

State of California  
The Resources Agency  
DEPARTMENT OF FISH AND GAME

BULL KELP, *NEREOCYSTIS LUETKEANA*, ABUNDANCE  
IN VAN DAMME BAY, MENDOCINO COUNTY, CALIFORNIA

by

ALLISON BARNES  
and  
PETER KALVASS

MARINE RESOURCES DIVISION

Administrative Report No. 93-6

1993

Bull Kelp, *Nereocystis luetkeana*, Abundance  
in Van Damme Bay, Mendocino County, California<sup>1</sup>

by

Allison Barns<sup>2</sup>  
and  
Peter Kalvass<sup>3</sup>

ABSTRACT

Size and density data were collected for *Nereocystis luetkeana* sporophytes from kelp beds in Van Damme Bay, Mendocino County during May, June and July 1990. Length and weight measurements were made on individual plants from representative size groups collected from depths of 6.1 m and 12.2 m. Mean sporophyte weight was 268 g (SD 393 g), while mean stipe length was 214 cm (SD 275 cm). Densities were determined separately for those plants which had reached the surface and for all plants within the water column. Sixty-five 12.7 m<sup>2</sup> surface quadrats yielded mean surface densities of 2.2 (SD 1.5) and 2.7 plants/m<sup>2</sup> (SD 1.3) in June and July, respectively. Individual plants were counted within 42 1x5 m plots along benthic transect lines yielding average densities of 2.7 (SD 4.5) and 5.2 plants/m<sup>2</sup> (SD 3.0) in May and July, respectively. Combined density and size data from July 1990 and kelp bed area estimates from fall 1988 for Van Damme Bay yielded a biomass estimate of 640 metric tons distributed over 45.7 hectares.

---

1 - Marine Resources Administrative Report No. 93-6  
2 - Humboldt State Univ., Arcata, CA 95521  
3 - CDFG, 19160 S. Harbor Dr., Fort Bragg, CA 95437

## ACKNOWLEDGMENTS

The authors wish to thank Ian Taniguchi, Catherine Talbot and John Mello of the Fort Bragg office of the Department of Fish and Game for their valuable assistance on this project. We would also like to thank Frank Henry and Diana Watters for editing this report.

## INTRODUCTION

It is a curious phenomenon of fisheries management that species which are long regarded as possessing little potential for human use may quickly become an object of considerable economic interest. This may be influenced by depletion of stocks of related species or simply a desire to explore new endeavors. Recently, commercial interest in the bull kelp, *Nereocystis luetkeana*, has increased in coastal northern California. Commercial abalone culturists have expressed interest in harvesting bull kelp for use as feed for their abalone, while others are interested in producing food additives and fertilizer products from this resource.

The ecological impacts of large-scale harvest of *Nereocystis* are not well known. Bull kelp forms extensive canopies which provide shelter and feeding grounds to bony fishes and invertebrates, including abalone (*Haliotis* spp.) and sea urchins (*Strongylocentrotus* spp.) (Burge and Schultz 1973, Bodkin 1986). In northern California, abalone are sought by sport divers and red sea urchins support a large commercial fishery. If large-scale harvest of *Nereocystis* develops, these economically important fisheries could be negatively impacted. Beginning in about 1985 in the Fort Bragg area, bull kelp beds appeared to increase in size and density, based upon aerial photographic surveys, coincident with intensive harvest of red sea urchins, a primary macroalgivore, by the commercial fishing industry (Kalvass, Taniguchi, and Buttolph 1990). Surface canopies apparently peaked in 1988, possibly reaching their maximum potential. Hobson (1989) has found evidence that the observed increase in bull kelp may have been a temporary response to urchin removals within a larger ecological framework, which may

lead to a future reduction in the bull kelp resource. In 1992, northern California bull kelp recruitment and growth appeared to be both delayed and reduced, possibly related to anomalously elevated nearshore sea temperatures coincident with reduced upwelling.

*Nereocystis* has a recorded range from Point Conception, California to Shumagin Island, Alaska (Burge and Schultz 1973). It is the dominant canopy-forming macrophyte in the nearshore waters of northern California. In addition to possessing a single stipe terminating in a large pneumatocyst, *Nereocystis* differs from its relative Laminarian, the perennial *Macrocystis*, in that there is no regrowth of damaged tissue once the upper plant has been destroyed, and only one stipe is produced during the lifetime of the sporophyte (Nicholson 1970). *Nereocystis* has an annual growth and reproductive cycle with sporophyte growth initiation in early spring, the first sporophytes usually reaching the surface by May, and typically reaching peak development by September or October. Spores are produced in fertile patches (sori) on the blades. Mature sori ready to release spores separate from the blades (Amsler and Neushul 1989). The first winter storms initiate the break up of bull kelp beds, with the slow deterioration of beds throughout winter providing drift algae to benthic macroalgivores (Burge and Schultz 1973). A few stipes may survive through the winter and it is possible for these old sporophytes to regenerate blades and again be reproductive (Nicholson 1970, Foreman 1970 in Burge and Shultz 1973).

The purpose of this study was to estimate the abundance of *Nereocystis luetkeana* in a cove near Fort Bragg, California during the late spring/early summer months and provide baseline density and length/weight data to

researchers for use in kelp harvest management planning. Additionally, an estimate of the maximum potential biomass of Van Damme Bay was made based upon aerial photographs from the fall of 1988.

#### STUDY AREA

Bull kelp beds at Van Damme Bay, a cove along the coast of northern California about ten miles south of Fort Bragg, Mendocino County, were chosen for the study site since this large cove is easily accessible and hosts some of the most extensive bull kelp beds in northern California (Figure 1). Beds in the cove ranged in depth from approximately 1.5 to 12.2 m.

#### METHODS

##### Field Sampling

##### Benthic *Nereocystis* Density

Benthic density data was collected in May and July, 1990. SCUBA divers examined forty-two, 5 m<sup>2</sup> quadrats at depths of 6.1 and 12.2 m. Once inside a selected kelp bed, divers descended to the bottom from the anchored skiff swimming in a northerly direction until encountering predominantly rocky substrate. A 30 m transect line, marked at 5 m intervals, was placed on the substrate in a north/south orientation. Each diver then used a movable 1 m long PVC pipe attached to the line to mark 1 m x 5 m quadrat boundaries on each side of the line. All sporophytes in a quadrat which could be identified as *Nereocystis* were tallied on a slate carried by each diver. Sporophytes are not identifiable as *Nereocystis* until they reach 6-10 cm total length at which time a vertical line marking the origin of the first blade division appears (Nicholson 1970). Individual bull kelp plants of representative size groups were removed from the substrate for length and weight measurements. We attempted to remove the plants with as much of the

holdfast intact as possible.

### Surface *Nereocystis* Density

Surface densities were calculated by counting all bull kelp pneumatocysts (bulbs) floating within 12.7 m<sup>2</sup> (roughly 2.5 x 5 m) quadrats on the sea surface from an anchored skiff within a study kelp bed. Free divers held the floating quadrat in place while bulbs were counted from the boat. Quadrats circled the boat, placed consecutively but not overlapping. We counted bulbs in 44 quadrats in June and 21 in July, 1990.

### Laboratory Analysis

#### Length and Weight Measurements

Length and weight measurements were combined from 44 *Nereocystis* sporophytes collected in May and July, 1990, covering a range of sizes observed during underwater surveys. The kelp was kept covered in sea water until measurements were taken at the Department's Marine Laboratory in Fort Bragg. Total wet weight, stipe length (from insertion into holdfast to tip of pneumatocyst), blade length (longest blade), total blade weight, number of blades, and weight of holdfast (if available) were recorded. Figure 2 shows the external structure of a bull kelp sporophyte.

#### Biomass Estimate

Though peak bed area may not have remained constant from 1988 to 1990, maximum potential kelp bed area at Van Damme was estimated using a 1988 aerial infrared photographic survey of kelp beds along the Mendocino/Sonoma county coast of California (Kalvass, Taniguchi and Buttolph 1990) (Figure 1). 1988 appears to have been the peak biomass year for bull kelp based upon annual aerial photographic surveys begun in the early 1980s. Foreman (1984) reported no change in bull kelp bed area despite changes in kelp

density during a six-year study in British Columbia. A grid system, with each grid representing 4,356 m<sup>2</sup>, was overlaid on a map (scale 1:7700) of the study area and used to estimate the kelp bed area. Average density and plant weight were combined with the bed area estimate to calculate the total biomass of *Nereocystis* at Van Damme.

## RESULTS

### Benthic *Nereocystis* Density

We counted 787 individual *Nereocystis* sporophytes over 210 m<sup>2</sup> of substrate from two discrete kelp beds. Mean *Nereocystis* density for the combined sampling periods was 3.7 plants/m<sup>2</sup> (SD 4.1). Mean density in May was 2.7 plants/m<sup>2</sup> (SD 4.5), increasing to 5.2 plants/m<sup>2</sup> (SD 3.0) in July. This increase may in part be attributed to small sporophytes which were not identified as *Nereocystis* during the first sampling period. It is also likely that small bull kelp sporophytes were present during both sampling periods but not identified as *Nereocystis* due to their small size. Since different locations within each bed were surveyed in May and July, the increased density in July may be due to variation among these locations.

### Surface *Nereocystis* Density

Sixty-five 12.7 m<sup>2</sup> surface quadrats were examined. Mean surface density for the combined sampling periods was 2.7 plants/m<sup>2</sup> (SD 1.5). Mean density for June was 2.1 plants/m<sup>2</sup> (SD 1.5), while mean density for July was 2.7 plants/m<sup>2</sup> (SD 1.3).

### Length and Weight Measurements

Mean plant weight was 268 g (SD 393). Mean stipe length was 214.1 cm (SD 275.2). The relationship between plant weight and stipe length is expressed by the regression formula of  $y=0.00+1.02x$  (Figure 3).



## Biomass Estimate

The maximum potential surface area of bull kelp beds at the Van Damme study area was estimated to be approximately 457,300 m<sup>2</sup> (113 acres) based upon the fall 1988 aerial photographic survey. Two types of biomass calculations were made: an estimate of potentially-harvestable kelp based upon surface counts, and a more inclusive water column estimate based upon benthic transect counts. July values were used for making the biomass estimates because they were taken closer to the time of peak biomass (September/October). We did not sample after July due to time and budget constraints.

The average surface density in July of 2.7 plants/m<sup>2</sup> (SD 1.3) yielded an estimated potential of 1,234,700 sporophytes for the entire Van Damme site (the 95% C.I. ranged from 964,900 to 1,504,500).

Average density from benthic surveys in July of 5.2 plants/m<sup>2</sup> (SD 3.0) yielded a potential of 2,378,000 sporophytes for the entire study area, with a 95% C.I. from 1,692,000 to 3,059,300. Applying the mean plant weight of 268 g/plant yields 1,394 g *Nereocystis*/m<sup>2</sup>. The kelp beds at Van Damme were estimated to contain a biomass potential of 640 metric tons of bull kelp at 1.4 kg/m<sup>2</sup>.

## DISCUSSION

Van Damme Bay was estimated to contain a biomass potential of approximately 640 metric tons of *Nereocystis* based upon maximum potential kelp bed area estimates from the fall of 1988. In British Columbia, Foreman (1984) reported 500,000 mt of bull kelp in 11,600 hectares of bed area, or 4.3 kg/m<sup>2</sup>. Burge and Schultz (1973) reported Diablo Canyon kelp beds had about 20.4 mt of bull kelp in an estimated 4,046 m<sup>2</sup> bed area, or 5.0 kg/m<sup>2</sup>. The British Columbia beds had three times while Diablo Canyon had about 3.6

times the biomass density of Van Damme. Since the present study does not include data for the fall season of peak biomass, these differences are perhaps more a reflection of within-season variation rather than true differences in peak biomass.

Foreman (1984) presented linear regressions of sporophyte weight upon stipe length for bull kelp from 11 different locations in British Columbia and at Salt Point in northern California. Regression coefficients varied from 1.94 to 7.38 compared to our value of 1.02. Our low value probably reflects a growth strategy in which the plants undergo rapid stipe elongation initially, apparently in search of light, followed by an increase in blade biomass. Most of our plant collections were too early in the season to show the later phase of growth. Growth rates of 6 cm/day have been recorded for bull kelp (Nicholson 1970).

Bull kelp beds are known to experience year to year fluctuations in density (Foreman 1984; Burge and Shultz 1973). Foreman (1984) found high *Nereocystis* densities correlated with years with low mean annual sea water temperatures and salinities, though bull kelp has a wide temperature and salinity tolerance (Vadas 1972 in Foreman 1984). This characteristic, along with an annual life cycle and rapid growth capability, appears to allow *Nereocystis* to inhabit sites not suitable for perennial competitors such as *Macrocystis*. It is possible that the present study and the British Columbia and Diablo Canyon studies mentioned above reflect atypical years. Biomass estimates for several successive years would be needed to increase accuracy.

Foreman (1984) found no observable deleterious impacts as the result of his experimental harvests of British Columbia *Nereocystis* beds. He suggested that the potential effects of biological and physical factors

(i.e. light intensity, temperature and salinity) on yearly fluctuations in *Nereocystis* density and standing crop be of primary concern to resource managers.

Bull kelp canopies serve as shelter and feeding grounds for many bony fishes and invertebrates. Bodkin (1986) identified 27 species of fish living in *Nereocystis* canopies off the central California coast. Bull kelp is a primary food source for abalone and sea urchins, both of which comprise important fisheries in the Fort Bragg area. In northern and central California 400 to 1500 metric tons of abalone were taken annually by sport fishermen between 1985 and 1989; 77 percent of this effort was in the same area being considered for kelp harvest (Mendocino and Sonoma counties) (K. Karpov, California Department of Fish and Game (CDFG), pers. comm.). The ten year (1980-1989) average of commercial sea urchin landings in Fort Bragg was 2,372 mt, worth \$1,355,000 (CDFG unpub. rpt. 1990).

A 1989 aerial photographic survey revealed that only about 11 percent of California's canopy forming kelp beds were in Mendocino and Sonoma counties (Van Wagenen 1990); north of Bodega Bay (Sonoma County), these kelp beds are almost exclusively comprised of bull kelp. Based upon long-term subtidal surveys in the vicinity of Van Damme Bay, Hobson (1989) suggest that as the urchin fishery in northern California stabilizes and subtidal kelp beds increase their colonization of formerly urchin dominated areas, there will be a decrease in the bull kelp bed density as lower growing perennials like *Laminaria* sp. and *Pterygophora californica* begin to outcompete *Nereocystis* germlings for light and space. The urchin/kelp dynamic appears to be undergoing a succession of significant magnitude, with the outcome unclear at this time.

## LITERATURE CITED

- Amsler, C.D., and M. Neushul. 1989. Diel periodicity of spore release from the kelp *Nereocystis luetkeana* (Mertens) Postels et Ruprecht. *Journal of Experimental Marine Biology and Ecology*, 134:117-127.
- Bodkin, J.L. 1986. Fish assemblages in *Macrocystis* and *Nereocystis* kelp forests of central California. *Fishery Bulletin*, 84(4):799-808.
- Burge, R.T., and S.A. Schultz. 1973. The marine environment in the vicinity of Diablo Cove with special reference to abalones and bony fishes. California Department of Fish and Game Marine Resources Technical Report No. 19, 423 p.
- Foreman, R.E. 1970. Physiology, ecology and development of the brown alga *Nereocystis luetkeana* (Mertens) P. and R. Ph.D. Dissertation, University of California, Berkeley. 114 p.
- Foreman, R.E. 1984. Studies on *Nereocystis* growth in British Columbia, Canada. *Hydrobiologia*, 116 (117):325-332.
- Hobson, E. 1989. Changes in the nearshore environment attributed to sea urchin fishery. NMFS-Tiburon Lab. Newsletter, p.25.
- Kalvass, P., I. Taniguchi, and P. Buttolph. 1990. Relative abundance and size composition of red sea urchin, *Strongylocentrotus franciscanus*, populations along the Mendocino and Sonoma county coasts, August 1988. California Department of Fish and Game, Marine Resources Division, Administrative Report No. 90-1, 101 p.
- Nicholson, N.L. 1970. Field studies on the giant kelp *Nereocystis*. *Journal of Phycology*, 6:177-182.
- Vadas, R.L. 1972. Ecological implications of culture studies on *Nereocystis luetkeana*. *Journal of Phycology*, 8:196-203.
- Van Wagenen, R. 1990. California coastal kelp resources, summer 1989. Rev. 1.0. Ecoscan (unpublished).

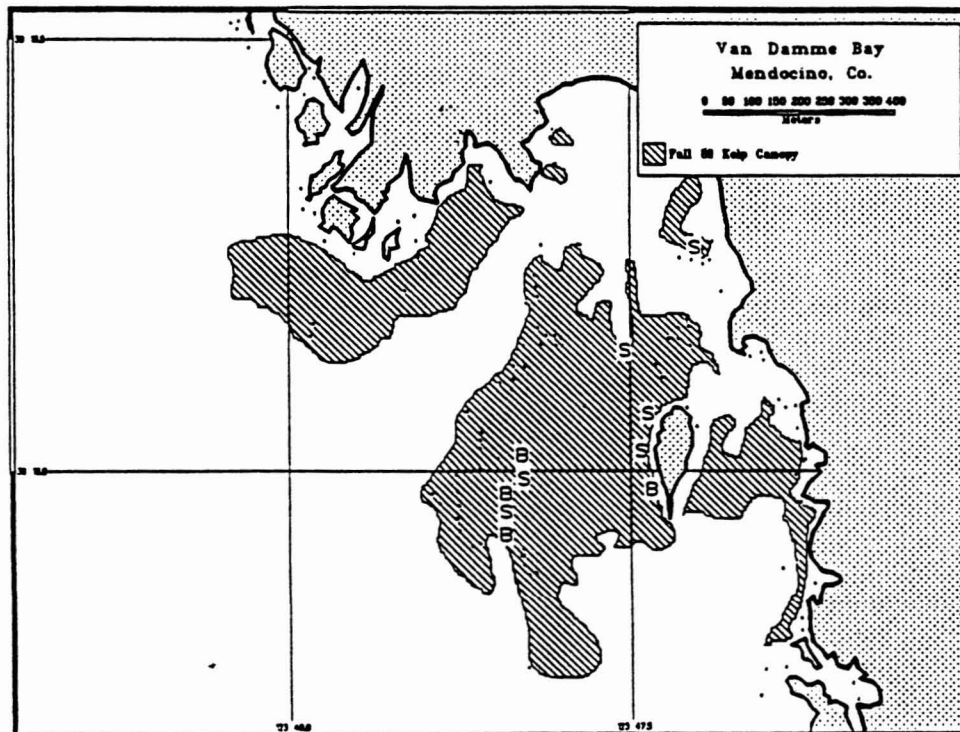
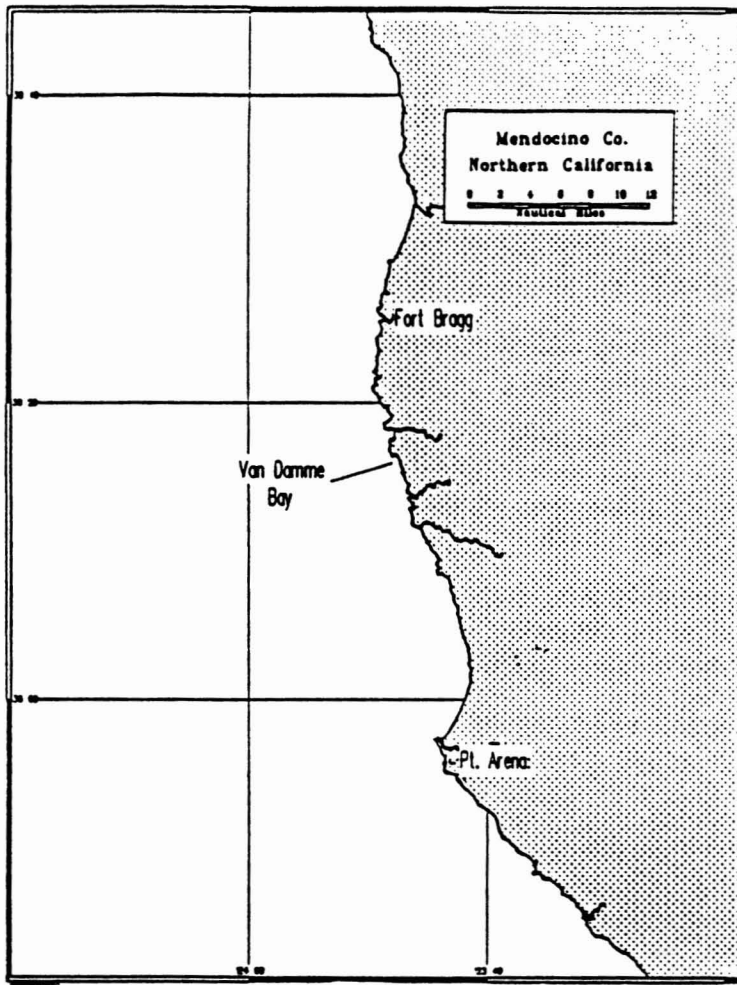


FIGURE 1. Location of Van Damme Bay, California (top). Peak bull kelp production in Van Damme Bay, fall of 1988 (bottom). Survey sites are S=surface, B=benthic.

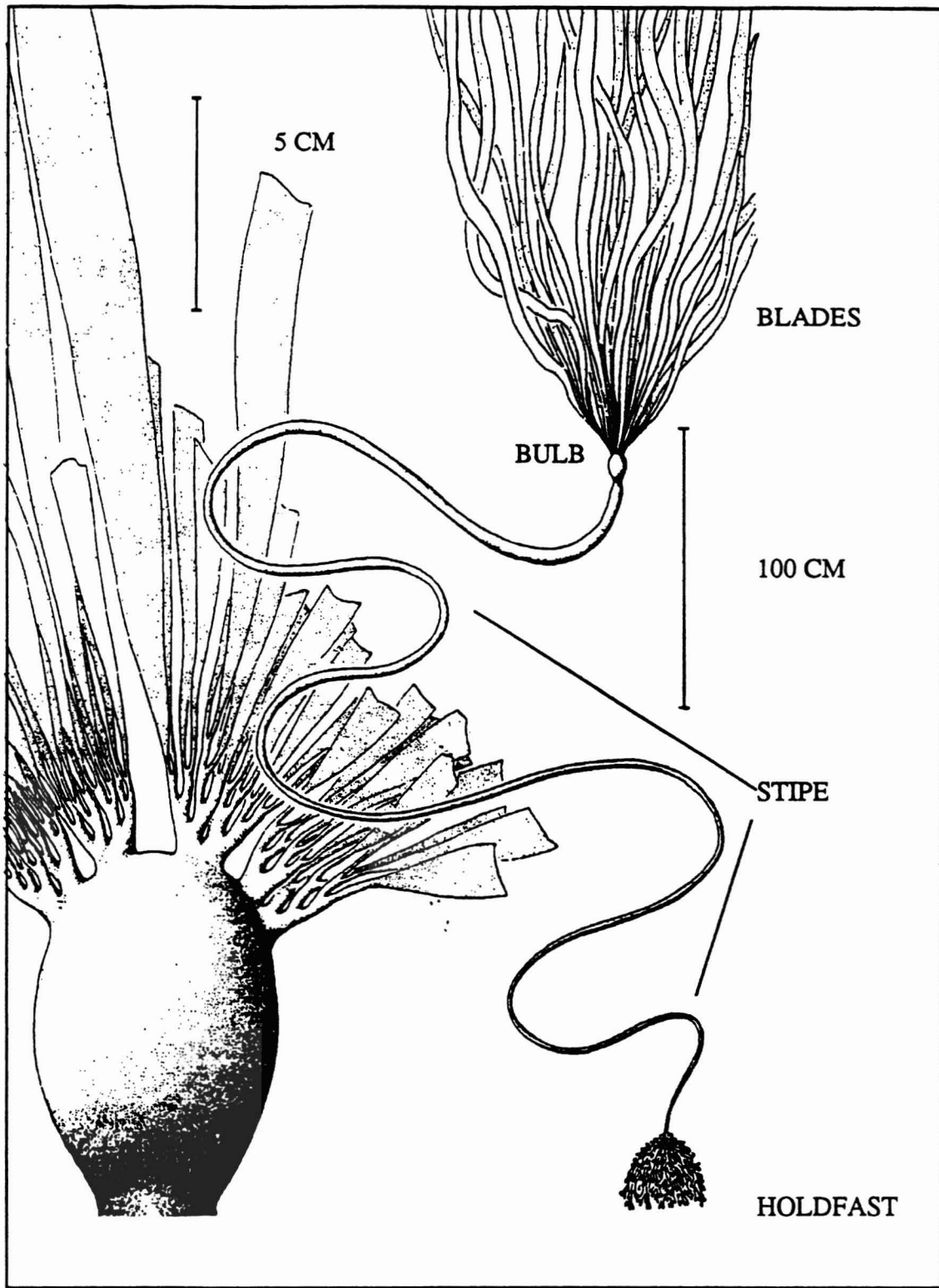


FIGURE 2. External structure of *Nereocystis luetkeana* (from Abbott and Hollenberg 1976).

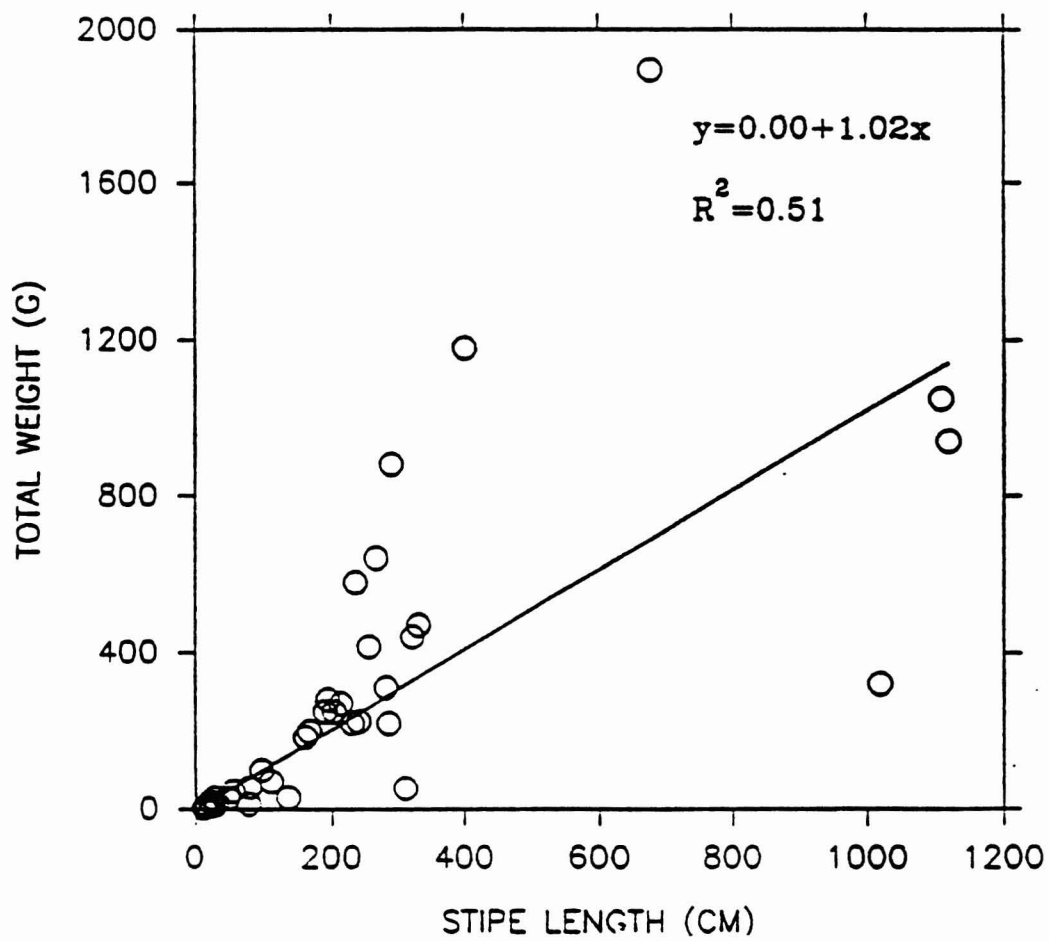


Figure 3. Linear regression of total plant weight on stipe length of *Nereocystis luetkeana* from Van Damme Bay, California.