# Point Reyes National Seashore

# Drakes Estero

*Photo © Robert Campbell*

*The waters of Drakes Estero were designated by Congress as potential wilderness by the 1976 Point Reyes Wilderness Act (Public Law 94-544). It designated 25,370 acres as wilderness, and 8,002 acres of potential wilderness. This is the only federal marine coastal wilderness from Washington State to the Mexican Border. Only 11 marine wilderness areas exist in the US.*

***July 27, 2007; Version 3***

# Drakes Estero

## *A Sheltered Wilderness Estuary*

### Background

Drakes Estero is a two thousand acre estuary within Point Reyes National Seashore, established in 1962. The estuary is the only coastal estuary with special congressional designation as wilderness in the western United States, south of Alaska. The estuary was recently designated a Western Hemisphere Shorebird Reserve Network (WHSRN), a site of Regional Importance in the U.S. Shorebird Conservation Plan because it is important to a great diversity and abundance of shorebirds. A portion of the estero is currently managed as Wilderness and the remainder is potential wilderness, all of which Congress mandated to be fully managed in accordance with the provisions of the (Public Law 94-544). Drakes Estero is adjacent to Estero de Limantour, a State Ecological Marine Reserve, established in 1974 by the California Department of Fish and Game. Coastal scrub and grassland habitat surrounds the estuary, and the only current human activities on, or adjacent, to the estuary include recreation, cattle/dairy grazing and oyster farming.

At the time of purchase in 1972, the National Seashore provided a 40 year Reservation of Use and Occupancy Agreement to Johnson's Oyster Company (JOC). The agreement allows for use of a park site for oyster processing, but requires compliance with local, state, and federal laws and regulations. The agreement expires in 2012. In 2005, the JOC sold the reservation of use interest to the Drakes Bay Oyster Company (DBOC). At the time of the sale, the NPS notified DBOC that the reservation of use would expire in 2012.

The waters of Drakes Estero were designated by Congress as potential wilderness by the 1976 Point Reyes Wilderness Act (Public Law 94-544). It designated 25,370 acres as wilderness, and 8,002 acres of potential wilderness. The legislative history (House Report 94-1680) indicates Congressional intent: "it is the intention that those lands and waters designated as potential wilderness, to the extent possible, with efforts to steadily continue to remove all obstacles to the eventual conversion of these land and waters to wilderness status." This is the only federal marine coastal wilderness along the Pacific coast from Washington to the Mexican Border. Only 11 marine wilderness areas exist in the US. The General Management Plan (GMP, 1980) designates the estuary as wilderness, where no mechanized equipment or development may occur.

*The need for wilderness and the refuge it offers to Americans will only increase with the passage of time. Our generation of Americans has an obligation to preserve for future generations more areas that qualify for wilderness designation."*

*--Theodore Roosevelt IV*

Approximately 1,000 acres of the estuary is used by DBOC for oyster cultivation under a lease by the California Department of Fish and Game (CDFG). The ocean floor was ceded by the State of California to the National Park Service, except for the "right to fish", which does not include mariculture. The estuary floor is thus owned by Point Reyes National Seashore which is the primary management authority within the estuary. This primary authority was reaffirmed in a May 2007 letter from CDFG to NPS.

The 2001 NPS Management Policies direct staff to actively seek to remove from potential wilderness the temporary, non-conforming conditions that preclude wilderness designation (6.3.1 Wilderness Resource Management). Moving from Congressionally authorized potential to full wilderness status is an administrative action that only requires publishing a notice in the Federal Register.

Point Reyes legislation also stipulates that "No freehold, leasehold, or lesser interest in any lands hereafter acquired within the boundaries of Point Reyes National Seashore shall be conveyed for residential or commercial purposes except for public accommodations, facilities, and services provided pursuant to the Act of October 9, 1953."

The activities of Johnson's Oyster Company (JOC) produced many adjudicated environmental problems. As a condition of a stipulated agreement (Marin County Superior Court No. 165361, March 1997), JOC was ordered to complete several actions, including obtaining building permits and upgrading facilities and septic systems to meet state and county code requirements. DBOC is in the process of upgrading the facilities but is still under a Cease and Desist Order from the California Coastal Commission. Under this order, DBOC is required to obtain a permit from the California Coastal Commission for the facilities, and is currently undergoing this process.

*Oyster bags that cover the shoreline at Bull Point*

*"Wilderness is a resource which can shrink but not grow. Invasions can be arrested or modified in a manner to keep an area usable either for recreation, or for science or for wildlife, but the creation of new wilderness in the full sense of the word is impossible."*

*--Aldo Leopold, Sand County Almanac*

**Point Reyes enabling legislation indicates that natural environment will be the park's first priority.**

*"the property acquired by the Secretary under such sections shall be administered by the Secretary without impairment of its natural values, in a manner which provides for such recreational, educational, historic preservation, interpretation, and scientific research opportunities as are consistent with, based upon, and supportive of the maximum protection, restoration, and preservation of the natural environment within the area . . . .* (16 USC Sec. 459c; Enabling Legislation for Point Reyes National Seashore)

## Ecology of the Estuary

An ecosystem consists of interactions of plants, animals, and microorganisms with their physical (e.g., soil conditions and processes) and climatic conditions. The primary natural processes that drive the ecological function of any estuary, including Drakes Estero, are the terrestrial hydrology (the timing and amounts of freshwater inputs), sedimentation from land and sea, terrestrial nutrient loading, and coastal shoreline change from tides, storms and sea level rise. The presence and abundance of plants and animals are based on their ability to adapt to these processes and persist in microhabitats within the larger estuary.

Drakes Estero complex (including Estero de Limantour) is a large, convoluted coastal estuary with one narrow, unobstructed opening to the open ocean on Drakes Bay. Shaped like a hand, the estuary consists of five fingers that feed into a 1,300 acre central bay; the estuary reaches a total area of 2,270 acres at the highest tides. Geologically, the estuary is recognized as a system of drowned river valleys invaded by the sea. Sea level rise following the Late Pleistocene glacial period formed the contemporary estuary by 6,000 years ago. The depth is mostly shallow, less than 6 feet deep, with a deeper channel (about 25 ft) that traverses the main bay. Intertidal sand and mud flats exposed at low tide make up approximately 1,200 acres of the estuary (Anima 1991). The estuary is surrounded by low bluffs composed of the Drakes Bay Formation which includes fine-grained siltstone embedded with mudstone (Galloway 1977). The bay is protected from ocean wave action by the sand spits of Drakes and Limantour Beaches (Mudie and Byrne 1980).

Tidal exchanges occur through a narrow inlet that is 21 feet deep. Tidal exchanges are cycled completely with a tidal bore that travels the length of the estero to Bull Point; however, exchanges are less complete in the fingers of the estero. The deepest point is 25 feet at the first bend along the major channel from the entrance. The tidal range is around nine feet from -2 to +7 feet with current speeds ranging from 32 cm/sec to 46 cm/sec. Because the estuary is mostly shallow, the water column is well mixed from wind and tides, resulting in a mostly homogenous saline level. Salinity ranges measured in 1987-88 varied little between the upper and lower reaches of the estuary (33.7-34.36 ppt; Anima 1990).

*Wilderness areas only comprise about 2.5 percent of all the land in the lower forty-eight states. Drakes Estero is the only bay wilderness on the Pacific coast south of Alaska*

The sediments of the outer estuary near the mouth consist mostly of sand from the long shore transport of sand from Drakes Bay, and the overtopping by tides and storms of the sandspits near the mouth. Rocky bottom is limited to the deep channels at the seaward part of the estuary near the mouth; no boulders were found in cores taken within the estero (Anima 1991 and Harbin-Ireland 2004). Pebble and cobble stones are limited to a few places along the shoreline in parts of Estero de Limantour, along bluffs in the main part of the bay and along the east shoreline in Home Bay.

*Drakes Estero from the air looking towards Point Reyes headlands showing extensive eel grass beds. Photo © Robert Campbell*

Within Drakes Estero, natural sediment and nutrient loading is relatively moderate and attributed to shifting sand bars and decomposed granite from streams. Tides and storm waves are an important source for sediment transport at the mouth of the estero, and streams are an important source in the upper reaches of the estero. Freshwater feeds into the estero from six perennial streams and four ephemeral streams/springs that drain the small watersheds surrounding the 7,847 acre estuary. The water quality throughout the estuary, as measured by the presence of coliform, is well within the safe established limits measured by the California Department of Public Health (NPS report 2006). Home Bay had a spike of elevated coliform counts one year, when a septic system failed, but this septic system was replaced by the Seashore in 2006. Ranching in the watershed is limited to grazing by approximately 1,000 beef cattle

managed by five separate ranches. None of Point Reyes' dairy ranches are within the Drakes Estero watershed.

Within Drakes Estero, there are several distinct, natural habitats. Along the shoreline, the dominant habitats are mudstone and sandstone flats (as occur at Bull Point), mudflats along the inner finger bays and sand flats near the mouth. The size and number of marshes are limited within the estero, but of that limited vegetation, Pickleweed (*Salicornia virginica*), arrow-grass (*Triglochin maritima*) and saltgrass (*Distichlis spicata*) are the dominant native species. Within the estuarine waters, dominant habitats include mudflats and sand flats exposed at low tides, eelgrass beds, and soft-bottom substrate. Cobble and hard substrate is limited towards the mouth of the estuary, and a sandstone shelf at Bull Point. Each habitat supports distinct communities. The dominant plants and animals of the estuary that are major drivers of the estuarine ecosystem include eel grass beds, invertebrates in the soft-bottom sediment, estuarine fish, migratory waterbirds and shorebirds, and harbor seals.

Eelgrass beds are highly significant to the ecological function of the estuary because they provide cover, food and a nursery habitat for fish and invertebrates. The eelgrass beds of Drakes Estero include around 740 acres, 355 acres of dense and 385 acres of patchy eelgrass, representing around 36% of the estuary (NPS GIS data, 2007). There has been an expansion of the eelgrass within the estero since a survey was conducted in 1991, coinciding with but not necessarily related to a reduction in the amount of oysters harvested within the estero between 1997 and 2003 (Tom Moore, CDFG biologist, oyster production data). Several marine species spend their larval and juvenile stages in eelgrass beds such as lingcod, English sole, speckled sanddab, several species of nearshore rockfish, and Dungeness crab. Large, eelgrass beds are found in only a few estuaries in California and many species are entirely dependent on them for a part of their life cycle. For example, many species such as Pacific herring, bay pipefish, gammarid and caprellid amphipods, the sea hare (*Phyllaplysia taylori*), and several shrimp species that occur in Drakes Estero are directly dependent on eelgrass beds. The Coastal Commission provides special protection to eelgrass beds in California and eelgrass beds are described by NOAA as a component of Essential Fish Habitat for steelhead trout and Coho salmon, both protected species under the Endangered Species Act (Magnuson Stevens Fisheries Management Act; http://swr.ucsd.edu/efh.htm).

The native invertebrates of Drakes Estero are primarily species adapted to soft-bottom sediment and eelgrass beds, and rarely include the common species found in rocky intertidal habitats around Point Reyes, such as limpets, chitons, and mussels. In Drakes Estero, the dominant species that filter feed phytoplankton from the water column are bivalves such as *Nutricola* sp., Washington clams (*Saxidomus nuttalli*), gaper clams (*Tresus capax*), and rock-boring piddock clams at Bull Point and the mouth of the Estero. In addition, predominantly deposit-feeding *Macoma* clams are found in densities up to 250 per square meter in the outer, sandy tidal flats of Drakes Estero. Additional dominant benthic invertebrates include tanaid crustaceans (*Leptochelia dubia*), cumaceans (*Cumella vulgaris*), phoronids (*Phoronopsis viridis*), shore crabs (*Hemigrapsus oregonensis*), gammarid amphipods, polychaete worms, and ostracods (Harbin-Ireland 2004, Press 2005). Native limpets, oysters, mussels and chitons have never been abundant in the esteros due to the lack of rocky substrate, except towards the mouth of the estero.

Approximately 60 fish species have been documented in the area (Miller 1972, Wechsler 2004, D. Jacobs, unpubl. data). A recent study identified 35 species from 20 families. Five species were dominant and represented 89% of the fish assemblage, including topsmelt, three-spined stickleback, staghorn sculpin, bay pipefish, and kelp surfperch (Wechsler 2004). Steelhead trout, a federally protected species, were documented in a tributary to Schooner Bay in the late 1990s.

The bird life in Drakes Estero and Estero de Limantour is highly diverse and abundant, and the esteros are recognized as significant sites for bird conservation. The Fish and Wildlife Service recognized Drakes Estero as a Western Hemisphere Shorebird Reserve and as significant for the conservation of shorebirds in the Southern Pacific Shorebird Conservation Plan. The maximum population of all shorebirds combined was estimated at between 10,000 and 100,000, and the estero regularly holds thousands of shorebirds in winter (Hickey et al. 2003; http://www.waterbirdconservation.org/). A similar designation is pending for waterbirds.

*Brown pelican and marbled godwits. Photos © Rich Stallcup.*

PRBO Conservation Science identified around 100 species of waterbirds and shorebirds during winter surveys in the 1980s and 1997-99 (White 1999). PRBO Conservation Science and NPS biologists identified several federally threatened, endangered, or species of special concern such as Osprey, White Pelican, Brown Pelican, Peregrine Falcon, Black Brant, and Western Snowy Plover. During the late summer and fall, shorebirds and waterbirds arrive and stay in the estero throughout the winter months to feed and rest.

*The bird life in Drakes Estero is highly diverse and abundant, and as a consequence, the estero is recognized as a significant site for conservation.*

From the summer through December, hundreds to thousands of Brown Pelicans, a federally protected species, congregate at the esteros, feeding on schooling fish such as anchovies, herring and smelt, and resting on tidal mudflats. Other species that occur in large numbers are Caspian Terns, Gadwall, Ruddy Duck, American Widgeon, Bufflehead, and Green-winged Teal, Western and Least Sandpiper, Dunlin and Black-bellied Plover. In the past 15 years, an egret colony formed near the mouth of the estero where Snowy Egrets, Great Egrets, and Great Blue Herons nest. In the past, Snowy Plovers nested at the mouth of the estero, but have not since the late 1990s due to predation, changes in habitat and disturbance.

*A flock of marbled godwits and willets. The waters and shoreline of the estuary provide a home to over a 100 species of birds. Photo © Rich Stallcup.*

Harbor seals are the only year-round, resident marine mammal in the estero. Other marine mammals that occur intermittently include California sea lions and northern elephant seals. The narrow mouth of the estero is restrictive to larger marine mammals; although, several dead whales have washed into and deposited at the mouth of the estero including an adult male sperm whale in 2004. The harbor seal population within the estero is one of the largest concentrations in California, annually producing between 300 and 500 pups, and reaching a maximum of nearly 2,000 seals during the breeding and molt seasons (Allen et al. 2004). Drakes Estero is the largest seal colony in Marin County and one of only five major seal colonies at Point Reyes. All together, the Marin County colonies represent around 20% of the state mainland population of harbor seals (Allen et al. 2004). Some of the seals that breed in the estero range nearly 500 km north as far as the Smith River in the winter months but return to Drakes Estero to breed (Allen 1988). The colony at Drakes Estero has grown significantly over the past 20 years, in part likely because the park implemented a seasonal closure to all boats during the pupping season and because the oyster company reduced operations in the outer and middle areas of the estero (Vanderhoof and Allen 2005).

*Harbor seals resting on sandbars. Photo by Jamie Hall.*

*Overlooking the harbor seal haul out sites in Drakes Estero.*

*Drakes Estero is one of only 5 major seal colonies in Point Reyes and together the colonies represent around 20% of the state mainland population of harbor seals, the highest concentration in the state (Allen et al. 2004).*

## Human Activities and Changes to Ecological Function

Ocean health globally is in dire condition according to a recent publication in the Journal Science (Worm et al. 2006), and if the long-term trend continues, the majority of harvested fish species are projected to collapse within the next 50 years. Already, the researchers found that 90 percent of all the fish and seafood species in the world's oceans have been depleted over the past 60 years as harvesting has steadily increased. Seven percent of the fish in several studies already have become extinct. Significantly, less than 1% of the global ocean is effectively protected from harvesting. Despite inclusion in this 1%, most ocean parks are experiencing degradation, deterioration and extirpation of species. The loss of historic coastal wetlands has been more than 91% in California (Dahl 1990).

Ocean parks have been degraded by habitat alterations that have had a cascading effect on ecosystem function. Coastal waters have been degraded by water diversion, development, chemical and biological pollution, oil spills, and noise. Invasive non-native species have been introduced through bilge water, mariculture and some recreational activities that further degrade ecosystems and water quality.

Specifically in Drakes Estero, the ecology has been altered over the past several decades due to activities associated with human activities including ranching and oyster farming. Other than the oyster operation, there is no development along the shores of the estuary.

*Oyster bags on sandbar in the middle of Drakes Estero.*

Sedimentation rates and the types of sediment have changed in Drakes Estero because of a combination of factors over the past 150 years. The streams that drain the watershed surrounding the estero were dammed by ranchers to create stock ponds for cattle, which reduced sediment input into the estero during winter rains. Oysters that are grown in Drakes Estero by the commercial oyster operation likely play an

important role in the deposition of fine-grained sediment, and in the trapping of sediment. The oyster operation presently has placed at least one thousand bags of oysters on top of intertidal mudflats and sandflats throughout the estuary, and there are 93 racks located on mudflats and open water channels. In other estuaries, mariculture bags and racks have been documented to trap fine particulate sediment resulting in an alteration of the hydrology and substrate type due to the placement of the cultivated species and related racks. Research in other estuaries has found that the deposition of oyster feces tends to be focused below and around mariculture structures (Cranford et al. 2003; Porter et al. 2004, Everett et al. 1995). Within Drakes Estero, USGS (Anima 1990) noted that oyster racks may act as a "baffle to tidal currents where rack density is highest …silt material accumulates on the leeward side of stacked oyster beds." Anima (1991) reported that the oyster operation likely played "an important role" in the sedimentation of Drakes Estero with oyster pseudofeces contributing to the amount of fine-grained sediment. Anima (1991) also noted that the sediment material is likely resistant to erosion because oyster racks are located in the upper reaches of the estero where tidal action is lowest. A graduate study in 2001, did not detect effects of oyster cultivation on sediment organic matter, but did indicate that some sediment erosion may be taking place due to the presence of the rack structures (Harbin-Ireland 2004). To determine the past and current effects of oyster operations on sedimentation rates within Drakes Estero requires a more focused and site specific study.

*Metal and plastic bags from oyster operations.*

Eelgrass is very sensitive to light, nutrients, pollution and sedimentation, and is thus an excellent indicator of estuarine health. Oyster farming reduces the amount of light available to eelgrass beds because of shading by racks, locally increases the amount of sedimentation due to deposition of oyster pseudo-feces and trapping sediment, and contributes pollution from treated construction materials and from general operations. One study in Florida indicated that native mussels may increase seagrass productivity (Peterson and Heck 1999), however, a study by Oregon State University of non-native oysters in Coos Bay, Oregon, a similar estuary to Drakes Estero, found through experimental tests that both stake and rack oyster culture (rack culture is practiced in Drakes Estero) reduced submerged aquatic vegetation by 25% after one year (Everett et al. 1995). Their findings were attributed to increased sedimentation and disturbance during placement and harvest of stakes, and increased shading and erosion

under racks. Everett et al. (1995) concluded that there was the potential for significant loss of submerged aquatic vegetation due to oyster culture. Although this study occurred in Oregon, the study focused on the same species and similar methods used in Drakes Estero. Two studies conducted in Drakes Estero by UC Davis researchers working in co-operation with the NPS, qualitatively noted that eelgrass growth was severely restricted under active oyster racks (Harbin-Ireland 2004, Wechsler 2004).

In 2003, Wechsler noted that 38 oyster racks were in operation, which would affect 5,700 square meters (1.5 acres) of affected eelgrass cover. A resurvey of the racks by NPS scientists in 2007 found that the number of active racks had increased by 66%, to a total of 63 active racks. There are a total of 93 oyster racks in varying states of integrity in Drakes Estero (NPS Trip Report March 13, 2007). A total of 89 of the 93 racks were either surrounded by or in eelgrass beds, but no usable racks and very few dilapidated racks had eelgrass growth underneath. Several of the dilapidated racks with no mariculture cultivation had some eelgrass regrowth. There were 8 acres of active oyster racks within eelgrass beds that had no eelgrass growth underneath.

In total, all oyster growing activity within the estero covers ~18 acres. However, recent aerial images indicate the impact is much larger, approaching 50 acres. Numerous channels cut into the eelgrass by boat propellers affect a much larger area, and frequent disturbance by boat traffic may significantly alter eelgrass coverage. The long-term effects, if any, from this impact need further study.

*Extensive outboard motor cuts in the eelgrass. Image taken 5/6/2007. (photo by Robert Campbell).*

*Didemnum infestation at Bull Point, May 2007.*

*Extensive outboard motor cuts in the eelgrass. Image taken 5/6/2007 (photo by Robert Campbell).*

Dense assemblages of oysters may reduce recruitment of other species with a planktonic larval stage and reduce plankton in the water column by filter-feeding. This feeding may limit the amount of food available to native bivalves and ostracods. A preliminary study found that clam abundance was reduced under oyster racks, possibly due to changes in bottom sediment grain-size, particulate organics that contribute to higher sulfide levels, or increased predation by fish and decapod crustaceans attracted to the oyster racks (Harbin-Ireland 2004). In one area of Drakes Estero where no oyster farming occurred, clams were found in extremely high densities - up to 250 per square meter; however, there was no evidence that the numbers were higher because of the absence of farmed oysters there (Press 2005).

More recently, Dr. Grosholz of University of California, Davis, provided expert opinion that addressed the potential effects of the oyster bags (Letters to NPS May 6, 2007 and July 15, 2007). He stated that "There is likely to be immediate impacts, mostly negative, on suspension feeders and surface deposit feeders immediately under the bags due to increased sedimentation, physical obstruction, decreased particle size and associated increased hypoxia. There may be positive effects for species requiring hard substrate for attachment." No studies to date have investigated the effects of the oyster bags on the underlying native marine invertebrate community, and more data are necessary to draw meaningful conclusions or to detect trends regarding potential effects of bags and racks on the invertebrate community.

*Oyster racks create habitat in the estero by acting as a hard surface substrate in an ecosystem composed of predominantly soft-bottom substrate. This direct change in habitat substrate significantly alters the native species composition and abundance, and provides habitat for non-native species.*

A recent California Department of Fish and Game Report (March 2007) indicated that the estuary now holds approximately 9,000,000 individual non-native oysters and 1,000,000 non-native Manila clams. This species of oyster generally filters ~ 50g/day, thus 450,000,000 gallons of water may be filtered by the non-native oysters in the bay, potentially depriving native species of these planktonic resources. While Drakes Estero likely receives much of its plankton with the daily ocean tides, the impact of the numerous non-native bivalves has not been adequately assessed.

Disturbance and displacment of wildlife by oyster farming activities have been documented at Drakes Estero and elsewhere. Kelly et al. (1996) documented how oyster racks influenced shorebird use of tidal flats in Tomales Bay by enhancing feeding opportunities and food for some species, such as gulls and willets, while decreasing them for others, such as dunlin. Additionally, the bags may create an anoxic zone by sedimentation and sequestering of oyster feces into the sediment under the bags, severely stressing the native invertebrate community beneath (Dr. Janet Thompson, USGS, pers. comm.); consequently, there would likely be less food available in the mud for birds to feed on. Currently, there are over a thousand oyster bags on mudflats in Drakes Estero, and the number of shorebird species and their distribution may be affected (Kelly et al. 1996).

*Dilapidated oyster racks within Drakes Estero.*

Harbor seals have been directly affected by oyster operations in the 1970s-1990s because of disturbance to seals resting onshore; and seals have been affected by placement of oyster bags on tidal sandbars where they rest and pup (Allen, pers. comm.). Seal haul out sites in the upper estero are more important to pupping seals than those at the mouth (Allen 1988), so mothers with pups tended to be disproportionately disturbed when disturbance was caused by the oyster operation. During the early 1980s, seals at Drakes Estero were disturbed on 29% of the days surveyed; primary sources for disturbance were fishermen (38%) and boats (28%) (Allen and Huber 1984). Kayaks were restricted during the breeding season (March-June) in 1995 and the oyster activity declined significantly in the 1990s. Consequently, the number of disturbances declined within the estero from both the oyster operation and kayaks (Allen et al. 2004). During the breeding season, researchers observed seals disturbed by motor boats several times in 1997 and once between 1998 and 2001.

Since March 2007, park biologists have documented oyster boats disturbing mothers with pups, and they noted that hundreds of oyster bags were located on or adjacent to sandbars where seals would normally give birth and nurse their pups. Two oyster bag arrays (approximately 5 acres) were within a regular harbor seal haul out site, and one other oyster bag site was within 50 meters of a regular harbor seal haul out site (NPS Trip Reports April 13 and 26, 2007).

Non-native species can have profound effects on ecosystems by changing ecosystem structure, function, species abundance, and community composition. The introduction of non-native, invasive species by oyster operations has been documented for decades in Marin County (Bonnot 1935, Carlton 1992, Cohen and Carlton 1998) and is a major concern (California Department of Fish and Game 2001). Carlton (1992) summarized the introduction of > 25 non-native species of mollusk into estuaries in the Pacific by oyster operations. Hard structures used to cultivate oysters provide habitat that would not otherwise exist, supporting non-native invertebrates (Tyrrell and Byers 2007). Examples of non-native species introduced into Drakes Estero include gem clam, green crab, slipper snail, Japanese oyster drill, Atlantic oyster drill and *Batillaria attramentaria.* The non-native *Batillaria*, a gastropod, was introduced with Japanese oysters to California and was documented to displace the native confamillial species in northern California (Byers 1999). This invasive gastropod was found in Drakes Estero (Byers 1999). Researchers recently documented that an invasive trematode parasite hitchhiked on the Japanese *Batillaria*, and that this parasite had infected birds and fish in North America (Science Daily December 2006). No studies have been specifically conducted to confirm the presence of the parasite in Drakes Estero.

A recent preliminary study examined the sessile marine invertebrates that grow upon the oysters and oyster racks in Drakes Estero. Elliott-Fisk et al. (2005) noted that "the marine invertebrate fouling community of sessile organisms could be properly characterized as "introduced" and "invasive" due to lack of hard, shallow water substrate in Drakes Estero. This community is present and associated with the oyster farming operation in Schooner Bay, but nearly non-existent in Estero de Limantour."

One, invasive, non-native species found on oyster farming structures in Drakes Estero was the colonial tunicate (*Didemnum* species A.). A recent study described how the species has spread rapidly on both the east and west coasts of North America by larval

settlement and fragmentation (Bullard et al. 2007a). This invasive could affect Drakes Estero's natural ecology and may provide a source of larvae and fragments that would facilitate spread of the species to other areas. This species has had substantial ecosystem and financial impacts in New Zealand, several west coast estuaries and the Grand Banks off Newfoundland. The San Francisco Estuary Institute noted that "In the Northwest Atlantic, a closely related species has covered 50-90% of the George's Bank. Such coverage can smother organisms living on the bottom and in the sediment, and block the settlement of larvae" (http://www.sfei.org/). In Drakes Estero, surveys in 2007 showed that many of the apparently older and larger oysters on the racks had extensive *Didemnum* growing on them, and a small infestation of the species was found on natural mudstone habitat at Bull Point (NPS Trip Report March 20, 2007). Additionally, current culture methods that involve scraping off the tunicate from culture apparatus may result in the release of large numbers of fragments into the estuary (Dr. Edwin Grosholz, UC Davis, Letter to the California Fish and Game Commission, June 1, 2007). In a laboratory study, Bullard et al. (2007b) demonstrated that damaged and torn fragments of *Didemnum* could survive and reattach to other substrates. Removal of oyster racks in Drakes Estero would greatly reduce habitat for this invasive species.

In conclusion, most scientific articles and experts in the field of marine ecology indicate that oyster farming in Drakes Estero likely would negatively affect the estero ecology, and point to the need for further research. A recent review article by Ruesink et al. (2005) summarized mariculture effects from around the world and reported that "oysters are ecosystem engineers that influence many ecological processes, such as maintenance of biodiversity, population and food web dynamics and nutrient cycling." Some significant effects have been identified already in Drakes Estero and point to the need for further research.

*Harbor seals resting on sand bar. Photo by Jamie Hall.*

## Synopsis of Drakes Estero

### Natural Resource Significance

- Only congressionally designated coastal bay wilderness area in the western United States, south of Alaska.
- Adjacent Estero de Limantour is a recognized as a Marine Protected Area by the state of California.
- One of only a few sites with significant eelgrass beds which are specially protected by California and critical for many species, including spawning fish, over-wintering birds and invertebrates.
- A Western Hemisphere Shorebird Reserve Network, identified as significant for the conservation of shorebirds in the Southern Pacific Shorebird Conservation Plan.
- PRBO identified around 100 species of birds during winter surveys, including several listed species or species of special concern such as Osprey, White Pelican, Brown Pelican, Peregrine Falcon, and Black Brant.
- The estuary is very important to over-wintering Black Brant that only migrate to a few places along the Pacific Flyway.
- The estero is important to resident and spawning fish where they are associated with eelgrass beds and benthic sediment. The federally listed steelhead trout spawns in the Schooner Bay tributary. NOAA identified the area as Essential Fish Habitat for federally listed salmonids.
- Harbor seal population is one of the largest in the state of California and the largest in Marin County, with up to 2,000 breeding/molting individuals and 300-500 pups, annually.

### Oyster farming impacts on the ecological communities

- Eelgrass beds are found in all suitable habitats within Drakes Estero, except beneath active oyster racks, where they do not exist due to shading and possibly other effects. In 2007, with 63 active oyster racks, this amounted to at least 8 acres of lost eelgrass cover. Approximately 50 additional acres were also affected, likely from boat propeller damage.
- Oysters that are grown in Drakes Estero likely play an important role in the deposition of fine-grained sediment, and in the trapping of sediment.
- Oyster racks and bags provide structural habitat that does not naturally occur in the estero except in limited areas. The equipment and structures may change the community composition and abundance of species and provide habitat for invasive, non-native species.
    - Invasive organisms were found on the hard substrates provided by the oysters and oyster racks in Schooner Bay.
    - The invasive non-native species, *Didemnum* sp. A, is commonly present on oyster racks and was discovered on natural habitat within the estero. Oyster processing methods have the potential to spread *Didemnum* by creating large numbers of fragments that can colonize new areas.
- The oyster operation is a potential source for invasive species because non-native species may hitchhike on oysters and equipment that are brought to the estero.
- Placement of oyster bags and racks in intertidal mudflats and sand bars displace wildlife such as shorebirds, black brant and harbor seals because of spatial coverage of racks and bags, and disturbance by oyster operations.

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*Douglas iris near the mouth of Drakes Estero. © Susan Van Der Wal.*

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*"...without impairment of its natural values, in a manner which provides for such recreational, educational, historic preservation, interpretation, and scientific research opportunities as are consistent with, based upon, and supportive of the maximum protection, restoration, and preservation of the natural environment within the area."*

P.L. 94-544 and 94-567 establishing the Point Reyes Wilderness

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*Aerial view of the mouth of Drakes Estero. © Alexandra Kruse*

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