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The Use of A Recording Fathometer For Determination of Distribution and Biomass of *Hydrilla*

MICHAEL J. MACEINA and JEROME V. SHIREMAN

Biologist and Associate Professor
Aquatic Weeds Research Center
University of Florida, Gainesville, Florida 32611

ABSTRACT

A recording fathometer was utilized to conduct vegetation surveys on two central Florida lakes from May, 1978 through June, 1979. The identification and differentiation of different submersed macrophytes was only for pure stands of vallisneria (*Vallisneria americana* Mich.) and hydrilla (*Hydrilla verticillata* Royle). Quantitative vegetation data, including total percent coverage of submersed vegetation, individual transect percent coverage, percent vertical cross sectional area infestation, mean vegetation height, hydrilla volume and total standing crop were determined. Fathometer biomass and direct biomass sampling methods were compared. The principal advantage of utilizing a recording fathometer for vegetation surveys is the savings in time and manpower. With a fathometer, both vertical and horizontal planes can be monitored, whereas other indirect or non-contact methods examine vegetation only in a horizontal plane.

INTRODUCTION

Aquatic vegetation is an integral part of aquatic ecosystems and is important to both fish and wildlife species (4, 3, 8). Uncontrolled growth of aquatic vegetation can alter both the abundance and structure of fish populations, limit recreational use, create health hazards and block navigational and irrigation routes (1).

In order to determine and evaluate control methods, quantitative and qualitative data pertaining to plant communities are needed. The purpose of this research project was to investigate the potential of a recording fathometer as a means of conducting vegetation surveys.

MATERIALS AND METHODS

A DE-719 Precision Survey Fathometer (Raytheon Marine Co., Manchester, New Hampshire) was utilized for all vegetation surveys conducted on two central Florida lakes from May, 1978 through June, 1979. An extendable bracket to house the transducer was permanently mounted on the transom of a 4.9 m aluminum flat boat powered by a 20 h.p. outboard motor. Calibration procedures were according to the instructions outlined by the manufacturer (6).

Recent aerial photographs were obtained for each study lake. Permanent landmarks were selected from these photographs and transects were conducted by transversing the lake from one landmark to another. Referral to the aerial photographs allowed for exact transect location.

While conducting a transect, the following procedure was utilized. After calibration, the boat was backed slowly to the edge of the lake and aligned between the starting point landmark and the landmark across the lake, and quickly accelerated to a speed of 2-3 m/second (4-5 knots). After boat speed was stabilized, a fix mark was placed on the chart paper. Within 10 m of the opposite shore, emergent vegetation or other structure, another fix mark was placed on the chart designating end of transect.

Identification and differentiation of various submersed macrophytes, from tracings, was accomplished by dropping a buoy over a vegetation community while transects were being conducted. A corresponding fix mark was placed on the chart marking the buoy position. Upon completion of a transect, a dredge was lowered at each buoy and vegetation was collected for identification. Quantitative vegetation data including total percent coverage of submersed vegetation, individual transect percent coverage, percent vertical cross sectional area infestation, mean vegetation height, percent vertical cover and distance from the top of vegetation to the water surface were calculated from the chart paper utilizing a ruler, planimeter and drafting tools. Volume of hydrilla was calculated by planimetry and the percentage of the lake volume infested with hydrilla derived by dividing hydrilla volume by lake volume. Further detail to the derivation and results of these various vegetation parameters will be described later in the text.

Hydrilla biomass was correlated with fathometer tracings to estimate total hydrilla standing crop in Lake Baldwin. While monthly transects were being conducted during August and December, 1978 and March, 1979, weighted numbered buoys were dropped to mark sampling stations. Simultaneously, fix marks were placed on the chart paper and the number of the buoy recorded. The following day, a circular core biomass vegetation sampler[1] was used to take replicate 0.257 m^2 samples at each buoy. Vegetation samples collected with the biomass sampler were washed and shaken in a nylon net to remove excess sand, muck and water and weighed to the nearest 5 g on a platform scale. Wet weights were later converted to kg/m^2 for analysis. A total of 202 samples was collected during these three dates at depths varying from 1.7 to 6.2 m.

Fourteen vegetation transects totaling 11.3 km in distance, were conducted monthly on Lake Baldwin in May, 1978 to June, 1979 and during May, August and November, 1978 and in February, 1979 from Lake Wales, Florida. Sixteen transects, 13.2 km in distance were run in Lake Wales on each date.

STUDY AREAS

Lake Baldwin. Lake Baldwin, located in Orlando, Florida, adjacent to the U.S. Naval Training Center, is an 80 ha lake with a maximum depth of 7.8 m (Figure 1a). The bottom sediments consist of 60% sand and 40% silt and detritus by area (7).

Lake Wales. Lake Wales, a 134 ha lake, is located within the city of Lake Wales, Polk County, Florida (Figure 1b). Maximum depth is 7.2 m and the bottom sediment consists primarily of sand with a mud layer found only in the deeper regions of the lake. Hydrilla is the dominant submersed plant in the lake. Vallisneria is found inhabiting some shallow shoreline areas and flats with cattails forming a fringe around the lake.

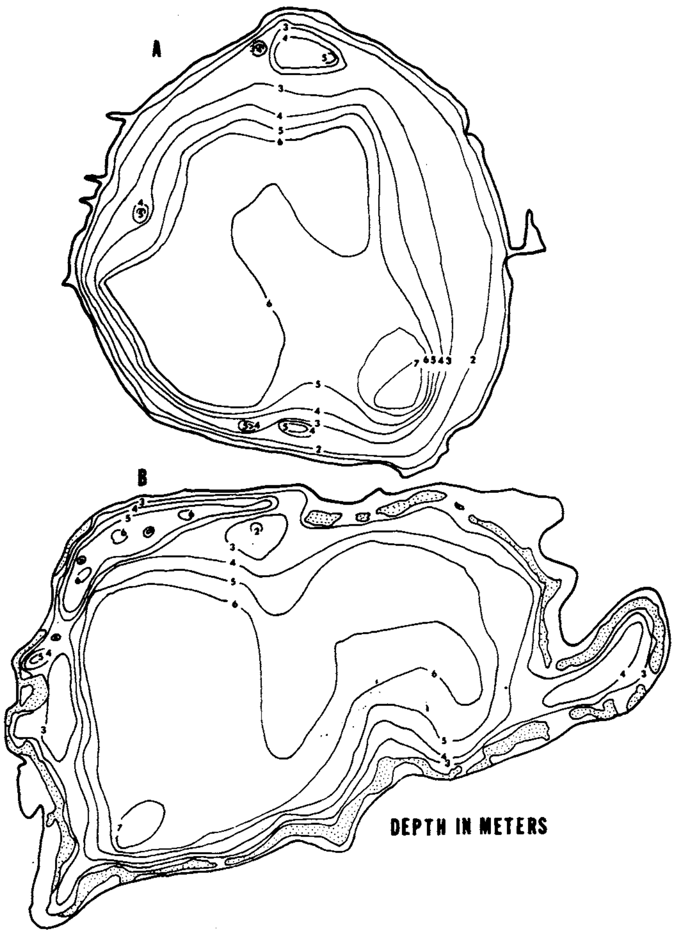

Figure 1. Bathymetric maps of Lake Baldwin (a) and Lake Wales (b) illustrating depth contours.

TECHNIQUES AND RESULTS

Differentiation of Various Submersed Macrophytes. During the study, hydrilla was the predominant macrophyte in Lake Baldwin. In Lake Wales, vallisneria grew in depths to 3.0 m, but did not reach a height greater than 0.7 m from the hydrosoil. During the late spring, summer and fall hydrilla was differentiated from vallisneria by examining differences in vegetation height on chart tracings. Typically, hydrilla grew taller than vallisneria during these months. In some areas, hydrilla produced a dense tracing pattern near the upper portion of the plant, while vallisneria tracing densities were more evenly distributed and less dense. This is expected, as the major portion of biomass production in hydrilla is located near the water surface (2). Evenly mixed stands of hydrilla and vallisneria appeared as hydrilla on the tracing, whereas, when vallisneria dominated, patterns were characteristic of pure stands of this plant.

A lake adjacent to Lake Baldwin, Lake Susannah, was sampled in order to characterize tracing patterns for other plants. Filamentous blue-green algae, *Lyngbya* sp., was recorded as a low flat mound as it characteristically grows 0.1-0.2 m in height above the hydrosoil. This pattern was distinguishable in the summer and fall from tracings of all other types of submersed macrophytes in the lake. Hydrilla, *Najas, Nitella* and *Chara* were found in different areas and

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[1] The biomass sampler was the same as described by Nall and Schardt (5).

distinct differences in tracing patterns were not detected. During the winter when the other submersed vegetation was near the bottom, *Lyngbya* could not be differentiated.

Total Percent Cover. In order to calculate total percent vegetation coverage and construct vegetation maps, the percentage of hydrilla per transect was determined. This was accomplished by dividing the linear measurement of hydrilla on the chart paper by the total chart paper length for a transect. These differences were measured along a horizontal plane parallel to the water surface. The maximum slope gradient for Lakes Baldwin and Wales for any one transect was 1:30, therefore, measurement biases were considered negligible. Measurements were made in a consistent fashion each month so that percent cover values among dates could be compared accurately.

Maps drawn for Lakes Baldwin and Wales were used to determine transects (Figure 1). The map length of the transect was divided by the corresponding transect chart length to derive conversion factors. From the starting point on the chart tracing, the distance of hydrilla infestation or open water was measured following the same procedures described for determination of transect percent cover. This value was multiplied by the conversion factor and the distance marked from the corresponding transect starting point on the map. Lines connecting vegetation types were drawn among the transects and entire vegetation communities were imposed upon the map. The total area of the lakes containing vegetation was determined by planimetry. Areas of emergent vegetation and areas inaccessible for conducting transects were not included in the determination of total area covered and total percent vegetation coverage.

When surfaced hydrilla occurred along the edge of Lake Baldwin, transects were started at the outer edge of the vegetation. From chart tracings along a transect, the depth at which surfaced vegetation ended could be determined. The distance of hydrilla was marked along the transect on a bathymetric map. Lines were drawn connecting surfaced portions of transects and adjustments made according to field observations.

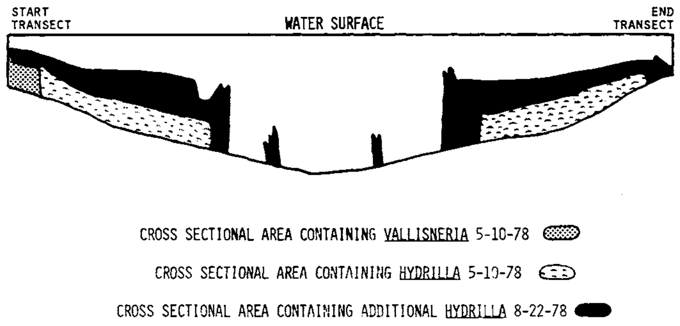

Figure 2. Cross sectional vertical profile of submersed vegetation in Lake Wales, May 10, 1978 and August 22, 1978.

Percent Vertical Area Infestation. Conducting a vegetation transect with a recording fathometer produces a vertical profile of the water column and submersed vegetation (Figure 2). Transects conducted throughout the year indicated that hydrilla grew towards the surface of the water before expanding horizontally. Percent cover data did not describe hydrilla growth in the water column; therefore, the percent vertical area of infestation was determined.

The cross sectional or vertical area occupied by hydrilla was determined by planimetry. The percentage of the water column infested with hydrilla was determined by dividing the hydrilla area by the total water area. A diagramatic representation, Lake Wales Transect 3, is presented as an example (Figure 2). Percent horizontal cover data for this transect indicated hydrilla increased from 49% to 64% during the study period, whereas percent cross sectional area infestation increased from 10% to 34% during the same time interval.

A transect percent cover value of 100% may not necessarily indicate a weed problem along a particular transect if the vegetation has not grown to the surface. A 100% vertical area infestation, however, infers total vegetation growth from the hydrosoil to the surface of the water and complete coverage along the length of the transect.

Correlation and Prediction of Hydrilla Biomass. Biomass data collected from August and December, 1978, and March, 1979 with a biomass sampler were combined for analysis. Two models correlating hydrilla biomass with fathometer tracings were determined based on tracing pattern characteristics and data collected with the biomass sampler. The first model, "thick hydrilla", was indicated by sampling stations where dense and thick hydrilla did not permit a clear reading of the lake bottom (Figure 3); whereas a second model, "sparse hydrilla", was indicated where sparse hydrilla permitted a clear reading of the hydrosoil (Figure 4).

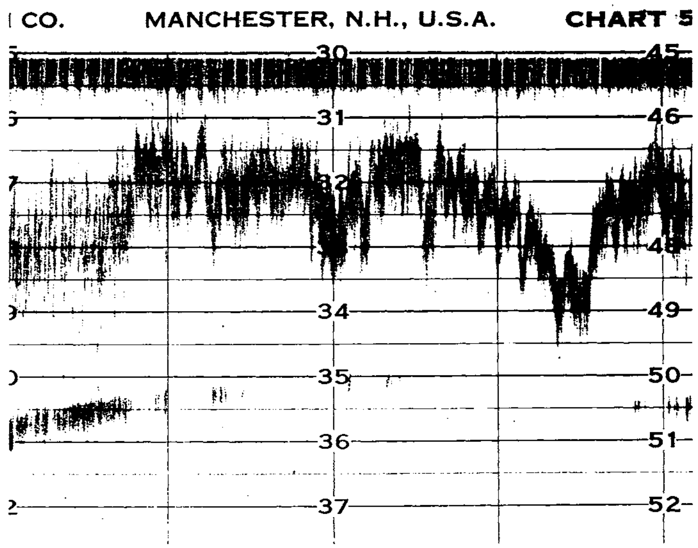

Figure 3. Fathometer tracing illustrating thick hydrilla where the lake bottom is not recorded.

The multiple regression for "thick hydrilla", $Y = 1.977 + 1.029X_1 - 1.341\ (\ln X_2)$ where: Y = the wet weight of hydrilla in kg/meter^2, X_1 = the height of hydrilla from the hydrosoil to the top of the plant along the fix mark in meters, and X_2 = the distance from the top of the hydrilla plant to the surface of the water along the fix mark, was found to be the best fitting ($r = 0.796$) and highest probable model ($P<0.01$) correlating "thick hydrilla" biomass

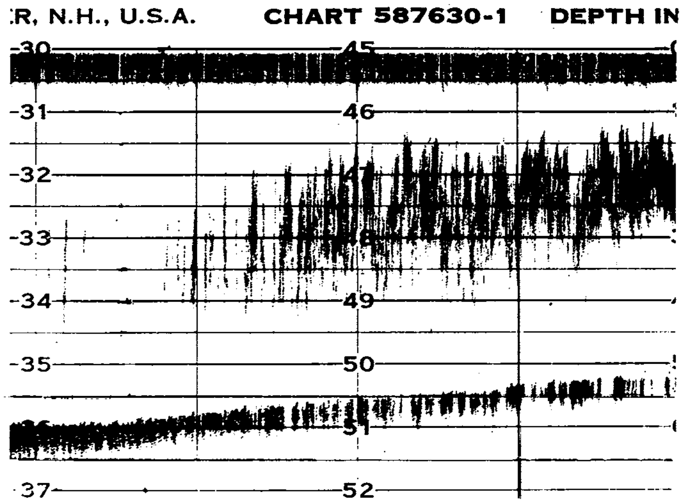

Figure 4. Fathometer tracing illustrating sparse hydrilla where thickness of hydrilla does not retard bottom tracing.

with tracing characteristics. A positive relationship between hydrilla height and biomass ($m = +1.029$) existed and as expected, a negative relationship between the distance from the top of the hydrilla plant to the water surface and biomass ($m = -1.341$) occurred.

The multiple regression for "sparse hydrilla", $\ln Y = -5.099 + 0.982 (\ln X_1) + 1.301 (\ln X_2) - 0.281 (\ln X_3)$ where: Y = the wet weight of hydrilla in kg/meter^2, X_1 = the height of hydrilla from the hydrosoil along the fix mark in meters, X_2 = the percent vertical cover of hydrilla on the tracing, and X_3 = the distance from the top of the hydrilla plant to the surface of the water along the fix mark in meters, was determined to be the best fitting ($r = 0.807$) and highest probable model ($P<0.01$) correlating "sparse hydrilla" biomass with tracing characteristics. Similar relationships existed between biomass and hydrilla height and the top of hydrilla to the surface of the water for "sparse hydrilla". A positive ($m = +1.301$) linear relationship existed between ln(biomass) and ln(percent vertical cover). Examination of multiple regression analysis utilizing Type IV sum of squares revealed that the ln(percent vertical cover) proved to be the strongest of the three independent variables ($F = 131.74$; 1,147 d.f.) explaining the variation due to the ln(biomass) of "sparse hydrilla".

Biomass regression models were used to determine total biomass in Lake Baldwin from monthly transects. A systematic design was formulated to accomplish this goal. On metric chart paper, vertical lines transversed the chart paper at 25.4 mm intervals. Starting with transect one, the first vertical line on the transect chart paper became the first prediction station. The vertical line was treated equivalently to the fix mark line which was utilized to calculate the independent model variables. Hydrilla height, percent vertical cover and the distance from the top of hydrilla to the surface of the water was determined for these stations utilizing the same procedures employed for correlating actual biomass. Each vertical line on the chart paper that crossed hydrilla on all transects was utilized as a prediction station. When the vertical line intercepted areas on the chart paper which indicated open water no measurements were made. Approximately 150 to 200 prediction lines were used per monthly sample.

For "sparse and thick hydrilla" prediction stations, mean values for hydrilla height, vertical percent cover and the distance from the top of the hydrilla plant to the surface of the water were calculated for six depth intervals; 1.0 to 1.9 m, 2.0 to 2.9 m, 3.0 to 3.9 m, 4.0 to 4.9 m, 5.0 to 5.9 m, and 6.0 to 6.9 m. Separation by depth intervals reduced variation about the mean. The majority of stations used to calculate "thick hydrilla" were between 4 and 6 m in depth.

The total area of each depth interval was determined by planimetry for Lake Baldwin, and the total area of hydrilla infestation was determined from vegetation maps for each depth interval. Each depth interval was assigned a percentage of the area in hectares according to the proportion of the entire area in which "sparse and thick hydrilla" vegetation type stations were observed. For example, if the 5.0 to 5.9 m depth interval contained 10.0 ha of hydrilla and 20 prediction stations, then the ratio of "thick" and "sparse" stations was determined. If 15 or 75% of these stations were "sparse hydrilla" and 5 or 25% were "thick hydrilla" stations, then 7.5 ha of the 10.0 ha was designated as containing "sparse hydrilla" and 2.5 ha as "thick hydrilla".

Mean vegetative values (hydrilla height, vertical percent cover and surface distance) for each depth interval and for both "thick and sparse hydrilla" vegetation types were entered into their respective multiple regression models. The mean weight of hydrilla in kg/m^2 (95% confidence interval) was generated for each depth interval and for the two hydrilla types. At each depth interval, the total vegetation area in hectares was converted to m^2 and multiplied by the mean weight of hydrilla per m^2 and multiplied by the mean weight of hydrilla per m^2 for both vegetation types. For each depth interval where "sparse and thick hydrilla" occurred, the total weight of hydrilla and the upper and lower confidence intervals were derived by summation. Weight of hydrilla and confidence intervals were summed for all depth intervals to determine total hydrilla standing crop.

Hydrilla standing crop in the 0.0-0.9 m depth interval was estimated by dividing the mean biomass (kg/m^2) of the 1.0 to 1.9 m depth interval by 2 and multiplying this value by 2.7 ha. We assumed this area contained 100% hydrilla coverage throughout the year. Confidence intervals were calculated from a percentage of the values determined in the 1.0 to 1.9 m depth interval. The 0.0 to 0.9 m depth interval contributed 1.4 to 2.8% of the total standing crop for any one estimate.

Hydrilla Volume. Total hydrilla volume in Lake Baldwin was calculated utilizing mean hydrilla height values and area of hydrilla infestations by depth intervals. Total lake volume was derived by plotting the areas of the contours against depth and the volume of this curve integrated by planimetry (9). Mean hydrilla height values were plotted on hypsographic volume curves at the mean depth calculated for each depth interval (Figure 5). The percentage of depth interval areas infested with hydrilla were considered and incorporated in each hypsographic figure.

A line was drawn connecting the points designating the top of the hydrilla plants along the depth intervals. The enclosed area from the top of the plants to the top of the hydrosoil represented the volume of hydrilla in the lake.

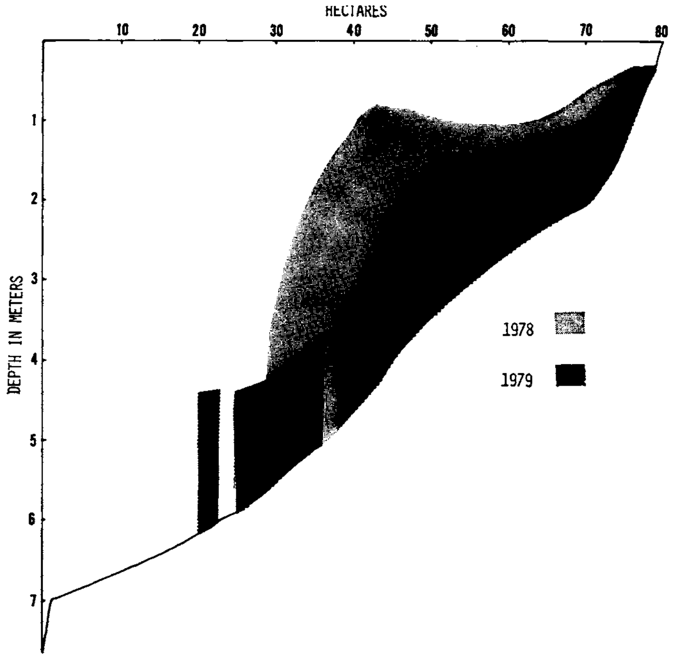

Figure 5. Hydrilla volume (hypsographic curve) of Lake Baldwin for June, 1978 and June, 1979.

Generally, hydrilla height values were comparable and similar to volume estimates. However, total percent coverage and the percent of the total lake volume infested with hydrilla did not always demonstrate similar trends. Total percent cover rose from 62 to 69% from June, 1978 to June of 1979, but percent hydrilla volume dropped from 31 to 21% during this time. A dramatic reduction in hydrilla height, especially in water depths greater than 4 m accounted for the overall decrease in hydrilla volume.

Comparison of Fathometer and Direct Biomass Sampling Methods. In order to evaluate the total hydrilla standing crop as determined by our models, hydrilla standing crop was also determined independently by the method reported by Nall and Schardt (5).

Direct random biomass sampling method determined a mean value of 1.21 ± 0.23 kg wet hydrilla/m^2 (± 0.05%) (Table 1). Total standing crop was calculated and found to be 0.95 ± 0.18 million kg hydrilla for the entire lake. The estimated mean biomass calculated from fathometer tracings was slightly lower, 1.04 kg hydrilla/m^2. These means were not tested statistically due to the difference in collection methods and derivation of variances, but the occurrence of overlapping confidence intervals exhibited by each mean might indicate that the mean values were not significantly different. The fathometer biomass estimate was generated from areas containing only hydrilla (70.5% of the lake area), whereas, the direct random sampling estimate was calculated for the entire lake area including those areas with and without hydrilla. Of the 100 biomass samples collected, only 14 samples did not contain hydrilla. Total standing crop estimates were larger for the direct random biomass sampling (946,640 kg) than the estimate calculated from fathometer tracings (576,000 kg) and it is likely that these values are significantly different as the confidence intervals do not overlap.

Data from the direct random biomass sampling method indicated that hydrilla was inhabiting 86% of the lake, whereas fathometer tracings revealed only 71% of the lake area sampled contained hydrilla. We feel that the 71% coverage figure calculated for the lake is very accurate due to the high number of transects (14) and the total distance covered by these transects (11.3 km). Therefore, calculation of mean hydrilla biomass and total hydrilla standing crop values from the direct random biomass sampling data overestimated the amount of hydrilla in the lake due to the number of samples taken in hydrilla. It appears, therefore, a disproportionate amount of sampling effort was placed in hydrilla infested waters by the direct random biomass sampling method.

DISCUSSION

The principle advantage of utilizing a recording fathometer for vegetation surveys is that savings in time and manpower can be accomplished. In Lake Baldwin, 14 transects covering a total distance of 11.3 km were completed in three hours. In Lake Wales, 16 transects covering 13.2 km were completed in approximately 3.5 hours. From previous experience, the completion of a 100 m (0.1 km) conventional line intercept-transect at 2 meter intervals requires 0.5 to 1.0 h and two surveyers. With experience, one person can operate the boat and fathometer simultaneously and sample a much greater portion of a lake than other sampling methods, and is advantageous since vegetation is monitored in two planes in the water column, vertical and horizontal.

The results of this study indicate that a recording fathometer is best suited for aquatic vegetation surveys in lakes where the problem plant exists as a monoculture even though vallisnaria was distinguishable from hydrilla in Lake Wales. Gross morphological differences in plant structure account for variation in recording chart tracing patterns. Future testing may prove that other submersed macrophytes can be differentiated from hydrilla by examination of chart tracing patterns. Our previous tests indicate that differentiation between hydrilla and submersed macrophytes of similar morphological structure (*Ceratophyllum, Myriophyllum, Utricularia, Cabomba* and *Egeria*) cannot be accomplished by examination of tracing patterns.

This method describing utilization of fathometer tracings for estimation of biomass eliminated the chance of error that occurs when employing a random numbers table for selection of sampling stations. A systematic approach of selecting biomass prediction stations on chart tracings allowed all water depths to be adequately sampled. Choosing biomass prediction stations containing only hydrilla eliminated observations not containing hydrilla, therefore, reducing variation about the mean. By determining predictive independent vegetation variables which were utilized to calculate mean biomass values at 1 m intervals, variation was further reduced in the models. A greater number of hydrilla biomass prediction stations, 152

TABLE 1. COMPARISON OF FATHOMETER AND DIRECT RANDOM BIOMASS SAMPLING METHODS FOR HYDRILLA BIOMASS AND TOTAL HYDRILLA STANDING CROP FOR LAKE BALDWIN, MARCH, 1979.

	Method	
	Fathometer tracings	Direct biomass sampling
Area Infested (ha)	55.3	67.4 (78.4)[a]
Percent Cover (%)	70.5	86 (100)[a]
Kg Hydrilla/Meter^2		
$\overline{X}$	1.04	1.21
L.B.	0.80	0.98
U.B.	1.31	1.44
Total Hydrilla (kg)		
$\overline{X}$	576,000	946,640
L.B.	441,620	768,320
U.B.	725,890	1,128,960

[a] Kg hydrilla/meter^2 and total hydrilla (kg) were calculated from the total area of the lake.

L.B. = 95% lower bound confidence value.

U.B. = 95% upper bound confidence value.

versus 86, for the biomass samples, was used in the analysis utilizing the fathometer method as compared to direct random biomass sampling method in March, 1979, in Lake Baldwin.

One major limitation of the fathometer for estimation of hydrilla biomass and total standing crop was the inability to conduct transects in water depths less than 1 meter. This prevented direct estimation in these depths. Also, when formulating predictive regression models correlating fathometer tracing patterns with actual biomass, only four observations in water depths less than 2 m were utilized in the analysis. Therefore, because of limited sampling, biomass estimates from these shallow water areas may be biased.

The primary limitation of conducting vegetation surveys with a recording fathometer was incurred when submersed vegetation approached the surface of the water. When vegetation was dense and within 0.7 m of the surface hydrilla tracing patterns merged with the transducer line, preventing the top of the hydrilla plant from being distinguishable on the chart paper, boat movement was impeded in these areas and occasionally caused complete stops while conducting transects and thick and dense stands of hydrilla prevent bottom sounding. Although determination of vegetation biomass with a fathometer has several limitations, it appears to be more accurate, faster and less expensive than other means of monitoring vegetation growths in lakes.

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