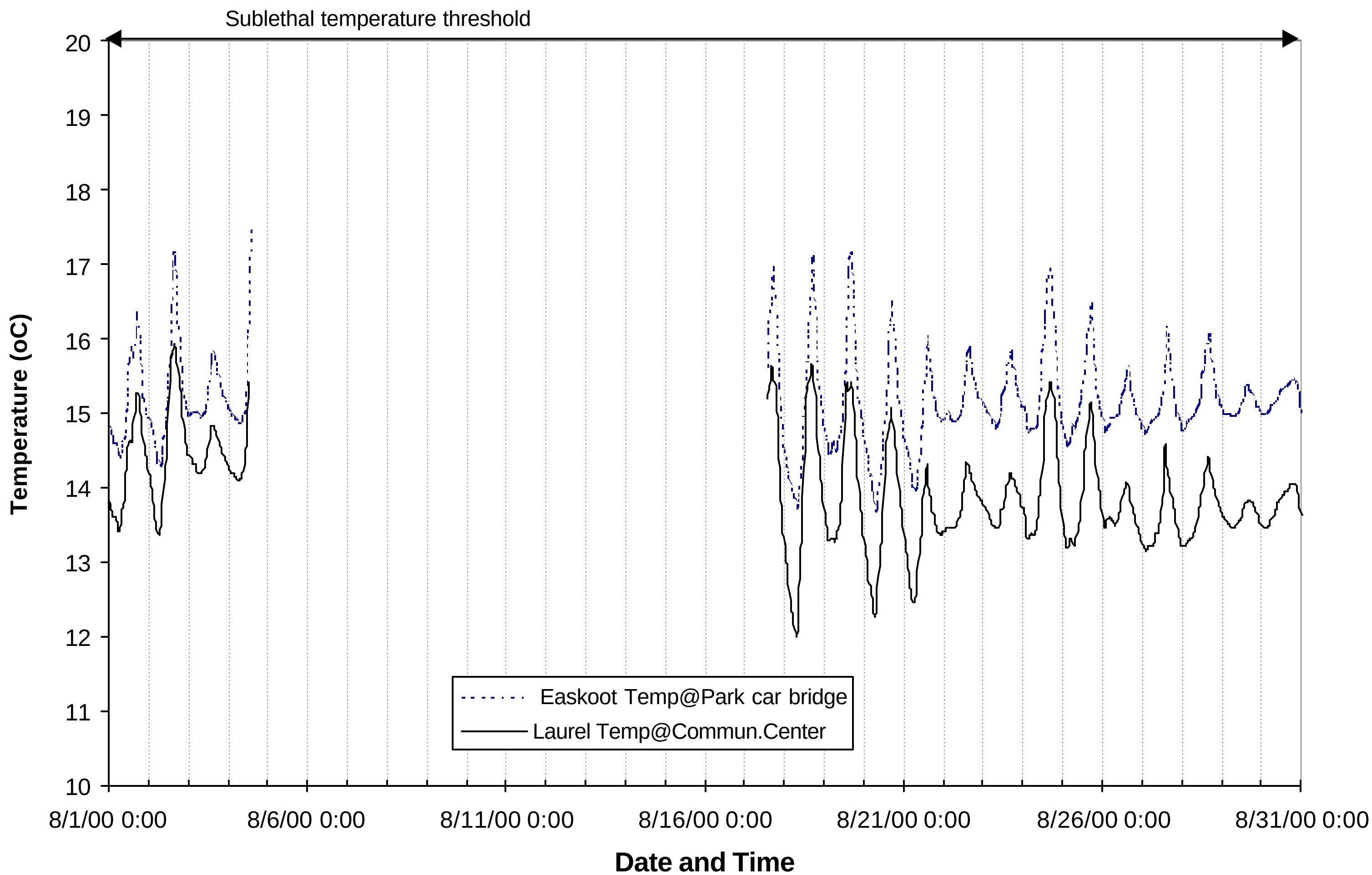


Figure 18c: Instream water temperature at Laurel and Easkoot CreekSampling Stations, Marin Co., September 2000

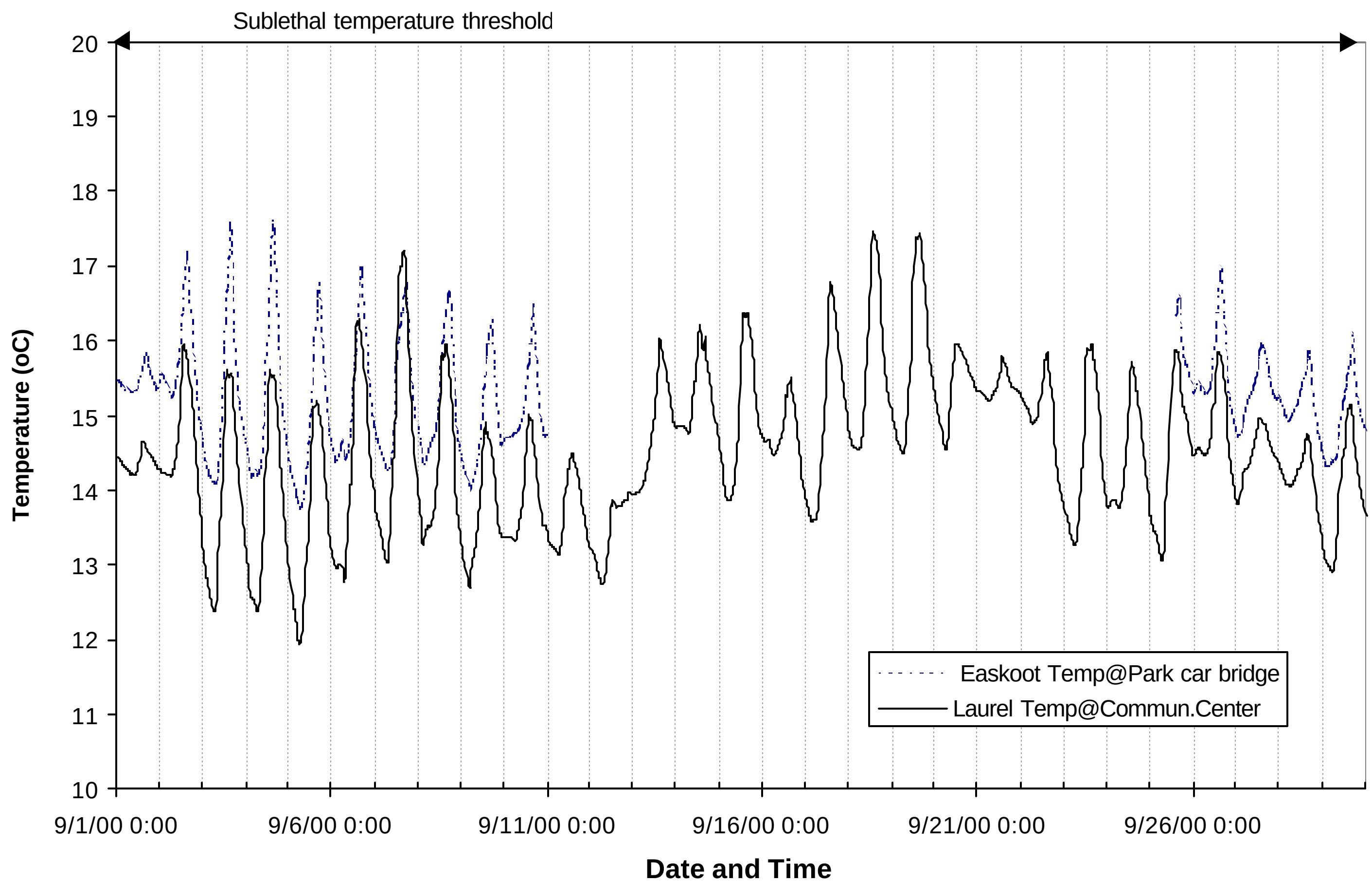
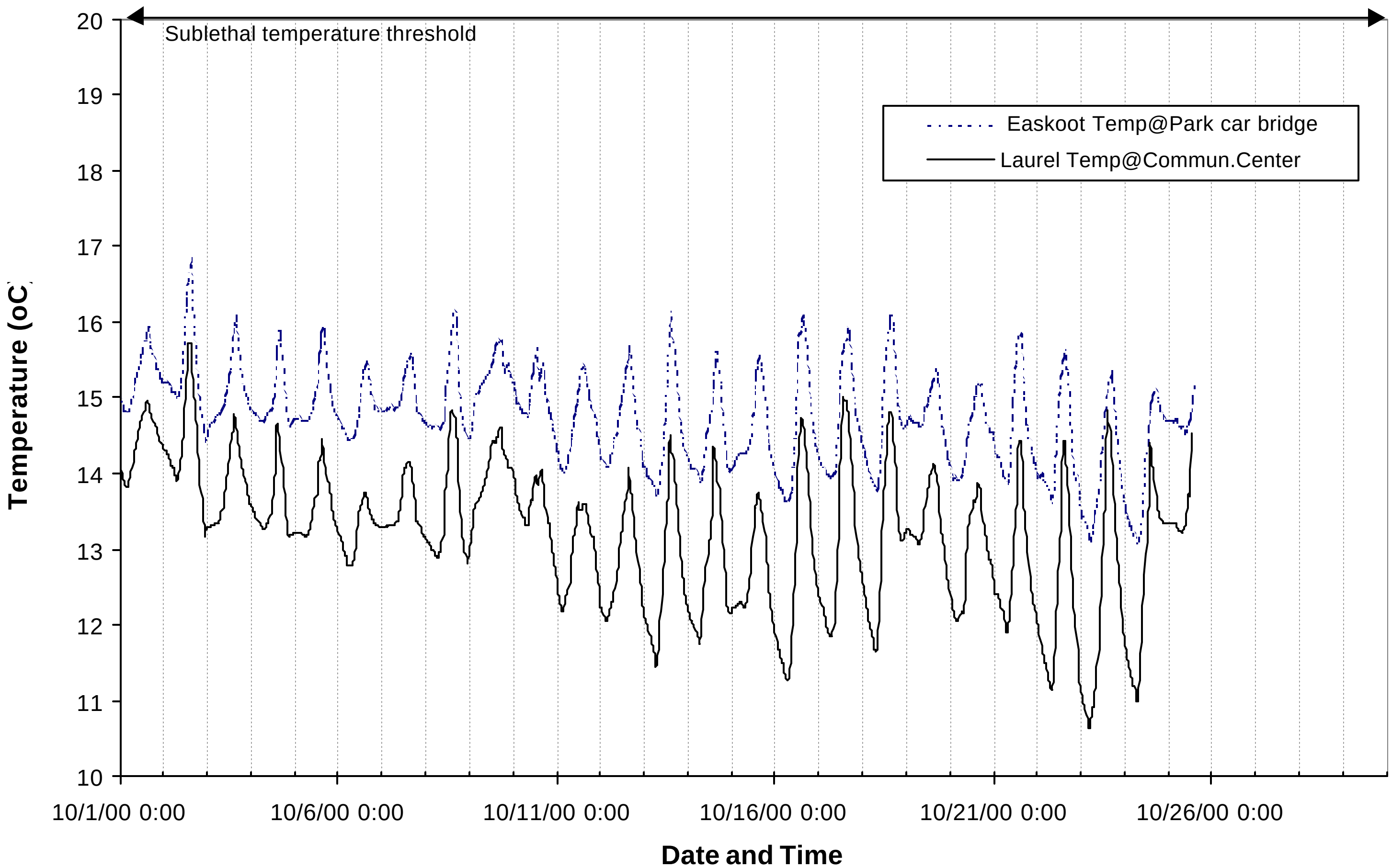


Figure 18d: Instream water temperature at Laurel and Easkoot Creek Sampling Stations, Marin Co., October 2000



Further investigation into the causes of the poor dissolved oxygen levels are warranted. Information is needed to determine whether poor dissolved oxygen levels in Easkoot Creek are related to seasonal instream flow conditions or possible human influence from increased nutrient inputs. Possible options include tests for biochemical oxygen demand (BOD) and caffeine/detergents from summer grab water samples selected during variations in visitation at Stinson Beach. Consistent BOD values and no detection of caffeine/detergents may indicate the role low instream flow, aquatic plants and algae in contributing to the depleted oxygen levels in the creek.

TEMPERATURE. Stream water temperatures in summer 1999 and 2000 were adequate for growth and survival of juvenile steelhead at the two sampled sites in the Easkoot Creek watershed. No stream temperatures exceeded 20^{o}C in either summer-fall 1999 or 2000 (Tables 10,12; Figures 17-18).

Fluctuations in maximum and minimum temperatures were smaller at the Easkoot Creek station relative to upstream Laurel Creek despite shaded conditions at both sites. There are a variety of factors that might explain this difference. Differences in the source of instream flows could be one explanation. It is possible that most flow in Laurel occurs as surface flow. Changes in water diversion rates are quickly reflected in instream flows at the Laurel Creek station within hours. Furthermore, the flow data indicate that changes in instream flow match the reported rate of diversion closely, suggesting minimal contribution or loss from banks or underflow. Also, temperatures in Laurel Creek closely track air temperatures. However, the reduced fluctuations in temperature at the Easkoot station despite lower discharge than the Laurel station indicate that streamflow at the lower station might result more from subsurface and bank contributions than surface flows (Figure 18). No surface flows upstream of the Park's Easkoot station are observable in late summer between the Arenal Bridge to Parkside Café. However, surface flows are present downstream. Subsurface flows through stream bed material would dampen the effects of temperature fluctuations. Other factors affecting temperature fluctuation could include input from other surface water streams (e.g., Black Rock) and discharge from septic systems.

Table 10: Summary of Air and Water Temperature (^{o}Celsius) for Easkoot Creek Gaging station, Marin Co., 1999.

Month	# Days	Mean Max Air	Mean Max H_20	Mean Min Air	Mean Min H_20
July	31	17.0 (1.7)	16.1 (0.9)	11.5 (1.4)	13.0 (0.6)
August	31	19.1 (2.5)	16.7 (0.9)	12.8 (1.0)	13.6 (0.5)
September	30	18.5 (2.9)	16.1 (1.0)	12.4 (1.1)	13.2 (0.7)
October	7	17.1 (1.7)	15.3 (0.5)	13.1 (0.8)	13.1 (0.8)

Table 11: Summary of Max-Min Differences in Dissolved Oxygen Concentrations* and Water Temperature for two sites within the Easkoot Creek watershed, Marin Co., 2000.

Month	# Days	# Days Min DO < 5 mg/l	Mean Max - Min DO (mg/l) (S.D.)	Mean Max - Min Temp (^oC) (S.D.)
EASKOOT CREEK STATION				
July	19	7	1.40 (0.64)	2.73 (0.83)
August	19	5	1.11 (0.39)	1.77 (0.90)
September	17	4	1.28 (0.65)	2.04 (0.94)
October	25	8	1.57 (0.57)	1.64 (0.51)
Grand Mean			**1.34**	**2.05**
LAUREL CREEK STATION				
July	19	0	0.47 (0.20)	1.99 (0.65)
August	19	0	0.36 (0.19)	1.61 (0.85)
September	30	0	0.49 (0.18)	2.23 (0.90)
October	25	0	0.49 (0.23)	2.15 (0.91)
Grand Mean			**0.45**	**2.00**

*Dissolved oxygen measured at pool bottoms with Datasonde logger

Table 12: Summary of Air and Water Temperature for Easkoot Creek Gaging station, Marin Co., 2000.

Month	**# Days**	**Mean Max Air**	**Mean Max H_20**	**Mean Min Air**	**Mean Min H_20**
April	27	19.3 (2.3)	14.0 (0.1)	7.8 (2.1)	11.1 (0.8)
May	31	21.3 (3.0)	14.6 (1.3)	8.8 (1.9)	12.1 (1.1)
June	30	21.4 (3.0)	15.7 (0.7)	10.6 (2.1)	13.5 (0.8)
July	31	21.7 (2.3)	15.6 (0.5)	10.2 (1.3)	14.0 (0.5)
August	16	23.1 (2.0)	16.1 (0.3)	11.3 (1.7)	15.0 (0.1)

SPECIFIC CONDUCTANCE. The lower Easkoot Creek station had consistently higher specific conductance values than its upstream station on Laurel Creek during our 2000 sampling season. Specific conductance ranged from 310 to 490 uS/cm versus 295 to 370 uS/cm at Laurel Creek. The lower Easkoot Creek station also experienced a wider daily fluctuation in specific conductance as well (Appendix I). Light rainfall in the late summer and fall seemed to influence specific conductance values. Immediately following a brief shower (0.08 inches/hour) on September 1, 2000, specific conductance rose at both stations (Appendix I). While Laurel Creek experienced a short-term rise in specific conductance from 315 to 325 uS/ cm, lower Easkoot Creek experienced a much greater rise from 350 to over 450 uS/cm. This difference may reflect the increased amount of urban runoff at the Easkoot Creek versus Laurel Creek station.

Hydrology

MORSE GULCH. The U.S.G.S. estimated daily mean discharge for a station located on Morse Creek (Station No. 11460160) from June 1, 1967 to September 30, 1969. During this time period, measured flows reflected unimpaired flows. No water appropriation activities currently occur in Morse Creek. Flow information would likely be similar at similarly sized watersheds along eastern Bolinas Lagoon such as McKinnon Gulch.

Discharge information indicates that surface flows cease in the lower reach between May and August and resume between November and December (Figure 19). Isolated pools may be present during these situations. Peak stream flow for the period of record was 21 cfs (Jan 20, 1969). Cessation of flows in May may prevent outmigration of steelhead smolts.

EASKOOT CREEK. Dominant bed materials, specific conductance, and salinity measurements (YSI Model 33) were used to determine the tidally influenced, estuarine portion of Easkoot Creek. During the summer of 1997, the estuarine portion of Easkoot Creek extended up to just above the foot bridge at Calle Ribera where salinity of 3 parts per thousand was measured on an incoming tide (Table 13). Above this location, dominant bed materials changed from mud (silts/clays) to gravel and larger size fractions.

Table 13: Salinity profile along lower Easkoot Creek, August 7,1997.

Locale	Distance from Start (m)	Air Temp (^oC)	Water Temp (^oC)*	Dominant Bed Material	Salinity (ppt)*	Spec. Conduct. (uS/cm)*
Across From Fire Station@ Seadrift Road	0	22.5	23.0	Mud	18.5	-
Below SBCWD Office	200	23.5	24.0	Mud	13.0	-
Nr Calle Ribera footbridge	400	23.0	22.0	Mud	3.0	-
	500	-	-	Gravel-Silt	-	-
Above Calle del Onda	600	22.0	18.0	Gravel-Silt	0	310
@ Stinson Beach Park	800	22.0	17.0	Gravel	0	330
Below Arenal Road	1000	19.5	20.0	-	0	320

* Water quality data was collected from 1030 to 1600 hr (local time). Lower low water in Bolinas Lagoon was at 0900 HR (0.3 ft mean lower low water) and higher high water was at 1513 HR (3.5 ft mean lower low water).

The Water Resources Division of NPS and GOGA operate a gaging station location located within Stinson Beach park along the lower portion of Easkoot Creek. Mean daily discharge data are computed from this gage. The period of record is from May 1999 to present. We also recorded flow measurements upstream of Highway One behind the town community center.

Summer surface flows within Laurel Creek appear to average 1-2 times more than that observed at the downstream gaging station. It is possible that the observed losses are associated with surface flows going subsurface through the alluvial materials and from evapotranspiration by riparian vegetation.

Flow information to date indicates perennial flow at the gaging station during the period of record. However, late summer base flows were typically around 0.01 cfs (Figure 20a). Maintenance staff at the Park routinely check the creek and record the date when lower Easkoot Creek becomes disconnected. We considered the stream disconnected when no surface water connecting pool segments was observed. This "disconnection" occurred in July 2000 when flows of 0.3 cfs were recorded at the gaging station. This dry reach occurs from just above the Arenal Bridge to just below the Parkside pedestrian bridge. Smolt trap data from local streams (Redwood Creek) indicate that most smolt outmigration is completed by June (Fong 1997).

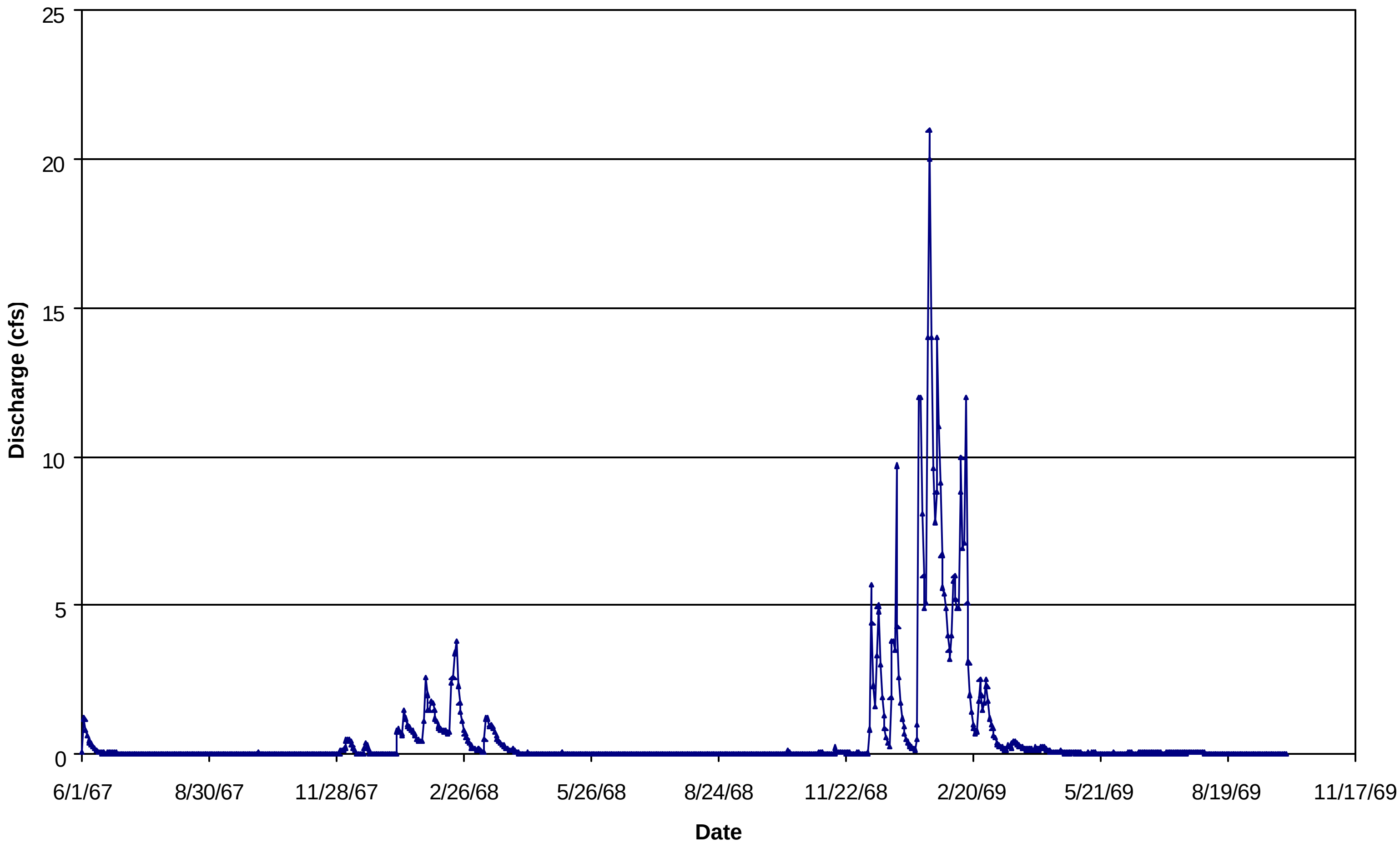


Figure 19: Daily mean discharge (cfs) at Morse Creek, Stinson Beach, CA 1967-1969.

LAUREL CREEK. In 2000, the stream upstream of the Highway One bridge became disconnected when flows approach 0.04 cfs (20 gallons/min) and 0.09 cfs (40 gallons/min) depending on the time of year. During the late summer, streamflows in excess of 0.04 cfs were sufficient to maintain a connection between pools behind the town community center. By late fall, streamflows in excess of 0.09 were required. It is likely that the falling water table over this time period resulted in the differences in surface flows needed to maintain connectivity.

Point measurements at the Laurel Creek station also show the strong influence exerted by water withdrawals on instream habitat conditions (Table 14a, Figure 20b). Prior to water diversion, instream flows at Laurel on August 10, 2000 (0730 HR PST), were measured at 57.5 gallons per minute. On August 10, 2000 (1030 HR PST), the water district started to withdraw 20 gallons per minute. Following this action, instream flows dropped nearly 20 gpm the following day. Conversely, cessation of water diversions resulted in a gain in an equivalent amount the following day. Also, minor amounts of precipitation (around 0.1 in/day) resulted in relatively quick increases in instream flow (Figure 21b) in September.

Table 14a: Partial record of Laurel Creek discharge and diversion rate, Marin Co., August 2000.

DATE	TIME (PST)	DISCHARGE (gpm)	Water Diversion Rate (gpm)*
Aug. 10, 2000	0730	57.5	0
Aug. 10, 2000	1030	--	20
Aug. 11, 2000	0700	39.4	20
Aug. 16, 2000	0700	20.3	20.5
Aug. 17, 2000	1000	--	0
Aug. 18, 2000	0600	43.1	0
Aug. 21, 2000	0700	47.6	0

*Data from Stinson Beach County Water District

Similarly, on Black Rock Creek, changes in instream flow directly reflect water appropriation activities. On August 18, 2000, diversions on Black Rock ceased at 1200 HR (PST). On August 21, 2000, instream flows recovered an amount equivalent to the levels of diversion (Table 14b).

Table 14b: Partial record of Black Rock Creek discharge and diversion rate, Marin Co., August 2000.

DATE	TIME (PST)	DISCHARGE (gpm)	Water Diversion Rate (gpm)*
Aug. 17, 2000	0756	17.95	16-21
Aug. 18, 2000	1200	--	0
Aug. 21, 2000	0700	37.25	0
Aug. 24, 2000	1230	--	15
Aug. 28, 2000	0700	19.75	15

*Data from Stinson Beach County Water District

If instream water appropriation activities continue into the future, a long-term flow, water quality, and fish community sampling program should be instituted at all sites with such activities. This includes Stinson Gulch which has not received much attention from the Park since most of the affected stream habitats are within ownership and management of Stinson Beach County Water District and Mt. Tamalpais State Park. A Park study in the Redwood Creek watershed, Marin Co., that assessed the influence of a water diversion on water quality, presence/absence of flow connectivity, and fish abundance proved invaluable. Disconnected pools in the Fall 2001 had dissolved oxygen concentrations below the sublethal effects threshold for juvenile salmonids and had correspondingly low numbers of fish (Fong, unpub. data, 2001). Currently, the Park is working with the Muir Beach Community Services District, Mt. Tamalpais State Park, California Department of Fish and Game, and State Water Resources Control Board to develop surrogate flow thresholds based on water depths at sentinel sites that would trigger water conservation measures. A similar cooperative effort could work at Stinson Beach.

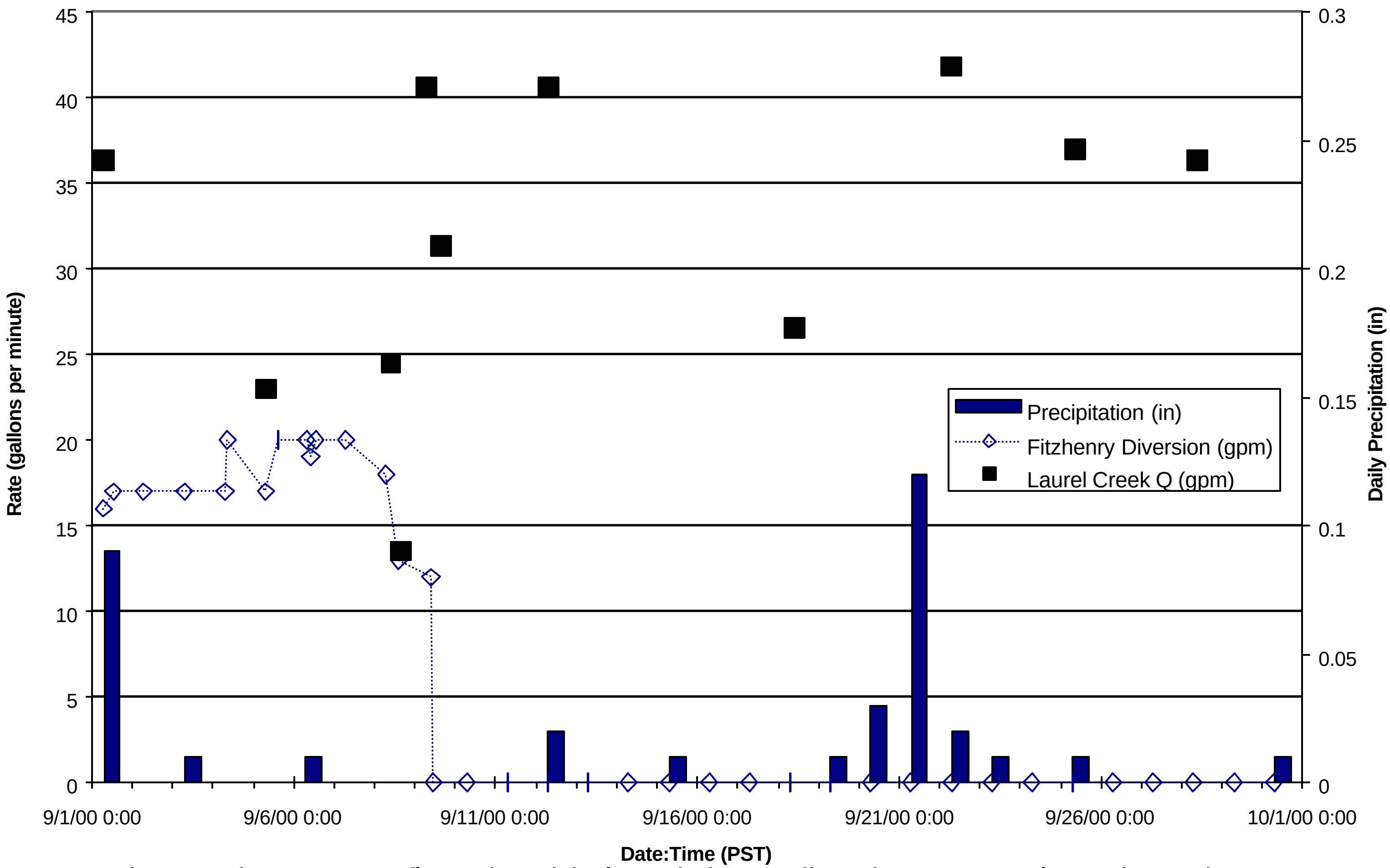


Figure 21b: Instream flows (gpm) below Fitzhenry diversion on Laurel Creek, Marin Co., California, September 2000

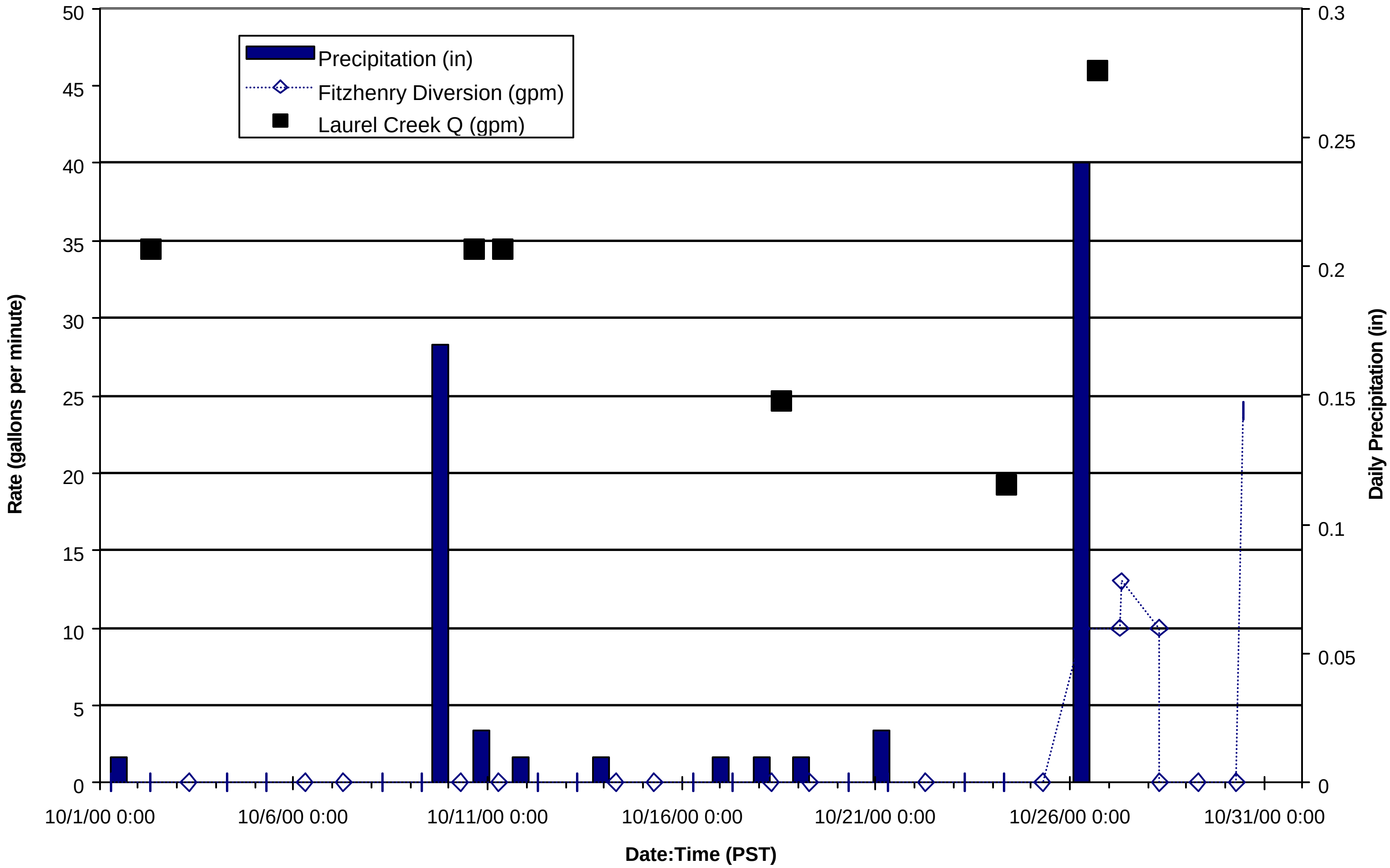


Figure 21c: Instream flows (gpm) below Fitzhenry diversion on Laurel Creek, Marin Co., California, October 2000

Stream Macroinvertebrates

EASKOOT CREEK WATERSHED (Appendix III). An interesting array of stream invertebrates were collected from Laurel and Easkoot Creeks. The taxa list and relative abundance are provided in Appendix III. Many of the taxa collected in Easkoot Creek are associated with slow-water habitats including empidid and tipulid larvae. Of particular interest, a rat-tail maggot (*Eristalis* sp.) was collected from Easkoot Creek. Such an occurrence indicates the persistence of poor dissolved oxygen conditions within lower Easkoot Creek. No rat-tail maggots were found in Laurel Creek. Such information is consistent with existing water quality data. Invertebrate data also indicate more stable conditions in Laurel Creek (Table 15). It has a higher number of predator taxa and taxa requiring more than one year in the stream. This, too, is consistent with our understanding of available stream habitats and flows. During the summer, roughly double the amount of flow is available within Laurel Creek versus downstream Easkoot. While riffle and flatwater habitats in Laurel may periodically go dry because of water appropriation, pool habitats are in greater abundance than downstream areas and may offer refuge during these events.

The taxa contributing to the bulk of the biomass were also different between the two sites. At lower Easkoot Creek, the bulk of the biomass were *Paraleptophlebia*, physid snail (*Physella*), and rattail maggot. Laurel Creek had the bulk of the biomass in stonefly nymphs (*Calineuria)*. Again, this difference reflects both water quality differences between the sites as well as the type of energy inputs. *Paraleptophlebia* are collector-gatherers and physid snails are likely scrapers. Both taxa would likely be found in areas where primary production (instream algae) was high.

Table 15: Comparison of Stream Invertebrate Data for Easkoot and Laurel Creek.

METRICS	**LOWER EASKOOT**	**LAUREL**
EPT Richness	11	15
Total Taxa Richness	25	22
No. of Predator Taxa	2	5
No. of semivoltine or longer	3	5

MCKINNON GULCH (Appendix III). This locality above Highway 1 had somewhat anomalous data. It had the fewest invertebrate taxa collected. All of the taxa were found at other sites with the exception of a horsehair nematode. Two of the taxa (*Calineuria* and *Heteroplectron*) are relatively long-lived.

MORSE GULCH (Appendix III). This site was located above Highway 1. While chironomid larvae represented the most abundant taxa, their contribution to the total collected invertebrate biomass was minimal. Very large *Calineuria* and

Heteroplectron dominated the invertebrate biomass. The dominance of large, long-lived taxa suggests that the creek has relatively stable conditions. In addition, the large numbers and biomass of Heteroplectron suggests that abundant woody riparian vegetation is present. This site had the highest taxa richness and several taxa where unique to the site. Of interest, water penny larvae (*Eubrianax* sp.) were common, indicating the presence of well-oxygenated conditions and bottom substrates of gravel or larger sizes.

STINSON GULCH (Appendix III). This site was located near the Stinson Beach County Water District water tank. Although downstream of water appropriation sites, this portion of the creek remains flowing throughout the year based on past field observations. As with other sites, the most abundant taxa were chironomid larvae. Again, they did not represent the dominant biomass. The bulk of the invertebrate biomass were from a net-spinning caddisflies from the *Hydropsyche/Ceratopsyche* group, *Heteroplectron*, and *Calineuria* sp.

Steelhead Distribution

Figure 22 and Table 16 describe the current distribution of juvenile steelhead within the surveyed streams. Uppermost distributions were inferred from what we believed were either impassable barriers or unsuitable habitats. Most of the barriers are of natural origin. These include a natural waterfall on Morses Gulch and series of cascades and step pools on the other streams. However, within the Easkoot drainage, hanging culverts along Black Rock Creek preclude access by steelhead where they used to be present historically (T.Lewis, pers. comm., 1999). With the exception of Easkoot Creek, most of the other creeks are dry in the lower alluvial reaches by the late spring and summer. This occurrence precludes use of the lower reaches by steelhead during this period for rearing.

Table 16: Distance of steelhead habitat within east-side tributaries to Bolinas Lagoon , Marin Co., CA,

Stream	Distance of Accessible Steelhead
Wilkins Gulch	1.2 (2 m cascade, step pools)
Morses Gulch	1.0 (8 m falls)
McKinnon Gulch	1.2 (2.5 m cascade, step pools)
Stinson Gulch	>1.0
Easkoot	>1.0

Within Stinson Gulch, steelhead were present beyond our surveyed area.

Redd Surveys

Spawner survey data indicate that steelhead redds were found throughout our surveyed streams. Redds were found not only in the low gradient areas but also in high gradient reaches where we felt minimal spawning habitat was available. In Easkoot Creek, no redds were found in upstream reaches above the Highway 1 bridge. However, during the summer of 1999 numerous YOY juveniles were sampled in step pools in this upstream area. Therefore, the redd counts should not be seen as an accurate estimate of reproductive effort. An unknown amount of redds have been missed.

Having said that, our redd surveys over the last several years indicate very low spawning activity, but similar to a similarly sized creek and watershed in San Mateo County (Tables 17-18). Redd densities for all streams in Spring 1999 and 2000 range from 2 to 5 redds per km. As comparison, in West Union Creek, redd densities for the Park reach were 4 redds/km in 1999 and 2.5 redds/km in 2000.

Table 17: Spring 2000 Redd Survey Data, Bolinas Lagoon Tributaries, Marin Co., CA

Location	Survey Date	Survey Distance (m)	New Redds	Note
Easkoot Creek	4/4/00	1000	2	Redds @ Calle Onda and Arenal
McKinnon Gulch	3/29/00	1000	2	100 m dry segment near mouth. Redds @ 200 and 900 m
Morse Gulch	3/29/00	1000	3	Redds clumped @ 300 m
Stinson Gulch	3/27/00	1300	2	Redds @ 700 and 1000 m

Table 18: Spring 1999 Redd Survey Data, Bolinas Lagoon Tributaries, Marin Co., CA

Location	Survey Date	Survey Distance (m)	New Redds	Note
Easkoot Creek	4/21/99	1000	3	Redds @ post office, below Parkside, and below Highway 1 Bridge
	4/1/99	1000	2	Redds @ gym above Calle Pinos and above Park entrance road
	2/24/99	1000	0	
	2/5/99	1000	0	
Subtotal			**5**	
McKinnon Gulch	4/19/99	1000	2	Redds @ 30 and 750 m
	4/1/99	1400	2	Redds @ 90 and 390 m
	3/2/99	1400	0	
	2/10/99	1400	0	
Subtotal			**4**	
Morse Gulch	4/16/99	1000	1	Redd @ 750 m
	4/1/99	1000	4	Redds @ 180, 220, 320, & 430 m)
	3/2/99	1000	0	
	2/12/99	1000	0	
Subtotal			**5**	
Stinson Gulch	4/21/99	1200	0	
	4/2/99	1200	2	Redds @ 960and 1030 m

Location	Survey Date	Survey Distance (m)	New Redds	Note
	3/3/99	1200	0	
	2/4/99	1000	0	
Subtotal			**2**	

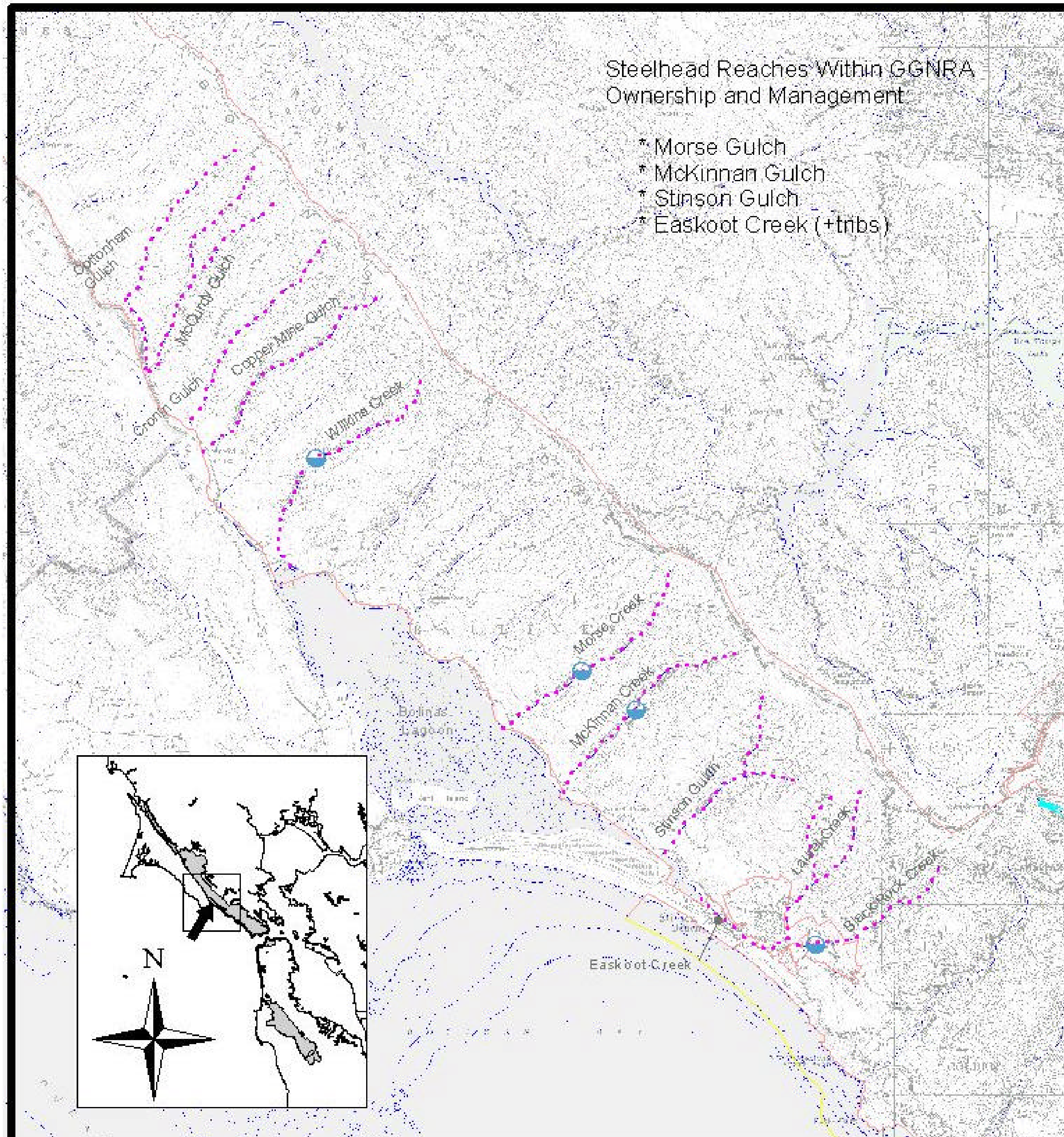


FIGURE 1B - Steelhead Trout (Oncorhynchus mykiss) Distribution in GGNRA (excluding Lagunitas Creek Watershed) , Marin Co.

Along selected creeks — GGNRA Boundary

* Estimated upper limit

2000 0 2000 4000 Meters

* Upper limit estimates are based on fish barrier information obtained from Data Source 24; where unmarked, upper limit unknown

Fish Density, Age/Size, and Distribution

EASKOOT CREEK WATERSHED. Accurate information regarding steelhead population characteristics is only available for Easkoot Creek where electrofishing was conducted. The Easkoot Creek watershed supports young-of-the-year, 1+, and 2+ steelhead (Figure 28). Of the collected scale samples, only 14 were readable because of scale regeneration. Based on these scale readings from fish collected in August 2000, young-of-the-year were less than 113 mm (FL); 1+ ranged between 113 and 170; and 2+ were greater than 170 mm in length. The age classes from scale readings are very similar to those created from interpreting the length-frequency distributions (Figure 23). Nevertheless, these ages should only be considered as estimates. Several studies have documented the problems with aging salmonids using scales including the frequent absence of a first year annulus, false annuli, and increased inaccuracies in aging older fish (Beamish and MacFarlane 1983, 1987; Rooper et al., 2000).

An unknown percentage of sampled fish were likely resident rainbow trout. Without destructive sampling, it would be hard to ascertain which individuals were residents. Many of the larger 2+ fish were possibly resident trout. Several had heavy dark spotting, olive gold coloration, and lacked parr marks.

Size class distribution appears to be dependent upon pool availability and depth. In Summer 1998, young-of-the-year and 1+ steelhead were found in lower Easkoot Creek below the Park entrance road (Table 19). Steelhead juveniles ranged from 40 mm to 170 mm (FL) (Figure 23). The sampled habitat was characterized as a mixture of wood-formed scour pools and shallow flatwater habitats.

This same area was sampled in the Summer 1999. Just two steelhead young-of-the-year were found. This low number cannot be explained by poor recruitment for the year. Sampling activities just upstream (Laurel Creek) found large numbers of young-of-the year steelhead (Table 20). The reduced number of fish and absence of 1+ and older steelhead juveniles may be due in part to the removal of woody material from the creek that helped maintain scour pools. Since the 1998 fish surveys, woody materials that formed scour pools were removed inadvertently by the local flood control district. These actions resulted in the conversion of scour pools into shallow flatwater areas during winter and spring high flow events.

In the Fall 1999, two bay root wads with their trunks were placed in the channel. Winter flows caused localized scour holes at these root wads and created new gravel bars immediately downstream that helped to narrow and deepen the low flow channel. By late summer 2000, the total density of fish (including young-of-the-year and 1+ steelhead) were using the sampled reach at higher densities than prior years (ANOVA, $p<0.05$, post-hoc Scheffe test, Figure 24).

Similar results also occurred at pools created in Fall 1998 on Laurel Creek. Creation of four boulder step pools in the Fall 1998 in a reach that had only shallow sheet flow over grout increased the abundance of all age classes of fish (Table 20, Figure 25).

Over the three summer sampling period, Laurel had a significantly higher density of aquatic vertebrates than lower Easkoot Creek (ANOVA, p=0.03; post-hoc Sheffe test, p=0.005). This difference is attributed to the higher numbers of YOY and older steelhead found in Laurel versus lower Easkoot Creek.

Distribution of fish species followed expectations. Threespine stickleback were only found in the lower portion of Easkoot Creek. Habitat in this area included abundant instream vegetation (e.g., watercress) that is conducive to the reproductive and feeding habitats of the fish. No stickleback were found in higher gradient step-pool habitats. For all years and sites, steelhead/rainbow juveniles compromised the dominant fish taxa. Prickly sculpin were found at most sampled habitats, although less abundant than steelhead. (Tables 19-20).

STINSON GULCH. Snorkel surveys were conducted during the summer 1997 at three locations (7 habitat units, totaling 31 m in length) upstream of the Stinson Beach County Water District's water tank in Stinson Gulch. No calibration of snorkel survey data with electrofishing was conducted. The snorkeled habitats were relatively small and the likelihood of detecting fish high. First and second pass snorkel data for one site had very similar results. The snorkel survey results show the presence of juvenile young-of-the-year and older steelhead. Mean density of young-of-the-year steelhead was 1.2 fish per m while 1+ and older fish were 0.2 fish per m. Surface water was absent from much of the lower Stinson Gulch from the Highway One bridge to just below the water tank- limiting the value of this site as year-round rearing habitat for aquatic life.

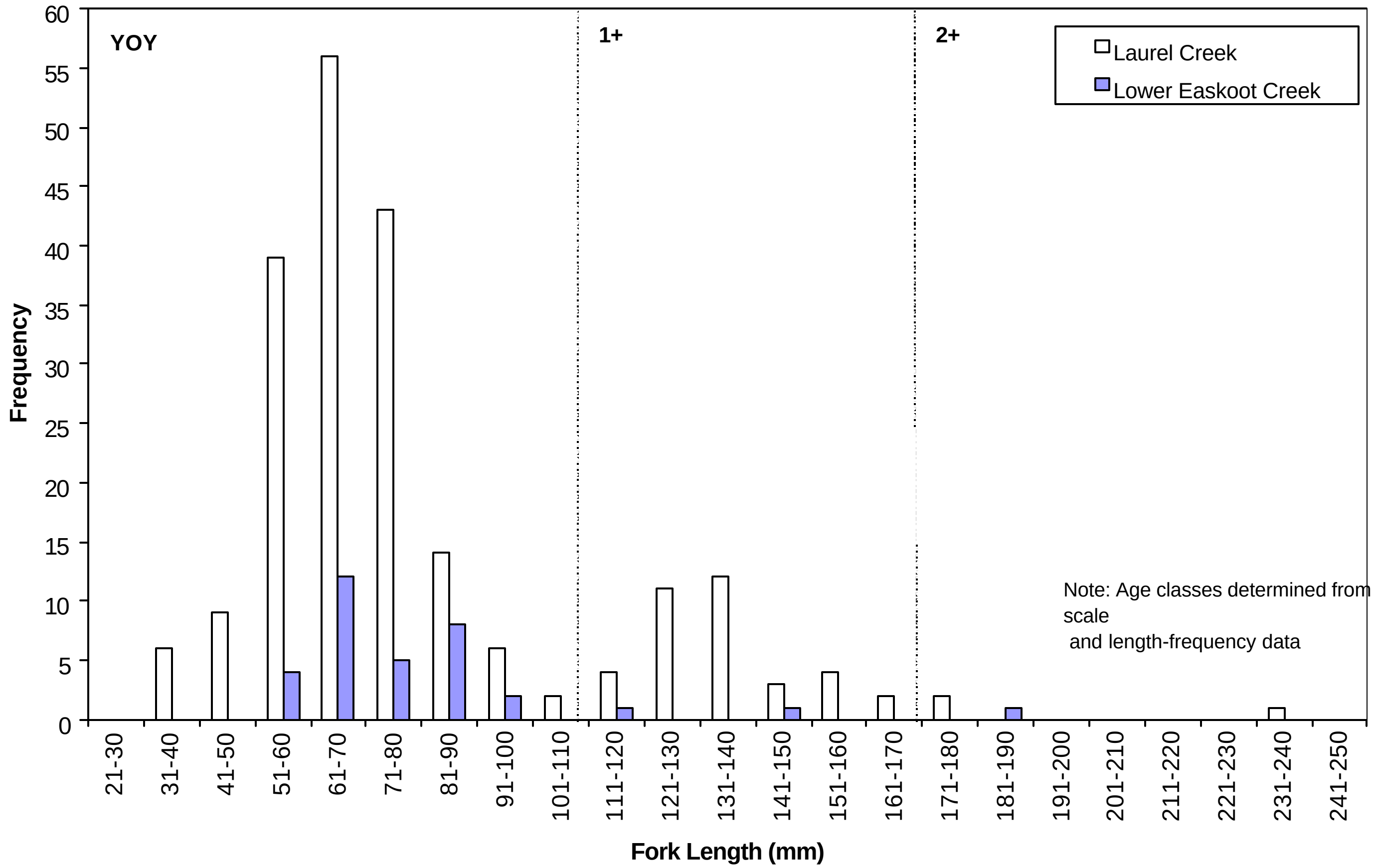


Figure 22: Length-frequency distribution of juvenile steelhead (Oncorhyncus mykiss) from two reaches in Easkoot Creek, Marin Co., Aug 3-4, 2000.

Table 19. Estimated mean density and standing biomass of sampled aquatic vertebrates in lower Easkoot Creek, Marin Co., California, Summer 1998-2000.

	SH YOY	SH 1+	SH 2+	SB	SC	CGS
July 1998						
# fish per m (s.d.)	0.7 (0.7)	0.3 (0.6)	0	0.2 (0.4)	0.2 (0.2)	0
standing biomass (g/m)	4.7 (3.1)	2.8 (6.3)	0	0.2 (0.1)	1.5 (2.4)	0
# fish per sq. m (s.d.)	0.3 (0.4)	0.03 (0.06)	0	0.09 (0.19)	0.04 (0.04)	0
standing biomass (g/sq. m)	0.3 (0.4)	0.9 (2.0)	0	0.08 (0.07)	0.5 (0.8)	0
August 1999						
# fish per m (s.d.)	0.03 (0.05)	0	0	0.03 (0.03)	0	0
standing biomass (g/m)	0.1 (0.2)	0	0	0.02 (0.03)	0	0
# fish per sq. m (s.d.)	0.02 (0.03)	0	0	0.02 (0.01)	0	0
standing biomass (g/sq. m)	0.06 (0.1)	0	0	0.01 (0.01)	0	0
August 2000						
# fish per m (s.d.)	0.9 (0.7)	0.04 (0.06)	0.01 (0.03)	0.3 (0.1)	0.5 (0.3)	0
standing biomass (g/m)	5.2 (4.5)	1.1 (1.6)	1.0 (2.3)	0.1 (0.1)	1.8 (2.0)	0
# fish per sq. m (s.d.)	0.4 (0.3)	0.02 (0.03)	0.01 (0.01)	0.1 (0.1)	0.2 (0.2)	0
standing biomass (g/sq. m)	2.6 (2.0)	0.6 (0.8)	0.5 (1.2)	0.05 (0.03)	0.9 (1.0)	0

SH-steelhead, SC-sculpin, SB-threespine stickleback, CGS-California giant salamander, Std deviation in parenthesis
1998-survey distance was 55.8 m (5 habitat units); 1999-survey distance was 52.6 (3 habitat units); 2000-survey distance was 95.6 m (5 habitat units)

Table 20. Estimated mean density and standing biomass of sampled aquatic vertebrates in Laurel Creek, Marin Co., California, Summer 1998-2000.

	SH YOY	SH 1+	SH 2+	SB	SC	CGS
July 1998						
# fish per m (s.d.)	0	0	0	0	0	0
standing biomass (g/m)	0	0	0	0	0	0
# fish per sq. m (s.d.)	0	0	0	0	0	0
standing biomass (g/sq. m)	0	0	0	0	0	0
August 1999						
# fish per m (s.d.)	15.3 (13.9)	0.7 (1.5)	0.2 (0.5)	0	0.3 (0.4)	0.04 (0.08)
standing biomass (g/m)	49.0 (48.9)	23.8 (51.9)	19.2(47.1)	0	4.0 (7.1)	0.1 (0.2)
# fish per sq. m (s.d.)	7.6 (6.6)	0.3 (0.7)	0.09 (0.2)	0	0.1 (0.2)	0.02 (0.05)
standing biomass (g/sq. m)	24.1 (22.2)	10.7 (23.6)	8.7 (21.4)	0	2.1 (4.1)	0.07 (0.14)
August 2000						
# fish per m (s.d.)	8.2 (6.7)	1.7 (2.2)	0.1 (0.2)	0	0.1 (0.2)	0
standing biomass (g/m)	37.6 (35.8)	52.4 (65.6)	14.0 (26.5)	0	1.5 (2.3)	0
# fish per sq. m (s.d.)	3.9 (2.7)	0.7 (0.9)	0.06 (0.1)	0	0.05 (0.07)	0
standing biomass (g/sq. m)	17.5 (15.0)	21.7 (26.6)	6.2 (12.3)	0	0.6 (1.0)	0

SH-steelhead, SC-sculpin, SB-threespine stickleback, CGS-California giant salamander, Std deviation in parenthesis
1998-survey distance was 23.1 m (2 habitat units); 1999-survey distance was 52.9 (6 habitat units); 2000-survey distance was 32.9 m (6 habitat units)

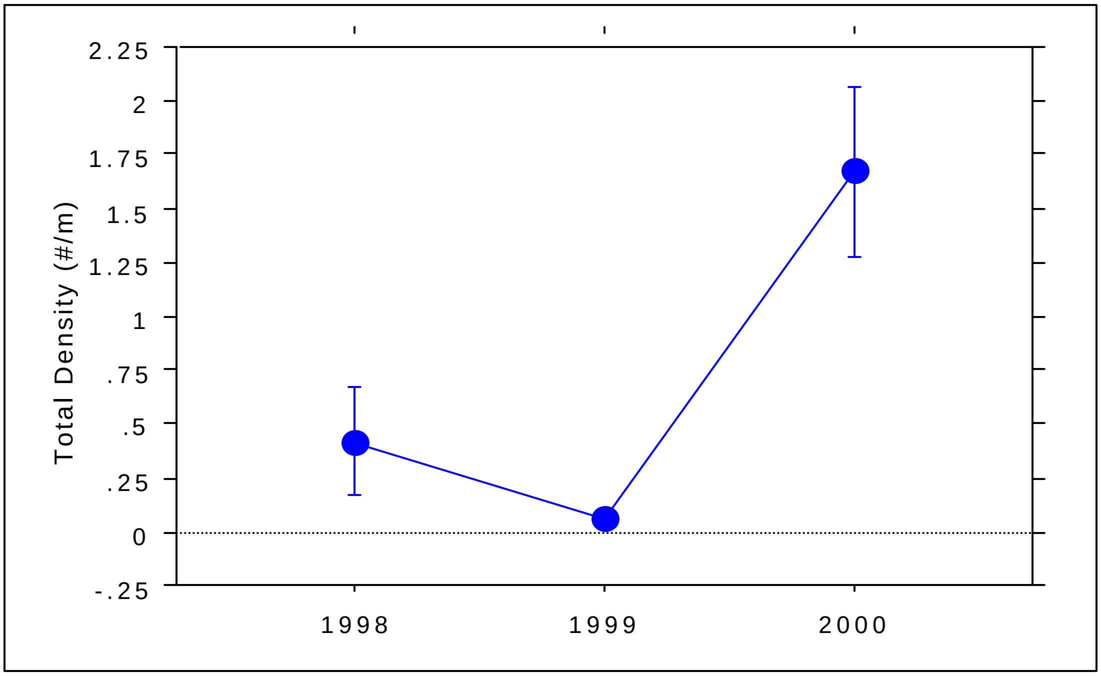


Figure 24: Total density of fish sampled using multiple pass electrofishing at lower Easkoot Creek, Stinson Beach Park, Marin Co., Summer 1998-2000.

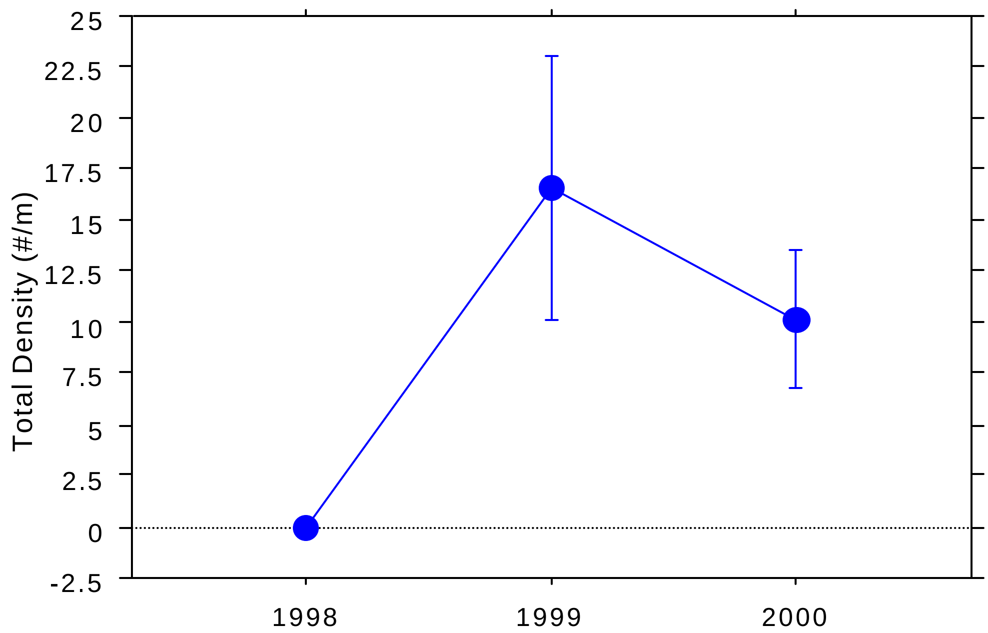


Figure 25: Total density of fish sampled using multiple pass electrofishing at Laurel Creek, Marin Co., Summer 1998-2000.

Standing Biomass of Vertebrates

The Laurel Creek station had much higher standing biomass of vertebrates than lower Easkoot Creek station when all years were considered (post-hoc Scheffe test, p=0.03). As with the density data, biomass of YOY and older steelhead were higher at Laurel Creek and were the main contributor to this difference.

Standing biomass data for Summer 1999 and 2000 provide similar information as the abundance data. Trends in standing biomass of aquatic vertebrates at the two reaches reflect changes in habitat. Total standing biomass and fish density at Lower Easkoot Creek increased in 2000 when more pool habitat was available (Figure 26).

Following the creation of step pools in Laurel Creek, mean standing biomass of vertebrates was around 100 g/ linear m for both 1999 and 2000 (Figure 27). This similarity in standing biomass was both astounding and indicative of the

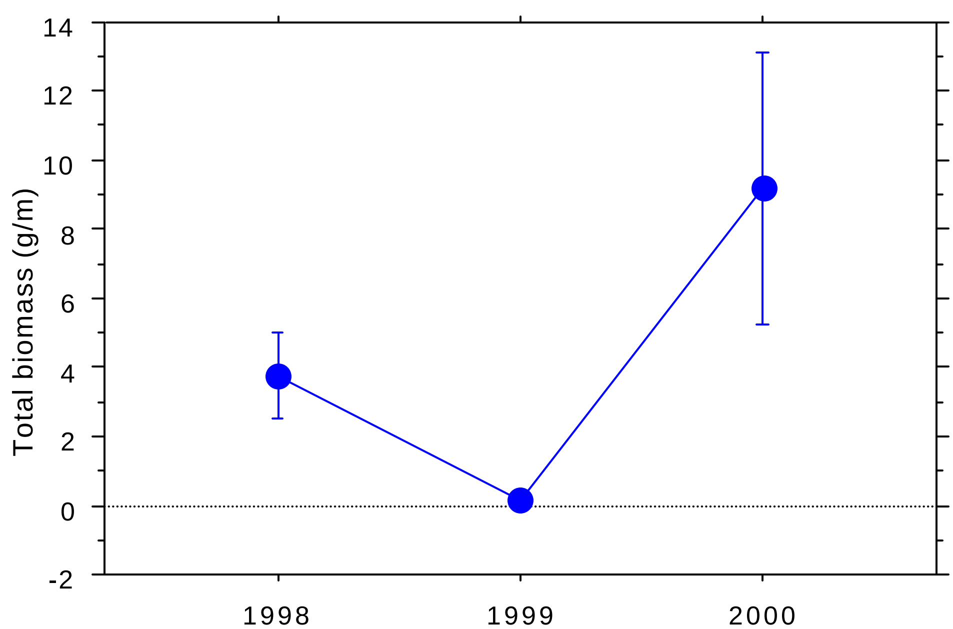


Figure 26: Total standing biomass sampled using multiple pass electrofishing at lower Easkoot Creek, Stinson Beach Park, Marin Co., Summer 1998-2000.

recuperative capacities of aquatic systems after a single disturbance. In October 1999, several months after the August 1999 fish sampling event, heavy water appropriation by the Stinson Beach County Water District caused all pools to dewater and resulted in the mortality of fish. Less than a year later, similar biomass of aquatic animals were present in these areas. However, repeated dewatering events may ultimately overwhelm the recuperative abilities of the system.

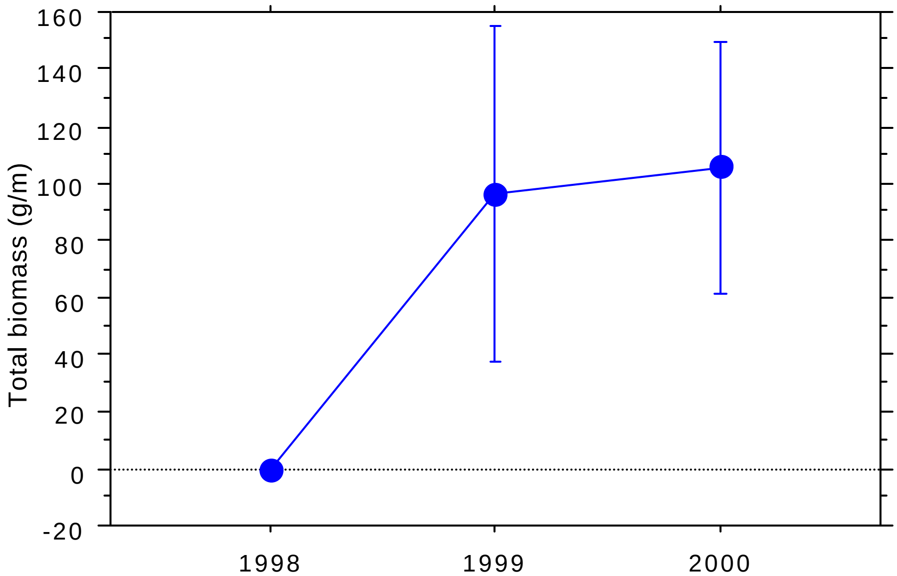


Figure 27: Total standing biomass sampled using multiple pass electrofishing at Laurel Creek, Marin Co., Summer 1998-2000.

Fish Condition

The mean Fulton condition factor and power function exponent ('b') for steelhead from lower Easkoot Creek and Laurel Creek were very similar (Table 21). When compared to West Union Creek, Easkoot Creek steelhead were in much better condition (Table 21). To demonstrate, a hypothetical 150 mm steelhead caught in 1999 at West Union Creek would weight 30 g while at Easkoot Creek, a fish of the same length would be 41 g. Insufficient length and weight data were available for comparison of sculpin and threespine stickleback.

Table 21: Summary of steelhead condition factors for Easkoot Creek, Marin Co., and West Union Creek, San Mateo Co.

LOCALE	Year	Power Function (R2) where w = weight (g), L= fork length (mm)	n	Mean Fulton's Condition Factor
Easkoot Watershed				
--Laurel Creek	1999	$W = 1.10 * 10^{-5} * L^{2.988}$ (0.95)	64	1.08
--lower Easkoot	2000	$W = 1.39 * 10^{-5} * L^{2.971}$ (0.98)	56	1.23
--Laurel Creek	2000	$W = 1.27 * 10^{-5} * L^{2.990}$ (0.99)	105	1.23
West Union Creek	1999	$W = 1.78 * 10^{-5} * L^{2.863}$ (0.99)	69	0.99

Other Aquatic Vertebrates

Habitat inventories and fish surveys encountered few other vertebrate species. Fortunately, we did not find non-native aquatic vertebrates common to other streams in Marin Co., (e.g., mosquitofish, bass, etc.). Observed species are provided below in Table 22.

Table 22: Other vertebrates found within in east-side Bolinas Lagoon tributaries, 1997-1998.

Common Name	Scientific Name	Easkoot Creek	Stinson Gulch	McKinnon Gulch	Morse Gulch	Wilkins Gulch
California giant salamander	*Dicamptodon ensatus*	x	x	x	x	x
Rough-skinned newt	*Taricha granulosa*	x				x
Prickly Sculpin	*Cottus asper*	x	x			
Threespine stickleback	*Gasterosteus aculeatus*	x				X

X = present

California giant salamanders were found in all drainages. Wilkins Gulch had a high abundance of California giant salamanders. Larvae were first detected 600 m above Highway One where surface flows were connected. An estimated 3.4 giant salamanders were observed per 100 m. This represents an underestimate of larval salamanders actually present because undercut banks and large rocks were not surveyed and density was determined based on total survey length rather than just the wetted distance.

It was not surprising to find only steelhead juveniles or California giant salamander larvae in many of the stream habitat units. Steelhead can ascend small, steep gradient streams unlike threespine stickleback. Also, resident fish such as prickly sculpin fare poorly in streams that frequently dry, whereas, a single drought year, while injurious to a particular year class, would not be catastrophic for steelhead and salamander adults that live away from the stream channel.

Historic Fisheries Data

During 2000, several long-term residents within the Stinson Beach community were interviewed regarding fisheries issues over the phone or in person by the Park's aquatic ecologist. A standardized list of questions were asked. Most of the longer interviews were taped with the verbal permission of those interviewed. A separate transcript of these interviews has been prepared.

In addition, the historical section of the Marin County and Mill Valley Library were scoured for articles on fish resources. The Stinson Beach Historical Society provided assistance in locating people for interviews as well as loaning of prints for duplication. A volunteer also reviewed local newspapers such as the San Francisco Examiner and the Marin Independent Journal for relevant fisheries information. Color photographs of DeYoung museum landscape portraits of California scenes were also perused. No information specific to the Bolinas area was obtained from the San Francisco Examiner and Marin Independent Journal.

WILKINS GULCH. No information regarding Wilkins Gulch was obtained from interviews with local residents. The lands adjacent to the creek have been managed in recent years as pasture for horses and cattle as part of Rancho Baulines.

STINSON GULCH and MCKINNON GULCH. Interview with local residents provided some information about past conditions in McKinnon and Stinson Gulches. When asked about fish in McKinnon or Stinson Gulch, one Stinson Beach resident (Ken Sherfey) noted that “there was good fishing in both of those places…there were baby steelhead in them” “McKinnon Creek was really good, we used to have to sneak in there…the guy was raising fighting cocks in there….that was probably between [19]55-[19]58, somewhere around in there.” He also noted that in Stinson and McKinnon Gulches the fish caught further upstream were different than those downstream. Fish caught downstream were “all real silver” while the upstream ones were “darker and had more color to them…and had the red bands on them.”

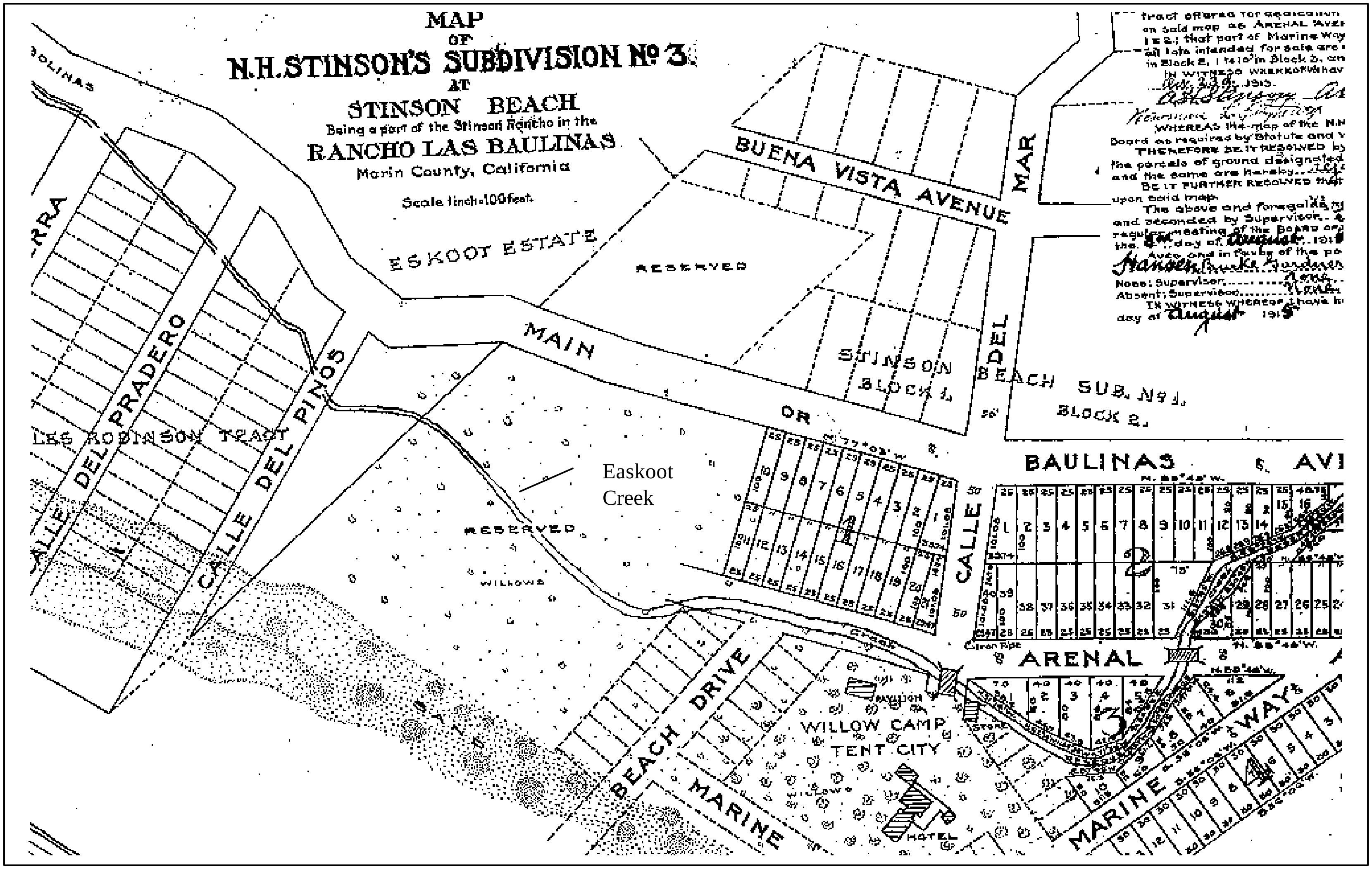
MORSE CREEK. No information is available regarding Morse Creek. Field surveys indicate that the lower section of the creek has been disturbed. It is likely that after the 1982 flood event, materials deposited into the channel may have been removed and spoiled on the banks similar to Stinson Gulch and Easkoot Creek. The banks have berms that appear to be of unnatural origin.

EASKOOT CREEK. Most of the historic habitat and fish data for the Stinson Beach area centered around Easkoot Creek. Historic photographs from the Stinson Beach Historical Society show a dense canopy of deciduous trees (mainly willows, alders, and some bay) along the existing corridor of Easkoot Creek (Figure 28). Also, there were several old photographs of Willow Camp or Poison Pond, an isolated freshwater pond just south of lower Easkoot Creek. According to interviews with long-term residents and a 1915 County Assessor's map (Figure 29), Easkoot Creek never flowed directly to the ocean via Willow Camp Pond. Rather, the creek drained into Bolinas Lagoon. Despite many alterations to Easkoot Creek, its current alignment generally matches the alignment in 1915.

Figure 28: Willow Camp/Poison Pond and areas north in the town of Stinson Beach, Marin Co., California.

Willow Camp Lake – (Poison Pond), Stinson Beach, 1904.
Source: Stinson Beach Historical Society, Accession #1993-267-P
No further dissemination permitted without the express written permission of the Stinson Beach Historical Society.

Figure 29: Alignment of Easkoot Creek in 1915 through the town of Stinson Beach, Marin Co., California



Sizable numbers of steelhead were likely present in Easkoot Creek through the mid-1970's. Craig Gillman, a former commercial fisherman, who first lived in Stinson Beach in 1955 recounted a winter event in the mid-1970's where 26 steelhead where found swimming in a thigh-deep pool, unable to ascend a cement/concrete dam just above the fire station (Figure 5). Craig and another person captured these adult steelhead and transported them above the passage barrier and later observed spawning activity. Several other long-term residents recalled seeing returning steelhead adults ascending to just below the second footbridge along the trail.

Many of the interviewed people recalled the large storm event in 1982-1983 that caused a debris flow in the upper channel which deposited large amounts of sediments within the low gradient reach of Easkoot Creek. The deposited materials filled the entire channel (Dick Danielsen, GOGA supervisory Visitor and Resource Protection ranger, pers. comm.). Bill Tacherra of the Stinson Beach County Water District (now retired) recalled operating an excavator from Calle del Arroyo up through Stinson Beach Park to remove deposited materials (Tacherra, pers. comm., 2000). The excavated materials were spoiled along the banks.

A large unnatural embayment in southern Bolinas Lagoon served as a causeway between Highway 1 and the Seadrift community (del Secco, pers. comm. 2000). The undersized culvert (likely 24-inch diameter) ponded water upstream during high winter flow events (del Secco, pers. comm., 2000). As mitigation for impacts associated with the Lone Tree Slide along Highway 1 in 1989, Caltrans removed the fill material associated with this causeway in 1994 (Josselyn and Obrebski 1997).

Not all actions that occurred within the creek resulted in habitat losses for steelhead juveniles. Until the mid-1990's, the Marin County Flood Control District routinely excavated deposited sediments at various bridge crossings along Easkoot Creek. Many of these "glory" holes were the only locales that contained deep pool habitats along the lower reach of Easkoot Creek. Most of the interviewed residents (Sherfey, Tacherra, Lewis) remarked about the concentrations of large steelhead juveniles found at these bridge areas.

The historic distribution of steelhead within the Easkoot watershed is roughly similar to their distribution today. Local residents indicate seeing steelhead swimming past the current fire station and up past the second Matt Davis Trail crossing. Beyond this area, habitat conditions are predominantly step-pool habitats within minimal if any spawning habitat. It is likely that either resident trout or steelhead still spawn in these areas because juvenile steelhead are seen throughout this area. It is likely that steelhead have lost use of the Black Rock tributary for spawning and rearing purposes. A local resident reported that this tributary was used by steelhead prior to having their access blocked by a hanging culvert just upstream of the Easkoot Creek confluence (T.Lewis, pers. comm., 1999).

Past water appropriation activities have resulted in adverse impacts to fish habitat and aquatic life. An article in the Point Reyes Light (August 26, 1993), noted that residents found stranded and dead juvenile steelhead in pools along Easkoot Creek. In the fall of 1999, a similar high water demand resulted in the loss of fish as pools dried.

HABITAT RESTORATION/PROTECTION ACTIVITIES

Since 1998, several community-initiated habitat protection and enhancement activities have been completed. Following a recent fish kill in Laurel Creek associated with water appropriation activities (Fall 1999), Streamatrix, a community-based organization, initiated a flow monitoring program with assistance from the Park. The intent of the monitoring program was to identify flow conditions that would maintain the connectivity of flow between pools. Dissolved oxygen data collected by the Park at West Union and Redwood Creeks clearly show relationship between low dissolved oxygen concentrations and pool connectivity. Such real-time flow data was used to modify water withdrawals from Laurel Creek to protect fisheries. Streamatrix also worked with the water district to ensure that the diversion on Fitzhenry Creek (tributary to Laurel Creek) was retrofitted with a "hole" to always allow a minimum bypass flow into the creek.

In 1999, the Park's Habitat Restoration Team expanded its work program to include the Easkoot Creek watershed. Several Sunday work parties were conducted along the stream. Work parties assisted with the inventory of riparian plant species and especially, with removal of cape ivy and other invasive non-native plants along Easkoot and Laurel Creeks. Because non-native plant control requires a commitment by the community outside the Park, several outreach activities were initiated including a riparian plant workshop and a door-to-door event that provided information about non-native plants to Park neighbors.

The Park and the National Marine Fisheries Service worked with Streamatrix to design and implement a fish passage and habitat enhancement project on Laurel Creek, above its confluence with Black Rock Creek. The design was intended to allow steelhead adults and juveniles to move upstream more easily, while also providing more rearing habitat than prevoiusly present. The pre-project channel conditions included a grouted rock bottom that was downstream of two, two-three foot high sacrete weirs. While the height of the weirs would not normally provide a passage barrier to adult steelhead, no pool habitat was available below the weirs to allow adults to hold and accelerate over the weirs (Figures 30-31). In addition, the grouted channel bottom had shallow sheet flow which would be unlikely to support the body of an adult except under infrequent high flow conditions. The implemented design included the creation of 4 new step-pools using excess 2-3 foot diameter boulders from the Marin County Public Works Department. The design was consistent with the natural habitat upstream of the project area. Because of the steep and narrow terrain, no heavy equipment was used to place the materials within the channel. Streamatrix organized a volunteer work party and spent a full weekend on construction and clean-up (September 11-12, 1998). The grout was broken and removed using an electric jack hammer. Boulders were placed using rock bars and hand jacks. Within a year, the created step pools provided essential summer rearing habitat for various steelhead age classes and supported the highest densities of aquatic animals within the surveyed Easkoot Creek watershed

(See prior results). Stream profile and cross-section data were collected to describe these topographic changes following habitat restoration activities (Figures 30,32). However, the permanency of these pools is unknown. While care was taken to place and wedge the boulders to prevent their movement, all rocks were lain directly on the stream bottom without being keyed in. As of February 2002, the created step pools are still intact.

Collaborative efforts to protect and restore stream resources within the Stinson Beach area are continuing. The Park is working with the local water district and community groups to ensure that sufficient flows are provided to maintain fish habitat. A restoration project is underway to increase winter and summer rearing habitat for juvenile steelhead and other aquatic life within Easkoot Creek. Future restoration activities may include riparian and stream habitat restoration along Stinson and McKinnon Gulches.

Figure 30: Pre- (3/1998) and Post-Restoration Project (4/2/1999) Longitudinal Profile of Easkoot Creek, Marin Co., CA

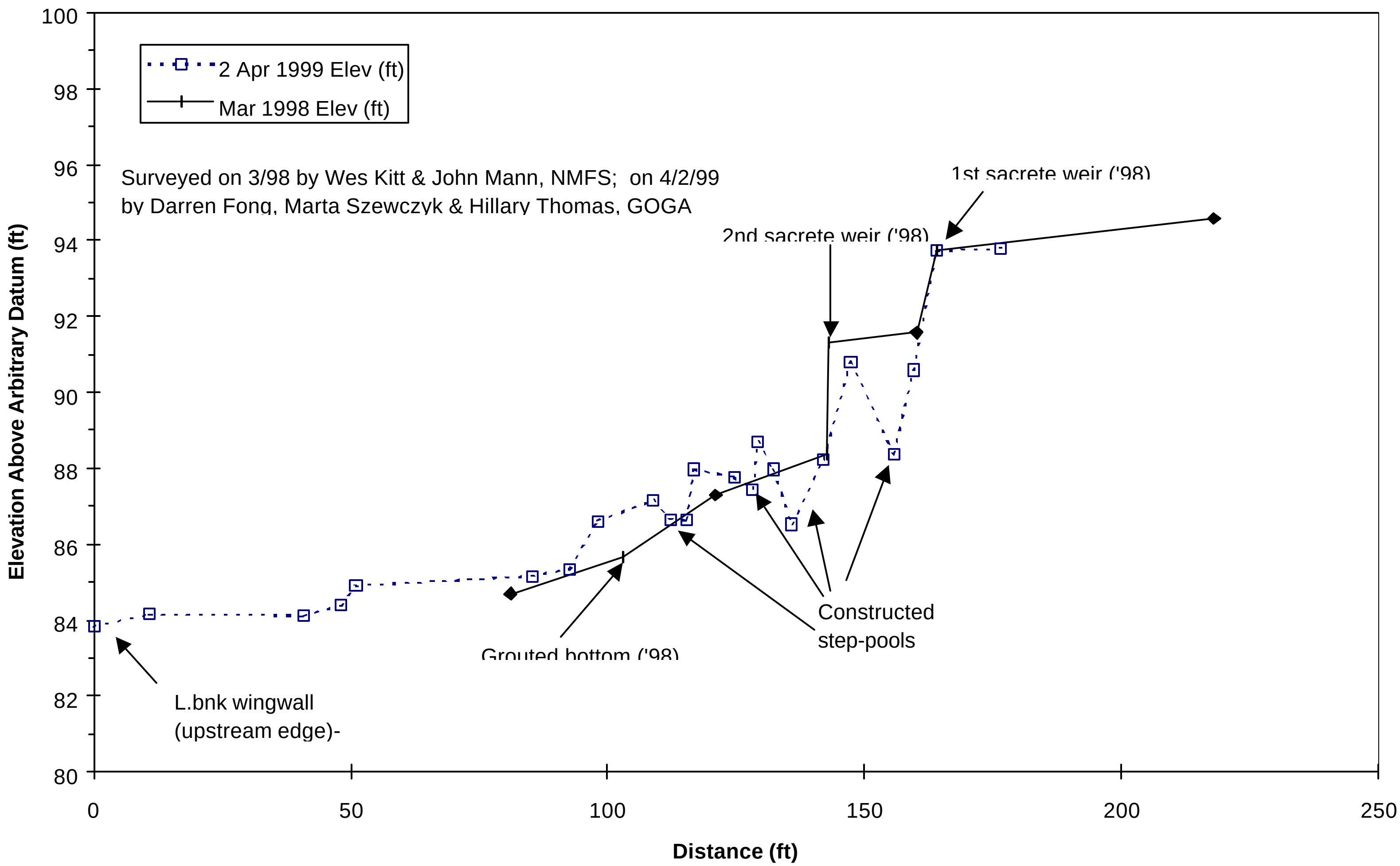
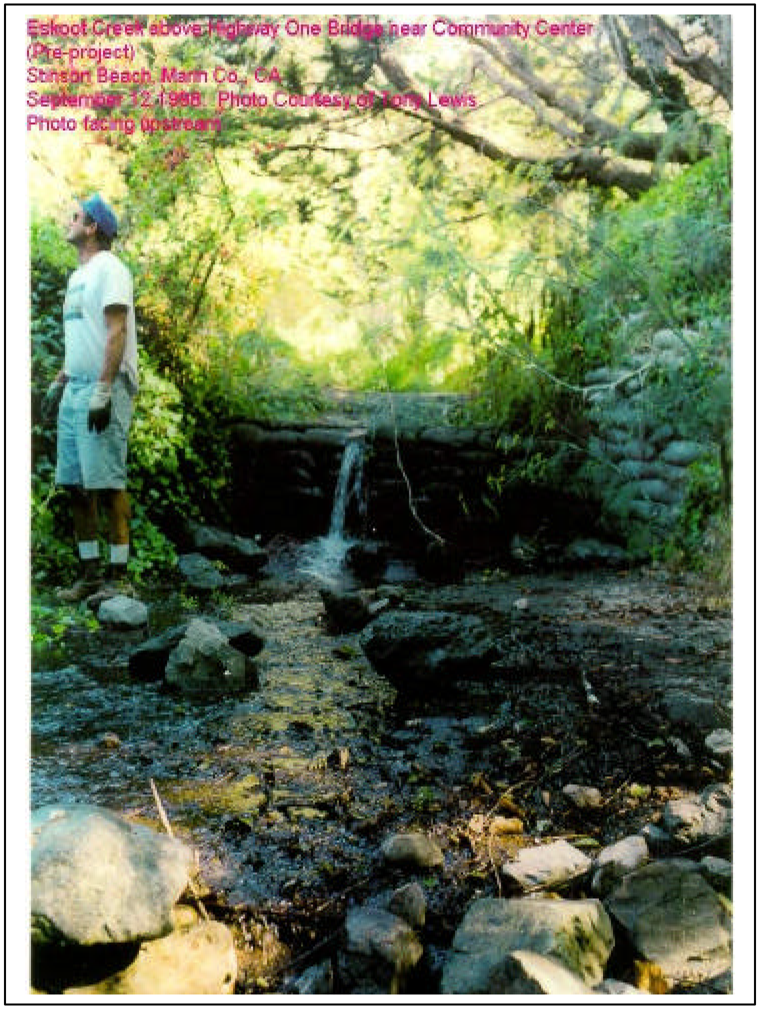


Figure 31: Photo (at left) looking upstream Laurel Creek at sacrete weir and grout structure just prior to construction (September 12, 1998) and photo (at right) looking upstream post-construction (1999) at created step-pools.



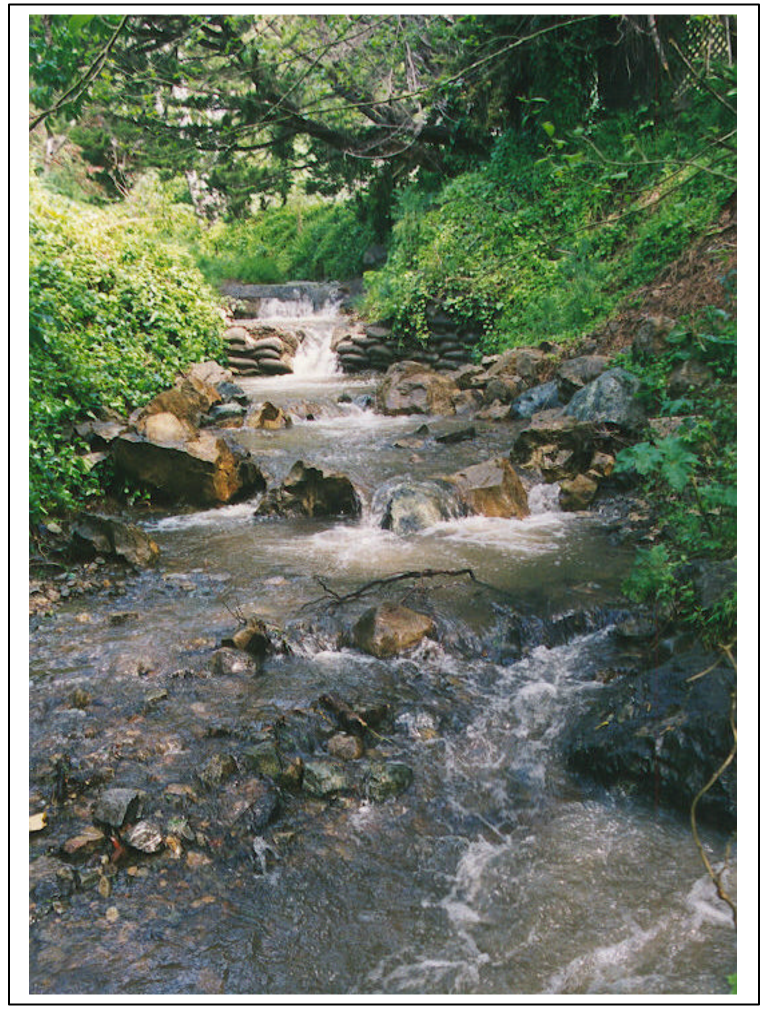
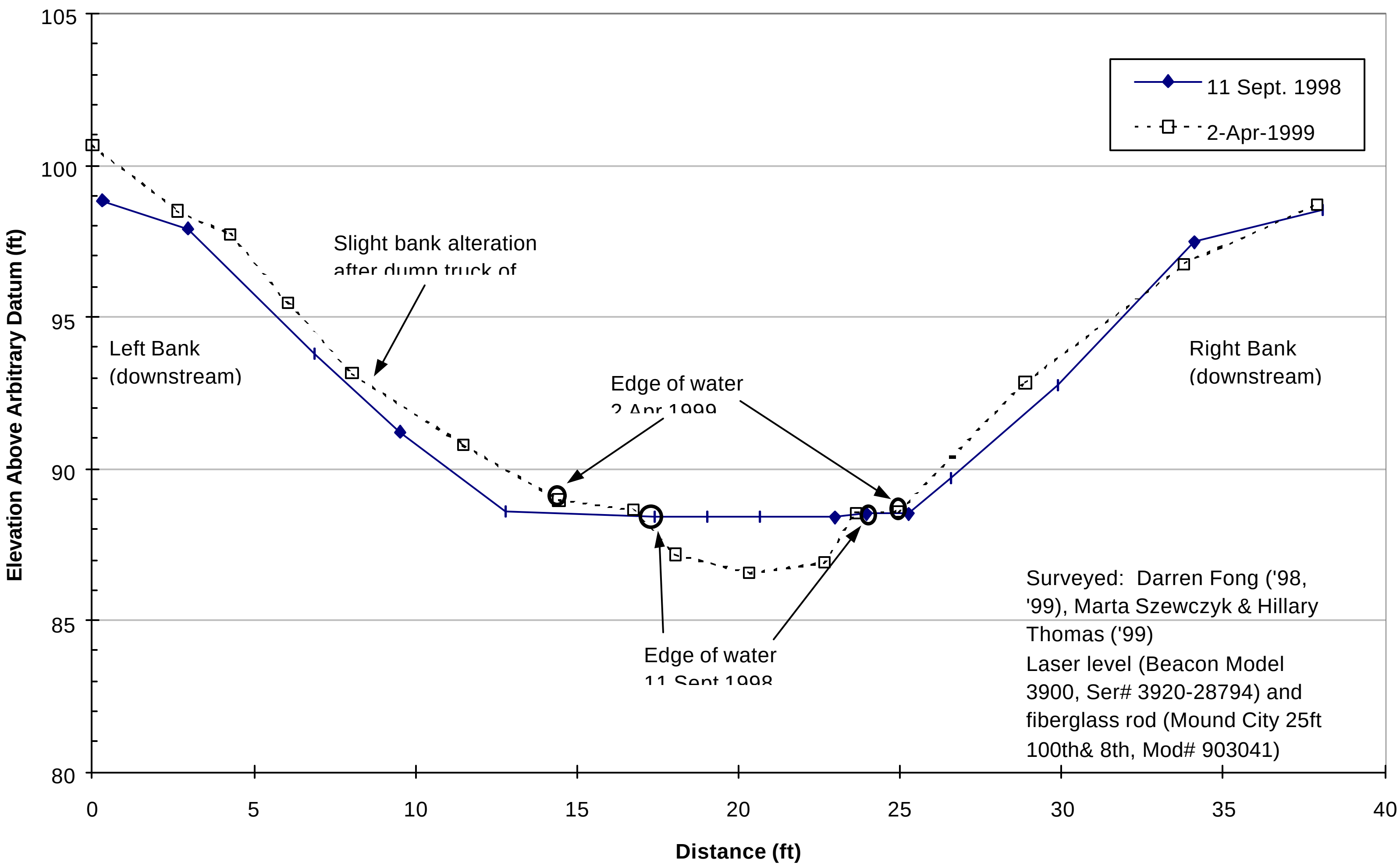


Figure 32: Pre- (3/1998) and Post-Restoration Project (4/2/1999) cross-section of Easkoot Creek at the Community Center above Highway 1, Marin Co.



FISHERY RESOURCE RECOMMENDATIONS

1. Work cooperatively with local community, resource agencies, and the Stinson Beach County Water District to develop and implement a stream resource monitoring plan that includes water quality, flow (or surrogate measurements), and fish community components and related “triggers” for water management actions.

2. Work cooperatively with local community, resource agencies, and Stinson Beach County Water District to ensure continuity of instream flows to protect aquatic life by providing technical assistance in the development of a natural resource “friendly” water management plan, appropriate land-use planning, and appropriate Park facility improvements.

3. Investigate cause of low dissolved oxygen conditions within lower Easkoot Creek.

4. Implement instream habitat and riparian improvements in lower Easkoot Creek for the benefit of aquatic life.

5. Facilitate community protection of instream and riparian habitat along private property portions of Easkoot Creek.

6. Institute a feasibility study for long-term riparian and channel improvements along lower Stinson Gulch and McKinnon Gulches. In the near-term, gather topographic data at both locations.

ACKNOWLEDGEMENTS

No report on freshwater fishery resources in the Bolinas Lagoon watershed would be complete without mention of the extraordinary efforts of Rudy Ferris, Tom Lambert, Tony Lewis, and John O'Connor. They spent countless hours helping protect, restore, and monitor the stream resources within this watershed. Assistance with habitat inventories was provided by Meshawn Ayala, Leanne Canevaro, and John O'Connor. Flow monitoring was conducted with field and technical assistance from Brad Gillies (Water Resources Division, NPS), Rudy Ferris, and John O'Connor. Brad and Jeff Hughes (Water Resources Division) also provided excellent comments on an early draft. Spawner surveys were conducted by Tsahai Codner, Eric Crandall, I. Gunzerodt, Mike Perlmutter, and Marta Szewczyk. Anne-Laure Rauber performed the steelhead scale analyses. Jane Slack from the Stinson Beach Historical Society graciously provided the Park Archives several wonderful photographic prints of the Stinson Beach area prior to its development. Richard Dinges and his staff from the Stinson Beach County Water District graciously provided water appropriation data

LITERATURE CITED

American Public Health Association (APHA). 1985. Standard methods for the examination of water and wastewater. 16th edition. 1268 p.

Anderson, R.O. and S.J. Gutreuter. 1983. Length, weight, and associated structural indices. Pages 283-300. *In*: L.A. Nielsen and D.L. Johnson (eds.) Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Beamish, R. J., and G. A. McFarlane. 1983. The forgotten requirement for age validation in fisheries biology. Transactions of the American Fisheries Society. 112:735–743.

Beamish, R. J., and G. A. McFarlane. 1987. Current trends in age determination methodology. Pages 15–42 *in* R. C. Summerfelt and G. E. Hall, editors. Age and growth of fish. Iowa State University Press, Ames.

Buchanan, T.J. and W.P. Somers. 1969. Discharge measurements at gaging stations. Techniques of Water-Resources Investigation of the UnIted States Geological Survey, Book 3, Chapter A8. United States Government Printing Office, Washington, D.C. 65 pp.

Carlisle, D. 2000. Ecological relevance: a neglected concept in the search for ecological indicators. Unpublished abstract. Water Resources Division/Aquatic Professionals Meeting, November 14-16, 2000, National Park Service.

Department of Commerce-National Oceanic and Atmospheric Administration. August 18, 1997. Endangered and threatened species: listing of several evolutionary significant units (ESUs) of west coast steelhead. Final rule. Federal Register 62(159):43937-43954.

Federal Emergency Management Agency. 1986. Flood insurance rate map: Marin County, California (unicorporated areas) Panel 420 of 525. np

Fuller, R.L. and K.W. Stewart. 1977. The food habits of stoneflies (Plecoptera) in the Upper Gunnison River, Colorado. Environmental Entomology. 6(2):293-302.

Gregory, K.J. and D.E. Walling. 1973. Drainage basin form and process: a geomorphological approach. John Wiley & Sons. 458 pp.

Josselyn, M. and S. Obrebski. February 1997. State Route 1-Lone Tree slide mitigation: Bolinas Lagoon mitigation project, mitigation monitoring annual report 1996. 36 pp.

Karr, J.R. and E.W. Chu. 1999. Restoring life in running waters: better biological monitoring. Island Press, Washington, D.C. 206 pp.

Merritt, R.W. and K.W. Cummins (eds.). 1996. An introduction to the aquatic insects of North America. 3rd Edition. Kendall/Hunt Publishing Co., 862 pp.

Munro-Fraser, J.P. 1880. History of Marin County, California. Alley, Bowen & Co. San Francisco, CA.

Pennak, R.W. 1989. Freshwater invertebrates of the United States: protozoa to mollusca. 3rd edition. John Wiley and Sons, N.Y. 628 pp.

Pfankuch, D. 1975. Stream reach inventory and channel stability evaluation. USDA Forest Service, Northern Region. 26 pp.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. EPA/440/4-89/001. np.

Raleigh, R.F., T. Hickman, R.C. Solomon, and P.C. Nelson. 1984. Habitat suitability information: rainbow trout. U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-82/10.60. 64 p.

Regional Water Quality Control Board. June 21, 1995. Water quality control plan-San Francisco Bay Basin (Region 2). Np.

Rich, A.A. May 1992. Feasibility study to rehabilitate the fishery resources of Easkoot Creek, Marin County. Prepared for the Environmental Action Committee of West Marin.

Rooper, C.N., M.D. Bryant, S.J. McCurdy. 2000. Use of Scales to Assess Summer Growth of Resident Cutthroat Trout in Margaret Lake, Alaska. North American Journal of Fisheries Management. 20:467–480.

Szychowski, L.S. 1999. Fish species identification and stream habitat evalutions of the three creeks that drain from Audubon Canyon Ranch, Bolinas, California. M.S. thesis, Univ. of San Francisco. 90 pp.

U.S. Geological Survey. 2000. Daily mean discharge data-Morses CA Bolinas CA. Tab-delimited text file from USGS website-http://waterdata.sugs.gov/nwis-w/CA.

van Kirk, S. July 2000. Historical Perspective of Bolinas Bay (Lagoon). Unpublished report prepared for Tetra Tech for the Bolinas Lagoon Ecosystem Restoration Feasibility Project. 62 pp.

Ward, B.R. and P.A. Slaney. 1988. Life history and smolt-to-adult survival of Keogh River steelhead trout (*Salmo gairdneri*) and the relationship to smolt size. Can. J. Fish. Aquat. Sci. 45:1110-1122.

Personal Communications

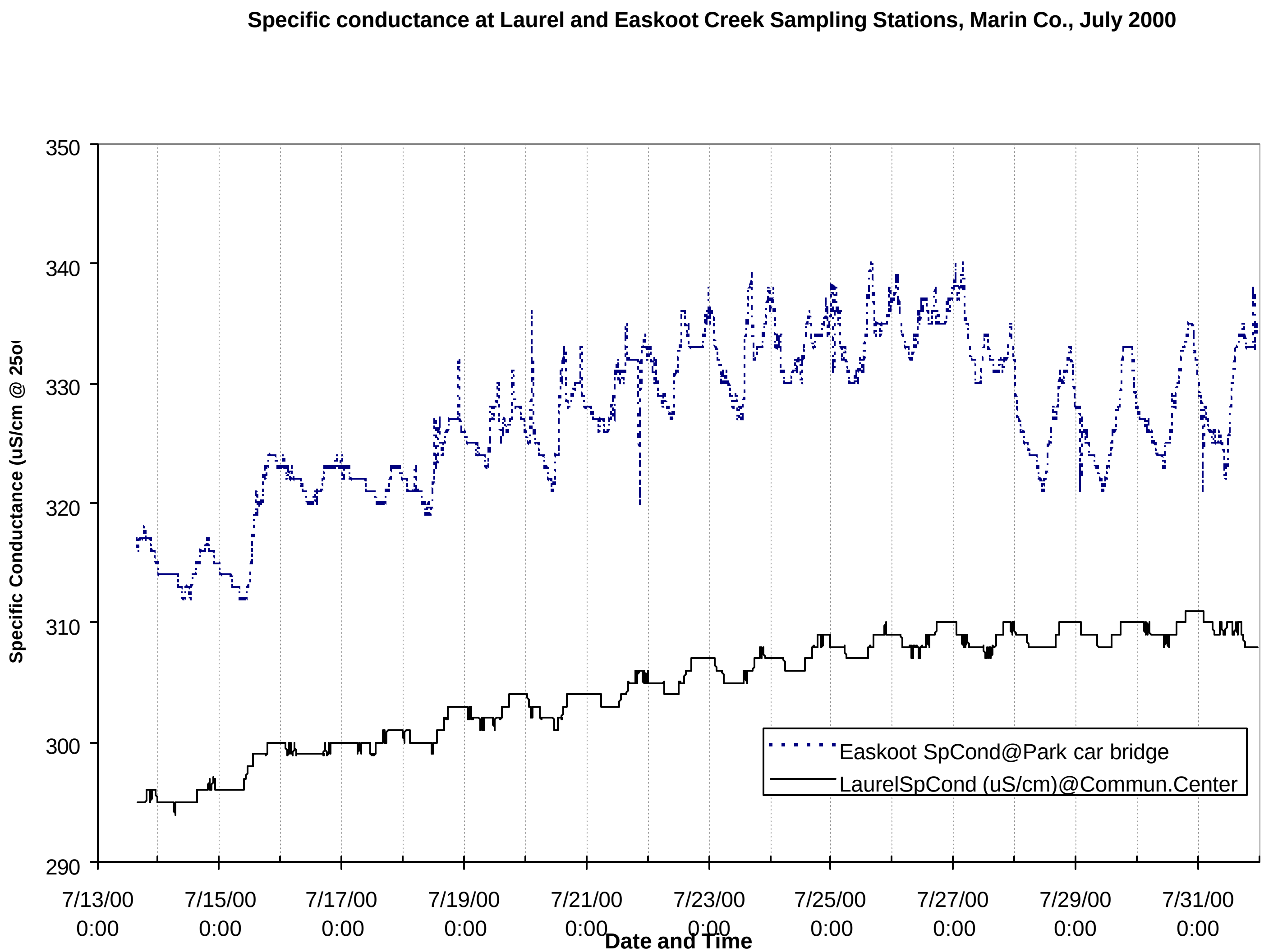
Tony Lewis, Director, Streamatrix. Telephone convers. 1999.

Bob del Secco, Visitor and Resource Protection Ranger, NPS, 2000.

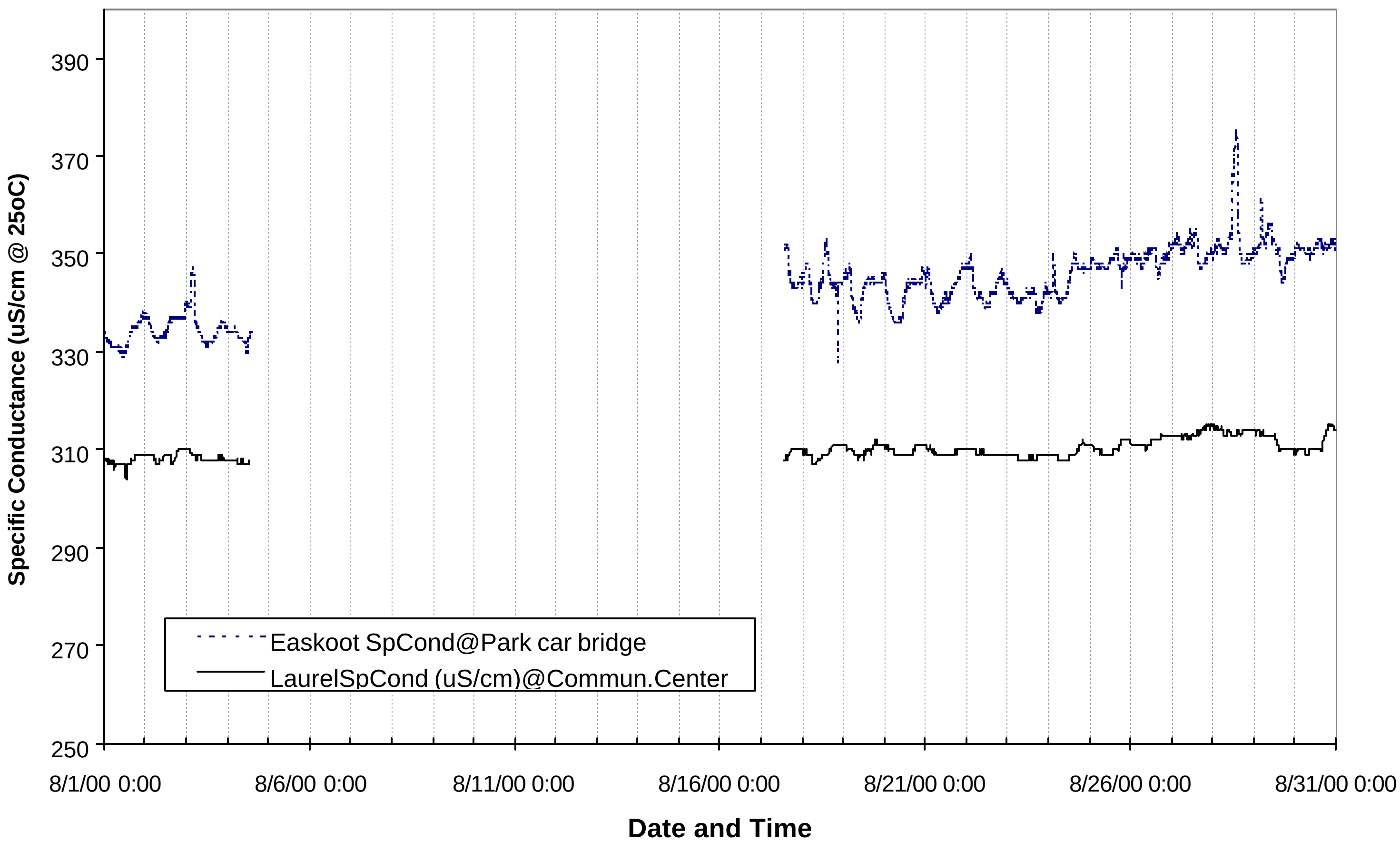
Dick Danielsen, Supervisory Visitor and Resource Protection Ranger, NPS, 2000.

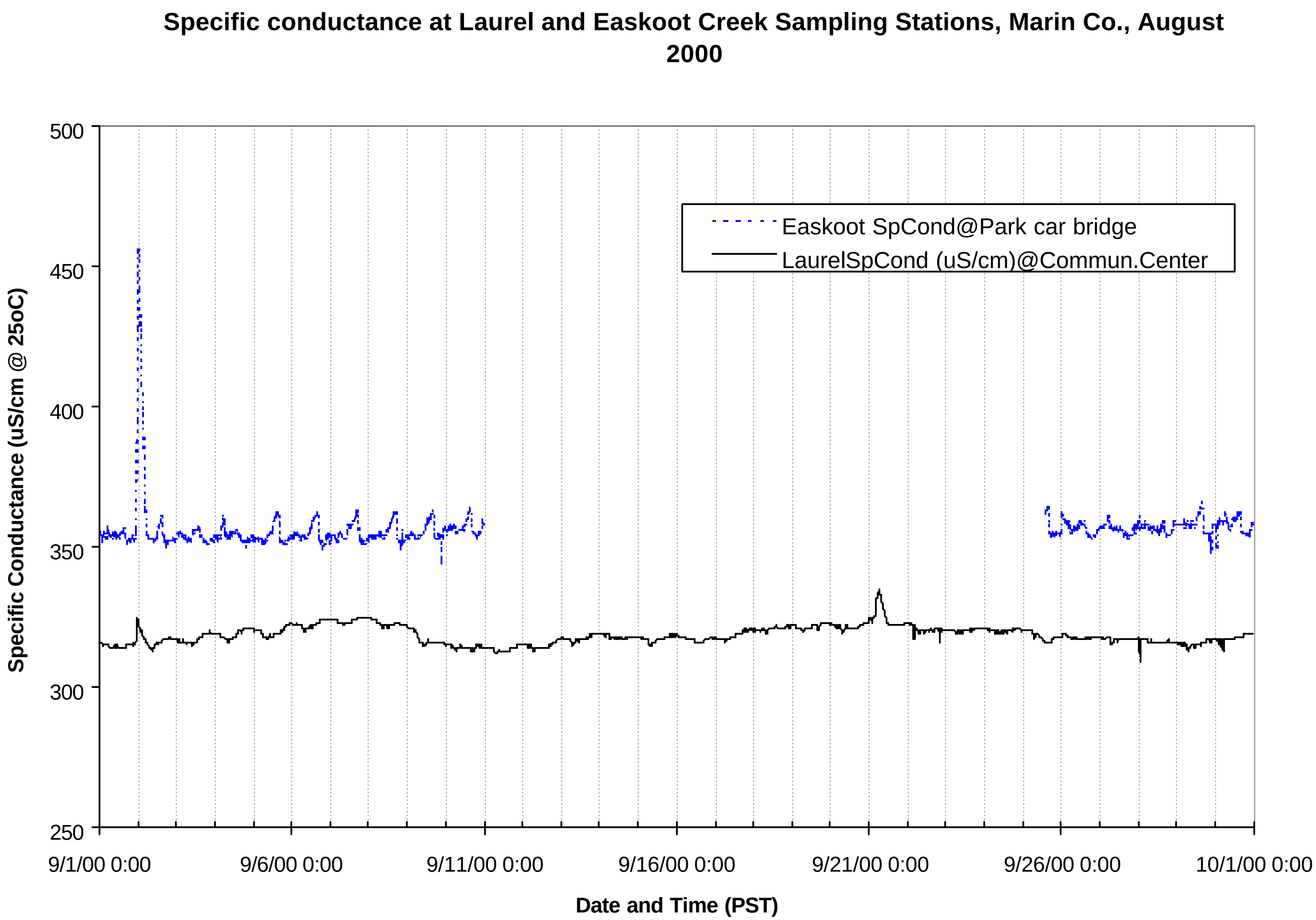
Steve Zempsch, hydrologic/geologic consultant, Watershed Science, 2001

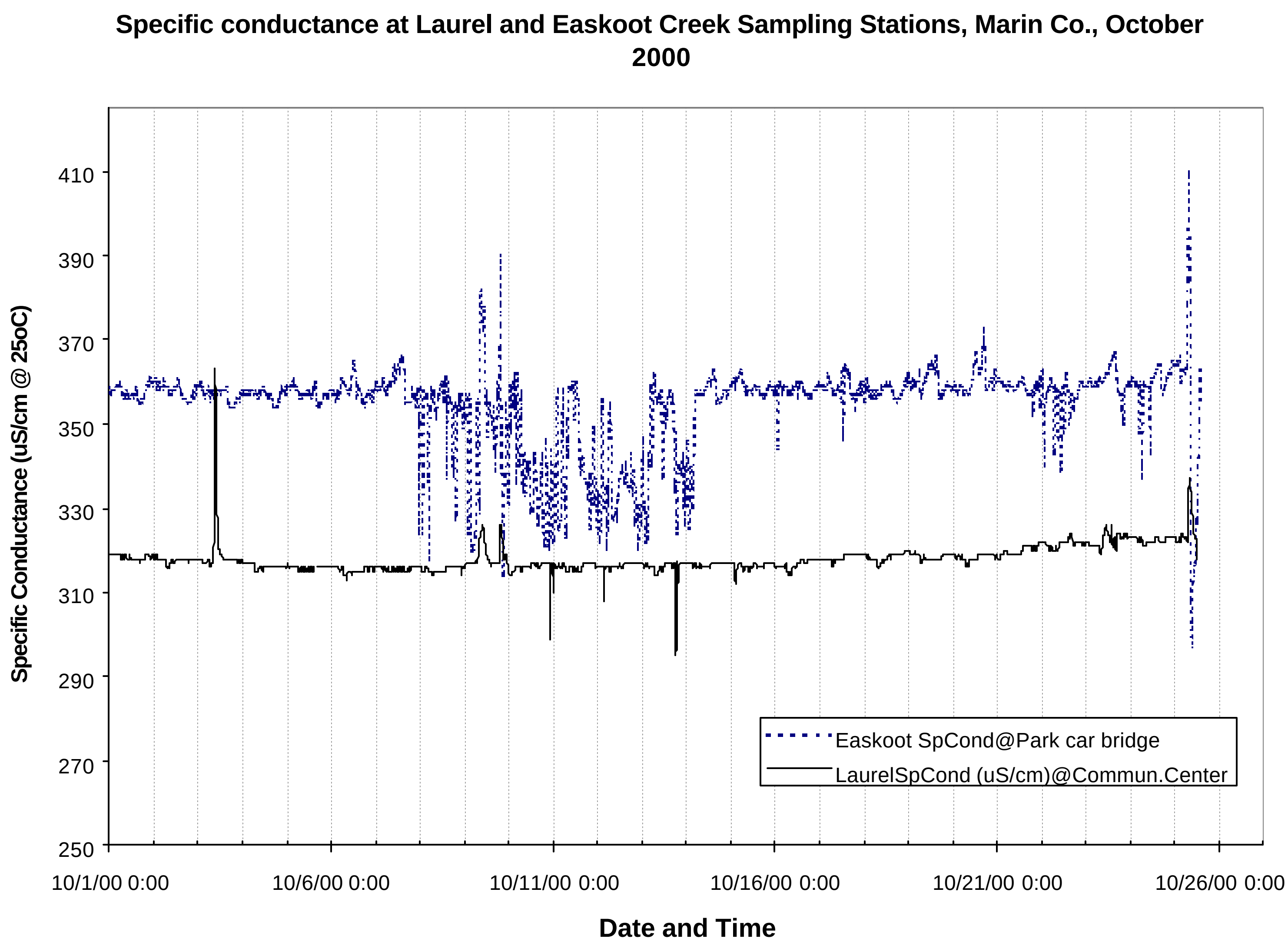
APPENDIX I: Specific conductance at Laurel and Easkoot Creeks, Marin Co., July-October 2000.



Specific conductance at Laurel and Easkoot Creek Sampling Stations, Marin Co., August 2000




Specific conductance at Laurel and Easkoot Creek Sampling Stations, Marin Co., August 2000
Easkoot SpCond@Park car bridge
LaurelSpCond (uS/cm)@Commun.Center
Specific Conductance (uS/cm @ 25oC)
500
450
400
350
300
250
9/1/00 0:00
9/6/00 0:00
9/11/00 0:00
9/16/00 0:00
9/21/00 0:00
9/26/00 0:00
10/1/00 0:00
Date and Time (PST)


Specific conductance at Laurel and Easkoot Creek Sampling Stations, Marin Co., October 2000
Specific Conductance (uS/cm @ 25oC)
410
390
370
350
330
310
290
270
250
10/1/00 0:00
10/6/00 0:00
10/11/00 0:00
10/16/00 0:00
10/21/00 0:00
10/26/00 0:00
Date and Time
Easkoot SpCond@Park car bridge
LaurelSpCond (uS/cm)@Commun.Center

APPENDIX IIA: Instream habitat conditions at Easkoot Creek during electrofishing activities (July 29-31, 1998)

Locale	Unit	Habitat Type*	Length (m)	Mean Width (m)	Mean Depth (m)	Area (sq. m.)	Volume (cu. m)	Max depth (m)	Min Depth (m)
North Parking Lot	1	fw	9.5	2.2	0.06	21.1	1.3		
	2	r	12.1	2.2	0.04	27.0	0.9		
	3	r/sc	7.75	1.9	0.05	14.7	0.7		
	4	fw	16.25	1.6	0.05	26.3	1.2		
	5	sc	10.2	3.1	0.18	31.6	5.6	0.87	0.03
Above Highway 1									
	6	mc	6.2	2.0	0.08	12.6	1.0	0.22	0.02
	7	fw (step)	45	1.8	0.15	81.0	12.2		
	8	sp	32	1.0		32.0		0.20	0.1

APPENDIX IIB: Instream habitat conditions at Easkoot Creek during electrofishing activities (August 4-5, 1999)

Locale	Unit	Habitat Type*	Length (m)	Mean Width (m)	Mean Depth (m)	Area (sq. m.)	Volume (cu. m)	Max depth (m)	Min Depth (m)
North Parking Lot	1	fw	23.3	1.8	0.04	41.7	1.8		
	2	mc	9.4	2.2	0.05	20.7	1.1		
	3	fw	19.9	2.2	0.03	42.8	1.5		
Above Highway 1	4	fw	16.0	1.5	0.02	23.5	0.5		
	5	sp	2.2	2.5	0.13	5.4	0.7	0.39	0.01
	6	sp	3.2	1.7	0.07	5.4	0.4	0.2	0.03
	7	sp	3.2	2.2	0.32	7.0	2.2	0.6	0.01
	8	sp	4.4	1.7	0.21	7.3	1.6	0.75	0.02
	9	fw (step)	23.9	2.0	0.03	48.6	1.5		

APPENDIX IIC: Instream habitat conditions at Easkoot Creek during electrofishing activities (August 3-4, 2000)

Locale	Unit	Habitat Type*	Length (m)	Mean Width (m)	Mean Depth (m)	Area (sq. m.)	Volume (cu. m)	Max depth (m)	Min Depth (m)	Cover (% area) EV	OV	LWD	L.COB	BO	UC
North Parking Lot	1	mc (only part to NPS bound.)	16.8	2.07	0.15	34.8	5.3	0.15	NA	10	15	0	0	0	0
	2	sc/fw	8.5	1.83	0.05	15.6	0.8	0.18	0.01	20	25	0	0	0	0
	3	mc	13.8	2.13	0.09	29.4	2.6	0.3	0.03	40	15	2P	0	0	0
	4	mc	16.5	1.97	0.10	32.5	3.1	0.33	0.03	50	10	1P	0	0	0
	5	fw	40	1.48	0.05	59.2	2.7			50	25	0	0	0	0
Above Highway 1	1	fw	13	1.62	0.04	21.1	0.9			0	20	0	15	0	0
	2	fw	6.4	0.88	0.06	5.6	0.3			0	0	0	25	0	0
	3	sp	2.6	2.25	0.12	5.9	0.7	0.4	0.03	0	0	0	10	10	0
	4	sp	3.8	1.53	0.06	5.8	0.3	0.3	0.02	0	0	0	10	10	0
	5	sp	3.8	2.78	0.19	10.6	2.0	0.6	0.05	0	0	0	0	5	20
	6	sp	3.3	2.15	0.27	7.1	1.9	0.78	0.05	0	0	0	0	10	10

*Habitat type: fw-flatwater, mc-main channel pool, r-riffle, sc-scour pool, sp-step pool

APPENDIX III: Stream Macroinvertebrate Taxa List for Morse Gulch Above Highway 1, McKinnon Gulch Above Highway 1, Stinson Gulch at Stinson Beach County Water District, Lower Easkoot Creek near Parkside Café, Table Rock (Laurel) Creek near Matt Davis Trail, November 8, 1995, Marin Co., CA

TAXA	Morse Gulch	McKinnon Gulch	Stinson Gulch	Lower Easkoot	Laurel Creek
NEMATOMORPHA		**Rare**			
GASTROPODA:					
Physidae					
Physella sp.				**Dominant**	**Common**
Planorbidae					
Gyraulus/Menetus sp.	**Rare**				
OLIGOCHAETA				**Rare**	
ARACHNIDA					
Acari	**Rare**		**Rare**	**Rare**	
CRUSTACEA:					
Hyalella azteca				**Common**	**Rare**
Ostracoda	**Rare**			**Rare**	
INSECTA:					
Ephemeroptera					
Baetidae					
Baetis sp.	**Abundant**		**Abundant**	**Rare**	**Rare**
Heptageniidae					
Ironodes sp.			**Rare**	**Rare**	**Common**
Rhithrogena sp.	**Rare**			**Rare**	
Leptophlebiidae					
Paraleptophlebia sp.	**Common**	**Common**		**Abundant**	**Common**
Odonota					
Gomphidae					
Octogomphus sp.			**Rare**		
Plecoptera					
Capniidae					
Allocapnia sp. (?)					**Rare**
Chloroperlidae					
Sweltsa sp.	**Common**			**Rare**	**Common**
Leuctridae	**Rare**				
Nemouridae					
Amphinemura sp.	**Rare**		**Common**	**Abundant**	
Perlidae					
Calineuria californica	**Common**	**Rare**	**Common**		**Common**
Hesperoperla sp.					**Rare**
Peltoperlidae					
Soliperla sp.			**Rare**		**Rare**
Megaloptera					
Sialidae					

TAXA	Morse Gulch	McKinnon Gulch	Stinson Gulch	Lower Easkoot	Laurel Creek
Sialis sp.	**Common**		**Rare**		**Common**
Trichoptera					
Calamoceratidae					
Heteroplectron californicum	**Abundant**	**Rare**	**Common**	**Rare**	**Rare**
Glossosomatidae					
Glossosoma sp.					**Rare**
Hydropsychidae					
Hydropsyche/Ceratopsyche sp.	**Rare**		**Abundant**	**Rare**	**Rare**
Lepidostomatidae					
Lepidostoma sp. #1	**Rare**	**Rare**		**Rare**	
Lepidostoma sp. #2				**Rare**	
Limnephilidae					
Apatania	**Rare**				
Cryptochia sp.			**Rare**		**Rare**
Psychoglypha sp.					
Odontoceridae					
Parthina sp.	**Rare**		**Common**		
Rhyacophilidae					
Rhyacophila grandis (grp)				**Rare**	**Rare**
Rhyacophila rayneri (grp)?			**Rare**		**Rare**
Rhyacophia sp. 1 (prognathous mandibles/palps)	**Rare**		**Common**		
Uenoidae					
Neophylax sp.					**Rare**
Unk. Trichoptera pupae	**Rare**				
Hemiptera					
Veliidae					
Microvelia sp.	**Common**				
Coleoptera		**Rare**			
Dytiscidae					
Unk. larvae				**Rare**	
Agabus sp.	**Rare**				
ELMIDAE				**Rare**	**Rare**
Optioservus sp. (larvae)	**Abundant**				
Psephenidae					
Eubrianax sp.	**Common**				
Diptera					
Ceratopogonidae					
Bezzia/Palpomyia sp.	**Rare**		**Rare**		
Chironomidae	**Dominant**	**Common**	**Abundant***	**Dominant***	**Abundant***
Culicidae					
Psorophora sp.					**Rare**
Dixidae					
Dixa sp.				**Rare**	**Common**
Meringodixa sp.	**Common**		**Rare**		
Empididae					

TAXA	Morse Gulch	McKinnon Gulch	Stinson Gulch	Lower Easkoot	Laurel Creek
Chelifera sp.				**Rare**	
Trichoclinocera sp.				**Rare**	
Simuliidae					
Simulium (?) sp.			**Rare**	**Common**	
Syrphidae					
Eristalis sp.				**Rare**	
Tipulidae					
Hexatoma sp.	**Rare**	**Rare**	**Common**		
Subfamily Limoniinae				**Rare**	
Unk Diptera pupae			**Rare**		
TOTAL TAXA	**26**	**8**	**20**	**25**	**22**

CATEGORIES

Rare: <3 indiv.; Common: 3-9; Abundant: >10; Dominant: >50. *Most abundant taxa for sample

APPENDIX IV: Fish data 1998-2000

EASKOOT-LAUREL SUMMER 1998

Unit	Species	Length (mm)*	Est.Weight (g)
1	psc	42	0.8
1	psc	60	2.5
1	sb	34	0.5
1	sb	29	0.2
1	sb	45	1.7
1	sb	32	0.3
1	sb	28	0.2
1	sb	30	0.3
1	sb	27	0.2
1	sb	25	0.1
1	sh yoy	80	6.0
1	sh yoy	85	7.2
1	sh yoy	74	4.7
1	sh yoy	85	7.2
1	sh yoy	90	8.6
1	sh yoy	72	4.4
1	sh yoy	94	9.8
1	sh yoy	65	3.2
1	sh yoy	75	4.9
1	sh yoy	64	3.0
1	sh yoy	62	2.8
1	sh yoy	75	4.9
1	sh yoy	42	0.8
1	sh yoy	60	2.5
1	sh yoy	70	4.0
1	sh yoy	68	3.7
1	sh yoy	70	4.0
1	sh yoy	65	3.2
1	sh yoy	75	4.9
2	sb	30	0.3
2	sh yoy	70	4.0
2	sh yoy	90	8.6
2	sh yoy	50	1.4
3	sb	30	0.3
3	sb	40	1.0
3	sh yoy	70	4.0
3	sh yoy	80	6.0
3	sh yoy	95	10.2
3	sh yoy	70	4.0
3	sh yoy	100	11.9
3	sh yoy	80	6.0
4	psc	50	1.3
4	sb	30	0.3
4	sb	40	1.0
4	sb	30	0.3
4	sb	30	0.3

Unit	Species	Length (mm)*	Est.Weight (g)
4	sb	30	0.3
4	sh yoy	70	4.0
4	sh yoy	80	6.0
4	sh yoy	70	4.0
4	sh yoy	75	4.9
4	sh yoy	80	6.0
4	sh yoy	100	11.9
4	sh yoy	70	4.0
4	sh yoy	90	8.6
4	sh yoy	70	4.0
4	sh yoy	80	6.0
5	crsc	95	11.3
5	crsc	81	6.7
5	crsc	50	1.3
5	psc	95	11.3
5	psc	80	6.4
5	psc	111	18.9
5	sb	30	0.3
5	sb	30	0.3
5	sb	30	0.3
5	sb	25	0.1
5	sb	30	0.3
5	sb	25	0.1
5	sh 1+	152	42.8
5	sh 1+	150	41.1
5	sh 1+	170	60.2
5	sh yoy	60	2.5
5	sh yoy	81	6.2
5	sh yoy	75	4.9
5	sh yoy	80	6.0
5	sh yoy	85	7.2
5	sh yoy	60	2.5
5	sh yoy	85	7.2
6			
7			

EASKOOT-LAUREL SUMMER 1999

Pass	Unit	Species	Length (mm)*	Weight (g)	Inj/mort
1	1	sb	34	0.5	
1	1	sh yoy	65	2.9	
1	1	sh yoy	75	4.4	
1-3	2				
1	3	sb	41	1.1	
1	4	cgs	83	2.8	
1	4	sh yoy	52	1.5	
1	4	sh yoy	32	0.4	
1	4	sh yoy	50	1.5	
1	4	sh yoy	45	0.9	
1	4	sh yoy	55	1.6	
1	4	sh yoy	45	1.2	
1	4	sh yoy	40	0.5	
1	4	sh yoy	43	0.9	
1	4	sh yoy	49	2.3	
1	4	sh yoy	43	0.3	
1	4	sh yoy	47	1.7	
1	4	sh yoy	53	2.1	
1	4	sh yoy	45	0.7	
1	4	sh yoy	57	2.2	
1	4	sh yoy	41	0.8	
1	4	sh yoy	52	1.4	
1	4	sh yoy	45	1.2	
1	4	sh yoy	48	1.1	
1	4	sh yoy	45	1.1	
1	4	cgs	82	2.8	
1	4	sh yoy	67	3.3	
1	4	sh yoy	44	0.7	
1	4	sh yoy	48	1.4	
1	4	sh yoy	57	2.0	
1	4	sh yoy	45	0.8	
1	4	sh yoy	46	1.2	
2	4	sh yoy	50	1.2	
2	4	sh yoy	54	1.7	
2	4	sh yoy	56	1.7	
2	4	sh yoy	62	2.8	
3	4	cgs	73	2.5	
1	5	sh yoy	67	3.4	
1	5	sh yoy	54	1.6	
1	5	sh yoy	63	2.9	
1	5	sh yoy	81	2.7	
1	5	sh yoy	45	0.8	
1	5	sh yoy	79	5.3	
1	5	sh yoy	71	3.7	
1	5	sh yoy	61	2.4	
1	5	sh yoy	54	1.9	
1	5	sh yoy	49	1.5	
1	5	sh yoy	50	1.6	

Pass	Unit	Species	Length (mm)*	Weight (g)	Inj/mort
1	5	sh yoy	67	3.4	
1	5	sh yoy	68	3.1	
1	5	sh yoy	68	3.4	
1	5	sh yoy	56	1.9	
1	5	sh yoy	56	1.7	
1	5	sh yoy	67	3.7	
1	5	sh yoy	66	2.7	
1	5	sh yoy	64	2.8	
1	5	sh yoy	76	4.9	
1	5	sh yoy	67	3.4	
1	5	sh yoy	55	1.6	
1	5	sh yoy	56	1.6	
1	5	sh yoy	84	6.5	
1	5	sh yoy	76	4.8	
1	5	sh yoy	73	3.9	
1	5	sh yoy	64	2.4	
1	5	sh 1+	135	29.6	
1	5	sh yoy	53	1.4	
1	5	sh yoy	88	4.7	
1	5	sh yoy	77	4.6	
1	5	sh yoy	64	2.8	
1	5	sh yoy	67	3.0	
1	5	sh yoy	47	1.3	
1	5	sh yoy	60	2.3	
2	5	sh yoy	94	8.7	
2	5	sh yoy	48	1.2	
2	5	sh yoy	92	8.1	
2	5	sh yoy	45	1.0	
2	5	sh yoy	71	3.8	
2	5	sh yoy	44	0.9	
2	5	sh yoy	57	1.9	
2	5	sh yoy	54	1.7	
2	5	sh yoy	46	1.0	
2	5	sh yoy	42	0.8	
2	5	sh yoy	47	1.1	
1	6	sh yoy	45	1.0	jaw agape
1	6	sh yoy	71	3.8	
1	6	sh yoy	68	3.3	
1	6	sh yoy	45	1.0	
1	6	sh yoy	42	0.8	
1	6	sh yoy	68	3.3	
1	6	sh yoy	51	1.4	
1	6	sh yoy	74	4.2	
1	6	sh yoy	79	5.2	
1	6	sh yoy	76	4.6	
1	6	sh yoy	53	1.6	
1	6	sh yoy	68	3.3	
1	6	sh yoy	52	1.5	

Pass	Unit	Species	Length (mm)*	Weight (g)	Inj/mort
1	6	sh yoy	62	2.5	
1	6	sh yoy			
1	6	sh yoy	83	6.0	
1	6	sh yoy	58	2.0	
1	6	sh yoy	74	4.2	
1	6	sh yoy	61	2.4	
1	6	sh yoy	48	1.2	
1	6	sh yoy	76	4.6	
1	6	sh yoy	42	0.8	
1	6	sh yoy	90	7.6	
1	6	sh yoy	74	4.2	
1	6	sh yoy	70	3.6	
1	6	sh yoy	42	0.8	
1	6	sh yoy	48	1.2	
1	6	sh yoy	87	6.9	
1	6	sh yoy	50	1.3	
1	6	sh yoy	67	3.2	
1	6	sh yoy	71	3.8	
1	6	sh yoy	55	1.7	
1	6	sh yoy	60	2.3	
1	6	sh yoy	55	1.7	
1	6	sh yoy	76	4.6	
1	6	sh yoy	45	1.0	
1	6	sh yoy	54	1.7	
1	6	sh yoy	54	1.7	
1	6	sh yoy	68	3.3	
1	6	sh yoy	59	2.2	
1	6	sh yoy	54	1.7	
1	6	sh yoy	54	1.7	
1	6	sh yoy	52	1.5	
1	6	sh yoy	64	2.8	
1	6	sh yoy	71	3.8	
1	6	sh yoy	86	6.7	
1	6	sh yoy	50	1.3	
1	6	sh yoy	57	1.9	
1	6	sh yoy	49	1.2	
1	6	sh yoy	46	1.0	
1	6	sc	123	26.5	
1	6	sc	111	18.9	
1	6	sc	93	10.5	
1	6	sh yoy	40	0.7	
1	6	sh yoy	80	5.4	
1	6	sh yoy	40	0.7	
1	6	sh yoy	48	1.2	
1	6	sh yoy	44	0.9	
1	6	sh yoy	70	3.6	
1	6	sh yoy	40	0.7	
1	6	sh yoy	46	1.0	
1	6	sh yoy	44	0.9	

Pass	Unit	Species	Length (mm)*	Weight (g)	Inj/mort
1	6	sh yoy	45	1.0	
1	6	sh yoy	48	1.2	
1	6	sh yoy	51	1.4	
1	6	sh yoy	47	1.1	
1	6	sh yoy	83	6.0	
1	6	sh yoy	48	1.2	
1	6	sh yoy	46	1.0	
1	6	sh yoy	47	1.1	
1	6	sh yoy	48	1.2	
1	6	sh yoy	40	0.7	
1	6	sh yoy	47	1.1	
1	6	sh yoy	53	1.6	
1	6	sh yoy	44	0.9	
1	6	sh yoy	50	1.3	
2	6	sh yoy	58	2.0	burns
2	6	sh yoy	62	2.5	
2	6	sh yoy	54	1.7	
2	6	sh yoy	42	0.8	
1	7	sh yoy	47	1.1	
1	7	sh yoy	77	4.8	
1	7	sh yoy	65	2.9	
1	7	sh yoy	66	3.0	
1	7	sh yoy	74	4.2	
1	7	sh yoy	80	5.4	
1	7	sh yoy	79	5.2	
1	7	sh yoy	71	3.8	
1	7	sh yoy	87	6.9	
1	7	sh yoy	88	7.1	
1	7	sh yoy	75	4.4	
1	7	sh yoy	46	1.0	
1	7	sh yoy	65	2.9	
1	7	sh yoy	73	4.1	
1	7	sh yoy	82	5.8	
1	7	sh yoy	70	3.6	
1	7	sh 2+	191	82.3	
1	7	sh yoy	71	3.8	
1	7	sh yoy	83	6.0	
1	7	sh yoy	80	5.4	
1	7	sh yoy	66	3.0	
1	7	sh yoy	73	4.1	
1	7	sh yoy	70	3.6	
1	7	sh yoy	75	4.4	
1	7	sh yoy	72	3.9	
1	7	sh yoy	80	5.4	
1	7	sh yoy	75	4.4	
1	7	sh yoy	77	4.8	
1	7	sh yoy	76	4.6	
1	7	sh yoy	79	5.2	
1	7	sc	93	10.5	

Pass	Unit	Species	Length (mm)*	Weight (g)	Inj/mort
1	7	sh yoy	78	5.0	
1	7	sh yoy	75	4.4	
1	7	sh 2+	205	92.0	
1	7	sc	90	9.4	
1	7	sh 1+	135	25.6	
1	7	sh 2+	188	68.8	
1	7	sh 1+	170	51.0	
1	7	sh 1+	155	38.7	
1	7	sh 1+	140	28.5	
2	7	sh yoy	60	2.3	
2	7	sh yoy	50	1.3	
2	7	sh yoy	53	1.6	
2	7	sh yoy	50	1.3	
2	7	sh yoy	45	1.0	
2	7	sh yoy	67	3.2	
2	7	sh yoy	90	7.6	
2	7	sh yoy	78	5.0	
2	7	sh yoy	70	3.6	
2	7	sh yoy	80	5.4	
2	7	sh yoy	50	1.3	
2	7	sh yoy	70	3.6	
2	7	sh yoy	60	2.3	
2	7	sh yoy	52	1.5	
2	7	sh 1+	154	37.9	
2	7	sh yoy	60	2.3	
2	7	sh 2+	230	125.7	
2	7	sh yoy	55	1.7	
2	7	sh 1+	140	28.5	
2	7	sh 1+	160	42.5	
2	7	sh yoy	80	5.4	
2	7	sh yoy	63	2.6	
2	7	sh yoy	83	6.0	
2	7	sh yoy	60	2.3	
2	7	sh yoy	74	4.2	
2	7	sh yoy	73	4.1	
2	7	sh yoy	70	3.6	
2	7	sh yoy	51	1.4	
2	7	sh 1+	130	22.9	
1	8	sh yoy	90	7.6	
1	8	sh yoy	90	7.6	
1	8	sh yoy	65	2.9	
1	8	sh yoy	80	5.4	
1	8	sh yoy	86	6.7	
1	8	sh yoy	85	6.4	
1	8	sh yoy	82	5.8	
1	8	sh yoy	40	0.7	
1	8	sh yoy	86	6.7	
1	8	sh yoy	70	3.6	
1	8	sh yoy	89	7.4	

Pass	Unit	Species	Length (mm)*	Weight (g)	Inj/mort
1	8	sh yoy	54	1.7	
1	8	sh yoy	63	2.6	
1	8	sh yoy	81	5.6	
1	8	sh yoy	75	4.4	
1	8	sh yoy	80	5.4	
1	8	sh yoy	74	4.2	
1	8	sh yoy	91	7.9	
2	8	sh yoy	60	2.3	
2	8	sh yoy	80	5.4	
2	8	sh yoy	70	3.6	
2	8	sh yoy	55	1.7	
2	8	sh yoy	77	4.8	
2	8	sh yoy	80	5.4	
2	8	sh yoy	93	8.4	
2	8	sh yoy	75	4.4	
2	8	sh yoy	60	2.3	
2	8	sh yoy	49	1.2	
1	9	sh yoy	50	1.3	
1	9	sh yoy	55	1.7	
1	9	sh yoy	65	2.9	
1	9	sh yoy	40	0.7	
1	9	sh yoy	62	2.5	
1	9	sh yoy	55	1.7	
1	9	sh yoy	50	1.3	
1	9	sh yoy	50	1.3	
1	9	sh yoy	60	2.3	
1	9	sh yoy	58	2.0	
1	9	sh yoy	50	1.3	
1	9	sh yoy	55	1.7	
1	9	sh yoy	45	1.0	
2	9	sh yoy	50	1.3	
2	9	sh yoy	50	1.3	
2	9	sh yoy	45	1.0	
2	9	sh yoy	65	2.9	mort
2	9	cgs	80	2.7	

EASKOOT CREEK SUMMER 2000

Unit	Pass	Species	Length (mm)*	Fish Weight (g)	Inju/Mort
1	1	sc	38	0.8	
1	1	sh	65	4.0	
1	1	sh	66	3.9	
1	1	sh	67	3.1	
1	1	sh	71	4.4	burn
1	1	sh	72	4.7	
1	1	sh	72	5.1	
1	1	sh	81	6.8	
1	1	sb	35	0.5	
1	2	sb	30	0.3	
1	2	sb	30	0.3	
1	2	sb	35	0.4	
1	2	sc	40	0.8	
1	2	sh	66	3.4	
1	2	sh	61	3.7	
1	2	sh	67	3.4	
1	2	sh	71	4.7	
1	2	sh	88	9.0	
1	2	sh	91	10.3	
1	3	sc	50	1.7	
2	1	sb	35	0.4	
2	1	sc	34	0.5	
2	1	sh	73	4.6	
2	1	sh	84	6.9	
2	1	psc	91	9.1	
2	2	sb	28	0.1	
2	2	sb	42	1.0	
2	2	sc	41	0.2	
3	1	sb	31	0.5	
3	1	sb	33	0.4	
3	1	sc	40	0.7	
3	1	sc	51	0.9	
3	1	sh	61	2.5	
3	1	sh	55	2.3	
3	1	sh	67	2.9	
3	1	sh	69	4.0	
3	1	sh	65	3.3	
3	1	sh	71	4.3	
3	1	sh	74	4.5	
3	1	sh	74	5.5	
3	1	sh	77	5.0	
3	1	sh	78	5.5	
3	1	sh	77	5.4	
3	1	sh	78	6.3	
3	1	sh	77	5.1	
3	1	sh	80	6.3	
3	1	sh	81	6.9	
3	1	sh	80	7.1	
3	1	sh	89	8.5	
3	1	sh	90	8.4	
3	1	sh	89	8.8	
3	1	sh	90	9.0	
3	1	sh	91	9.6	
3	1	sh	93	9.3	
3	1	sh	95	10.1	
3	1	sh	95	10.3	
3	1	psc	109	15.2	
3	1	psc	109	17.1	
3	1	sh	141	33.3	
3	1	sb	30	0.3	
3	1	sb	31	0.3	
3	1	sb	34	0.5	
3	2	sc	43	1.0	
3	2	sc	56	2.6	
3	2	sc	42	0.8	
3	2	sc	40	0.6	
3	2	sh	69	4.0	
3	2	sh	78	5.8	
3	2	sh	91	9.2	
3	2	sh	60	2.6	
4	1	sb	30	0.3	
4	1	sb	37	1.1	
4	1	sc	48	1.3	
4	1	sh	62	3.4	
4	1	sh	68	4.2	
4	1	sh	70	4.5	
4	1	sh	75	4.7	
4	1	sh	78	5.2	
4	1	sh	77	5.3	
4	1	sh	81	6.9	
4	1	sh	87	8.1	
4	1	sh	88	8.5	
4	1	sh	90	8.9	
4	1	sh	92	9.1	
4	1	sh	97	10.7	
4	1	sh	113	17.1	
4	1	sb	23	0.1	
4	1	sb	21	0.0	
4	1	sb	23	0.1	
4	1	sb	23	0.1	
4	2	sc	37	0.3	
4	2	sc	50	1.5	
4	2	sh	78	5.0	
4	2	psc	114	24.5	
4	2	sh	150	37.3	
4	2	psc	140	41.3	
4	2	sh	181	86.3	
4	2	psc	97	12.1	
5	1	sb	25	0.1	
5	1	sb	25	0.1	
5	1	sc	42	0.8	

Unit	Pass	Species	Length (mm)*	Fish Weight (g)	Inju/Mort
5	1	sc	46	1.0	
5	1	sh	71	4.4	
5	1	sh	58	2.4	
5	1	sh	68	3.8	
5	1	sh	68	3.8	
5	1	sh	70	4.2	
5	1	sh	83	7.0	
5	1	sh	63	3.1	
5	1	sh	63	3.1	
5	1	sh	81	6.5	
5	1	sh	70	4.2	
5	1	sh	88	8.3	burn
5	1	sh	86	7.7	
5	1	sh	58	2.4	
5	1	sh	63	3.1	
5	1	sh	60	2.6	
5	1	sh	65	3.3	
5	1	sh	58	2.4	
5	2	sb	30	0.3	
5	2	sb	23	0.1	
5	2	sh	70	4.2	

LAUREL CREEK SUMMER 2000

Unit	Pass	Species	Length (mm)*	Fish Weight (g)	Inju/Mort
1	1	sh	38	0.7	
1	1	sh	48	1.4	
1	1	sh	51	1.6	
1	1	sh	47	1.2	
1	1	sh	48	1.6	
1	1	sh	53	1.7	
1	1	sh	51	1.8	
1	1	sh	51	1.5	
1	1	sh	55	1.9	
1	1	sh	54	1.9	
1	1	sh	55	2.3	
1	1	sh	56	2.6	
1	1	sh	60	2.8	
1	1	sh	60	2.6	
1	1	sh	58	2.6	
1	1	sh	60	2.5	
1	1	sh	63	2.8	
1	1	sh	61	3.0	
1	1	sh	68	3.9	
1	1	sh	70	4.4	
1	1	sh	71	5.1	
1	1	sh	74	4.9	
1	1	sh	74	4.9	
1	1	sh	70	4.7	
1	1	sh	76	5.8	
1	1	sh	85	8.3	
1	2	sc	35	0.6	
1	2	sh	61	2.8	
1	2	sh	54	1.9	
1	2	sh	83	7.0	burn
1	2	sh	50	1.5	
2	1	sh	32	0.2	
2	1	sh	35	0.3	
2	1	sh	46	1.2	
2	1	sh	75	5.1	
2	1	sh	70	4.2	
2	1	sh	54	1.9	
2	1	sh	60	2.6	
2	1	sh	57	2.3	
3	1	psc	99	13.9	
3	1	sh	31	0.4	
3	1	sh	53	1.9	
3	1	sh	56	2.4	
3	1	sh	60	3.1	
3	1	sh	62	3.5	
3	1	sh	74	4.9	
3	1	sh	74	6.0	
3	1	sh	74	5.1	

Unit	Pass	Species	Length (mm)*	Fish Weight (g)	Inju/Mort
3	1	sh	75	5.4	
3	1	sh	74	5.3	
3	1	sh	75	5.5	
3	1	sh	74	5.9	
3	1	sh	80	6.3	
3	1	sh	80	6.5	
3	1	sh	80	6.5	
3	1	sh	82	7.6	
3	1	sh	94	9.6	
3	1	sh	99	11.0	
3	1	sh	97	11.7	
3	1	sh	130	25.2	
3	1	sh	135	30.6	
3	1	sh	140	31.8	
3	1	sh	149	38.5	
3	1	sh	82	6.7	
3	1	sh	69	4.0	
3	1	sh	63	3.1	
3	1	sh	82	6.7	
3	1	sh	55	2.0	
3	1	sh	79	6.0	
3	1	sh	69	4.0	
3	1	sh	58	2.4	
3	1	sh	68	3.8	
3	1	sh	85	7.5	
3	1	sh	80	6.2	
3	1	sh	85	7.5	
3	1	sh	76	5.3	
3	1	sh	74	4.9	
3	1	sh	79	6.0	
3	1	sh	70	4.2	burn
3	1	sh	73	4.7	
3	1	sh	90	8.9	
3	1	sh	80	6.2	
3	1	sh	61	2.8	
3	1	sh	74	4.9	
3	1	sh	55	2.0	
3	1	sh	80	6.2	
3	1	sh	61	2.8	
3	2	sh	85	7.5	
3	2	sh	73	4.7	
3	2	sh	71	4.4	
3	2	sh	71	4.4	
3	2	sh	54	1.9	
3	2	sh	84	7.2	
3	2	sh	43	1.0	
4	1	sh	80	6.2	
4	1	sh	45	1.1	
4	1	sh	90	8.9	

Unit	Pass	Species	Length (mm)*	Fish Weight (g)	Inju/Mort
4	1	sh	54	1.9	
4	1	sh	62	2.9	
4	1	sh	94	10.1	
4	1	sh	68	3.8	
4	1	sh	55	2.0	
4	1	sh	33	0.4	
4	1	sh	54	1.9	
4	1	sh	68	3.8	
4	1	sh	68	3.8	
4	1	sh	60	2.6	
4	1	sh	62	2.9	
4	1	sh	85	7.5	
4	1	sh	64	3.2	
4	1	sh	97	11.1	
4	1	sh	70	4.2	
4	1	sh	54	1.9	
4	2	sh	67	3.7	
5	1	psc	98	13.1	
5	1	sh	40	0.5	
5	1	sh	67	3.8	
5	1	sh	66	4.5	
5	1	sh	69	4.1	
5	1	sh	70	4.3	
5	1	sh	75	5.3	
5	1	sh	72	4.8	
5	1	sh	79	5.8	
5	1	sh	90	8.4	
5	1	sh	100	13.7	
5	1	sh	109	13.8	
5	1	sh	107	14.2	
5	1	sh	120	19.0	
5	1	sh	119	20.2	
5	1	sh	120	21.1	
5	1	sh	125	22.9	
5	1	sh	127	23.5	
5	1	sh	130	27.0	
5	1	sh	132	27.1	
5	1	sh	135	27.6	
5	1	sh	129	28.3	
5	1	sh	135	28.4	
5	1	sh	133	28.9	
5	1	sh	137	30.9	
5	1	sh	139	32.3	
5	1	sh	140	33.7	
5	1	sh	145	35.9	
5	1	sh	154	41.0	
5	1	sh	164	53.2	
5	1	sh	180	67.4	
5	1	sh	69	4.0	
5	1	sh	69	4.0	
5	1	sh	55	2.0	
5	1	sh	66	3.5	
5	1	sh	69	4.0	
5	1	sh	66	3.5	
5	1	sh	70	4.2	
5	1	sh	78	5.8	
5	1	sh	63	3.1	
5	1	sh	69	4.0	
5	1	sh	72	4.5	
5	1	sh	60	2.6	
5	1	sh	60	2.6	
5	1	sh	68	3.8	
5	1	sh	70	4.2	
5	1	sh	78	5.8	
5	1	sh	42	0.9	
5	2	sh	70	4.3	
5	2	sh	130	27.0	
5	2	sh	127	23.5	
5	2	sh	70	4.6	
5	2	sh	79	6.2	
5	2	sh	65	3.3	
5	2	sh	68	3.8	
5	2	sh	69	4.0	
5	2	sh	64	3.2	
6	1	sh	60	2.7	
6	1	sh	66	3.8	
6	1	sh	74	5.0	
6	1	sh	72	5.1	
6	1	sh	78	5.6	
6	1	sh	89	9.1	
6	1	sh	112	15.6	
6	1	sh	128	23.5	
6	1	sh	133	26.4	
6	1	sh	130	26.2	
6	1	sh	139	29.9	
6	1	sh	141	32.0	
6	1	sh	125	23.5	
6	1	sh	128	25.3	
6	1	sh	155	40.9	
6	1	sh	139	33.3	
6	1	sh	160	48.6	
6	1	sh	162	48.9	
6	1	sh	153	40.1	
6	1	sh	180	67.6	
6	1	sh	240	150.2	
6	1	sh	55	2.0	
6	1	sh	70	4.2	
6	1	sh	55	2.0	

Unit	Pass	Species	Length (mm)*	Fish Weight (g)	Inju/Mort
6	1	sh	67	3.7	
6	1	sh	70	4.2	
6	1	sh	63	3.1	
6	1	sh	58	2.4	
6	1	sh	76	5.3	
6	1	sh	74	4.9	
6	1	sh	64	3.2	
6	1	sh	65	3.3	
6	1	sh	80	6.2	
6	1	sh	73	4.7	
6	1	sh	64	3.2	
6	1	sh	58	2.4	
6	2	sh	70	4.2	
6	2	sh	58	2.4	
6	2	sh	68	3.8	
6	2	sh	68	3.8	
6	2	sh	50	1.5	
6	2	sh	59	2.5	
6	2	sh	60	2.6	
6	2	sh	72	4.5	
6	2	sh	62	2.9	
6	2	sh	69	4.0	