Comparisons of Wegener Ring and 0.08-Hectare Block Net Samples of Fishes in Vegetated Habitats

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ABSTRACT: Density, biomass, and species composition of fish 6 cm total length (TL) were determined in 4 aquatic plant communities in Lake Okeechobee, Florida, with 0.08-ha block nets and Wegener Rings (0.004 ha). Wegener Rings were placed within block nets prior to rotenone application. In Illinois pondweed (*Potamogeton illinoensis*), mean density and biomass estimates derived with the 2 gears were not significantly different. In eel-grass (*Vallisineria americana*) and hydrilla (*Hydrilla verticillata*), mean density estimates derived with Wegener Rings were significantly higher than those derived with block nets, but mean biomass estimates were similar. In yellow water-lily (*Nymphaea mexicana*), Wegener Rings provided significantly higher estimates of both mean density and biomass. Gear comparisons within sample sites revealed that at the highest fish densities encountered in each vegetation type, Wegener Rings provided significantly higher density estimates than block nets. If it is assumed that more complete retrieval of small fish from the Wegener Rings provide more accurate estimates of density, then block net samples in Illinois pondweed, eel-grass and hydrilla underestimated total fish density from 17% to 397% and total biomass from 0% to 26%. In yellow water-lily, block nets underestimated total fish density from 451% to 936% and underestimated biomass from 30% to 56%. Wegener Rings collected 62% to 91% of the species collected by block nets. Species not collected in Wegener Rings were present in low densities in block nets. Data suggest Wegener

Rings can be used to estimate density and biomass of small fish within block nets in shallow (<1.5 m depth), densely vegetated habitats. Wegener Rings provided similar or more accurate estimates than block nets and reduced total effort necessary to collect and process samples.

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Sampling with rotenone is a common technique for assessing fish stocks (Davies and Shelton 1983). Data from rotenone samples provide information on species composition, standing crop, and age and size structure of a fish population (Grinstead et al. 1977, Aggus et al. 1980). Because rotenone sampling is labor intensive (Davies and Shelton 1983), recent studies have focused on blocknetting smaller areas (≤0.41 ha), rather than the traditional method of blocking off coves (Timmons et al. 1979, Shireman et al. 1981, Hightower et al. 1982, Johnson et al. 1988). Sampling smaller areas allows more replications, increases statistical precision, and allows greater spatial coverage of a water body.

Sampling with rotenone can be species or size selective depending on the size of the area sampled. For example, block nets encompassing relatively small areas may provide information on density and size-distribution of abundant forage or young-of-year fish, but may inadequately sample less abundant species or large, more mobile adults (Miller and Guillory 1980, Kushlan 1981, Jacobson and Kushlan 1987). Use of larger nets may result in collection of larger fish; however, if there is a lack of sufficient manpower to retrieve all fish, it can result in underestimates of the abundance of small fish (Timmons et al. 1979, Shireman et al. 1981). This underestimate may be especially pronounced in shallow vegetated areas where densities of small fish are high (Barnett and Schneider 1974, Haller et al. 1980, Killgore et al. 1989, Serafy et al. 1988).

In fall 1989, a rotenone sampling program was initiated on Lake Okeechobee, Florida, to assess fish community structure and abundance in several different vegetation communities within the littoral zone. Block nets which encompassed 0.08 ha were used (Shireman et al. 1981). Preliminary results obtained with these nets suggested we underestimated the abundance of small forage fish in certain dense vegetation types. This underestimate occurred because of the extremely high abundance of small fish and because dense vegetation and soft organic substrates impeded retrieval of fish. In an attempt to better quantify the abundance of small fish and to more efficiently utilize available manpower, we initiated a subsampling program within each blocknet using Wegener Rings. Wegener Rings, which encompass an area of approximately 4 m^2, have been shown to be an effective tool for sampling fish in shallow vegetated habitats (Wegener et al. 1973, Miller and Guillory 1980). Wegener Rings were placed within each block net prior to rotenone application and the numbers of fish collected within the rings were extrapolated to estimate numbers of small fish within the entire net. In this paper we compare species composition, density, and biomass estimates derived from the Wegener Rings to estimates obtained from the block nets in 4 different vegetation communities.

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Methods

Sampling was conducted in fall 1989 on Lake Okeechobee, a 182,000-ha lake located in south-central Florida. Vegetation communities sampled included submergent, Illinois pondweed, eel-grass, and hydrilla, and floating yellow water-lily. Attempts were made to sample monotypic populations of each vegetation type; however, other plant species were frequently encountered. Illinois pondweed and eel-grass were often intermixed. All yellow water-lily was intermixed with sparse submergent coontail (*Ceratophyllum demersum*) and southern naiad (*Naias guadalupensis*). Illinois pondweed and eel-grass communities were sampled at 3 different lake sites (A, B, and C), and hydrilla and yellow water-lily communities were sampled at 2 (A and B). To be selected for sampling, vegetation communities at each site had to be relatively dense (>85% coverage) and distributed such that densities were relatively uniform throughout the net. Depths at all sites sampled ranged from 0.4 to 1.5 m.

Three block nets, each encompassing 0.08 ha, were set in each vegetation type in each area sampled. Each block net had 3-mm bar mesh and was 3.4 m deep. The nets were set from the front of a flat-bottom john boat pushed by personnel in the water. This reduced both disturbance of the area and prevented fragmentation of the vegetation. Each corner of the net was anchored individually, and the net was inspected to insure the leadline was in contact with the bottom. After placement of the block net, 3 Wegener Rings were placed randomly within the net. Wegener Rings were constructed of 3-mm mesh netting, were .15 m to 2.0 m deep, and each encompassed an area of 0.0004 ha (Wegener et al. 1973). Two people carried each ring into an area of the net chosen for sampling and tossed it approximately 5 m. The ring was then inspected to insure the steel ring was in contact with the bottom.

Within each block net, rotenone was applied at a concentration of 2 mg/liter with an airboat. To insure application throughout the water column, rotenone was pumped through a hose connected to a hand held steel pipe which could be easily pushed through the vegetation.

Fish were collected from each block net for 3 days. Fish were collected on the first day by a 6- to 8-man crew and on each subsequent day by a 3- to 5-man crew. Fish were separated by species, grouped into 2-cm length intervals, and weighed. Length-weight tables constructed from first day weights were used to assign weights to fish collected on days 2 and 3. When large numbers of small fish were encountered, they were grouped together and subsampled. Species composition, number, and biomass of the entire sample were extrapolated from these subsamples.

Processing of fish collected from Wegener Rings was similar except that large numbers of small fish were not subsampled. Because only 6 Wegener Rings were available, fish were collected from Wegener Rings set in 1 block net on the first day only and in the other 2 block nets for 3 days. Percentages of fishes collected on days 2 and 3 from Wegener Rings placed in similar vegetation types were used to extrapolate total density and biomass of fish in Wegener Rings which were removed after the first day. Data summarized from the Wegener Rings was combined with data from the block net in which the rings were set to obtain total abundance and biomass estimates for the block net. For comparative analyses, Wegener Ring data were expanded to density and biomass per 0.08 ha.

Block net and Wegener Ring catches were compared statistically with analysis of variance (ANOVA). Mean catch rates within each vegetation type were tested with 2-way ANOVA; sample site and gear type were the main effects tested. Differences in catch between gears within individual sample sites was tested with 1-way ANOVA. In all analyses, significance was assumed at $P \leq 0.1$. All data were transformed to the $\ln(x + 1)$ before analysis.

Results

Analysis of length frequency distributions of fish collected in all vegetation types indicated Wegener Rings were selective against fish >8 cm. On the average, only 1 fish >8 cm was captured per Wegener Ring and fish >8 cm comprised <1% of the total number of fish captured. To minimize the effect of size-selectivity on abundance and biomass estimates, we chose 6 cm as the maximum size we believed to be completely vulnerable to the Wegener Ring. Comparisons of catch data between Wegener Rings and block nets were performed only for fish <6 cm.

Overall mean density and biomass estimates derived from Wegener Rings were greater than 1.5 times those derived from block nets in all vegetation types (Table 1). Mean differences were significant for densities of fish in eel-grass and hydrilla and for both density and biomass of fish in yellow water-lily (Table 1). Mean density and biomass of fish in each vegetation type varied considerably between sample sites (Table 1). Differences were significant for both density and biomass in Illinois pondweed ($P = 0.002$) and eel-grass ($P < 0.001$). There were no significant site-by-gear interactions in any of the vegetation types sampled.

Analysis of differences in catch within sample sites revealed that at the highest fish densities encountered in Illinois pondweed, eel-grass, and hydrilla (>13,000 per 0.08 ha), Wegener Rings provided significantly higher density estimates than block nets (Table 1). Differences in biomass were significant at the highest densities encountered in eel-grass and were nearly significant at the highest densities encountered in Illinois pondweed ($P = 0.11$). Differences in biomass were not significant at the highest densities encountered in hydrilla. Densities of small fish in yellow water-lily were the highest of any vegetation type sampled (Table 1). At both yellow water-lily sites, density and biomass estimates derived from Wegener Rings were 5 to 10 times higher than those derived from the block nets ($P < 0.01$).

Total density and biomass estimates for all size fish determined from the block

Table 1. Means and standard deviations of catch per unit effort (adjusted to 0.08-ha) of fishes 6 cm^{TL} collected by Wegener Rings and block nets in 4 vegetation types in Lake Okeechobee, Florida. P = probability of a difference in catch between gear types. Asterisk indicates significant difference at $P < 0.1$.

Sample site	Number					Weight (g)				
	Wegener Ring		Block net			Wegener Ring		Block net		
	Mean	(SD)	Mean	(SD)	P	Mean	(SD)	Mean	(SD)	P
					Illinois pondweed					
A	1,444.4	(1,495.2)	1,204.7	(1,458.6)	0.39	678.0	(904.4)	1,157.9	(1,066.1)	0.20
B	44,466.7	(40,644.6)	8,286.0	(2,447.5)	0.02*	8,695.8	(9,986.1)	2,022.6	(466.2)	0.11
C	3,888.9	(3,255.9)	2,526.0	(2,276.0)	0.85	1,944.9	(1,573.3)	1,575.6	(1,354.0)	0.94
Overall mean	16,600.0	(30,273.7)	4,005.6	(3,736.1)	0.81	3,772.9	(6,675.3)	1,585.4	(968.0)	0.42
					Eel-grass					
A	7,777.8	(5,343.6)	2,614.0	(1,050.5)	0.14	1,864.2	(1,080.4)	919.5	(161.9)	0.36
B	47,444.4	(19,441.9)	23,678.0	(1,814.0)	0.03*	11,197.1	(3,164.1)	6,967.8	(1,114.2)	0.06*
C	4,311.1	(2,383.5)	2,872.3	(1,422.4)	0.55	2,560.7	(1,413.7)	1,978.3	(878.2)	0.67
Overall mean	19,844.4	(22,900.8)	9,721.4	(10,544.4)	0.03*	5,207.3	(4,771.5)	3,288.5	(2,886.9)	0.12
					Hydrilla					
A	13,875.0	(6,908.3)	5,554.7	(5,343.5)	0.05*	3,783.8	(2,473.5)	1,764.7	(584.0)	0.21
B	12,444.4	(14,267.0)	3,588.7	(4,212.4)	0.35	2,316.9	(2,205.6)	1,160.0	(1,135.5)	0.54
Overall mean	13,117.6	(11,099.3)	4,571.7	(4,436.0)	0.07*	3,007.7	(2,382.6)	1,462.4	(872.8)	0.25
					Yellow water-lily					
A	30,955.6	(15,587.1)	5,440.3	(1,363.2)	<0.01*	4,331.8	(3,548.8)	960.4	(607.2)	<0.01*
B	71,488.9	(67,533.3)	6,797.7	(2,560.0)	<0.01*	7,325.1	(6,140.6)	1,305.5	(312.9)	<0.01*
Overall mean	51,244.4	(51,919.9)	6,105.0	(1,973.6)	<0.01*	5,828.4	(5,103.2)	1,133.0	(471.6)	<0.01*

Table 2. Comparison of total number and biomass of fish collected from block nets to estimates derived from the same block nets adjusted by substituting in Wegener Ring data for fish <6 cm TL. Each value is extrapolated to a per hectare basis.

	Number			Weight (kg)		
Vegetation	Block net	Adjusted block net	% Diff.	Block net	Adjusted block net	% Diff.
Illinois pondweed	17,654	20,650	+17%	124.2	118.2	−5%
	113,810	566,069	+397%	680.8	764.2	+12%
	40,708	57,744	+42%	212.6	217.2	+2%
Eel-grass	34,804	99,352	+186%	51.3	64.4	+26%
	310,708	607,788	+96%	310.7	363.6	+17%
	43,988	61,973	+41%	141.7	149.0	+5%
Hydrilla	75,421	179,425	+138%	176.7	201.9	+14%
	52,113	162,809	+212%	243.4	257.9	+7%
Yellow water-lily	70,729	389,670	+451%	142.2	184.3	+30%
	86,417	895,057	+936%	135.0	210.3	+56%

nets were compared to adjusted total estimates derived by replacing block net data for fish 6 cm with data derived from Wegener Rings (Table 2). Adjusted block net densities ranged from 17% to 936% higher than unadjusted densities (Table 2). Adjusted estimates of biomass were 2% to 55% higher than unadjusted estimates at all sites except 1 (Table 2). At Illinois pondweed site A, adjusted biomass estimates were 5% lower than unadjusted estimates.

Wegener Rings collected 62% to 91% (x = 78%) of the total number of species collected in block nets. The most abundant species collected by both gears were bluefin killifish (*Lucania goodei*), mosquitofish (*Gambusia affinis*), least killifish (*Heterandria formosa*), and small sunfish (*Lepomis* spp.). Species not collected by Wegener Rings generally occurred in low densities in block nets (<2 fish/0.0004-ha).

Discussion

We believe Wegener Rings provided more accurate density and biomass estimates of small fish than block nets because small fish could be retrieved more effectively from the smaller rings. Vegetation in the rings could be more easily sorted through and frequently nearly all vegetation could be removed. By sampling smaller areas, capture efficiency of very small fish (<2 cm) was increased. The inability to collect all fish from the block net was related to the high density of fish, soft substrates which made movement difficult, size of the area, and the dense vegetation which prevented fish from floating. Lower estimates in the larger net may have been exacerbated by the tendency of small fish to decompose and sink relatively rapidly (Shireman et al. 1981) and the occurrence of fragmented vegetation in the sample which interfered with sorting.

If it is assumed that more complete retrieval of smaller fish from the Wegener Ring samples provided more accurate density estimates, our results indicate block net sampling alone may significantly underestimate densities of small fish in vegetation when fish densities are high. For example, block nets at site B in yellow water-lily underestimated true density and biomass of fishes by >800,000 fish and 75 kg per ha, respectively. At site B in Illinois pondweed, block nets underestimated true density and biomass by >430,000 fish and 83 kg per ha, respectively. Differences of these magnitudes may be especially important when block net data are used to calculate various ratios such as available prey/predator ratios (AP/P; Jenkins and Morais 1976) or forage/carnivore ratios (F/C; Swingle 1950).

Whereas block nets are frequently used to sample fish communities in vegetated habitats, potential biases associated with the incomplete recovery of small fish is rarely addressed. Haller et al. (1980) used mark-recapture techniques to estimate recovery rates of small fish from 0.08-ha block nets set in hydrilla. Although this technique may be effective for many species, marking fish <2-cm is difficult and mark-recapture studies may require the addition of considerable manpower. Haller et al. (1980) reported that obtaining the most accurate results required from 20 to 30 hours of pickup per net. Because adjustment factors for individual fish species may vary with vegetation type or density, this approach may be time prohibitive when a large number of nets must be set.

Underestimates of the abundance of small fish in block nets varied both between and within vegetation types. Differences between vegetation types were related to fish community structure and abundance, growth form of the macrophytes, and bottom conditions. For example, the greatest underestimate of abundance by block nets occurred in yellow water-lily. Yellow water-lily communities typically consisted of an extremely dense mat of entangled underwater stems covered entirely by floating leaves. Bottom conditions consisted of soft muck. These conditions, which impeded the efficient retrieval of dead fish in block nets, were exacerbated by the fact that this community was dominated by small forage fish at densities between 380,000 and 890,000 fish per ha. Variability in fish densities within vegetation types may have been related to differences in vegetation density between sample sites. Although vegetation density was not measured in this study, it has been demonstrated to be an important factor influencing fish abundance (Crowder and Cooper 1979, Killgore et al. 1989) and may have been at least partly responsible for the spatial variability in observed fish abundance.

Wegener Rings have been used to sample vegetated habitats in a number of studies (Wegener et al. 1973, Carlson and Duever 1977, Miller and Guillory 1980). Our results suggest that because Wegener Rings are highly selective against fish <8 cm TL, Wegener Ring data alone is inadequate for estimating standing stocks of fishes. We suggest a combination of block nets and Wegener Rings provide the best estimate of the abundance of fish in vegetated habitats when water depth is 1.5 m. Block nets provide estimates of the density and biomass of large fish whereas Wegener Rings provide more accurate estimates of the density and biomass of small fish. By reducing the amount of effort required to collect and process small fish in the block net, Wegener Rings can reduce the overall manpower required to process block nets samples. The amount of effort required to retrieve small fish from either block nets or the Wegener Rings varied with vegetation type and density. However, the time required to retrieve and process 3 Wegener Ring samples were generally less than one-fifth that required for the entire block net.

Although Wegener Rings were more efficient for sampling small fish than block nets, there are potential biases associated with extrapolating results from a few Wegener Rings to the area of the entire block net. For example, adjusted mean biomass estimates at site A in Illinois pondweed were approximately 5% less than unadjusted estimates (Table 2). This occurred because juvenile redear sunfish (*Lepomis microlophus*), a species common but not extremely abundant in the block net, were not captured by the Wegener Rings. Extrapolations resulting from the collection of 1 or 2 individuals in Wegener Rings may result in overestimates of actual values if the species is actually rare within the block net. Conversely, there is potential that relatively rare species will not be collected by Wegener Rings. These biases, as well as large within-net variances in catch due to gregarious distributions of species, could be reduced by increasing the number of Wegener Rings samples per net; however, this would require a substantial increase in manpower and equipment. Disadvantages of Wegener Rings are that they are bulky, somewhat cumbersome, and require 2 men for operation. Other methods used to sample vegetated habitats such as 1 m^2 throw traps (Kushlan 1981) may provide useful estimates of the densities of small fish with lower manpower requirements. Sampling of smaller areas would also allow for additional replications within nets.

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