Assessment and Protection of Kelp Project

Kelp Value and Threats

Introduction

This document represents an initial compilation of scientific understanding related to the ecological function, benefits and anthropogenic threats for understory and floating kelps in San Juan County, Washington. The objective of the report is to provide a summary of known scientific information on kelps to inform relevant planning processes including the San Juan County Critical Areas Ordinance Update, Marine Stewardship Area Strategic Plan and Shoreline Master Program Update.

Kelps are protected under the Environmentally Sensitive Areas section of the San Juan County Unified Development Code (SJCC 18.30.110.5) and are listed as a priority habitat type by the Department of Fish and Wildlife's Priority Habitats and Species Program. Washington State Administrative Code (WAC 220-110-250.1.d and e) also specifically protects kelps used as spawning substrate by Pacific herring and as settlement/nursery grounds for juvenile rockfish. See also the discussion about harvesting regulations below.

Ecological Function

Kelp is defined as benthic brown algae in the order Laminariales (Duggins *et al.* 2003, Gabrielson 2006). In lay terms, most large brown algae (i.e. not red or green) attached to the seabed in this region are kelps. In San Juan County, these algae include understory kelps, such as *Costaria costata*, *Agarum fimbriatum*, *Saccharina subsimplex* (previously *Laminaria bongardiana)*, and *Laminaria complanata*, as well as the canopy forming "bull kelp", *Nereocystis luetkeana* (Garielson 2006). It does not include the common benthic brown algae *Fucus*, brown algae in the order Desmarestiales, or the invasive species *Sargassum muticum*. Understory kelps grow to a meter or two in length on rocky substrate from the intertidal to depths of approximately 45ft (~14m). Bull kelp attach to rock with a holdfast usually in 10-30ft (~3-9m) water depths to a maximum of 80ft (~24m), and grow to the surface with an gas filled float which holds the blades where energy from the sun for photosynthesis is greatest.

The life history of kelp species includes alternation of generations, with the large plant (sporophyte) producing planktonic spores which remain in the water column for a period of time before settling onto the bottom (Mumford 2006). Once on the bottom, the spores germinate into small plants (male and female gametophytes) that require certain environmental conditions to produce eggs or sperm which fertilize then grow quickly into the large kelp plant (Mumford 2006).

Kelp Value and Benefits

Kelps provide many ecosystem services, such as primary ecosystem productivity as well as habitat for many organisms, including marine mammals, fish and invertebrates (Dayton 1985, Steneck *et al*. 2002).

Kelp-derived carbon is important to productivity of temperate nearshore marine ecosystems, such as the marine waters of San Juan County. For example, carbon photosynthesized by kelps is found throughout nearshore food webs, and growth rates of benthic suspension feeders increase in the presence of organic detritus originating from kelps (Duggins *et al*. 1989). Many invertebrates in San Juan County rely on drift algae as a food supply, especially urchins (Britton-Simmons, *pers. com.*).

Understory kelps provide physical habitat structure on the seabed. These effects include reduced fluid transport near the bottom, greater rates of particulate deposition and penetration of suspended particles from the water column to the bottom (Eckman *et al*. 1989). These hydrodynamic effects probably play important roles in the ecology of animals that inhabit understory kelp environments, particularly regarding larval dispersal and settlement, and growth of suspension feeders.

Kelp has been shown to dampen waves and hence alter the energy regime on beaches. This in turn influences beach sediment grain size and sediment –biotic suitability such as suitability for beach spawners (Mumford, *pers. com.*).

Salmon use kelp habitats. Simenstad *et al.* (1979) found chinook, coho, and chum salmon kelp beds of the Strait of Juan de Fuca. Murphy *et al*. (2000) found greater densities of seven species of salmonids in habitat with kelp than without in Southeast Alaska. A similar study by Dean *et al.* (2000) found sculpins and rockfish primarily associated with kelps. In the Strait of Juan de Fuca, Washington Department of Fish and Wildlife research found that juvenile salmon and surf smelt, an important forage fish, preferentially utilized kelp bed habitats (Shaffer 2003).

Kelp habitats are very important to juvenile fishes. Young-of-the-year copper and quillback rockfish strongly associate with understory kelp (Hayden-Spear 2006). Bull kelp "forests" are especially important habitat for very young copper rockfish that settle into shallow reef habitats from the plankton (Haldorson and Richards 1987). These fish eventually migrate down plants to the reef habitat (Buckley 1997). Leaman (1980) documented the extensive use of kelp habitat by fishes in Barkley Sound, British Columbia and found a higher diversity and abundance of fishes in kelp beds than elsewhere.

Threats

Sedimentation can negatively affect kelp. This occurs in two ways, first, through impacting the microscopic kelp life history stages by inhibiting settlement of spores, reducing light availability in the water column and smothering gametophytes and young sporophytes after they have settled (Mumford 2006, Britton-Simmons *pers. com.* and Duggins *pers. com.*). Suspended sediments also reduce the amount of light available to the plants, reducing growth rates, and eliminating the plants in the lowest regions (Mumford, *pers. com.*). Sedimentation can be caused by poor land use practices and resuspension by boat wakes. In the second primary impact of sediment on kelp, large inputs of sediment can reduce the rocky habitat substrate available for kelps by directly burying it (Britton-Simmons, *pers. com.*). Studies have shown reduced bull kelp density in areas associated with landslides (Shaffer and Parks 1994). Dam removal projects, such as planned for the Elwha watershed across the Strait of Juan de Fuca, could create similar sediment inputs as landslides and negatively impact kelps.

Fresh water inputs can be detrimental to kelps. Kelp exposed to freshwater for a week show tissue deterioration (Brown 1915) and bull kelp develop blisters when subjected to rapid reductions in salinity (Hurd 1916). No studies of the effects on kelp of elevated salinity, such as found in the outfall plume of de-salinization plants, could be found.

Climate change and increased frequency of El Niño events appear to influence the amount and distribution of kelp. Annual surveys conducted by the Washington Department of Natural Resources since 1989 showed a 75% reduction in bed size for bull kelp on the outer coast during the 1997 El Nino event (Berry *et al*. 2001). El Nino events also cause less coastal upwelling, which stratifies the upper water column, causing lower nutrient conditions and high temperatures. However, elevated atmospheric carbon dioxide, a major driver of global climate change, appears to increase the photosynthetic rate of bull kelp (Thom 1996).

Over-water structures reduce benthic vegetation, such as kelp, presumably due to reduction in light energy reaching the benthos. Less kelp thereby reduces epibethic prey resources which use this vegetation for habitat and are prey items for juvenile salmon (Haas 2002). The overall effect is reduced prey availability for juvenile salmon under over-water structures, such as docks, due to reduced abundance of kelp.

Kelps are sensitive to exposure to petroleum products. Initial experiments with bull kelp and three petroleum products: diesel fuel, intermediate fuel oil (IFO) and crude oil, verified the susceptibility of bull kelp tissue to the negative effects of petroleum, including direct tissue damage and a greatly reduced photosynthesis rate (Antrim *et al.* 1995).

Kelps are harvested for many reasons, including human consumption, fertilizer production, and for feed at aquaculture farms (Kalvass *et al*. 2004). Harvest of kelp and all other seaweeds is regulated by law (RCWRCW 77.32.520, 79.135.400-430). Most harvest of kelp in Washington State is associated with the harvest of herring roe, an activity that occurs primarily in mariculture facilities in the Strait of Juan de Fuca and other locations outside of San Juan County (Lance *et al.* 2004). This practice is limited to the collection of *Macrocystis*, which does not occur in San Juan County (Mumford *pers. com.*). Limited, small-scale experimental harvest has been monitored in British Columbia with no significant effects on recruitment and re-growth of beds in two years following (Foreman 1984). However, another study found that harvest could negatively influence both the amounts of canopy biomass available as habitat and detritus for associated fish and invertebrates as well as recruitment to the bed in subsequent years (Roland 1985). There has not been a large scale non-tribal commercial kelp harvest in Washington State, but recreational harvest allows for collection of up to 10 pounds of algae (wet weight) per person per day. No records of tribal harvest could be located.

Invasive species, such as the alga *Sargassum muticum*, pose a threat to kelp habitat. This species was introduced to Puget Sound from Japan in the 1940s (Giver 1999). In a removal experiment in the San Juan Islands, kelp was more abundant in plots without *S. muticum* (Britton-Simmons 2004). In addition, the most abundant brown alga, (*Saccharina subsimplex* (=*Laminaria bongardiana)*, grew more then twice as fast in plots where *S. muticum* was absent. The negative effect appears to be shading, rather than changes in water flow, sedimentation or nutrient availability. Removals also had a positive effect on red urchins, presumably because of increased abundance of the species on which they feed.

Fishery removals of grazers by humans, especially urchins and abalone, affect kelp abundance by reducing grazing. In addition, population fluctuations in predators of these invertebrates, such as sea otters, also cause fluctuations in kelp density (Vanblaricom and Estes 1988).

Researchers with the Washington Department of Natural Resources Nearshore Habitat Program have inventoried canopy forming kelp distribution since 1989 (Berry *et al.* 2005). Between 1994 and 2000 DNR characterized all Washington State Shorelines through the ShoreZone inventory, which included categories for both understory and canopy kelp habitat distribution (Berry *et al*. 2001). Much less is known about the status and trends of understory kelp because it is more difficult to monitor and historical information is not available.

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