**Park News**

National Park Service
U.S. Department of the Interior

# Point Reyes National Seashore

# Drakes Estero

*Photo © Robert Campbell*

## *A Sheltered Wilderness Estuary*

*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.*

# Drakes Estero

## *A Sheltered Wilderness Estuary*

### Background

Drakes Estero is within Point Reyes National Seashore, established in 1962. The estuary is the only coastal bay 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 that will be fully managed as Wilderness when a mariculture lease expires in 2012. 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 leasehold interest to the Drakes Bay Oyster Company (DBO). At the time of the sale, the NPS notified DBO that the lease 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 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*

The General Management Plan (GMP, 1980) designates the estuary as wilderness, where no mechanized equipment or development may occur.

The estuary area of approximately 1,000 acres is used by DBO 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." The estuary floor is thus owned by Point Reyes National Seashore.

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 only requiring 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."

*"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*

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. DBO is in the process of upgrading the facilities but is still under a Cease and Desist Order from the California Coastal Commission.

*Oyster bags that cover the shoreline at Bull Point.*

Under this order, DBO is required to obtain a permit from the California Coastal Commission for the facilities, but has not yet acquired a Coastal Development Permit for its activities.

DBO wishes to extend the lease past 2012; NPS has instructed DBO that the issuance of a new lease cannot be extended beyond 2012 because of the GMP, NPS Management Policies, and the enacted Wilderness legislation.

**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 eek out a living in microhabitats within the larger estuary.

Drakes Estero complex is a large, convoluted coastal estuary with one narrow, unobstructed opening to 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 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 1990). The estuary is surrounded by low bluffs composed of the Drakes Bay Formations 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).

The sediments of the outer estuary near the mouth consist mostly of sand, which is the long shore transport of sand in 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 1990 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.

*Wilderness areas only comprise about 2.5 percent of all the land in the lower forty-eight states.*

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 twelve feet from -6.0 to 6.6 feet with currents ranging between 32 cm/sec to 46 cm/sec (Anima 1990). 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 (33.67-34.356 ppt; Anima 1990).

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

In Drakes Estero, natural sediment and nutrient loading is relatively moderate and attributed to shifting sand bars and decomposed granite from streams. 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 when a septic system failed. This septic system, though, is being replaced by the Seashore in 2006. Ranching in the watershed is limited to grazing around 1000 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 sandstone flats (as occur at Bull Point), mudflats along the inner finger bays and sand flats near the mouth. Pickleweed (*Salicornia virginica*), arrow-grass (*Triglochin maritima*) and saltgrass (*Distichlis spicata*) are the dominant shoreline native vegetation; however, the size and number of marshes are limited. 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. 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 such as herring, 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 for fish and invertebrates. The eelgrass beds of Drakes Estero include around 642 acres, or 36% of the estuary. 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 (see Larson and Mello – www.dfg.ca.gov/local). 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, within Drakes Estero many species such as Pacific herring, bay pipefish, gammarid and caprellid amphipods, the sea slug (*Phyllaplysia taylori*), and several shrimp species are directly dependent on eelgrass beds.

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, mussels, and native oysters. 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, which filter-feed, 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 ostsracods (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. Currently, there is a modest number of invasive invertebrate species in Drakes Estero relative to a highly urbanized estuary such as San Francisco Bay, such as green crabs (*Carcinus maenas*).

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 (Elliott-Fisk et al. 2005, 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 identified over 100 species of waterbirds and shorebirds during winter surveys in the 1980s and 1997-99 (White 1999), and 86 species of birds at Drake's Cove during 2004, with counts of Buffleheads, Ruddy Ducks, Western Sandpipers, Least Sandpipers, and Dunlin numbering over 1000 individuals. PRBO and NPS biologists identified several federal threatened, endangered, or species of special concern such as Osprey, White Pelican, Brown Pelican, Peregrine Falcon, Black Brant, Western Snowy Plover and Marbled Murrelet. 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.*

The estero is one of only a few locations where thousands of Black Brant over-winter where they rest and feed on eelgrass (Shuford et al. 1989). "Brant is a holarctic species (it has populations in boreal regions all around the world) that nests on tundra near saltwater environments" (http://www.prbo.org/obs_cms). They are on the Audubon species Watch List because of their sensitivity to habitat loss. From the summer through December, hundreds to thousands of Brown Pelicans, a federally protected species, congregate at the esteros, feeding on large 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. 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 largest seal colony in Marin County and one of only five major seal colonies at Point Reyes. All together, the Marin County colonies represents around 20% of the state mainland population of harbor seals, and are the highest concentration of seals in California (Allen et al. 2004). 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 10 years, in part because

the park implemented a seasonal closure to kayaks during the pupping season and because JOC was operating at a reduced level in the mid-1990s (Vanderhoof and Allen 2005). The pup count in 1986 was 255 compared with 464 in 2004, an 82% increase.

*Harbor seals resting on mudflats. 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 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, all 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 within the past century. Seven percent of the fish in several studies already have become extinct. Significantly, less than 1 percent of the global ocean is effectively protected right now. Despite inclusion in this 1%, most ocean parks are experiencing degradation, deterioration and extirpation of species.

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, chemical and biological pollution, oil spills, and noise. Invasive non-native species have been introduced through bilge water, mariculture and recreational activities that further degrade ecosystems and water quality.

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

Sedimentation rates and types of material have changed because of a combination of factors over the past 150 years. The primary water arteries into the estuary were dammed by ranchers to create stock ponds for cattle. These impoundments reduce the flushing action of winter rains and the size of marshes at the stream mouths flowing into the esteros. The commercial oyster operation has also changed the type and rate of sedimentation where oyster equipment is located. The oyster operation included 1) stakes with plastic tubing that were embedded into intertidal mudflats, 2) bags that were placed on top of the intertidal mudflats, and 3) racks that were located on mudflats and open water channels. Oyster bags and racks have been documented in Drakes Estero and elsewhere to trap fine particulate sediment resulting in an alteration of hydrologic function and the type of substrate, and have integrated feces into the sediment below and around the structures (Anima 1990, Cranford et al. 2003, Porter et al. 2004). The reduced freshwater flushing from the watershed enables fine-grained sediments to build up within the estero around the oyster racks. USGS (Anima 1990) collected sediment cores from the estero and identified pseudo feces of oysters as the primary source for sediment fill, as has been seen in studies elsewhere. An estimate of 0.6 to 1.0 metric tons of fecal matter can be produced per year by a 60 meter square oyster raft. This sediment material is resistant to erosion because oyster racks are located in upper reaches of the estero where tidal action is lowest and the arrangement of the oyster racks acts as a "baffle to tidal currents where rack density is highest …silt material accumulates on the leeward side of stacked oyster beds (Anima 1990)."

*Affiliated debris found with oyster operations.*

*Metal and plastic bags from oyster operations.*

The ecology of the estero is altered by changes in hydrology and sedimentation, which in turn change habitats and their associated species. Eelgrass beds, for example, in Estero de Limantour where there is no oyster farming, had higher densities of standing stock, as measured by the number of turions and blades, compared to Drakes Estero (AMS 2002). Eel grass 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, 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 (trash). Researchers from Oregon State University found through experimental tests that both stake and rack culture (as practiced in Drakes

Estero) reduced submerged aquatic vegetation by 25% after one year. This was attributed to increased sedimentation and disturbance during placement and harvest of stakes, and increased shading and erosion under racks (Everett et al. 1995). They conclude that there is the potential for significant loss of submerged aquatic vegetation due to oyster culture. UC Davis researchers working in co-operation with the NPS have qualitatively noted that eelgrass growth is severely restricted under active oyster racks in Drake's Estero (Elliott-Fisk et al. 2005).

In 2003, Wechsler noted that 38 oyster racks were in operation, which would affect 5,700 square meters (nearly 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. On 03/13/2007, 63 racks were usable and had some mariculture activity (2 of which were recently repaired), 3 appeared usable but had no mariculture activity on that day, and 27 racks were so dilapidated that they are unlikely to be usable without repair. The unusable racks ranged from frames with no cross members for hanging oysters to merely a set of old posts.

A total of 89 of the 93 racks were in eelgrass beds, but no usable racks and very few dilapidated racks had eelgrass growth underneath. Seven of 27 dilapidated racks had some eelgrass regrowth, likely due to lack of mariculture on the racks. The area of racks within eelgrass beds but no eelgrass growth underneath oyster racks was 8 acres.

There are 12 areas where oyster bags are scattered in intertidal areas covering a total of approximately 10 acres (some site areas estimated from a distance). Since eelgrass does not grow in intertidal areas, these bag sites come up to the edge, but are not within eelgrass areas. There were also many anchored and floating oyster bag lines which were mapped. 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, however, no hauled out seals were sighted on this survey.

In total, all oyster growing activity covers ~18 acres in the estero. However, recent aerial images indicate the impact is much larger approaching 50 acres. Hundreds of channels cut into the eelgrass by boat propellers affect a much larger area. Frequent disturbance by boat traffic may significantly alter eelgrass coverage.

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

Most of the apparently older and larger oysters growing on racks had extensive non-native, highly invasive tunicates (*Didemnum* Species A) growing on them (See images). This species is an aggressive invader that has had substantial ecosystem and financial impacts in New Zealand, several west coast estuaries and the Grand Banks off Newfoundland. Other fouling organisms (native and non-native sponges, tunicates, bryozoans, and mussels) were observed on both oysters and racks throughout the estuary.

*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 limits the amount of food available to native bivalves and ostracods. Clam abundance is 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. In other parts of Drakes Estero, clams can be found in extremely high densities - up to 250 per square meter.

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. Oysters generally filter ~ 50g/day, thus 450,000,000 gallons of water may be filtered by the non-native oysters in the bay, depriving native species of these plankton resources. This is about 10 times the volume of a large oil tanker filtered every day. "The result of culturing bivalves in systems such as Drakes Estero is that there is a shift in the carbon from the pelagic food web to the benthic food web ….. we would also expect a shift in organic matter and nutrients to the bed. The pelagic to benthic shift can result in quite dramatic losses in the pelagic communities (zooplankton and fish) as have been seen with some exotic bivalve introductions (Zebra Mussel, Asian clam)" (Dr. Janet Thompson, a USGS benthic scientist, letter dated May 7, 2007).

*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.*

Wechsler (2004) detected few Pacific herring; even though this species was historically found in high numbers and spawns in eelgrass beds (Blunt 1984). D. Jacobs surveyed for tidewater goby, another federally listed species, throughout the seashore in the mid-1990s and did not find them in Drakes Estero, speculating that they may have been extirpated by the presence of predatory, non-native fish (D. Jacobs, pers. com.).

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 the dunlin. Additionally, the bags create an anoxic dead zone underneath by smothering native infauna and trapping sediment; consequently, there is less food available in the mud for birds to feed on. Currently, there are thousands of oyster bags on mudflats in Drakes Estero throughout the estero, and the number of shorebird species and their distributuion may be affected.

*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 racks on tidal sandbars where they rest and pup (Allen, pers. com.). Seal haul out sites in the upper estero are more important to pupping seals than those near the mouth, so mothers with pups were disproportionately disturbed when disturbance was caused by the oyster operation (Allen 1988; pers. obs.). 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 associated with the oyster operation six times in 1997 and once between 1998 and 2001. Disturbances to resting and breeding seals increased dramatically in 2007. Since March, park biologists documented oyster boats disturbing mothers with pups, and they noted that oyster bags were located on sandbars where seals would normally give birth and nurse their pups. One area where

250 seals nursed more than 100 pups two years ago, have around 50 total seals including around 25 pups in 2007, an 80% decline.

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 28 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 and fish. 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, pers. com.; Press, pers. com.). 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 spp.*), a highly aggressive, invasive species that could alter Drakes Estero ecology. "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/). A small infestation of the species was also found on natural sandstone habitat at Bull Point in May of 2007. Removal of oyster racks in Drakes Estero would eliminate habitat for this invasive species.

*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 Reserve 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 Black Brandt, 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 over 100 species of birds during winter surveys in 1999 and 2000, including several listed species or species of special concern such as Osprey, White Pelican, Brown Pelican, Peregrine Falcon, Black Brant, and Marbled Murrelet.
- 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.
- Harbor seal population is one of the largest in the state of California and the largest in Marin County, with as many as 2,000 breeding/molting individuals and 300-500 pups, annually.

### Oyster farming impacts on the ecological communities of Drakes Estero

- A USGS researcher stated that a source for sediment fill in the estero was from oyster feces and from structures trapping sediment.
- Eelgrass beds are found in all suitable habitats within Drakes Estero, except between active oyster racks, where they do not exist due to shading and possibly other effects. In 2003, with 38 active oyster racks, this amounted to at least 1.5 acres of lost eelgrass cover
- Oyster racks and bags provide structural habitat that does not naturally occur in the estero except in limited areas. The equipment and structures 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 oyster racks in Schooner Bay. These organisms were limited in Estero de Limantour where no oyster facilities exist.
    - The invasive non-native species, *Didemnum spp.,* is commonly present on oyster racks and is a highly aggressive, invasive species that could alter Drakes Estero ecology.
    - Schooner Bay, where there are many oyster racks, supported a different fish community than Estero de Limantour where no mariculture occurs.
- Clam abundance is reduced under oyster racks, possibly due to changes in bottom sediment composition or increased predation by fish and decapod crustaceans attracted to the oyster racks. In parts of Drakes Estero, clams are found in extremely high densities away from oyster racks - up to 250 per meter squared.
- The oyster operation is a potential source for many invasive species because non-native species 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 and harbor seals because of spatial coverage of racks and disturbance by oyster operations. In 2007, oyster bags and disturbance have reduced one sub colony by 80%

## References


Applied Marine Sciences. 2002. Intertidal monitoring program at Point Reyes National Seashore. Report prepared for the National Park Service. 57pp.

Anima, R. 1990. Pollution studies of Drakes Estero, and Abbotts Lagoon, Point Reyes National Seashore. U.S. Geological Survey. 233 pp.

Allen, S.G. 1988. The movement and activity patterns of harbor seals in Drakes Estero, California. M.S. Thesis, Univ. of California, Berkeley, 70pp.

Allen, S. G. and H. R. Huber. 1984. Human/pinniped interactions in the Point Reyes/Farallon Islands National Marine Sanctuary. Final Rpt. to U. S. Dept. of Commerce, Sanctuary Programs Office. 27 pp.

Allen, S., S. Waber, W. Holter and D. Press. 2004. Long-term monitoring of harbor seals at Point Reyes, California: five year annual report 1997-2001. National Park Service Technical Report. 66pp.

Bonnot, P. 1935. A recent introduction of exotic species of mollusks into California waters from Japan. The Nautilus. 49:1-2.

Blunt, C.E. 1984. Atlas of California coastal marine resources. CDFG.

Byers, J.E. 1999. The distribution of an introduced mollusk and its role in the long-term demise of a native confamillial species. Biological Invasions 1:339-352.

California Department of Fish and Game. 2001. California's living marine resources, a status report.

Carlton, J. T. 1992. Introduced marine and estuarine mollusks of North America: an endof-the-20th-century perspective. Journal of Shellfish Research 11: 489-505.

Cohen AN Carlton JT 1998 Accelerating invasion rate in a highly invaded estuary. Science 279: 255--558

Cranford, P., M. Dowd, J. Grant., B. Hargrave, and S. McGladdery. 2003. Ecosystem Level Effects of Marine Bivalve Aquaculture. In: Volume I: A Scientific Review of the Potential Environmental Effects of Aquaculture in Aquatic Ecosystems. **Canadian Technical Report of Fisheries and Aquatic Sciences** 2450. p. 51-84.

Elliott-Fisk, D.L., S. Allen, A. Harbin, J. Wechsler, D. Schirokauer, B. Becker. 2005. Assessment of Oyster Farming in Drakes Estero, Point Reyes National Seashore. Final Completion Report. 105 pp.

Everett, R. A., G. M. Ruiz, and J. T. Carlton. 1995. Effect of oyster mariculture on submerged aquatic vegetation: an experimental test in a Pacific Northwest estuary. Marine Ecology Progress Series 125:205-217.

Galloway, A.J. 1977. Geology of the Point Reyes Peninsula, Marin County, California. Calif. Divi. Of Mines and Geology. Bull. No. 202., 72 pp.

Harbin-Ireland, A. C. 2004. Effects of mariculture on the benthic invertebrate community in Drakes Estero, Pt. Reyes Peninsula, California. Master's thesis, University of California, Davis. 68 pp.

Hickey, C., W.D. Shuford, G.W. Page, and S. Warnock. 2003. Version 1.1. The Southern Pacific Shorebird Conservation Plan: A strategy for supporting California's Central Valley and coastal shorebird populations. PRBO Conservation Science, Stinson Beach, CA.

Kelly, J.P., J. Evens, R. Stallcup, D. Wimpfheimer. 1996. Effects of aquaculture on habitat use by wintering shorebirds in Tomales Bay, California. Calif. Fish and Game 82:160-174.

Miller, D.J. and R. N. Lea. 1972. Guide to the coastal marine fishes of California. California Fish and Game Fish Bulletin #157. University of California Press, Oakland CA 249 pp.

Mudie, P.J. and R. Byrne. 1980. Pollen evidence for historic sedimentation rates in California coastal marshes. Estuar. Coast. Mar. Sci. 10:305-316.

Porter, E.T., Cornwell, J.C., and L. P. Sanford. 2004. Effect of oysters Crassostrea virginica and bottom shear velocity on benthic-pelagic coupling and estuarine water quality. Mar. Ecol. Prog. Ser. 271:61-75

Press, D. 2005. Ecological impacts of green macroalgal mats on estuarine tidal flats. Masters Thesis, University of California, Davis. 63pp.

Shuford, W. D., G. W. Page, J. G. Evens, and L. E. Stenzel. 1989. Seasonal abundance of waterbirds at Point Reyes: a coastal California perspective. Western Birds **20(4)**:137-265.

Vanderhoof, M. and S. Allen. 2005. Harbor seal monitoring at Point Reyes National Seashore and Golden Gate NRA. Annual Report to the National Park Service, Inventory and Monitoring Program. 19pp.

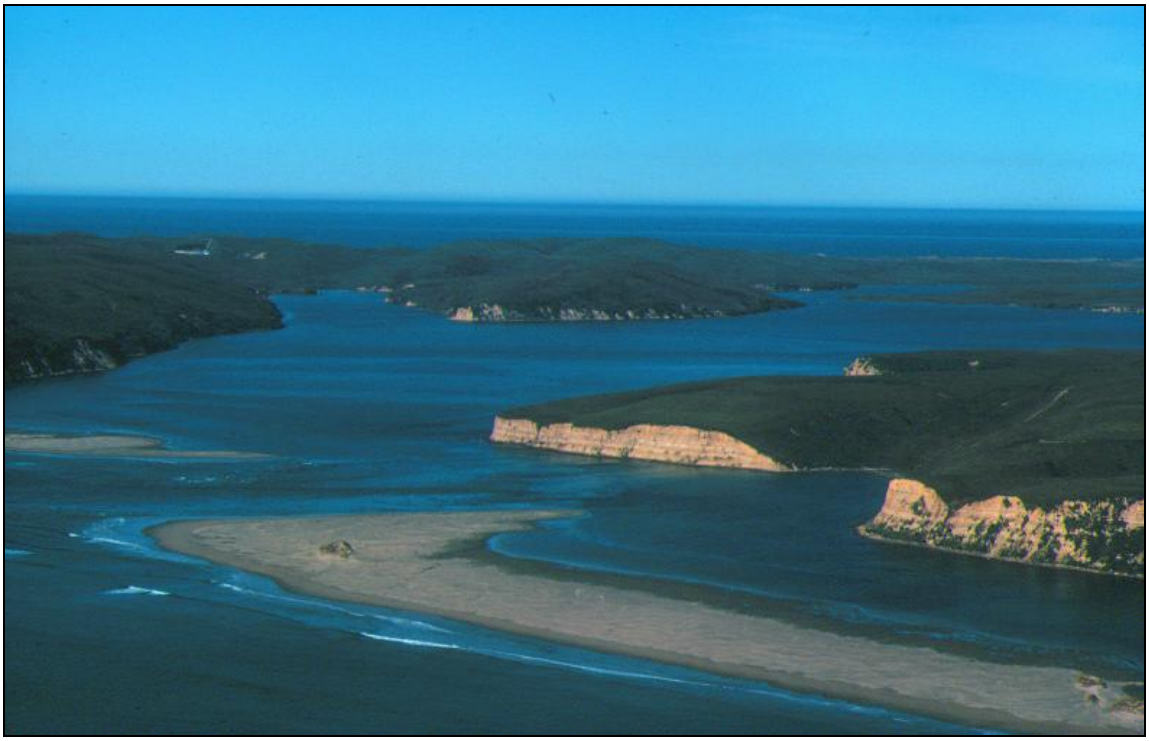
Weschler, J.F. 2004. Assessing the relationship between the ichthyfauna and oyster mariculture in a shallow coastal bay, Drakes Estero, Point Reyes National Seashore. Masters Thesis, University of California, Davis. 36pp.

White, J. 1999. Bird inventory of three national parks of the San Francisco Bay Area: wintering waterbirds and shorebirds. Report by the PRBO Conservation Science. 36pp.

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

*"...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



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

*The National Park Service cares for special places*
*saved by the American people*
*so that all may experience our heritage.*

United States Department of the Interior
National Park Service
Point Reyes National Seashore
Point Reyes Station, CA 94956
www.nps.gov/pore

printed on recycled paper

Acknowledgment of corrections to previous versions of the Park News document “Drakes Estero – A Sheltered Wilderness Estuary”

Research conducted by Dr. Roberto Anima of the U.S. Geological Survey in Drakes Estero in the late 1980s resulted in a report to the National Park Service (Anima 1990) and a U.S. Geological Survey report (Anima 1991). The NPS incorrectly interpreted the report by Dr. Roberto Anima (1990) stating that he had detected oyster feces and pseudofeces in sediment core samples, that he estimated the amount of fecal matter produced by oyster rafts, and that he considered oyster farming as the primary source of sedimentation in the estero. Instead, Anima (1991; page 92) states that “Because they are filter feeders, the oysters being grown and harvested in the estero play an important role in the deposition of fine grained sediment". Although, Anima did not quantify sedimentation related to the oyster farming, he references another study - "Ito and Imai (1955) calculated that in Japanese waters a raft of oysters 60 m square would annually produce 0.6 to 1.0 metric tons (dry weight) of fecal material."

Fish research in Drakes Estero conducted by Jesse Wechsler, a geography graduate student at UC Davis, resulted in his Master’s thesis (Wechsler 2004) and contributed to a report to the National Park Service (Elliott-Fisk 2005). The NPS incorrectly interpreted that the Estero de Limantour supports a different fish community than Schooner Bay. To clarify, the fish found at sampling sites in Estero de Limantour were most different from sites associated with the oyster racks in Schooner Bay, not the entirety of Schooner Bay. Although not tested for statistical significance, Wechsler reports that “Four of the five indices used to asses the similarity of the fish assemblage showed the greatest compositional divergence was between Estero de Limantour and Schooner Adjacent”.

NPS acknowledges the errors and will periodically update information when corrections and new information are available.