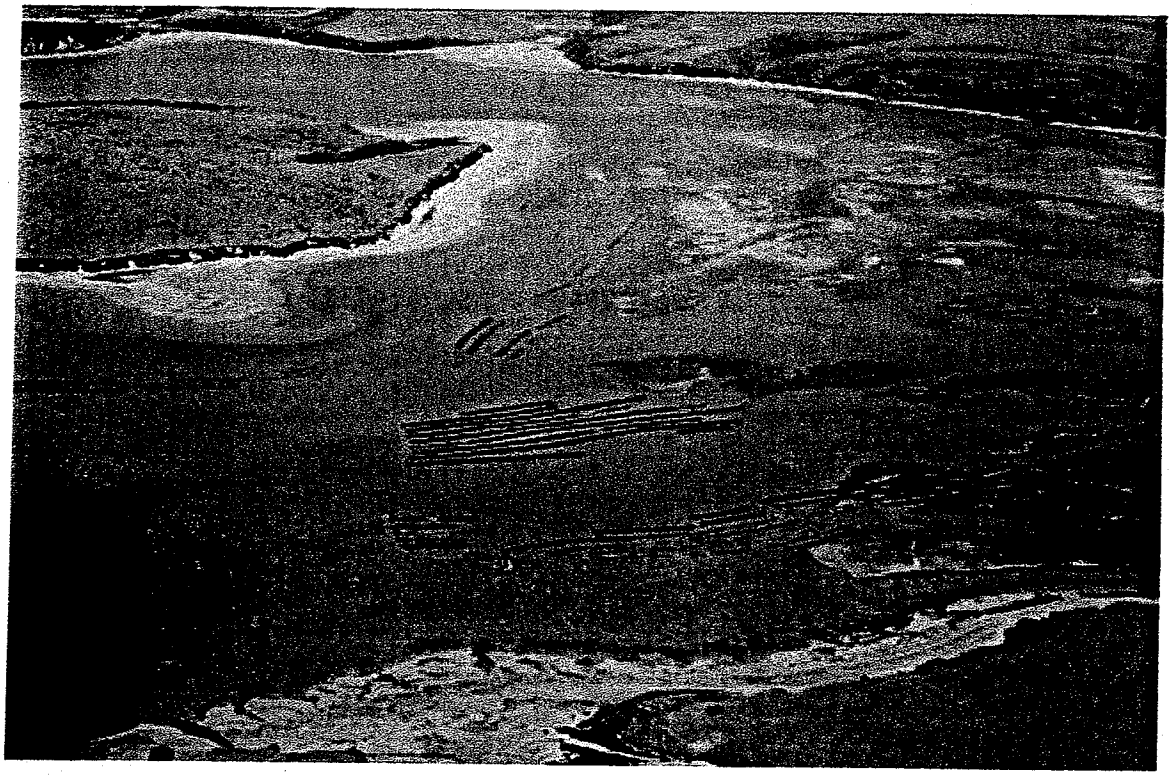
FINAL

Technical Report #06-13

SANITARY SURVEY REPORT
SHELLFISH GROWING AREA CLASSIFICATION
FOR
DRAKES ESTERO, CALIFORNIA



California Department of Health Services
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Environmental Management Branch

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Final

SANITARY SURVEY AND SHORELINE SURVEY
DRAKES ESTERO LEASE: M-438-01 & M-438-02

I. EXECUTIVE SUMMARY

This is the 12-year Sanitary Survey Report for Drakes Estero Aquaculture Leases M-438-01 and M-438-02, located in the Point Reyes National Seashore. These state leases are issued to Mr. Kevin Lunny, Drakes Bay Oyster Company, by the California Department of Fish and Game. The Sanitary Survey Report is issued in conformance with the requirements of the National Shellfish Sanitation Program Model Ordinance (2003). The National Shellfish Sanitation Program requires that a Sanitary Survey be performed by the shellfish authority prior to the classification of the growing area for harvest of shellfish for human consumption, and then at least every 12 years thereafter. In California, this authority is the California Department of Health Services, Environmental Management Branch, Preharvest Shellfish Sanitation Unit.

The Sanitary Survey is the written evaluation report of all environmental factors, including actual and potential pollution sources, which have a bearing on water quality in a shellfish growing area. The Sanitary Survey Report includes the data and results from a shoreline survey, a survey of bacteriological water quality, an evaluation of the hydrographic, meteorological, and geographic characteristics, and an analysis of all these data. The results of this evaluation and analysis are used to determine the appropriate growing area classification.

Drakes Estero, Marin County, California, is located within the Point Reyes National Seashore, approximately 50 miles northwest of San Francisco. A single oyster farm has operated in the Estero since 1954. Johnson's Oyster Company was a family run business in Drakes Estero from 1954 until 2005. A significant development since the last sanitary survey was the purchase of the oyster company in January 2005 by a local rancher, Kevin Lunny, who now owns the California Department of Fish and Game leases. The name of the business was changed to Drakes Bay Oyster Company. The oyster company operates in the Estero on two state aquaculture leases with a combined area of 1,060 acres.

Most of the leased area in the Estero is classified *Conditionally Approved*, except for two areas. There is a 25 acre portion near the mouth of the Estero that is classified *Approved*. Also, there are several areas in the Estero that are functionally classified *Prohibited*. A small area immediately offshore from the Drakes Bay Oyster Company plant is classified *Prohibited*, and the inner reaches of three of the bays in Drakes Estero are not classified and therefore considered *Prohibited*. There are two rainfall thresholds for the *Conditionally Approved* areas. The majority of the *Conditionally Approved* area is closed for 3 days after more than 0.75 inch of rain falls within a 24-hour period. Inner Schooner Bay is closed for 7 days after more than 0.7 inch of rain falls within a 24-hour period.

Drakes Estero and its watersheds are contained entirely within the Point Reyes National Seashore. The Estero is recognized as one of the most pristine estuaries on the west coast. There is no urban or industrial development and very few people reside within its watersheds. Therefore the pollution impacts to Drakes Estero are minimal compared to

some other shellfish growing areas in California. Drakes Estero contains the only growing area with an *Approved* classification in the state. The pollution sources are solely non-point sources. The most significant potential non-point source of pollution is rainfall runoff from cattle pasturelands in the watershed. Other potential sources include waste from the local sewage systems, waste from wildlife, and overboard discharges from recreational boat use.

Beef and dairy cattle ranches surround the Drakes Estero shoreline. There are approximately 1000 cattle in the Drakes Estero watershed, with some animals coming very close to the shoreline. During storm events, rainfall from cattle pastureland enters the Estero either directly (e.g., hillside runoff) or indirectly (e.g., via a tributary to the Estero). Most of the microbiological pollution found in Drakes Estero is observed after rainfall events and presumably can be traced back to cattle that occupy the surrounding watershed. Tributaries discharge into the Estero at the inner reaches of its four bays, and these are the areas most impacted after rainfall events.

Potential impact from humans associated with Drakes Bay Oyster Company has decreased since the mid-1990s. In the mid-1990s the septic system could not meet the capacity of the approximately 90 people who lived on-site, and the leach field reportedly failed. A new septic system was installed in 1998 that has an increased capacity, and the number of employees who reside on the property has decreased significantly. In addition, a second septic system was installed in 2005 that collects waste from the plant operations. Therefore, the oyster company has significantly reduced the impact from its own operations.

There is a large migrant population of birds that utilize the Estero during the winter. It is difficult to assess the impact of birds on water quality in shellfish growing areas, but results from fecal coliform monitoring suggest that impacts from birds are minimal. A significant number of harbor seals haul out onto Drakes Estero mudflats during pupping season in spring and early summer months.

Recreational use of Drakes Estero has increased in the last 12 years. Specifically, there are more kayakers that put in and paddle in the Estero. Results from monitoring suggest that kayakers have minimal impact to the Estero. However, fecal discharge from boats is usually sporadic and unpredictable and therefore difficult to monitor. In addition, discharges from boaters impose a more significant threat to water quality because of their direct contact with the oysters and because human waste has greater potential to contain harmful pathogens.

During the 2005-2006 winter season there were several incidences of elevated fecal coliform concentrations during open harvest conditions in three of the bays in Drakes Estero. Three potential sources were identified as possible origins of the contamination. These sources were higher than average runoff due to the extreme amount of rainfall that occurred from January to April 2006, changes in cattle grazing practices in the Home Bay watershed, and failing septic systems at the Home ranch complex located at the head of Home Bay. At the end of April 2006, the National Park Service abandoned the septic

system at the main house and capped the effluent line for a second system. Based on estimates of bacterial and viral die-off rates, Home Bay was closed for three weeks after the system was capped. Samples collected from Home Bay on May 30, 2006 showed that water quality in Home Bay was within NSSP limits, and Home Bay was reopened for harvesting. The National Park Service is working with cattle ranchers to improve the cattle management practices in the Point Reyes National Seashore. Some management practices have been implemented which help keep cattle away from waterways during wet weather months. More of these practices should be implemented to keep cattle away from the shoreline, specifically during months of rainfall. Historic data from Drakes Estero shows that water quality is more heavily impacted during periods of heavy rainfall. More rainfall related data should be collected to determine whether a cumulative rainfall threshold should be established.

Results from water quality sampling at all primary sample stations show that the *Conditionally Approved* growing areas consistently meet National Shellfish Sanitation Program classification standards during open periods. The *Approved* growing area also meets National Shellfish Sanitation Program standards for its classification.

II. TABLE OF CONTENTS

Abbreviations

This document contains numerous acronyms and abbreviations. In general, an abbreviation will be given in parentheses ( ) following the first time a title or term is used, and the abbreviation will be used in almost all cases in place of that term later. The following alphabetical list of abbreviations used in this document is provided for the convenience of the reader:

CDFG = California Department of Fish and Game
CDHS = California Department of Health Services
CDHS/FDB = California Department of Health Services, Food and Drug Branch
CDHS/PSSU = California Department of Health Services, Preharvest Shellfish Sanitation Unit
DBOC = Drakes Bay Oyster Company
FC = Fecal coliform bacteria
g = grams
JOC = Johnson Oyster Company
mL = milliliters
MPN = Most probable number
NPS = National Park Service
NSSP = National Shellfish Sanitation Program
PRNS = Point Reyes National Seashore
WQ = Water quality

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National Park Service
Point Reyes National Seashore
Point Reyes Bird Observatory
University of California Cooperative Extension

III. DESCRIPTION OF THE GROWING AREA

A. LOCATION AND SITE DESCRIPTION

Drakes Estero is located in western Marin County, California, approximately 50 miles northwest of San Francisco (Figure 1). The Estero mouth is located at the Estero's south end, and opens into Drakes Bay. Drakes Estero has the appearance of an open hand with a main body that is connected to four bays. From west to east the bays are: Barries Bay, Creamery Bay, Schooner Bay, and Home Bay (Figure 2). Estero de Limantour is located to the east of Drakes Estero and shares a mouth with Drakes Estero; therefore the two bodies are considered a single estuarine system, and the Drakes Estero watershed surrounds both esteros (Figure 3).

Drakes Estero covers about 2.8 square miles at high tide. Drakes Estero is characterized by relatively shallow water; low tide reveals several expanses of mud and sandy flats within the center of the main body as well as along the shoreline. In the body of the Estero, trending north-south, is a main channel that eventually leads to the Estero mouth. The deepest waters in the Estero are located in the main channel (23 - 26 feet) (Anima, 1991). In the northern portion of the main body and in the bays there are extensive beds of eelgrass (Elliott-Fisk et al. 2005).

The Drakes Estero watershed has a total area of approximately 31 square miles, including the Drakes Estero itself (Figure 3). Its watersheds lie entirely within the park boundaries of the Point Reyes National Seashore (PRNS), which is part of the National Park Service (NPS). Several perennial streams discharge into the Drakes Estero watershed system. Major streams are Laguna, Muddy Hollow, Glenbrook, Home Creek, East and North Schooner and Creamery Creeks. Minor watersheds are Limantour, North Home Creek and Barries Bay Creek (Brannon Ketcham, NPS, pers. comm.) (Figure 4). The Estero is surrounded by ranches, but its watershed includes wilderness area (Figure 3).

Shell mounds near the Drakes Estero shoreline bear evidence that there has been shellfish harvesting from the Estero for thousands of years (Stewart & Praetzellis, 2003). Shellfish mariculture has occurred in the Estero at least since the 1930s. Drakes Estero is one of the largest commercial shellfish aquaculture areas in California. One certified commercial harvester operates in Drakes Estero, the Drakes Bay Oyster Company (DBOC). It grows and harvests shellfish on two state aquaculture leases that consist of 1060 acres (Table 1). The state water bottom leases issued to DBOC cover a large portion of Drakes Estero, including a portion of the four bays: Barries Bay, Creamery Bay, Home Bay, and all but the central channel of Schooner Bay (Figure 5). The leases are granted by the California Fish and Game Commission and administered by the California Department of Fish and Game (CDFG). Current production is entirely Pacific oysters (*Crassostrea gigas*). The methods of culture are submerged lines and bottom bags. Submerged lines are suspended from racks and bottom bags are placed on shallow mudflats. Both racks and mudflats are designated as oyster 'beds'. Shellfish product is sold both in the shell and as shucked product. The approximate locations of individually

numbered oyster beds are shown in Figure 5. These beds are currently used by DBOC, other beds in the Estero are inactive and not shown on the map.

The onshore facilities of DBOC are located on the northeastern end of Schooner Bay. These facilities occupy 1.43 acres of land that are within the boundaries of the Point Reyes National Seashore (PRNS). Johnson Oyster Company (JOC) was granted a lease by the National Park Service for use of the onshore property through the year 2012. After Mr. Lunny purchased the mariculture company from the Johnsons he removed several of the buildings on the property. There are currently four structures associated with oyster harvesting and production, and five residential structures on the property.

B. CLASSIFICATION HISTORY

Six companies have farmed oysters in Drakes Estero since 1934. The original leased area contained 6000 acres and included Estero de Limantour (Tom Moore, CDFG, pers. comm.). By 1955 the leased area had decreased to 2130 acres. Johnson's Oyster Company was the sole oyster company in Drakes Estero from 1954 until January 2005 when the business was sold to Kevin Lunny. In December 2005 the sale of JOC to Mr. Lunny was completed and the name of the business changed to Drakes Bay Oyster Company.

In 1972 the National Park Service (NPS) purchased the five acres occupied by the land-based portion of JOC's business. Since then the oyster company has leased 1.43 acres of the property from NPS.

The California Department of Health Services (CDHS) originally classified shellfish growing waters in Drakes Estero in 1982, when it was established that portions of the Estero were subject to intermittent microbiological pollution. It was determined that the major source of contamination came from dairy operations located in the immediate watershed, above Schooner and Home Bays. The pollution from these sources occurred primarily during rainstorms. Therefore, in 1982 most of the Estero was classified as *Approved*, while Schooner and Home Bays were classified as *Conditionally Approved*.

In 1994, the entire Estero was reclassified to *Conditionally Approved* because coliform data showed that primary water quality (WQ) stations in the Estero were impacted by rainfall related pollution. The Estero was closed to harvesting when rainfall exceeded 0.75 inch within a 24-hour period; the closure period was three days (72 hours) (Hansgen, 1994). A small area immediately offshore from the JOC plant remained classified *Prohibited*.

In 1995, the shellfish grower was given the responsibility of performing the monthly compliance water quality sampling in the shellfish growing areas (Gomsi, 1995). In accordance with a signed sampling plan from 1995, DBOC conducts its own sampling of the shellfish growing water and samples are analyzed at a State certified laboratory. Environmental Management Branch (EMB) staff provides training for samplers and monitors sampling activity of Drakes Bay Oyster Company.

In 1995, the inner reaches of Home, Creamery and Barries Bays were declassified to unclassified. Areas that are not classified are considered *Prohibited*. This was done because water quality sample sites 10, 11, and 12 in the inner reaches of Home, Creamery and Barries Bays, respectively, exceeded National Shellfish Sanitation Program (NSSP) criteria during open harvest conditions (Gomsi, 1995).

In 1997 JOC converted from sampling under the Adverse Pollution Conditions (APC) strategy to the Systematic Random Sampling (SRS) strategy. This change facilitated CDHS's ability to audit the self-monitoring program that was implemented in 1995. It also helped ensure that water quality samples were collected each month (Gomsi & Langlois, 1998).

CDHS worked with JOC to determine whether a portion of the main body of the Estero might be suitable for reclassification to *Approved*. Two new stations (WQ stations 16 and 17) and two existing stations (WQ station 13 and 14), located in the middle of the Estero, were sampled under adverse pollution conditions from 1994 to 1997. Results from this sampling showed that the body of the Estero has very good water quality. Water samples collected from station 17 had a geometric mean of 4, and one of 18 samples exceeded a fecal coliform (FC) concentration of 43 most probable number (MPN). Water samples collected from WQ 13 had a geometric mean of 4 and two of 59 samples exceeded the concentration of 43 MPN. Other sites in the body also had very good water quality, and it was recommended that sampling be continued at these sample sites to "better define the relationship between water quality and rainfall at these sites" (Gomsi and Langlois, 1998). A 25-acre parcel located in the outermost portion of the growing area was reclassified to *Approved* in January 1998. This site is represented by water quality station 17 (Figure 5).

In 1999 it was determined that fecal coliform concentrations in the inner portion of Schooner Bay increased beyond acceptable limits with rainfall less than the 0.75 inch threshold and did not decrease within the three day closure period. A second rainfall threshold was established for inner Schooner Bay, represented by water quality station 8 (Figure 5). The new rainfall threshold was .7 inch of rainfall in a 24-hour period and the new closure period was seven days (Langlois, 1999).

The current classification status of the Estero is as follows: the majority of the Estero is classified as *Conditionally Approved*, with two rainfall thresholds. One threshold (0.7 inch) is for inner Schooner Bay and the other (0.75 inch) is for the remaining portion of the *Conditionally Approved* areas in Drakes Estero. There are several small portions of the Estero that are classified as *Prohibited*; a 50-foot radius around the oyster plant in inner Schooner Bay and the inner reaches of the three other bays. A 25-acre portion is classified *Approved* near the mouth of the Estero (Figure 5).

IV. POLLUTION SOURCE SURVEY

Drakes Estero is recognized as one of the most pristine estuaries on the west coast. However, it is potentially impacted by intermittent pollution from several non-point sources. The following is a description of fecal contamination that may impact the water quality of Drakes Estero.

A. POTENTIAL NON-POINT SOURCES

"Non-point sources" of pollution come from many diffuse sources. Non-point source pollution is caused by rainfall moving over or through the ground. The sources of pollution that adversely affect water quality in Drakes Estero are non-point sources.

1. Runoff from Cattle Pasture Land.

Drakes Estero is surrounded by ranches that have been in operation for over 100 years. These ranches are located on PRNS land, and operate under Special Use Permits administered by NPS. The ranches are eligible for the National Register of Historic Places as part of the Point Reyes Ranches Historic District, and are recognized for their contribution to local commerce as well as to the area's cultural history (Statement for Management, 1993).

There are nine cattle ranches located in the Drakes Estero watershed (Table 2, Figure 3). The ranches contain primarily beef cattle with some dairy cattle. No dairy or other confined animal waste ponds are located in the Estero watershed, and have not been in the watershed for at least two decades. The old dairies that were located in the Drakes Estero watershed were converted to cattle operations many years ago. Dairies are thought to contribute more pollution than cattle ranch operations, therefore it is expected that this transition has decreased the amount of pollution entering the Estero. The last dairy in the Drakes Estero watershed to convert to a cattle ranch, D Ranch, converted in 1998 (Brannon Ketcham, NPS, pers. comm.), although its dairy barn and pond were located outside of the Estero's watershed. The E Ranch, which borders portions of Barries Bay and Creamery Bay, is a holding area for dairy cattle; the actual dairy facilities are located at the A Ranch, which is located outside of the Estero watershed on the Point Reyes peninsula. Rainfall runoff from cattle pastureland enters the Estero as hillside runoff directly into the Estero and via the tributaries. Table 2 lists acreage and the number of animal units for each operation in the watershed.

There are approximately 1377 cattle in the ranches that surround Drakes Estero. An animal unit is defined as a 1000 pound cow and its calf (John DiGregorio, NPS, pers. comm.). Some of the ranches are located entirely within the watershed (e.g. N Ranch) wile others have only a small portion of their area located within the DE watershed (e.g. H Ranch) (Figure 3). Therefore, it is unlikely that at any one moment all 1377 animal units are located within the watershed. Cattle are responsible for the majority of the microbial pollution found in Drakes Estero. Distributions of fecal coliform concentrations in Drakes Estero correlate with distribution of cattle. Highest fecal coliform concentrations were

found in Schooner Bay and the Schooner Bay watershed contains the greatest number of cattle (approximately 500 cattle). The watersheds of the other three bays contain about 100-200 cattle each. Variations in fecal coliform densities observed in these three bays may be explained by proximity of cattle to the tributaries and shoreline of each of the bays.

Grazing practices have an immediate effect on water quality in Drakes Estero. Fecal coliform produced by cattle located higher in the watershed adhere to soil particles as it travels through the watershed towards the tributaries or the Estero. Increased retention time in the watershed allows for increased die-off and lower pathogen concentrations reaching the Estero. In contrast, fecal coliform produced by cattle located in or near the tributaries or the shoreline enter directly into the Estero without being abated. Practices that keep cattle away from waterways will reduce the manure loading, and therefore decrease the potential for impacts on water quality from grazing live stock. "It has been shown that providing a water trough, as an alternative drinking source, may reduce the instream fecal deposition during the winter by as much as 90 percent" (Moore et al. 1993). Cattle are frequently observed along the shoreline of Drakes Estero, and are also known to enter some of the creeks. This is probably one of the largest impacts to Drakes Estero water quality.

Some ranchers in the Drakes Estero watershed have implemented best management practices (BMPs), including Kevin Lunny, whose family owns the historic G ranch that borders part of the northwest corner of the Drakes Estero shoreline. Some of the actions implemented by the ranchers include fencing streams to keep cattle out, and, in the rainy season, directing grazing away from pasturelands close to waterways. The NPS is working with the cattle ranchers to improve the cattle management practices in PRNS. It is expected that these types of management practices will help improve water quality in Drakes Estero. It is anticipated that future resource management projects will be implemented in the Drakes Estero watershed and that NPS will be involved in their execution.

2. DBOC Septic Systems.

Very few residences are located in the Drakes Estero watershed and all are served by onsite sewage disposal systems (e.g., septic tank and leach field systems). Historically (since the 1970s) the system of greatest concern has been the one located at the DBOC facility itself at the head of Schooner Bay. The system had a history of failure, but in the last decade several improvements have made their waste collection system significantly more effective. A new septic system was installed in 1998, which has a larger capacity than the previous one, and the number of people residing on the property decreased from ninety (in the 1990s) to nine (as of February 2006). In addition, DBOC installed a separate septic system in 2005 to collect the commercial waste produced by plant operations (primarily shucking).

The current septic system, installed in 1998, serves the residential facilities and the public restroom, and has a 27-bedroom capacity. In the late 1980s and early 1990s the number

of people residing on the property increased significantly, which led to the failure of the septic system in 1994. Now there are five residential structures: two wood framed structures and three trailers, with 12 bedrooms and approximately nine people residing on the property. The leach field is located east of the septic tank, approximately 3000 feet away at an elevation of 260 feet (Kevin Lunny, DBOC, pers. comm.). The leach field consists of 2400 linear feet and has four zones that are manually switched every three months. The system has a serial overflow design. The County of Marin requires that the system be inspected by a registered sanitarian on a quarterly basis as prescribed by its Operating Permit (Armando Allegria, Marin County Environmental Health Services, pers. comm.).

All plant wastes were discharged into the Estero via a holding pond until 2005. A second septic system was installed in 2005 to collect commercial wastewater that is generated. The leach field for this new system is located in the reconditioned old field used by JOC's original septic system (prior to 1998). Three drains in the plant bring waste to this system: in the temporary shucking container, in the plant, and in the future retail area.

3. Industrial Wastes

No industrial wastes enter Drakes Estero, with the minor exception of non-hazardous wastewater associated with oyster washing from the DBOC plant itself. Waste water from the oyster washing and shucking operations was previously disposed into a sump, approximately 50 feet north of the plant, which was installed under a waiver from the California Regional Water Quality Control Board, San Francisco Bay Region. In summer 2004 the California Department of Health Services, Food and Drug Branch (CDHS, FDB) ceased shucking operations at the JOC shore facility. JOC temporarily moved its shucking operations to Santa Rosa, California, but shucked there for less than a year. All shucking operations ceased from summer 2005 until February 2006. DBOC has resumed shucking in a portable building, and the wastewater enters the dedicated septic system. DBOC intends to resume shucking in the original plant, but will have to complete the permitting process required for renovating the building's structure before it can.

The company brings harvested oysters from the Estero and washes them at the facility during open harvest conditions. The water intake pipe used for these operations is located outside of the *Prohibited* zone, in Inner Schooner Bay, near water quality station 8. The wastewater from this activity reenters Inner Schooner Bay adjacent to the dock, which is within the closure zone. When Inner Schooner Bay is closed, but the outer Estero is open, DBOC washes harvested oysters on-site in the growing area. During these washing operations, DBOC brings a barge to the growing area, and subsurface water is sprayed onto the oysters to clean off sediment and megafauna.

A small *Prohibited* area was established at the upper end of Schooner Bay because of the residential units, the commercial operations, and the on-site septic system. This area extends approximately 50 feet outward in all directions from the shucking plant loading area. The *Prohibited* zone was established to prevent the use of these near-shore waters for wet storage or relaying due to the possibility of accidental

contamination from the on-shore facilities. While the potential pollution produced at the shoreline facilities has been effectively contained, there is still considerable human, animal (pets) and boat traffic in the area, and CDHS/PSU considers it prudent to maintain the *Prohibited* status of the 50-foot radius around the plant. Sampling station 8 (Figure 5) is located outside the *Prohibited* area within the inner Schooner Bay *Conditionally Approved* area. data omitted

4. Wildlife

Drakes Estero is a haven for a large number of bird species, particularly during the winter months. The impact of birds on the water quality of Drakes Estero has not been determined but may be a reason for occasional higher fecal coliform counts at some of the stations. Birds may have intermittent impacts on Drakes Estero water quality in winter months, but historically there have been very few occurrences of elevated FC concentrations during open harvest conditions. This suggests that the impact from birds is insignificant.

Drakes Estero is also home to a substantial population of harbor seals, estimated by the Point Reyes National Seashore (PRNS) to be about 400 to 600 resident individuals, increasing to 1200 - 1500 animals, including pups, during the breeding season from March through July (Sarah Allen, NPS, pers. comm.). California Sea Lions and Northern Elephant Seals are rare visitors in the Estero, but do occur regularly outside the Estero mouth, primarily around the Pt. Reyes headlands. No specific studies have been made of the coliform contamination from marine mammals, in particular harbor seals, in the Estero. The effect could be significant, at least locally in and near the popular haul-out areas. The probability of impact to WQ from harbor seals is expected to be highest in summer months when animal numbers are highest, however FC concentrations are consistently very low in the summer. The Company voluntarily minimizes harvesting and planting activities on the mudflats in the *Approved* area during the harbor seal pupping season (March 1 through June 30) in order to reduce impact to harbor seals that use the outer Estero mudflats for pupping.

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The Point Reyes National Seashore supports healthy populations of coastal blacktail deer, coyote, bobcat, rabbits, and numerous other kinds of mammalian wildlife. Their combined impact on water quality in Drakes Estero is considered insignificant.

5. Boats and Other Watercraft.

Drakes Estero is accessible to boats at the DBOC Schooner Bay facility and via Drakes Bay. Access from Drakes Bay is possible only during high tides; the shallow nature of the Estero, and the presence of a sand bar across its mouth, discourage boaters from entering. The only watercraft on the Estero are the DBOC work boats and barges, and an increasing number of canoes and kayaks launched at Schooner Bay. There are ten kayak companies that bring guided tours of kayakers to Drakes Estero, and private individuals also kayak on the Estero. Blue Waters Kayaks provides its tour groups with education regarding potential threats to public health, and bring bags for customers who

added

may get ill while on the water. In the 2005 calendar year 460 individuals kayaked as part of a tour on the Estero (Kevin McKay, NPS, pers. comm.). The companies have commercial use authorization through the NPS to bring tours to Drakes Estero. As part of this authorization they may not bring kayakers to the Estero during the harbor seal pupping season of March 1 through June 30 (Kevin McKay, NPS, pers. comm.). NPS monitors bacteria in the area where the kayakers put their boats in the water at the head of Schooner Bay, north of the plant facility. Water samples are collected and analyzed for total coliform, *Escherichia coli (E. coli)* and *Enterococcus*. Results from this monitoring suggest that kayakers have minimal impact to this particular area. No monitoring is done in the waters where kayakers traverse, however, and fecal and/or oral discharge from boats would be a sporadic and unpredictable occurrence and therefore difficult to monitor.

B. POTENTIAL POINT SOURCES

There are no point sources of pollution located in the Drakes Estero watershed. No wastewater treatment plants (WWTPs) discharge effluent to Drakes Estero, nor to any tributaries to the Estero. Therefore, no prohibited areas are established as safety zones around WWTP point source dischargers. Drakes Estero contains no marinas, so no prohibited areas of this type are necessary.

V. HYDROGRAPHIC AND METEOROLOGICAL CHARACTERISTICS

A. TIDES

The tides in Drakes Estero are characterized by semi-diurnal inequality. Data collected by the National Ocean Service at Point Reyes show a 10-year mean tidal range (Mean Low Water to Mean High Water) of 3.9 feet, and a diurnal tidal range (Mean Lower Low Water to Mean Higher High Water) of 5.7 feet (NOAA, 1996-2006). The mouth of Drakes Estero is kept perpetually open due to tidal scouring, so tidal exchange is a significant factor in rapidly restoring and maintaining high water quality in the Estero. Flushing rates are highest at the mouth of the Estero, and slowest within the inner reaches of the bays.

B. CURRENTS

Currents in Drakes Estero are tidally driven. The highest currents occur near the mouth of the Estero; and range between 1.08 ft/s and 1.55 ft/s (Anima, 1991). Over a period of years a sand spit forms that extends from the west side of the mouth and projects eastward across the mouth. Once the sand spit is formed, it is scoured away. This causes the location of the mouth to shift over years from west to east and back again (Figure 7). This cycle of generation and destruction takes place over decades, but in a year 262.5 feet of sand can be built up or scoured away (Anima, 1991). Tidal flushing may be significantly effected by the position of the Estero mouth, which may in turn impact water quality.

C. RAINFALL

Total annual precipitation at Point Reyes averaged 24.5 inches a year from 2002-2005 California Data Exchange Center (CDEC), Point Reyes gauge (PTR) (Figure 8). Precipitation in the region is strongly seasonal and sporadic (storm event controlled), even during the rainy season. The rainy season normally extends from October through April, accounting for about 91 percent of the annual precipitation (Figure 8). Most days during the winter, however, receive little rainfall. The number of days with measurable precipitation (0.01 inch or more) averages 73 days per year.

D. WINDS

The effects of wind blowing across Drakes Estero can be significant. Strong northerly or southerly winds have been observed to influence tidal flow and height. In addition, wind blowing over some reaches in the Estero can make the water choppy, which can contribute to mixing bottom sediments into the water column.

E. RIVER DISCHARGES

Drakes Estero and Estero de Limantour are considered a single estuarine system because the two esteros share a single mouth leading to Drakes Bay (Figure 4). Therefore they have a single watershed, called the Drakes Estero watershed. The

Drakes Estero watershed covers an area of about 31 square miles, of which the Estero itself (3.1 square miles) represents about ten percent. There are several perennial streams and a few ephemeral streams that comprise the Drakes Estero watershed (Figure 4). Major streams are Laguna, Muddy Hollow, Glenbrook, East Home Ranch, East and North Schooner Creek and Creamery Bay Creek. Minor watersheds are Limantour Creek, North Home Ranch and Barries Bay Creek. Some of the creeks drain primarily wilderness areas, while other creeks drain areas used by cattle (Figure 4). Creeks located in wilderness areas have lower fecal coliform concentrations than those utilized by cattle (Ketcham, 2001). New sentence added

F. SUMMARY

The circulation of Drakes Estero is almost completely tidally driven. Tidal amplitude may be strongly influenced by strong northerly or southerly winds. Freshwater has very little influence on circulation because the freshwater input is episodic and very small relative to the tidal prism of the Estero and its bays.

During extreme hydrographic conditions Estero water floods into the oyster company's plant area. Extreme high tides (over 6 feet), rainfall and winds can all combine to bring water over the Estero banks and into the DBOC plant area. This occurs once or twice a year (Kevin Lunny, pers. comm.).

VI. WATER QUALITY STUDIES

The National Park Service has conducted or supported several research projects either within the Estero itself or in its watershed. The following is a summary of water quality data that has been generated from the Estero or its watershed.

A. WATER QUALITY STUDIES

2001- Point Reyes National Seashore. Water Quality Monitoring Project.
Several creeks in the Drakes Estero watersheds are monitored for fecal coliform concentrations, nutrients and sediments. East Schooner, Home Ranch, Muddy Hollow and Laguna Creeks were monitored from 1999 through 2004, and Creamery Creek was monitored from 2001 through 2004. FC concentrations in creeks located in wilderness areas were an order of magnitude less than FC concentrations in creeks that flow through ranch lands. Creeks located in ranchlands had high fecal coliform concentrations independent of rainfall suggesting that cattle physically enter the creeks. Of the streams that run through pasturelands, Creamery Creek contained FC concentrations at least two-fold higher than Home Ranch Creek or East Schooner Creek.

entire paragraph omitted

B. ANALYSIS OF CDHS WATER QUALITY DATA

1. Water Quality Monitoring Background

Compliance with growing area criteria is determined from bacteriological analyses of water samples collected at each primary sampling station. These data must comply with the fecal coliform standards established in the NSSP Model Ordinance (2003), Chapter IV. The applicant conducted compliance sampling in accordance with a self-monitoring agreement between the grower and CDHS. CDHS/PSU personnel collected additional samples in the growing area and throughout its watershed.

The NSSP Model Ordinance (2003), Chapter IV, states that *Conditionally Approved* areas must meet *Approved* area water quality standards when open to shellfish harvesting for human consumption. This standard is: "The fecal coliform median or geometric mean MPN of the water does not exceed 14 MPN per 100 mL and the ninetieth percentile of the data set consisting of the past three years of data cannot exceed an estimated ninetieth percentile value for FC of 43 MPN/100 mL".

Six primary water quality (WQ) stations represent the *Conditionally Approved* portions of the two leases and one primary water quality station (WQ 17) represents the *Approved* area on lease M-430-01 (Figure 5). At least 30 samples are required from each primary station in the growing areas to determine proper classification. Secondary water quality stations were previously established to help determine the impacts of non point sources of pollution on the shellfish growing areas (Figure 2). The samples analyzed to reevaluate the current growing area classifications were collected from July 1, 2003 through June 30, 2006. In addition approximately 140 samples from the twelve-year

period July 1, 1994 through June 30, 2006 were examined. For both the *Conditionally Approved* areas and the *Approved* area, one sample was considered for each month and the designated compliance sample was used when possible. If there were multiple samples in a month and none were distinguished as the compliance sample, then the first sample collected in that month was used for the evaluation. For reevaluation of the current growing area classifications, only data collected during times of open harvest were included for the *Conditionally Approved* areas.

Prior to 1997, samples were collected whenever possible during periods of adverse pollution conditions, such as immediately following a rainstorm that did not exceed the closure threshold, or on the first day of reopening following a rainfall closure. In 1997, JOC began conducting routine water quality monitoring under the NSSP's systematic random sampling (SRS) strategy. Under this system, samples are collected on prearranged dates, which are scheduled well in advance so as not to bias the selection of sampling times. If a given growing area is closed on the scheduled date, then samples are to be collected on the first day of reopening for that area. Sampling in the *Approved* area shall always occur on the scheduled date.

The closed data that were used to calculate the ninetieth percentile were composed of samples that were collected under both the Adverse Pollution Condition Strategy (APC) (1994-1997) and the systematic random strategy (1997-2006). This may influence the analysis if the years when samples were collected according to the APC strategy contain more rain related samples than the years when SRS was used to schedule sample collection. From 1994–2006 there were approximately 60 samples collected during rainfall events (i.e., at least .1 inch of rain fell in a 24-hour period in the previous three days), and these data points are relatively evenly distributed through the twelve years of data.

Samples are collected one foot below the surface of the water in 100 milliliter (mL) sterile bottles. Samples are stored in an insulated container and maintained at 4° Celsius during transport to the laboratory. All samples are assayed for fecal coliform (FC) bacteria. The Sonoma County Public Health Laboratory assayed most samples collected during the study period. This laboratory uses the modified A-1 multiple tube fermentation technique for estimating bacterial density. The reporting unit for this method is the most probable number (MPN) per 100 milliliters (mL) for water and MPN/100 grams (gm) for shellfish samples.

2. Water Quality Monitoring Data Interpretation

Samples collected from July 1, 2003 to June 30, 2006 were analyzed to determine whether the growing area meets its current classifications. Water quality in the *Approved* area meets the NSSP standard for the *Approved* classification. Water quality in *Conditionally Approved* areas in Drakes Estero meets NSSP criteria for samples collected both during open harvest conditions and almost all stations during open and closed harvest conditions (except water quality station 8, which exceeded NSSP criteria for the ninetieth percentile) (Table 3). However, the ninetieth percentile standard in the

Conditionally Approved areas was exceeded when considering samples that were solely collected during closed harvest conditions (Table 3, Figure 9). These results are expected in an area impacted by rainfall related pollution (e.g. hillside runoff and creek discharge). Observed fecal coliform concentrations were higher in the bays than in the body, and generally higher in the inner bays than in the mid bays. While overall water quality in Drakes Estero is very good, there were incidences of elevated fecal coliform concentrations that occurred during open harvest periods. Most of these incidences occurred during high rainfall events. More rainfall data should be collected to determine whether a cumulative rainfall threshold should be established.

Evaluation of Current Classifications:

Approved area:

The *Approved* area is represented by water quality station 17 (Figure 5). Samples collected during adverse pollution conditions (24-48 hours after rainfall exceeding 0.75 inch in a 24-hour period) have shown that the entire body of the Estero has very good water quality. The geometric means and ninetieth percentiles were significantly below the NSSP standard (Table 3). The *Approved* area meets the requirements for the *Approved* classification.

Conditionally Approved areas:

The three-year geometric means and ninetieth percentiles were significantly below the NSSP standard during open harvest conditions at all primary stations (Table 3). Geometric means and ninetieth percentiles were also determined from samples that were collected during both open and closed conditions. At most sites three-year geometric means and ninetieth percentiles of samples collected during open and closed harvest conditions were also less than the NSSP standard, although higher than those considered solely during open harvest conditions (Table 3). Ninetieth percentile values calculated from closed harvest samples exceeded NSSP standards (43 MPN) at all primary stations. These results demonstrate that the current rainfall thresholds in Drakes Estero are appropriate, and the growing areas meet the requirements of the *Conditionally Approved* classification.

Long-term trends in Drakes Estero Water Quality:

Twelve years of data were examined to evaluate long-term trends in Drakes Estero water quality. Twelve-year geometric means during open conditions were approximately the same as three-year geometric means during open conditions (Tables 3 and 4). Twelve-year ninetieth percentiles during open conditions were higher than three-year ninetieth percentiles at all stations except WQ station 13 and WQ station 7. There was no significant difference between the ninetieth percentile at water quality station 13 in the three-year analysis and the twelve-year analysis. The three-year ninetieth percentile at station 7 was approximately 12.5% higher than the twelve-year ninetieth percentile. During the winter 2005-2006 there was degradation in the water

quality in Home Bay; represented by WQ station 7. This may explain why the three-year ninetieth percentile value is higher than the 12-year ninetieth percentile value at WQ station 7. An analysis of trends in fecal coliform data shows that water quality in Drakes Estero is variable, and is subject to periods of degradation.

Continuous ninetieth percentile values determined from open condition samples were calculated in 30 sample increments from 1994 to 2006 and plotted to examine long term trends in fecal coliform concentrations (Figure 10). Under NSSP guidelines, the ninetieth percentile should not exceed 43 MPN. Barries Bay (WQ 4) and Schooner Bay (WQ 8) contained increased concentrations of FC from 1998 to 2001 (Figure 10). Barries and Home Bays contained increased FC concentrations from 2002-2005. These periods may correspond to El Nino events that occurred in 1997-1998 and 2002–2003. Generally, higher than average rainfall is associated with El Nino events that occur along the central California coast. Rainfall records for these years are patchy, so actual rainfall data is not available. If these periods of increased FC concentrations do correspond to El Nino years and higher than normal rainfall it provides evidence that high cumulative rainfall is a factor that has significant impact on water quality in Drakes Estero. The body of the Estero has had consistently very low fecal coliform concentrations for the past twelve years (Figure 10).

In 1998, the ninetieth percentile at water quality station 8 exceeded the 43 MPN standard. It was determined that the rainfall threshold was not properly managing water quality in Inner Schooner Bay. As a result of this exceedance the rainfall threshold for Inner Schooner Bay (represented by water quality station 8) was decreased from 0.75 to 0.7 inches, and the closure period was extended from 3 to 7 days. After the rainfall threshold was changed, the ninetieth percentile at water quality station 8 decreased to values significantly less than the 43 MPN NSSP standard (Figure 10).

FC distributions:

Fecal coliform concentrations are lowest in the body of the Estero and higher in the bays (Figure 11). Mid-bay FC concentrations were usually lower than inner bay FC concentrations (Table 4, Figure 6). Two factors determine FC distributions in Drakes Estero. Hillside runoff and creek discharge introduce FC bacteria into the Estero. Creeks can receive FC bacteria from runoff or when cattle physically enter the creeks. Tidal exchange is primary factor that flushes FC out of the Estero.

Highest fecal coliform densities were observed in Schooner Bay (represented by water quality stations 8 and 9) (Tables 3 and 4). The second worst water quality has been observed in Barries Bay, but recently the second worst has been Home Bay. Creamery Bay (represented by water quality station 15) has historically had the lowest fecal coliform concentrations of the four bays. Generally, samples from secondary sites in the inner bays are underrepresented.

In the last 12 years, almost all incidences of elevated fecal coliform concentrations (over 43 MPN) were associated with rainfall. Most of these occurred during rainfall closures,

but some occurred during open harvest conditions (i.e. high FC concentrations occurred when rain did not cause a closure, or after reopening following a rainfall closure). Most cases of elevated FC concentrations during open conditions occurred in the inner bays, none occurred in the body of the Estero (Figure 11), the others occurred in the mid-bays. Increased concentrations of FC are correlated with increased rainfall. There is also a correlation between fecal coliform concentrations and salinity. Almost all cases of elevated fecal coliform concentrations occurred in water that contained less than 30 parts per thousand salinity. Ninetieth percentile values during closed conditions were four times higher at bay sites than at Estero body sites (Table 3). At all sites in the Estero, lowest fecal coliform concentrations were observed during months with little to no rainfall (June through September) (Figure 11).

Recent Issues in Water Quality:

In winter 2005-2006 there was a significantly higher incidence of elevated FC concentrations during open harvest conditions. They were all associated with rainfall events and they all occurred in the bays of the Estero. It became evident that existing rainfall closure rules were not effectively managing water quality in the Estero's bays. The primary locations impacted were Home and Schooner Bays. It appeared that there was a new source of contamination affecting Drakes Estero. An investigation into the watershed led to the identification of three potential sources: 1) higher than average runoff due to the extreme amount of rain that fell this season, 2) changes in cattle grazing practices in the Home Bay watershed, and 3) faulty septic systems at Home Ranch located at the head of Home Bay.

Northern California received a record amount of rainfall in winter 2005-2006. The average cumulative rainfall from January through April at Drakes Estero is approximately 12 inches, compared to the 20 inches that fell from January through April in 2006. The soil became supersaturated such that very small amounts of rainfall resulted in runoff. An increased amount of runoff will introduce greater amounts of fecal coliform to the Estero.

A different manager is operating the 200 cattle located at Home Ranch. This person has allowed the cattle to come very close to the Home Bay shoreline during winter months while the previous manager kept cattle away from the shoreline during the rainy season. Cattle close to waterways have a greater impact on water quality than those that are kept further up in the watershed. In summer 2006 the NPS put new fencing through Home Ranch pastures such that cattle are now kept out of the low lying areas near the shoreline at the head of Home Bay.

changed

It was also discovered that the septic system associated with the main house at Home Ranch was failing. The septic system was abandoned, the tank was filled and the waste and effluent lines were capped off. A portable toilet was placed at the property and the resident was not able to discharge gray water. The NPS replaced all three septic systems associated with Home Ranch in summer 2006.

data omitted & added

The failing septic system represents the most alarming threat to the growing areas because human waste has the potential to carry more harmful pathogens than cattle waste. As a result, CDHS applied an automatic three-week closure from the time that the septic system was abandoned to allow for both bacterial and viral die-off. Fecal coliform concentrations in Home Bay on June 1st were less than 1.8 MPN at both water quality stations 7 and 20. Therefore, water quality in Home Bay was within NSSP standards, and the growing area was reopened.

VII. CLOSURE CRITERIA

A. RAINFALL CLOSURES

Drakes Estero is classified for commercial shellfish production in accordance with the National Shellfish Sanitation Program (NSSP) Manual of Operations, Part I, Section C. The majority of the Estero is classified *Conditionally Approved* (Figure 6). The *Conditionally Approved* area is subject to rainfall closure periods in accordance with rainfall closure and reopening rules established in the "Management Plan for Commercial Shellfishing in Drakes Estero, California". There are two different rainfall closures that have been established for Drakes Estero. The demarcation between the two thresholds is between WQ station 8 and WQ station 9 in Schooner Bay. The northern portion of Schooner Bay north of water quality station 8, and including station 8, is closed for harvesting of shellfish for human consumption immediately after 24-hour cumulative rainfall of 0.7 inch is exceeded, and remains closed for seven days. The rest of the *Conditionally Approved* area of Drakes Estero will be closed for harvesting of shellfish for human consumption after 24-hour cumulative rainfall of 0.75 inches is exceeded and remains closed for three days. The *Approved* portion of Drakes Estero is not regulated by rainfall closure rules, and is always open for harvest, barring an emergency closure.

B. PSP CLOSURES

The Drakes Bay Oyster Company submits one mussel sample per week collected from a buoy located in the channel and another mussel sample from bed #12, one oyster sample per week collected from bed #12, and one sample of oysters collected from the current harvest location. These samples are submitted to the CDHS Environmental Microbial Diseases Laboratory and are tested for marine biotoxins.

In compliance with the NSSP Model Ordinance (2003), the alert level for PSP toxin is reached when the concentration of the toxin in shellfish meat equals or exceeds 80 micrograms of PSP toxin per 100 grams of meat. The alert level for domoic acid in bivalve shellfish established by Canadian authorities and accepted by FDA is reached when the concentration of the toxin in shellfish meat equals or exceeds 20 micrograms per gram of tissue (i.e., 20 parts per million (ppm)).

DBOC was in compliance with the required weekly submittal of shellfish samples to the California Department of Health Services (CDHS) laboratories in Richmond for PSP toxicity testing. The company has complied with all closures relating to elevated PSP

added

toxin levels and has been of great assistance in providing additional samples for tracking spatial and temporal patterns of toxicity in Drakes Estero. In addition, DBOC continues to be very helpful in providing weekly phytoplankton samples as part of CDHS's volunteer-based phytoplankton monitoring program. The information from these samples has been of tremendous assistance in learning more about the distribution and abundance of toxigenic phytoplankton in the Estero.

C. OTHER CLOSURES

Areas determined to be exposed to chronic pollution sources have been designated as permanent *Prohibited* zones, where shellfish mariculture is always *Prohibited*. These are located in the inner areas of all the bays in the Estero (Figure 5).

Other closures occur during emergency pollution events that adversely affect bay water quality, and will cause a closure of the shellfish growing areas.

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

There are few potential sources of pollution either in Drakes Estero or its watershed, and they are all non-point sources. The primary source of pollution to the Estero comes from fecal waste produced by cattle in the watershed, which is washed into the Estero during times of rainfall. Proximity of cattle to waterways presents one of the largest potential threats to water quality in Drakes Estero. Some cattle management practices have been implemented to help keep cattle away from waterways during winter months. NPS should encourage and assist more ranchers to implement these management practices. Cattle should not have access to the Drakes Estero shoreline. The majority of Drakes Estero has been classified *Conditionally Approved* because of the predictable water quality degradation that occurs following rainfall, and rainfall closures prevent shellfish harvesting from occurring during these times. Water quality in the body of the Estero is least affected by impacts caused by runoff from pasturelands. Sporadic periods of water quality degradation may occur during periods of higher than average rainfall (such as during El Nino years) when rainfall thresholds may not be adequate to ensure safe water quality. More rainfall related data should be collected to determine whether a cumulative rainfall threshold should be established.

B. RECOMMENDATIONS

- Continue with the *Conditionally Approved* and *Approved* Classifications.

- Continue with the Self-Monitoring Plan for Water Quality.

- Educational literature should be posted by NPS and DBOC citing the delicate nature of the Drakes Estero ecosystem and should advise the public that no waste should be discharged into the waters of the Estero.

- Perform rainfall related sampling in Drakes Estero to determine whether a cumulative rainfall threshold should be established. Samples should be collected in the outer Estero within 24 hours after the .75-inch rainfall threshold has been exceeded and the seven-day cumulative rainfall total is at least one inch.

- The ranchers and NPS should work together to implement cattle management practices that will decrease the manure load entering Drakes Estero. Specifically, cattle should be moved higher into the watershed, and away from creek beds during wet weather months. Additionally, cattle should be kept away from the Drakes Estero shoreline.

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X. TABLES

Table 1. California Fish and Game aquaculture leases in Drakes Estero, California.

Company	CDFG Lease	No. Acres[1]	Product	Contact Person
Drakes Bay Oyster Co. 17171 Sir Francis Drake Bl. Inverness, CA	M-438-01, parcel 1	350	Pacific oysters	Kevin Lunny
	M-438-01, parcel 2	709	Pacific oysters	
	M-438-02	1	Rock scallops/Manila clams	

[1]Lease boundaries provided by NPS. Lease locations are approximate.

Table 2. Cattle in the Drakes Estero watershed.

Ranch	Animal Units per Ranch[1]	Number of Acres[1]	Apprx. Number of Acres in Watershed	Number of Animal Units per Acre in Watershed	Apprx. Number of Animal Units in Watershed[2]
F Ranch	175	1510	1325	0.116	153.7
G Ranch	90	1151	500	0.078	39
H Ranch	280	1033	220	0.27	59.4
Rogers Ranch	66	398	398	0.165	65.6
M Ranch	175	1109	1085	0.157	170.3
N Ranch	90	925	925	0.097	89.7
Home Ranch	300	2575	2575	0.116	298.7
E Ranch	175	1010	864	0.173	149.5
E Ranch Creamery Bay	26	329	329	0.079	26

[1]Numbers of animal units and acreage provided by NPS.
[2]Assumes even distribution of animal units through the ranch.

Table 3. Summary of fecal coliform concentrations at primary stations from 7/1/2003 through 6/30/2006.

Sites	Sample No.	Geometric Mean <Open>	90th Percentile <Open>	Sample No.	Geometric Mean <Open and Closed>[1]	90th Percentile <Open and Closed>	Sample No.	Geometric Mean <Closed>	90th Percentile <Closed>
Primary									
8	36	3.16	9.89	46	5.16	44.5	10	23.5	698.0
9	36	3.03	11.12	47	4.6	35.25	11	17.97	349.8
13	36	2.65	6.08	47	3.57	13.95	11	9.4	68.4
15	36	2.68	6.58	45	3.66	15.13	9	12.65	93.9
4	36	2.83	7.44	46	3.7	20.1	10	9.7	178.9
7	36	2.95	8.99	47	4.22	28.74	11	13.6	290.0
17	36	2.37	5.39		N/A	N/A		N/A	N/A

[1]Open/Closed data: For any given month, all closed samples were included, and a single open sample was included. For months when there were multiple open samples, if one sample was a designated compliance sample, it was used, if there were none, or multiple samples were designated compliance samples then the first sample in the month was used in the calculating geometric mean and 90th percentile.

Table 4. Summary of fecal coliform concentrations from 7/1/1994 through 6/30/2006.

Sample Sites	Sample No.	Geometric Mean <Open>	90th Percentile <Open>	Sample No.	Geometric Mean <Open and Closed>[1]	90th Percentile <Open and Closed>
Primary						
8	130	3.76	16.93	166	6.0	50.58
9	139	3.2	13.4	164	4.34	31.16
13	138	2.63	6.05	170	3.32	11.4
15	125	2.68	8.12	142	3.26	14.07
4	139	2.99	12.04	161	3.45	17.61
7	138	2.76	7.93	162	3.51	17.67
17	113	2.48	6.87			
Secondary						
1	30	4.55	37.27	38	6.92	74.71
2	32	3.16	12.9	48	4.5	31.48
3	27	3.55	15.69	32	3.9	16.56
18	15	3.55	12.0	26	4.56	23.05
19	14	4.59	22.29	25	4.57	19.75
10	13	7.0	59.28	18	18.03	317.8
11	13	6.19	64.95	16	9.23	101.85

[1]Open/Closed data: For any given month, all closed samples were included, and a single open sample was included. For months when there were multiple open samples, if one sample was a designated compliance sample, it was used, if there were none, or multiple samples were designated compliance samples then the first sample in the month was used in the calculating geometric mean and 90th percentile.

XI. FIGURES

Figure 1. Drakes Estero and Pt. Reyes, California.

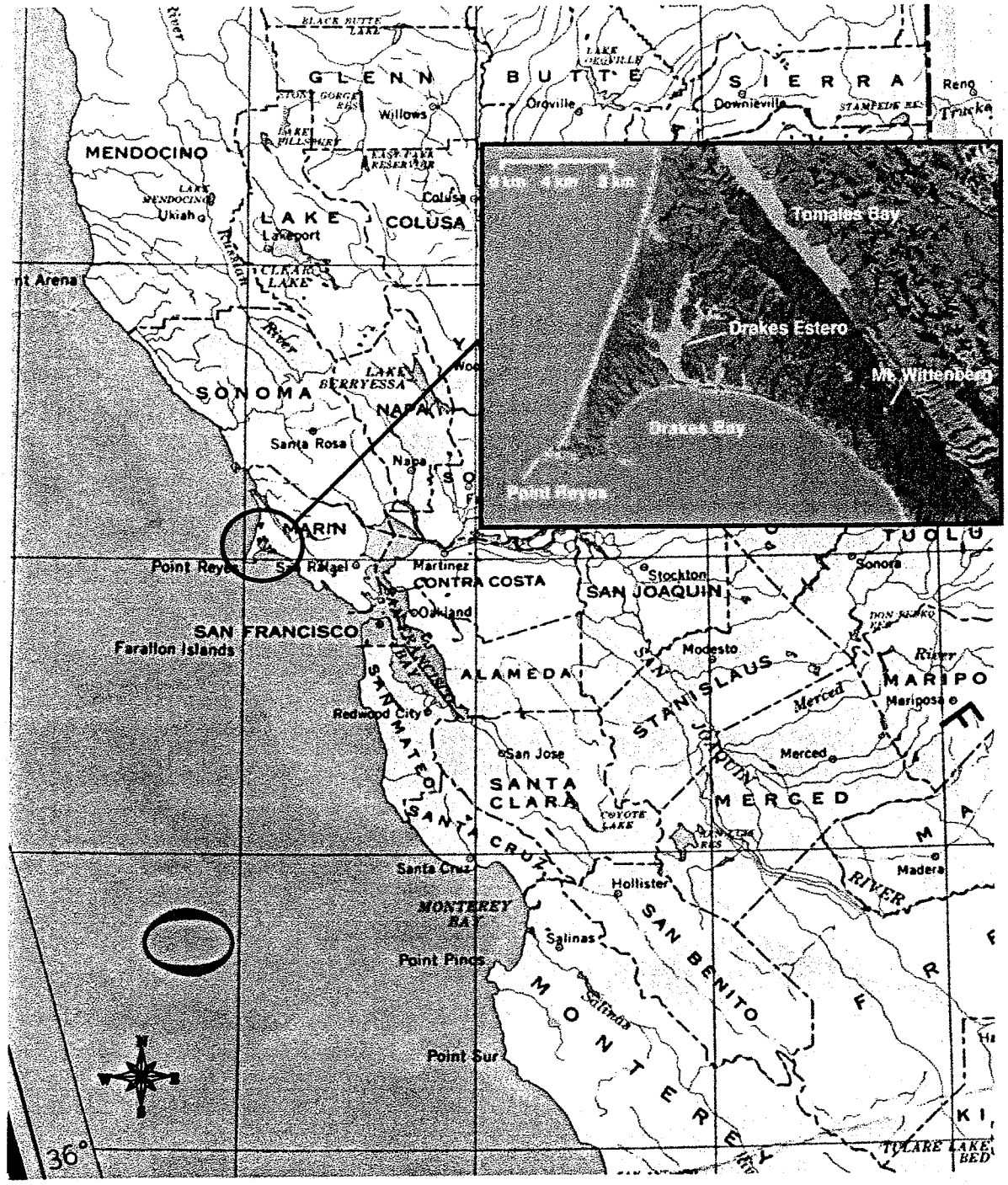


Figure 2. Drakes Estero, California showing Barries, Creamery, Schooner, and Home Bays, and Estero de Limantour.

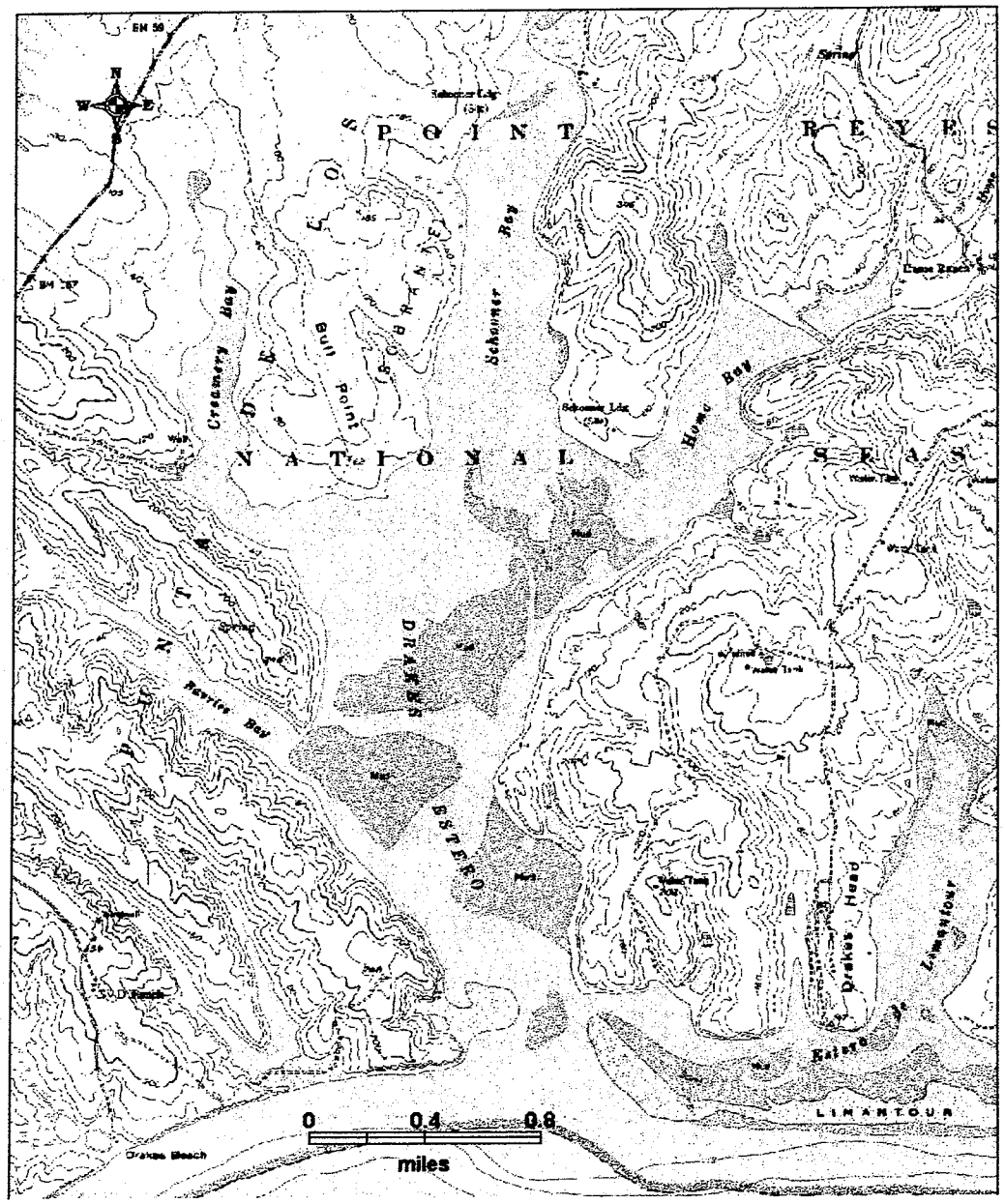


Figure 3. Drakes Estero watershed and the ranches surrounding the Estero.

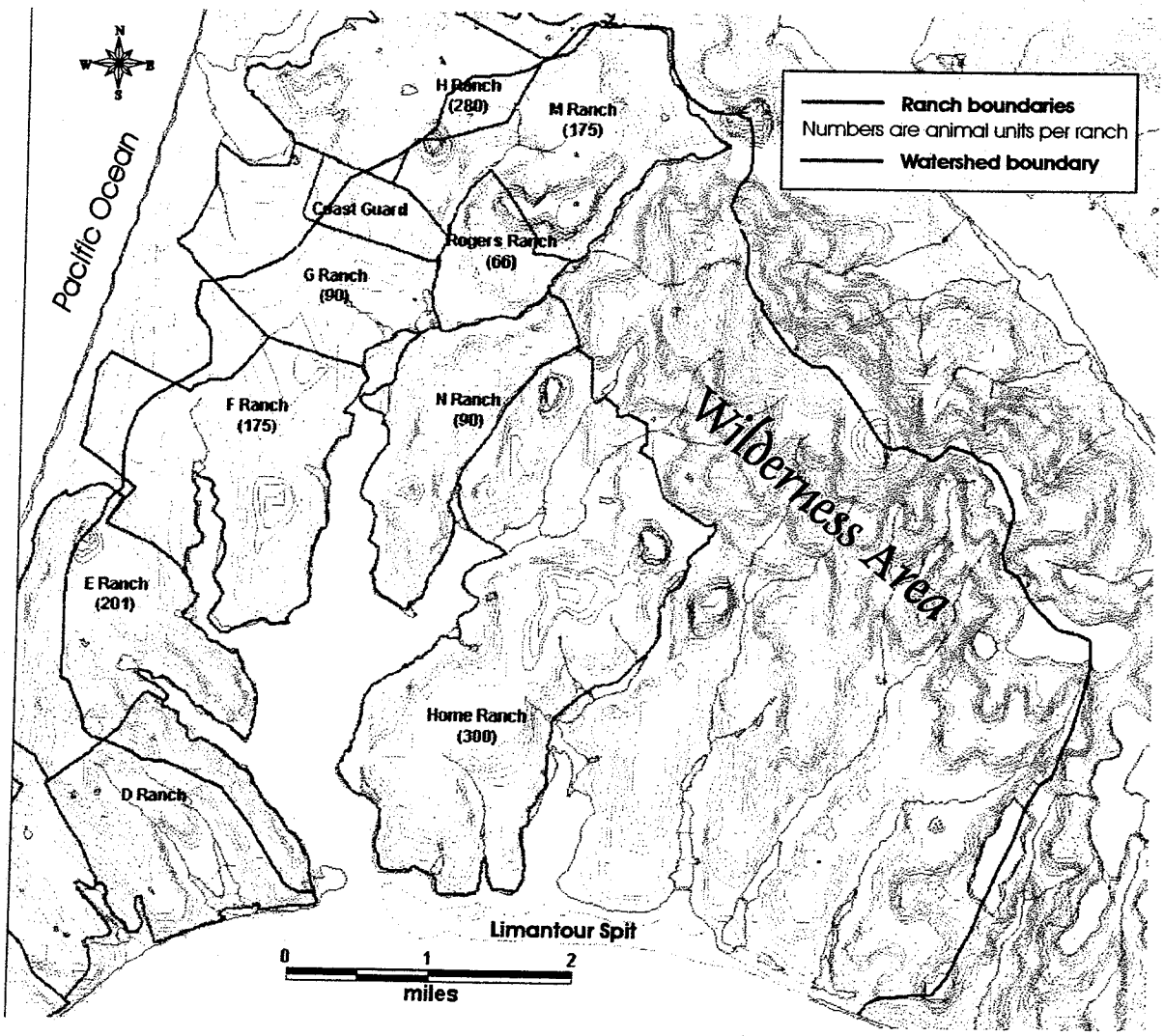


Figure 4. Streams in Drakes Estero watershed.

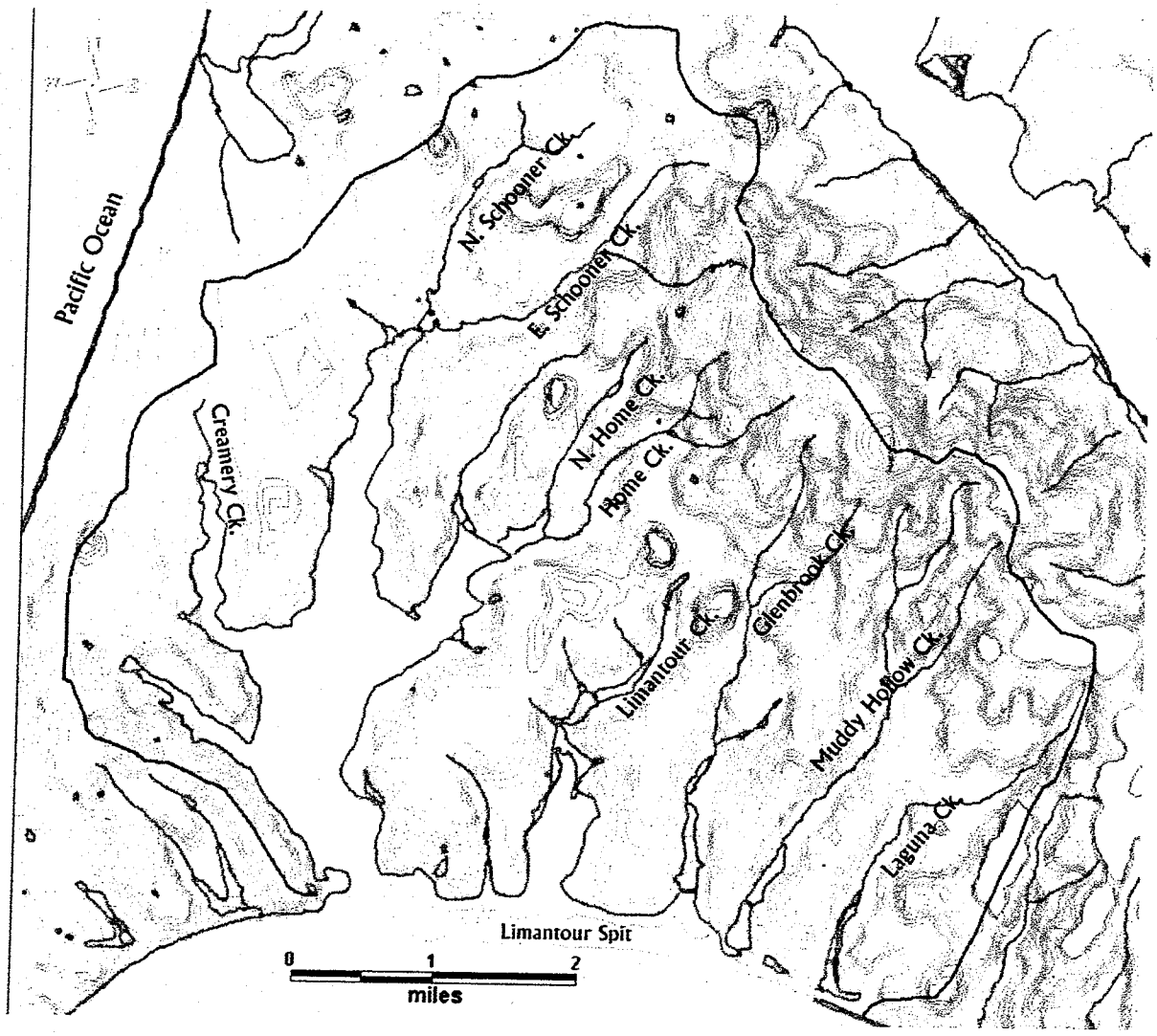


Figure 5. Active oyster beds and aquaculture lease boundaries in Drakes Estero, California.

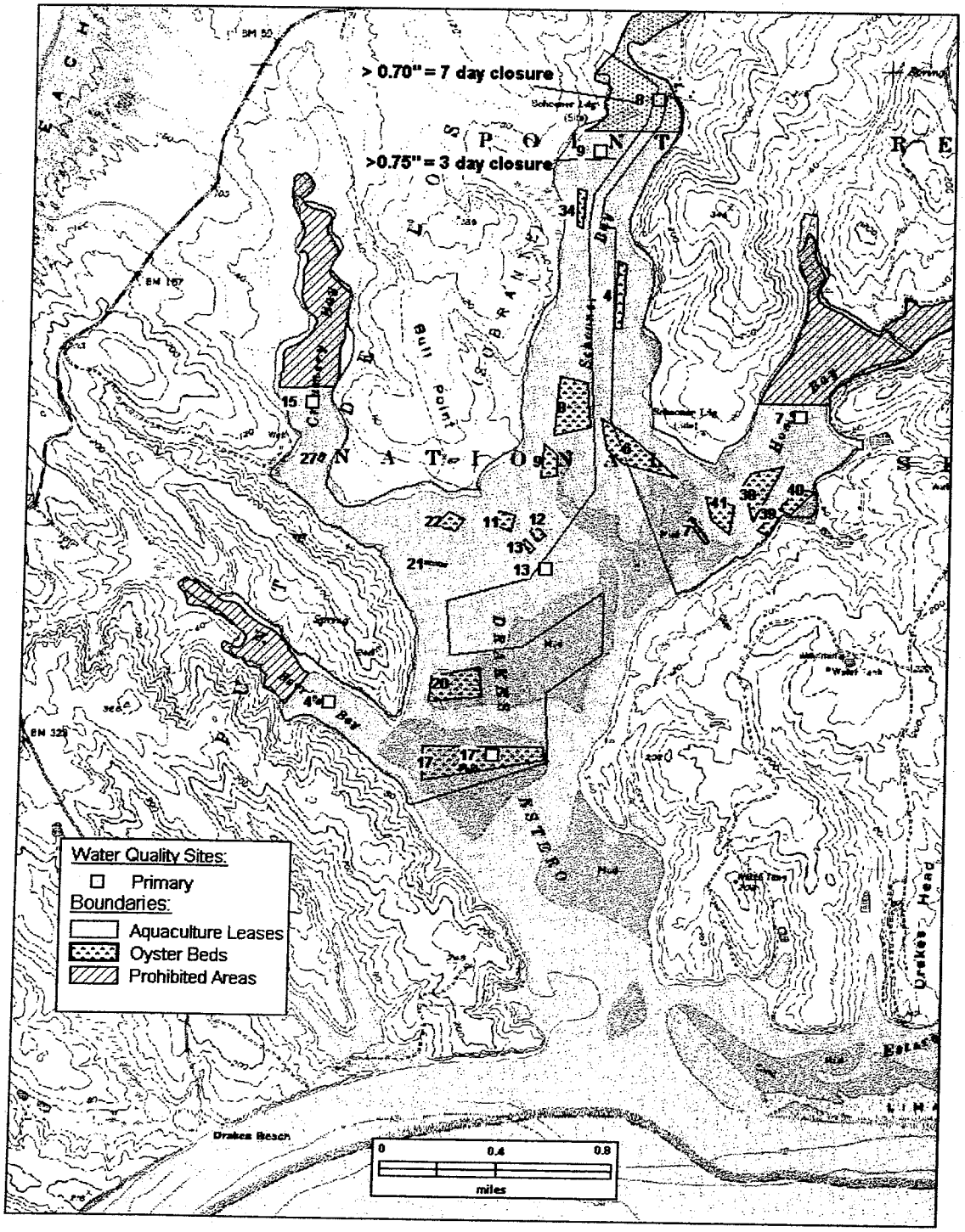


Figure 6. Primary and secondary sampling sites in Drakes Estero, California.

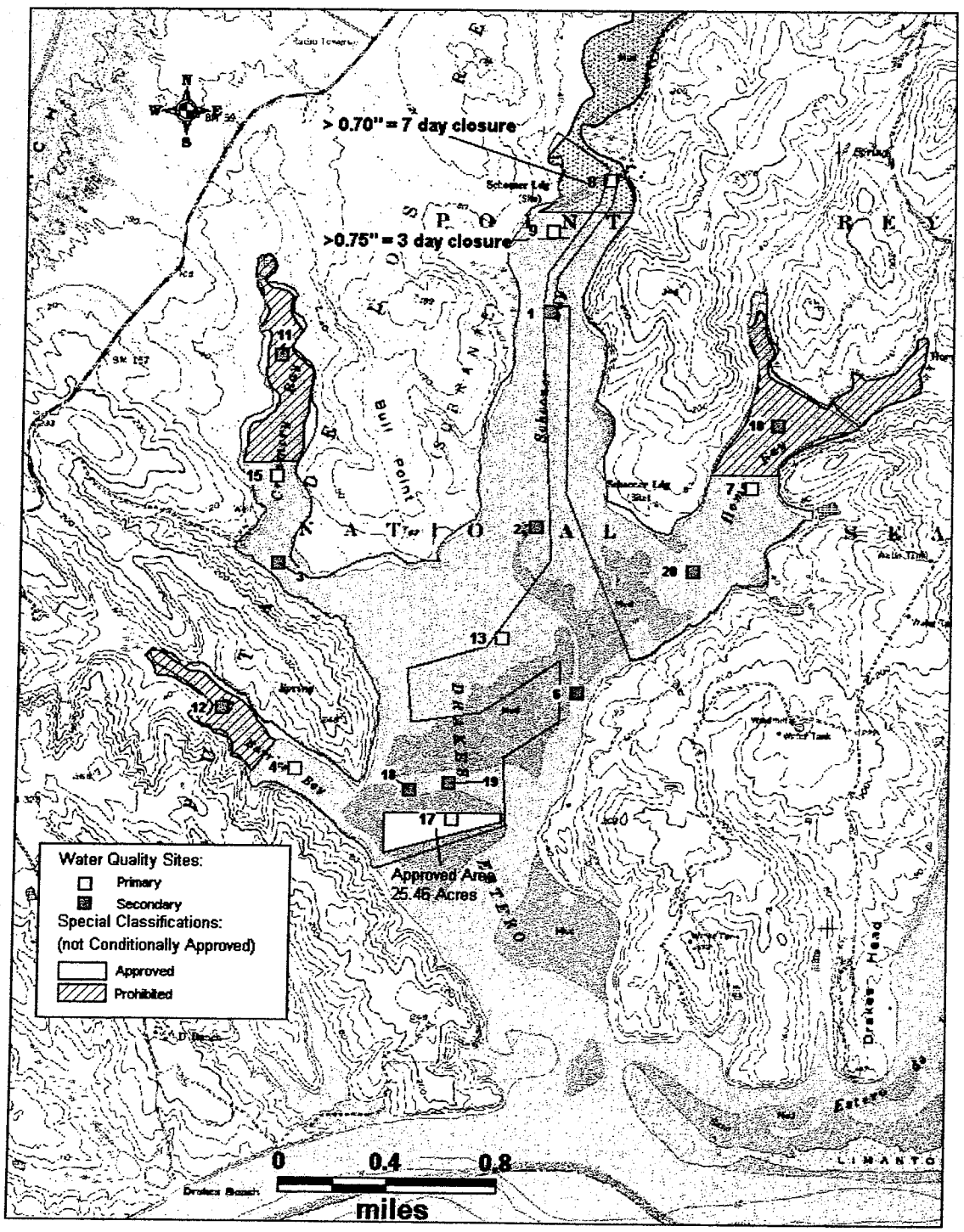
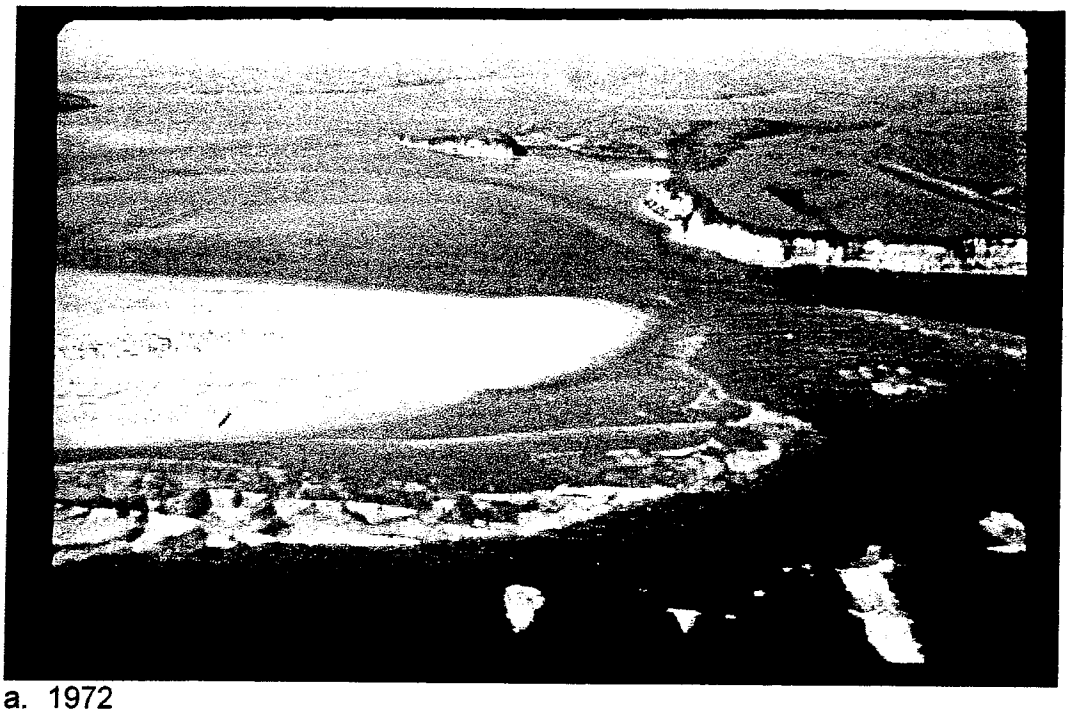
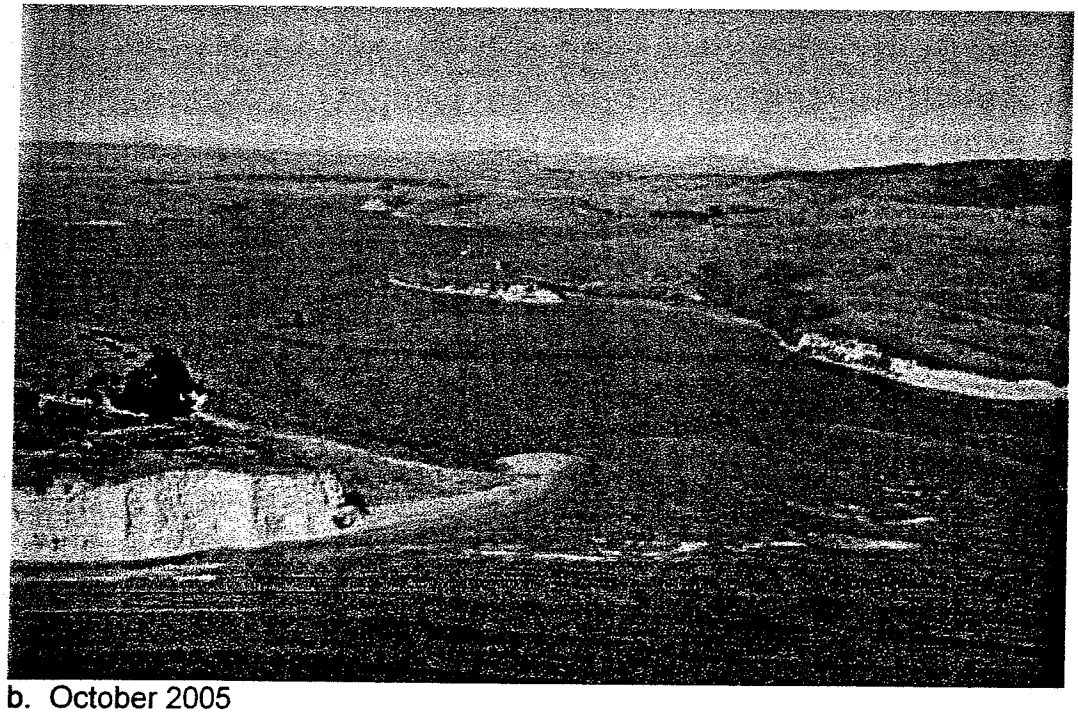


Figure 7. Aerial views of Drakes Estero mouth in 1972 and 2005.



a. 1972



b. October 2005

Figure 8. Averaged monthly rainfall totals. Error bars are standard deviation.

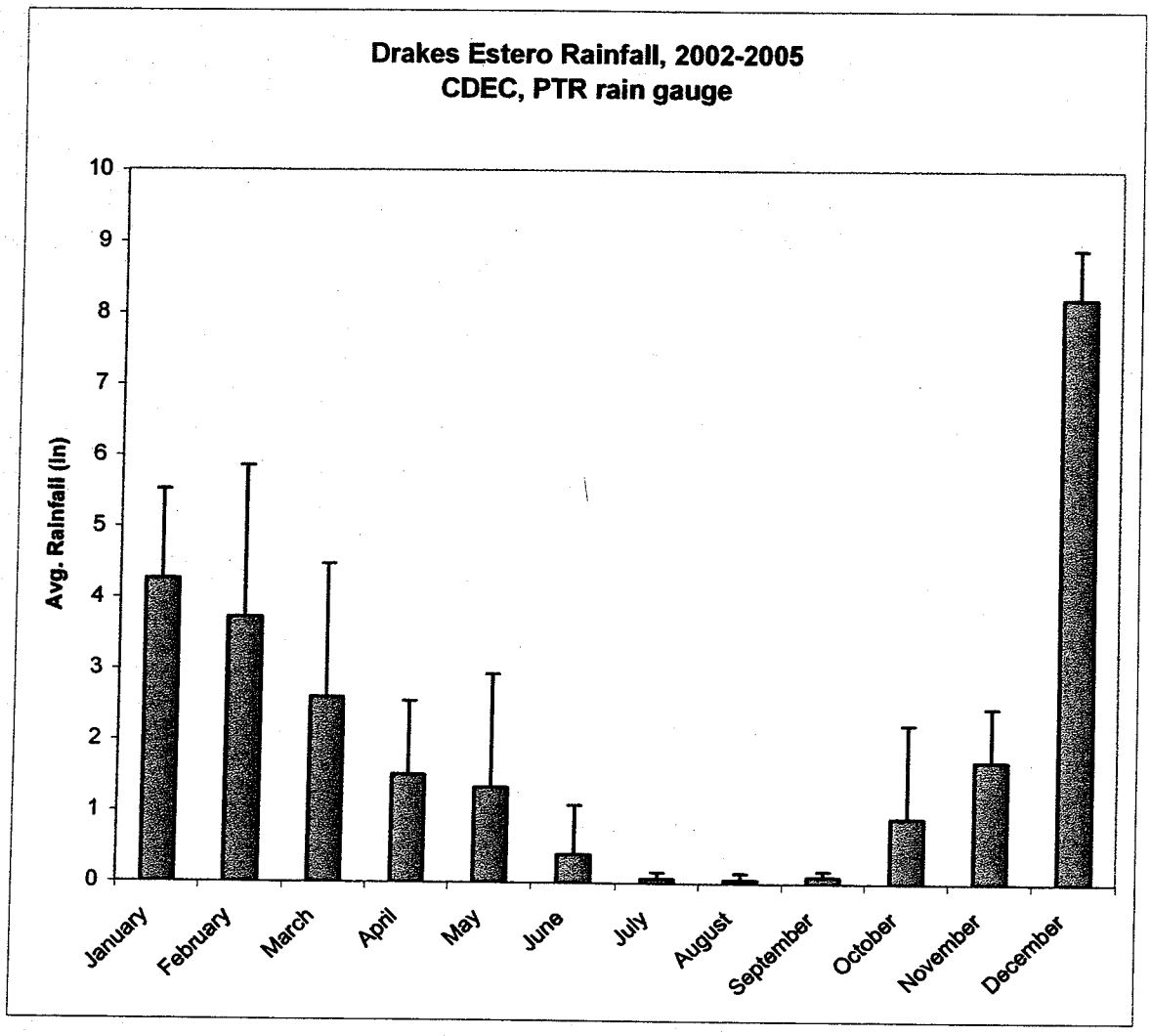


Figure 9. Summary of fecal coliform concentrations during open, open and closed and closed conditions.

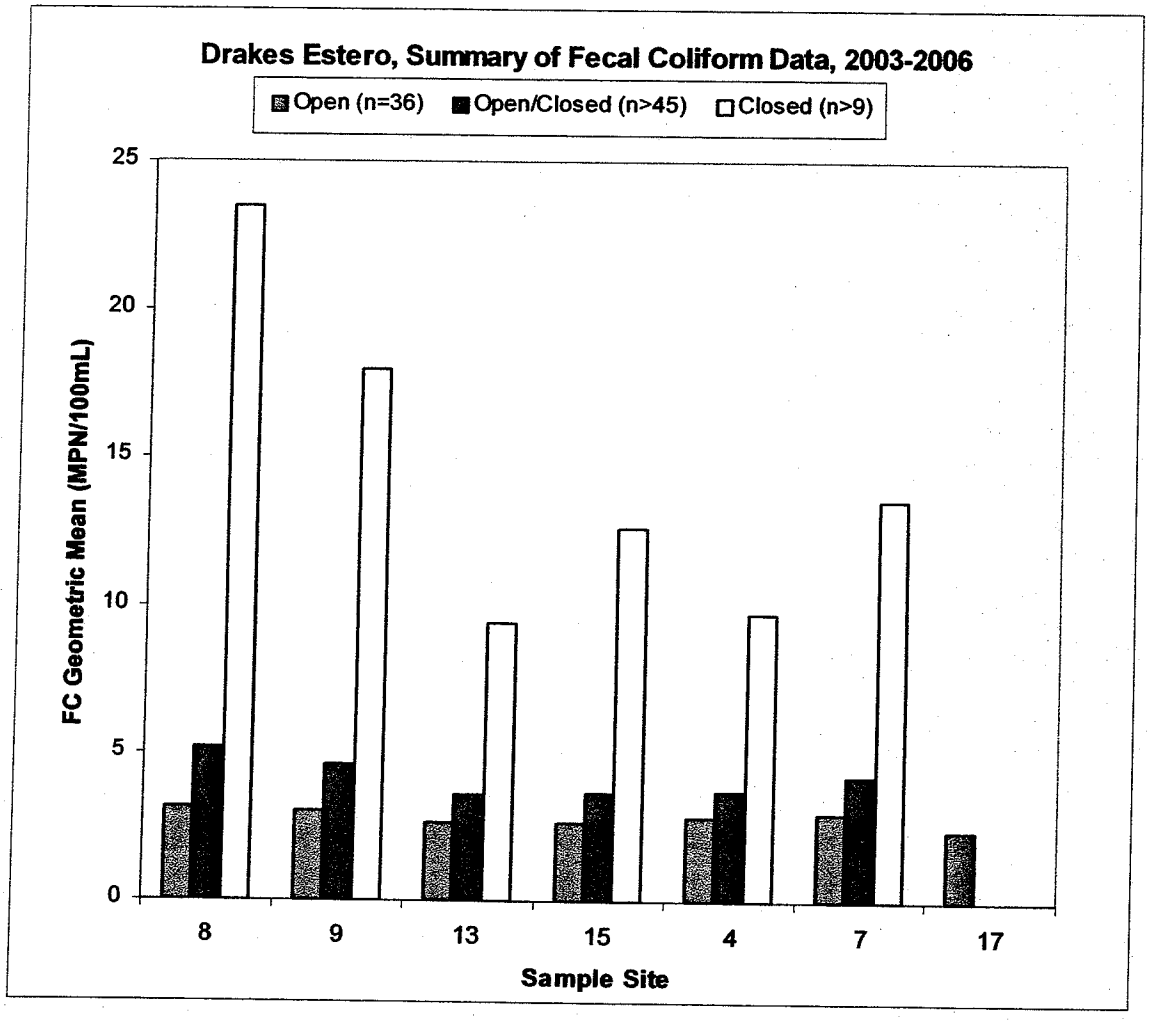


Figure 10. Running ninetieth percentile from 1994-2006 for Home Bay (WQ 7), Estero body (WQ 13), Barries Bay (WQ 4) and Schooner Bay (WQ 8). NSSP standard of 43 MPN shown in red for reference.

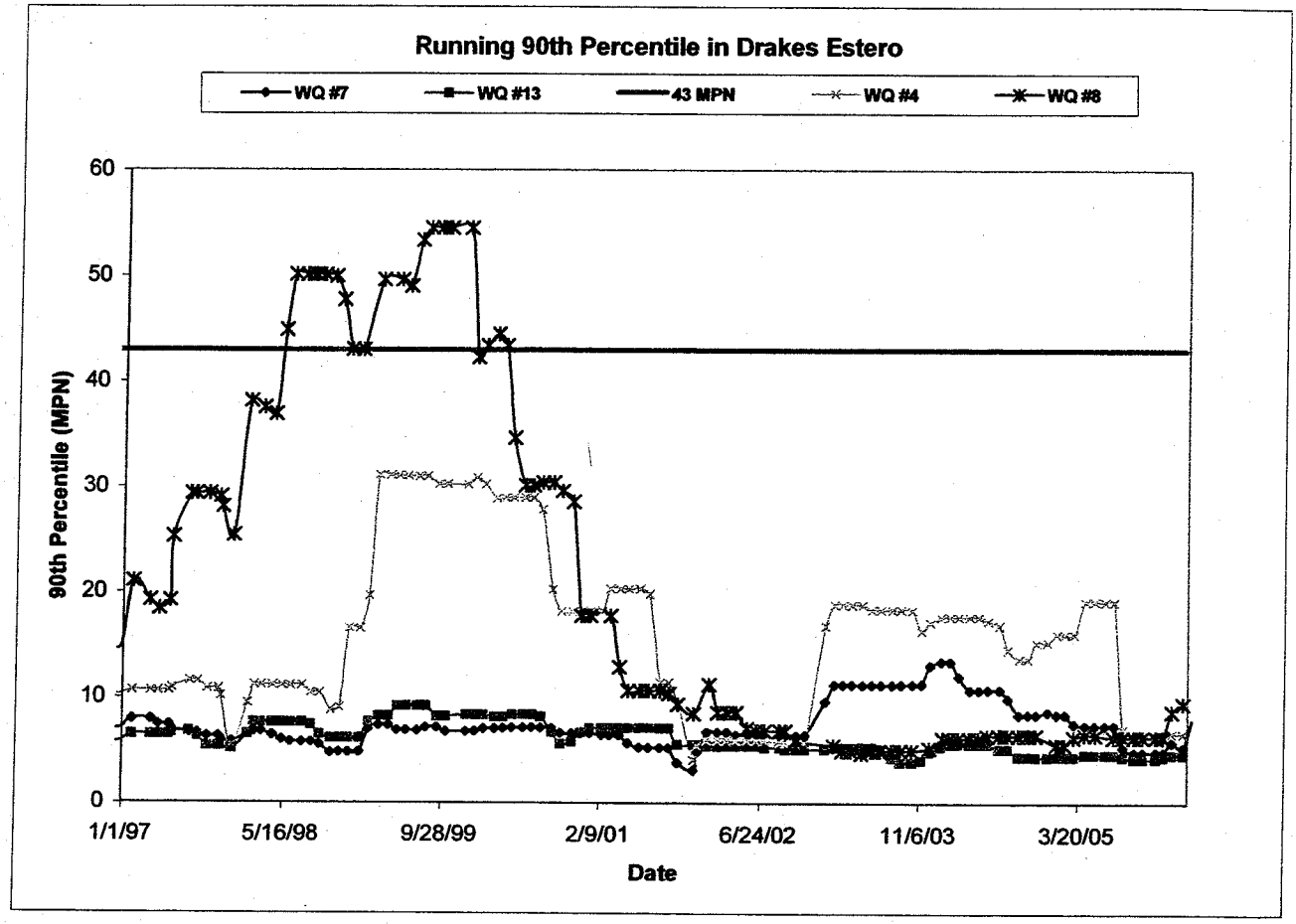


Figure 11. Average fecal coliform concentrations in Inner Schooner Bay (WQ 8) and Estero body (WQ 13), both open and closed samples considered, 1994- June 2006.