2. BULL KELP

Overview of Use and Harvest

Bull kelp, *Nereocystis luetkeana*, has commercial and recreational value as a harvestable resource, intrinsic value as habitat and food for hundreds of species in the nearshore ecosystem, and aesthetic value for non-consumptive users such as scuba divers. Because of the multiple uses of bull kelp, management concerns are much more complex than for most species.

Until the late 1980s, there was little targeted harvest of bull kelp in California except as a small component of the localized edible seaweed industry. In central California, bull kelp and giant kelp, *Macrocystis pyrifera*, often occupy the same beds. It is likely that bull kelp is incidentally harvested in these beds, although no separate records are kept of bull kelp harvest. Department of Fish and Game (DFG) records indicate that between 1993 and 1999 about 19 tons of kelp, probably a mixture of bull kelp and giant kelp, were harvested from bed 302 in the Bodega Bay/Tomales Bay area (Marin County) and used by local abalone culturists. The bull kelp's thick, central stalk (called the stipe) is pickled and marketed as a specialty food product, and the dried parts are used for arts and crafts. In southern Oregon, bull kelp was harvested from Orford Reef in the mid-1990s for use in liquid fertilizer (the Oregon Division of State Lands no longer permits this harvest).

California's kelp bed management strategy has been largely passive, with effort spent on giant kelp restoration and intermittent aerial surveys of the giant kelp canopy. The Fish and Game Code (§6654) gives the Commission authority to close a kelp bed to harvest for up to one year if it is determined that the bed is being damaged. However, the information necessary for sustained-yield management—regular and formal stock assessments of the State's kelp resources—has been largely unavailable.

In 1996 the Fish and Game Commission (Commission) developed a "300 series" numbering system for all the kelp beds north of San Francisco and established a kelp bed leasing program similar to the program for giant kelp in central and southern California. Before 1996 no such program existed, and any northern kelp bed could be harvested for commercial purposes.

In anticipation of increasing demand for large-scale harvest of the northern California bull kelp resource, the Commission acted in a precautionary manner in 1996 by closing beds 303 through 307 to future commercial harvest. The Commission also required limiting the remaining beds in the 300 series to a maximum harvest of 15% of the biomass as determined by a DFG-approved annual survey conducted by the lessee. In 2001, the Commission provided further protection for the bull kelp resource by adopting a new suite of regulations that:

- Closed beds 301, 302, 310, and 311
- Restricted the harvest from April 1 through July 31 within the boundary of the Monterey Bay National Marine Sanctuary
- Required a harvester to have a Commission-approved harvest plan prior to taking kelp with a mechanical harvester in open beds north of Santa Rosa Creek (San Luis Obispo County)

The Commission can also respond more quickly to potential resource concerns by designating open beds, or portions thereof, as harvest control areas where harvest is limited for a specified period of time. These regulations have created a *de facto* bull kelp reserve along much of the northern California coastline, protecting essential kelp bed habitat for resident species such as heavily-exploited sea urchins and abalones.

As of 2002, only three of the State's 13 beds that mostly contain bull kelp were open to harvest. Of these three, only one is currently leased, with one firm harvesting significant quantities of bull kelp. Since leasing the bed, the firm's peak harvest has been 149 tons, with only 11 and 44 tons landed in 2000 and 2001, respectively. This low harvest rate is due to a reduced demand for kelp and is not indicative of the resource available in the area.

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 (Santa Barbara County). Along the central California coast, giant kelp and bull kelp occur together, forming extensive kelp forests. However, from the Monterey Bay area northward to Alaska, bull kelp 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 ft, where it provides habitat and food for hundreds of species, many of them commercially and recreationally valuable.

Distribution of marine algae is restricted by the availability of hard substrate and a number of other factors within the nearshore environment, including water movement, light, temperature, nutrients, pollution, competition, and predation. The complex feeding interactions among sea otters, larger kelp grazers and kelp have been documented by a number of researchers. Generally, sea otter predation on invertebrate kelp grazers such as abalone limits the population of these grazers in a kelp forest community, thereby increasing kelp productivity. In northern California, where sea otters are absent, commercial and sport fishermen have significantly reduced populations of sea urchins and abalone, which are two major kelp grazers. Although kelp populations off California generally seem to have increased, the competition among marine plants for space and light makes it impossible to determine the specific impacts of grazer populations on bull kelp.

The appearance of bull kelp is quite different from that of giant kelp. The most notable difference is that bull kelp possess only one gas-filled flotation bladder (called a pneumatocyst) located on the end of the hollow stipe. In contrast, giant kelp have many such bladders running the entire length of the kelp. The bull kelp's pneumatocyst typically bears from 30 to 64 blades, which resemble long, flat leaves. This canopy of blades provides most of the photosynthetic and nutrient-absorbing surface for energy production. Blade lengths of more than 13 ft have been reported for mature kelp, but it is typical to find a range of blade sizes (from 2 to 11 ft).

Although both giant kelp and bull kelp are attached to the substrate by holdfasts (root-like growths) the size of the holdfast is much smaller in bull kelp. Bull kelp stipes can reach lengths of up to 130 ft. The bull kelp's stipe does not have the same tensile strength as giant kelp's, but it is more elastic under stress. The bull kelp stipe can stretch more than 38% of its length before breaking.

Reproduction in bull kelp undergoes a cyclic alternation of generations similar to that of other kelp and other algae in the order Laminariales. The large plant commonly referred to as bull kelp represents the spore-producing (or sporophytic) generation, while the gamete-producing (or gametophytic) generation is microscopic. Bull kelp reproductive structures (called sporangia) are located on the blades of sporophytic plants in aggregations called *sori*. Mature sori are located in patches near the tip of the blade, and immature sori are located near the base of the blade. Production of spores within the sori usually begins several weeks after the blades reach the surface. As the spores mature during the summer and fall, the sori are shed from the blades and the spores released. They germinate upon settlement, and over the course of several weeks develop into gametophytic plants. After about 11 weeks, sperm and eggs are released from "male" and "female" gametophytic plants, and fertilization takes place. The resulting young plants (termed zygotes) grow into tall, familiar, sporophytic bull kelp. Once the plant reaches the surface, stipe and blade elongation rates decrease while the weight, or biomass, of the kelp increases.

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. Kelp that begins growing in late March may develop sori prior to reaching the surface in May, and can release spores as early as June. Maximum bull kelp growth occurs under optimal light, nutrient and water clarity levels. Bull kelp stipes can grow up to 5 in. per day, while blades may grow up to about 3.5 in. per day just prior to reaching the surface. The holdfasts of mature bull kelp can grow an average of about 0.2 in. per day.

The biggest factor in the growth of bull kelp is the availability and quantity of light. Light levels below the surface canopy have been shown to decrease by almost 100%; below secondary canopy, light levels are well below the minimum level necessary for growth. Thus, in established kelp communities there can be insufficient light and hard substrate available for recruitment and growth of new bull kelp plants.

Bull kelp is an opportunistic colonizer that takes advantage of substrate clearing caused by storms, sand scouring, and other disturbances. While bull kelp can rapidly colonize a newly-cleared location, its longevity as the dominant canopy-forming species depends on environmental conditions that favor it over major competitors.

Water temperature also plays an important role in the growth of bull kelp. Mean sea surface temperatures over the kelp's distributional range vary from a high of 59° F off southern California to a low of 39° F off the Aleutian Islands. The introduction of unusually warm water can have a negative effect on bull kelp. For example, the bull kelp population in Diablo Cove (San Luis Obispo County) 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 bull kelp that occurs during El Niño events.

Status of the Beds

The kelp resources of the eastern Pacific coast, from the Gulf of Alaska to Cedros Island, Baja California, were first mapped in 1912. Subsequent surveys along the central coast of California between Point Montara (San Mateo County) and Point

Conception (Santa Barbara County) have not differentiated between bull kelp and giant kelp. Since the first survey in 1912, little work has been done along the north coast of California, primarily due to the absence of the more valuable giant kelp in this region. A 1967 kelp survey from Point Montara to the U.S.-Mexico border did not differentiate between bull kelp and giant kelp, and did not extend far north into the preferred bull kelp habitat. Current knowledge of the population levels of bull kelp off the north coast is based on 1989 and 1999 surveys of the California coast, and information provided by a kelp harvester in the Crescent City area (Del Norte County).

Despite the high spatial and temporal variability in bull kelp coverage, both the 1912 and the 1989 surveys estimated approximately 6.5 sq. mi. of canopy north of Point Montara. The 1999 survey, however, indicated a sharp drop in canopy coverage in most beds north of Point Montara, which may be attributed to several factors. 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. Also, improved interpretation methods for aerial photographs probably resulted in more accurate estimates of kelp canopy coverage in 1999. Comparing the estimates from these latest surveys with previous surveys raises questions about the accuracy of previous canopy estimates, which may have been too great. An additional consideration is that kelp bed coverage and density naturally varies from year to year.

The 1912 survey estimated that about 32% of the 17.55 sq. mi. kelp canopy in central California was bull kelp. Recent surveys have not been undertaken to estimate the proportion of bull kelp in central California kelp beds. In central California, bull kelp is generally restricted to areas unsuitable for giant kelp such as the outer edges of giant kelp beds and within the surge zone. However, following winter storms with heavy wave disturbance, bull kelp can become more abundant as it replaces the giant kelp removed by the storms. The DFG has recently acquired new technology which will hopefully allow biologists to more accurately differentiate between bull kelp and giant kelp in aerial images.

Kelp abundance has changed in various locations over time. For example, during the period from 1975 to 1982, the amount of bull kelp at Diablo Cove declined from 200 tons per acre to 4.8 tons per acre. In the Crescent City area, peak abundances ranged from 24 to 28 tons per acre from 1994 to 1996. South of Fort Bragg (Mendocino County), bull kelp beds decreased sharply from 1989 to 1999, whereas beds north of Fort Bragg increased sharply. The Fort Bragg area kelp beds appeared to increase in size and density between 1985 and 1988 based on aerial photographic surveys of the area. Bull kelp beds were thought to have reached their maximum potential during this period. The increase coincided with the removal of over 32,500 tons of red sea urchins from areas off 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 the resource.

Management Considerations

The DFG conducted a review of the commercial and sport bull kelp "fisheries" in 2000 and 2001, and recommended a number of management changes for the commercial fishery. The Commission adopted a new suite of regulations in 2001 based on the DFG review and public comments; these regulations are described in the "Overview of Use and Harvest" section. Other management measures that should be considered to ensure a productive future for California's bull kelp resource and the species dependent on it include:

- Minimizing local impacts by modifying the present 15% harvest limit on the lease-only 300-series beds to require distribution of the harvest throughout the bed
- Prohibiting harvest of bull kelp in beds where the bull kelp resource has been chronically diminished during the past several decades
- Encouraging the use of alternative feeds, such as those already developed for cultured species such as red abalone
- Conducting at least one annual statewide aerial survey, preferably during the late summer, to document abundance and distribution of kelp canopy
- Conducting research to examine the impacts of various harvest strategies on kelp abundance, distribution and long-term stability

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Revised May 2002
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Further Reading

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