Bull Kelp

History of the Use and Harvest

Until the late 1980s, there was little targeted harvest of bull kelp (*Nereocystis luetkeana*) in California, except as a small component of the localized edible seaweed industry. In central California, *Nereocystis* and *Macrocystis* often form mixed beds and it is likely bull kelp would have been incidentally taken during harvest of those beds, but not recorded separately on harvest records. Department records indicate about 19 tons of kelp, probably a mixture of *Macrocystis* and *Nereocystis*, were harvested from what is presently bed 302 off the Bodega Bay–Tomales Bay area between 1993 and 1999. All of this kelp was used by local abalone culturists. Other uses of bull kelp include pickling the stipe and marketing it as a specialty food product, and using the dried parts for arts and crafts. In southern Oregon, bull kelp was harvested from Orford Reef in the mid-1990s as an ingredient in liquid fertilizer. The Oregon Division of State Lands has since discontinued permitting that harvest.

Currently, there is only one mariculture firm harvesting significant quantities of bull kelp for abalone food. This business is located in Crescent City, Del Norte County, and has been harvesting bull kelp from Point Saint George to Crescent City harbor since 1988. Because bull kelp declines in the winter months, they often augment their supply with giant kelp from central California. From 1990 to 1994, the company and the department worked together to determine the possible effects of small scale harvesting on *Nereocystis* populations. The company kept detailed records of harvest amount, location, bed condition, and effort in hours. Though not required by regulation, they hand-harvest to a depth of about 2.5 feet below the surface, which allows the take of the upper portion of the stipe, the pnuematocyst and all the fronds, resulting in the loss of the entire plant. During this experimental period annual harvest ranged from six to 149 tons, and impact to the local beds was considered to be minimal. In 1996, the Fish and Game Commission developed designation numbers (300 series) for all the kelp beds north of San Francisco and established beds that could be exclusively leased by interested parties, a program similar to the one in use for giant kelp harvest. Prior to this, there were no official designations in this area, so any northern kelp bed could be harvested for commercial purposes.

The Crescent City firm applied for and received exclusive lease privileges for bed 312 in 1997. In accordance with department regulations, they were required to produce a kelp bed biomass estimate prior to harvest. They estimated 205 acres of kelp beds in the approximately five miles of coastal area between Pt. St. George and Whaler Island within bed 312 (an area representing only a fraction of the entire geographic area of bed 312). The November 1996 survey yielded a point estimate of 5,475 tons of bull kelp within those 205 acres, at 27 tons per acre. Based on that survey, their annual harvest would be limited to 15 percent of that estimate, equivalent to 821 tons. While their harvest up to that time was only 132 tons (in 1996), or 16 percent of their allowance, their bid application projected steady harvest increases through 2001, peaking at a 500-ton projected harvest. Through 1999, their highest harvest in any year has been 149 tons.

Bull Kelp, *Nereocystis luetkeana*
Credit: CA Sea Grant Extension Program

Status of Biological Knowledge

Bull kelp is primarily found adjacent to exposed shorelines along the Pacific coast of North America, ranging from Unalaska Island, Alaska to Point Conception, California. Along the central California coast, *Macrocystis* and *Nereocystis* occur together, forming extensive kelp forests in this region. However, from the Monterey Bay area northward to Alaska, *Nereocystis* becomes the dominant canopy kelp species in coastal waters. Within the nearshore environment, bull kelp, like giant kelp, is associated with hard substrates at depths of approximately 10 to 70 feet, where it provides habitat and food for hundreds of species, many of them commercially and recreationally valuable.

Distribution of marine algae is not only restricted geographically but also limited by a number of other factors within the nearshore environment, including water movement, light, temperature, nutrients, pollution, competition, and predation. The complex trophic interaction among sea otters, macro-herbivores and kelps has been documented by a number of researchers. Generally, the occurrence of sea otters in a kelp forest community greatly limits the population of invertebrate kelp grazers, thereby increasing kelp productivity. In northern California, absent the sea otter, commercial and sport fishermen have acted to significantly reduce populations of sea urchins and abalone, two major kelp grazers. While

kelp populations have increased, the competition among seaweeds for space and light rules out any generalizations regarding specific impacts on bull kelp due to the reduction of these grazer populations.

The morphology of bull kelp is quite different from that of giant kelp. The most notable difference is the possession by bull kelp of only one pneumatocyst, situated on the end of the hollow stipe for flotation. Giant kelp has many gas bladders running its entire length. While bull kelp is also attached to the substrate by a holdfast, the size of the holdfast is much smaller than that of giant kelp. The holdfast resembles a small disk with many finger-like haptera. Much like giant kelp, the stipe of a bull kelp sporophyte is long, reaching lengths of up to 130 feet. The bull kelp stipe does not have the same tensile strength as giant kelp but is more elastic under stress. Bull kelp is able to stretch more than 38 percent of its length before breaking. The pneumatocyst gives rise to short dichotomous branches from which up to 64 blades are borne. The bull kelp canopy provides most of the photosynthetic and nutrient absorbing surface for energy production. Blade lengths of more than 13 feet have been reported for mature plants, but it is typical to find a range of blade sizes (two to 11 feet) on most plants. The reproductive structures (sporangia) are located on the blades in aggregations called sori, with mature sori located in patches near the blade tips and immature regions near the base of the blades.

Reproduction in bull kelp undergoes a cyclic alternation of generations similar to that of giant kelp and other laminarians. The large plant commonly referred to as bull kelp represents the sporophytic phase while the gametophytic phase is microscopic. During its sporophytic phase, spore production usually begins several weeks after the blades reach the surface. Biflagellate spores are formed within the sporangia on the blades. As the spores reach maturation during the summer and fall, the sori are abscised from the blades and the spores released. Upon settlement, germination begins, and over the course of several weeks, somatic growth gives rise to the gametophyte. After about 11 weeks, motile sperm are released and fertilization of the eggs takes place. The resulting zygotes grow as sporophytes. Once at the surface, stipe and blade elongation rates decrease while the plant increases in biomass.

As an annual plant, bull kelp has evolved an optimal reproductive strategy that involves accelerated stipe growth to reach the ocean surface where it can initiate spore production and release. Plants initiated in late March sometimes have developing sori prior to reaching the surface in May and spore release via abscission of the sorus begins as early as June. Maximum bull kelp growth rates occur under optimal environmental conditions of high light, nutrient and water clarity levels. Bull kelp stipe elongation can reach five inches per day, while blade growth accelerates to about 3.5 inches per day just prior to the plant reaching the surface. At maturity the growth rate of the holdfast can average about 0.2 inches per day.

Water temperature plays an important role in the growth of *Nereocystis*. Mean sea surface temperatures over the distributional range of *Nereocystis* vary from 55° F to 59° F at the southern end to 39° F to 50° F off the Aleutian Islands. The population of bull kelp in Diablo Cove has been adversely affected by the warm water discharge from the Diablo Canyon power plant which began in 1985. Plants in contact with the discharge experienced deterioration of blade tissue, which resulted in early death. This observation helps to explain the decline of *Nereocystis* that occurs during El Niño events.

Nereocystis is an opportunistic colonizer that takes advantage of substrate clearing caused by storms, sand scouring, or other disturbances. While bull kelp can rapidly recruit to a newly cleared location, its longevity as the dominant canopy-forming species depends on environmental conditions being conducive for its survival and detrimental for its major competitors. The biggest factor in growth of *Nereocystis* is the availability and quantity of light. Light levels below the surface canopy have been shown to decrease by almost 100 percent and below the secondary canopy, well below the minimum level necessary for growth. Thus, in established kelp communities there can be insufficient light and hard substrate for recruitment and growth of bull kelp.

Status of the Beds

The kelp resources of the eastern Pacific coast were first mapped in 1912. The survey extended from the Gulf of Alaska to Cedros Island, Baja California. Along the central coast of California between Point Montara, San Mateo county and Point Conception, subsequent coastwide surveys have not differentiated between *Nereocystis* and *Macrocystis*. Since the first survey in 1912, little work has been done along the north coast of California, primarily due to the absence of the commercially valuable *Macrocystis pyrifera* in this region. Current knowledge of the population levels of *Nereocystis* off the north coast is based on 1989 and 1999 surveys of the California coast, and information provided by a kelp harvester about the resource in the Crescent City area. Population abundance estimates resulting from these surveys are usually expressed in terms of square miles of surface area.

Despite the year-to-year variability in bull kelp coverage, both the 1912 and the 1989 surveys yielded similar results for the northcoast and about 6.5 square miles of canopy.

The 1999 survey, however, indicates about a 42 percent decline in kelp coverage in the Point Montara, San Mateo county to Shelter Cove, Humboldt county area. This decline is contrary to anecdotal observations along the Mendocino county coast in 1999, which indicated one of the most extensive kelp canopies in the last decade. The apparent decline may be due in part to the timing of the 1999 survey, which was conducted after a major storm had passed through the region, destroying portions of the kelp beds. Another factor to be considered is the improved method used to interpret aerial photographs in 1999, which resulted in a more accurate representation of kelp beds. This would seem to indicate that previous surveys may have overestimated the true extent of the beds. And finally, kelp beds are subject to high variability in coverage and density from year to year.

The 1912 survey estimated that about 32 percent of the 17.55 square mile kelp canopy in central California was bull kelp. However, since that survey there has not been an effort to estimate the proportion of bull kelp in the area. In this region, bull kelp is generally restricted to areas unsuitable for giant kelp and the outer edges of giant kelp beds and inshore of *Macrocystis* within the surge zone. However, following winter storms with heavy wave disturbance, bull kelp can become more abundant, sometimes replacing giant kelp removed by the storms.

Changes in kelp abundance over time and location are evident. For example, during the period from 1975 to 1982, biomass at Diablo Cove in San Luis Obispo County declined from 200 tons per acre to 4.8 tons per acre. At Van Damme Bay in Mendocino County, a density of six tons per acre was calculated in July 1990. Peak abundances in the Crescent City area ranged from 24 to 28 tons per acre during the period from 1994 to 1996.

Researchers reported that the Fort Bragg, Mendocino County area kelp beds appeared to increase in size and density between 1985 and 1988 based on aerial photographic surveys of the area. The *Nereocystis* beds were thought to have reached maximum potential during this period. The increase was coincident with the removal of over 32,500 tons of red sea urchins from Mendocino and Sonoma Counties by commercial divers. In 1992, the same beds showed delayed and reduced kelp recruitment and growth. The causes of the poor recruitment in 1992 may have been associated with the El Niño event of that year. These examples illustrate the kind of fluctuations that occur in the recruitment of bull kelp along the north coast and the factors that may play a role in the variability of this resource.

Management Considerations

See the Management Considerations Appendix A for further information.

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