COMPUTER PROGRAM FOR ANALYSIS OF THE HOMOGENEITY AND GOODNESS OF FIT OF FREQUENCY DISTRIBUTIONS, FORTRAN IV

Routinely, in the study of the dynamics of a fish population, one of the initial steps is the examination of length measurements, viz, the frequency distribution of lengths, average length at age, and differential length distribution by gender. Often, length measurements are the only information available from which to estimate the age structure of the population. Standard statistical techniques such as chi-square tests are often used to analyze length-frequency distributions before pooling data, e.g., to estimate the age structure of the population (Yong and Skillman 1975).

I have developed a computer program which forms frequency distributions from length measurements and then calculates a chi-square statistic which is used to test the homogeneity of the frequencies for the purpose of pooling. Theoretical frequencies from a normal distribution based upon the sample mean and variance of each length-frequency distribution are used in calculating chi-square tests of goodness of fit (Li 1959). The program does not partition the chi-square test of homogeneity but does pool adjacent class frequencies when expected frequencies are small in the case of the test of goodness of fit. Observed adjacent class frequencies are pooled if their expected frequencies are too small and then the test of goodness of fit is calculated. The usual caution against using small samples and expected frequencies less than five in chi-square tests of goodness of fit should be followed (Sokal and Rohlf 1969).

Data required are either individual length measurements in millimeters (from 1 to 1,000 mm) or pairs of length class midpoint and frequency for each of up to five length-frequency distributions per data set; maximum frequency must be less than 1 million. Program storage could be increased to accommodate more than five length-frequency distributions, depending on the capacity of the computer being used. Class interval width must be specified; lengths are then tallied by up to 100 classes which are identified by midpoint on the output. Multiple data sets are processed sequentially without limit.

Output includes listings of arithmetic mean, variance, standard deviation, standard error of the mean, total sample size, and chi-square statistic of goodness of fit for individual groups and for the pooled frequency distribution. The chi-square value for the test of homogeneity is printed with its degrees of freedom; appropriate tables should be consulted for critical values used in testing hypotheses. The goodness of fit test for the pooled data would not apply to the situation where the distribution is clearly multinomial. Histograms of all frequency distributions are produced as full-page printer charts, scaled if necessary to 50 units by up to 100 class intervals. The pooled frequencies and class midpoints are punched on cards to facilitate additional analyses.

The program was developed on an IBM 360/65 OS System[1] and required 56,811 bytes of storage. A copy of the FORTRAN IV source program listing, example input and output, and an instruction manual are available from the author.

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PORTABLE TRIPOD DROP NET FOR ESTUARINE FISH STUDIES[1]

Since the introduction of a portable drop net system by Jones et al. (1963) several designs have been utilized for freshwater and estuarine fish studies (Moseley and Copeland 1969; Kjelson and Johnson 1973; Kushlan 1974; Adams 1976). The value of these sampling systems in estimating the density and biomass of certain fish species has been well documented by these authors (Table 1).

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TABLE 1.—Basic drop net design characteristics of previous studies and the current net system.

Author	Fixed or portable	Mesh size (mm)	Sample area (m²)	Method of sample collection	Dominant species in the sample
Hellier 1958, 1962	fixed	9.5	252.9 1,011.7	seine	*Anchoa, Mugil* *Lagodon*
Hoese and Jones 1963	fixed	19.0	118	seine	*Lagodon, Gobiosoma, Mugil*
Jones et al. 1963; Jones 1965	portable, helicopter	19.0	100.4	pursed net	*Brevoortia, Mugil, Cynoscion*
Moseley and Copeland 1969	portable, float	10.0	16	pursed net	*Brevoortia, Mugil, Cynoscion*
Kjelson and Johnson 1973	portable, float	6.0	16	pursed net	*Anchoa, Lagodon, Eucinostomus*
Kjelson et al. 1975	fixed	3.0	4	pursed net	*Lagodon, Leiostomus, Anchoa*
Adams 1976	portable, float	3.2	9	pursed net	*Anchoa, Lagodon, Orthopristis*
Current design	portable	3.2	10	seine	*Gobiosoma, Lagodon, Eucinostomus, Anchoa*

A drop net design was needed which would not significantly disturb the water surface and yet take an adequate sample. Some previous portable drop net designs sampled a larger area, but with greater water surface contact (Moseley and Copeland 1969; Kjelson and Johnson 1973). This new gear design allows less water surface disturbance (i.e., noise and shading) than previous drop nets and yet is capable of sampling 10 m² without compromising portability. The sample area is rigidly controlled and all fishes are collected from the sample area. The design criteria and success of this drop net system is comparable with, and in some cases surpasses, previous drop net designs in the literature with regard to sample area control and the capture of certain small demersal fish species. This study was conducted to compare this new drop net system with a larger haul seine system sampling 1,160 m² used concurrently for shallow water estuarine fish studies. The duration of this study was from April to December 1976.

Drop Net Description and Operation

The drop net apparatus consists of two primary sections: the collapsible aluminum tripod with the trigger mechanism and the drop net (Figure 1). The 5.2-m tripod legs are held together by aluminum hinges at the upper end and three 4.0-mm flexible steel support cables attached to the legs below the upper hinges. Two sheaves are mounted to the upper ends of two of the tripod legs, one to carry the winch line (i.e., upper frame harness line) to hoist the net and the other to carry the drop frame harness line that is released as the net is triggered.

After the sample site is straddled by the tripod, the drop net (3.16 × 3.16 m) is deployed using a pontoon boat. The boat is floated under the open tripod legs to prevent disturbing the bottom within the sample area. To lift the net, the drop frame harness plate and the upper frame harness plate are coupled together with a steel set pin (Figure 1a). The net is then lifted from the boat deck using the winch. After the net is in the set position, the drop frame harness line is set on the trip lever via a set ring (Figure 1b), and the pontoon boat is pushed out from under the net. The trip lever is held down with a notched trigger pin attached to the remote trigger line. The remote trigger line has a fluorescent floating jar attached to the distal end 20 to 30 m from the net apparatus. Once the net is set at the correct height, the steel set pin is pulled, and the drop frame plate and harness are free to fall when the trigger mechanism is tripped. Within 15 min three people can deploy a single net set to drop.

The trigger mechanism and drop frame are released with one pull of the remote trigger line. Once the net has fallen, the drop frame harness is unclipped from its harness plate and a drop net seine, made of tubular aluminum and 3.2-mm mesh netting, is used to seine the enclosure (Figure 1c). The seine fits closely against the inside walls of the drop net, and it is pulled by three people, two on either handle and one pulling a line attached to the bottom, center of the seine. The seine frame is kept firmly on the bottom and a standard five hauls are made to collect the sample. For night operations, an amber flashing light is attached to one tripod leg. Once the net has dropped, a lantern can be hung from the flexible steel support cable. Although night operations may take longer, ½ h is generally taken from the drop to complete sample removal.

To store and disassemble the drop net the pontoon boat is brought under the raised net. The net and frame are lowered onto the deck. The harness

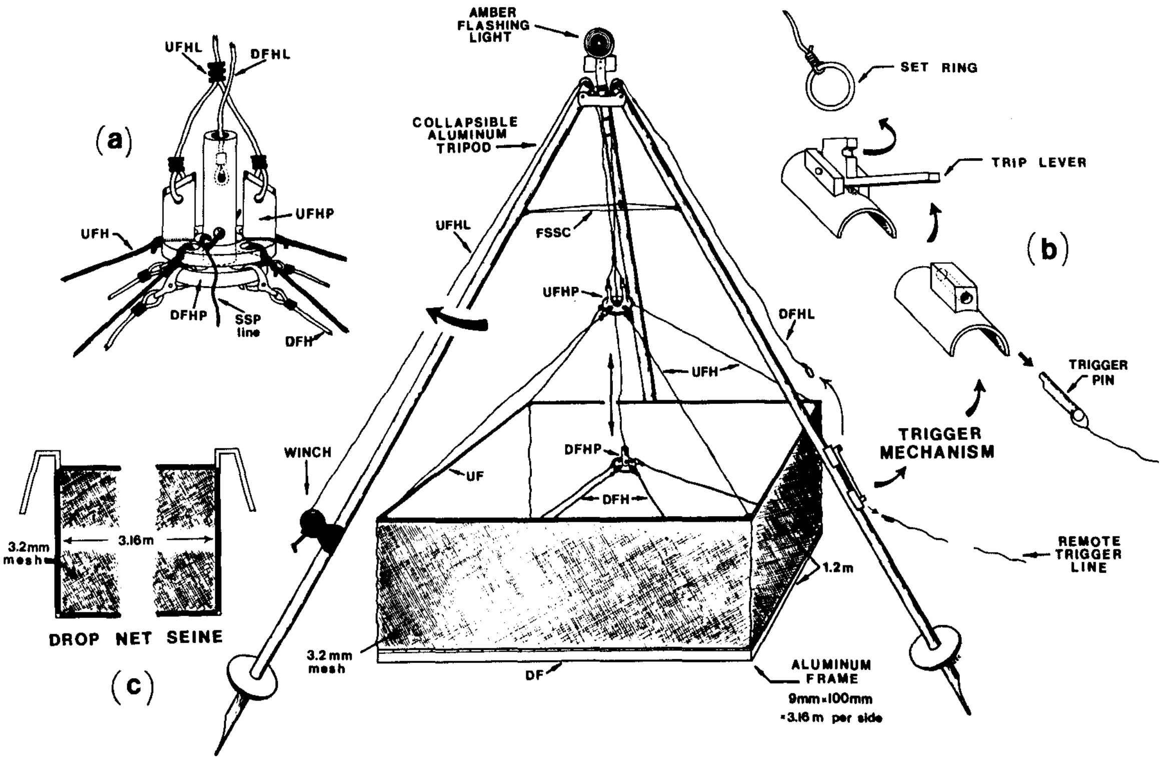

FIGURE 1.—Drop-net apparatus with insets of (a) harness plates, (b) trip lever mechanism, and (c) seine. UFHP = upper frame harness plate; UFH = upper frame harness; DFHP = drop frame harness plate; DFH = drop frame harness; DFHL = drop frame harness line; UFHL = upper frame harness line; UF = upper frame; DF = drop frame; SSP = steel set pin; FSSC = flexible steel support cable.

clips to the upper frame harness and drop frame harnesses are released from their respective plates. The tripod (weight 56.3 kg) can now be collapsed and stowed with the drop net (weight 52.7 kg) on the pontoon boat. Disassembly of the drop net apparatus generally takes 10 min. Not counting the arbitrary waiting period between set and drop, the described procedure takes approximately 1 h.

The drop net was released 1 h after it was set once a month beginning in April 1976. These samples were taken in a shallow seagreass bed (i.e., *Thalassia, Halodule,* and *Syringodium*). This drop net design is limited to depths <1.2 m. A seine haul was made within an hour of each drop net sample in a seagrass bed approximately 75 m from the drop net site. A 62 × 1.8 m bag seine (3.2-mm mesh) was pulled with one end anchored on shore and the seaward end stretched perpendicular to shore. A 15.2 × 1.8 m barrier net (3.2-mm mesh) was set 30.5 m down the beach and parallel to the 62-m seine. The seaward end of the large seine was pulled by hand to the seaward end of the barrier net and then to shore covering approximately 1,160 m^2/haul. The entire seine haul is made within 10 min.

All specimens taken using both drop net and seine were identified, counted, measured, and weighed (wet weight). The percent occurrence was calculated based on the number of samples in which a species occurred out of the total number of samples taken. A comparison was then made between fish samples taken by both gear types (Table 2).

Results and Discussion

The drop net captured fewer individuals and species than the seine and mostly small demersal and semidemersal forms (Table 2). However, the total fish density and biomass values from drop net samples surpassed seine sample values. April to December drop net samples gave fish density values from 1.8 to 19.3 fish/m^2 ($\bar{x}$ = 9.0) and biomass values from 1.3 to 29.4 g/m^2 ($\bar{x}$ = 15.0). In seine samples fish density ranged from 0.09 to 2.14

TABLE 2.—Partial species comparison, numerical catch, fish densities (no./m^2), and percent occurrence in samples for simultaneous seine and drop net collections (nine samples each). This is a partial species list, 17 of 61 species taken with the seine and 12 of 29 species taken with the drop net.

	Seine (10,440 m^2)			Drop net (90 m^2)		
Type and species	No.	No./m^2	Occurrence	No.	No./m^2	Occurrence
Schooling planktivores:						
Anchoa mitchilli	97,981	9.38	1.00	452	5.58	0.33
A. hepsetus	539	.05	.78	0	—	—
A. nasuta	656	.06	.67	1	.01	.11
A. cubana	248	.02	.44	1	.01	.11
Harengula jaguana	2,725	.26	.67	0	—	—
Opisthonema oglinum	521	.05	.33	0	—	—
Sardinella anchovia	3	.00	.11	0	—	—
Semidemersal predators:						
Bairdiella chrysura	1,102	.11	1.00	14	.16	.22
Cynoscion nebulosus	22	.00	.44	2	.02	.22
Diapterus auratus	944	.09	1.00	0	—	—
Eucinostomus sp.	1,404	.13	1.00	43	.48	.67
Lagodon rhomboides	1,225	.12	1.00	191	2.12	1.00
Lutjanus griseus	23	.00	.89	1	.01	.11
Orthopristis chrysoptera	326	.03	.56	25	.28	.33
Demersal species:						
Achirus lineatus	0	—	—	3	.03	.22
Bathygobius soporator	6	.00	.22	0	—	—
Gobiosoma robustum	632	.06	.44	336	4.15	.89
Gobionellus boleosoma	0	—	—	6	.07	.44
Microgobius gulosus	8	.00	.33	18	.22	.67

fish/m^2 ($\bar{x} = 0.53$) and biomass from 1.3 to 4.0 g/m^2 ($\bar{x} = 2.0$). The high fish density and biomass values of drop net methods versus lower values using seine methods has been demonstrated in previous studies (Kjelson and Johnson 1973; Kjelson et al. 1975). Schooling, nektonic species (e.g., anchovies and herring) and adults of larger species (>150 mm SL) were seldom taken in the drop net yet proved common in seine samples (Table 2). The drop net bias toward nonschooling fishes or those that do not have a clumped distribution has been documented by Kjelson and Johnson (1973) and Kjelson et al. (1975). However, the drop net designs of Hellier (1958, 1962), Hoese and Jones (1963), Jones et al. (1963), Jones (1965), and Moseley and Copeland (1969) captured large numbers of schooling fishes (e.g., *Brevoortia* and *Anchoa;* Table 1). These schooling fishes, because of their irregular occurrence (Table 2), occasionally presented a problem with subsequent sample analysis (Jones 1965). Small gobies (e.g., *Gobiosoma robustum* and *Microgobius gulosus*) were common in our drop net samples and were only occasionally seen in our seine samples. Most of those fishes captured by the drop net were grass flat residents and resident juveniles of adult populations living elsewhere. The seine not only captured grass flat residents and juvenile fish but adults and juveniles of migratory schooling forms and large top predators (⩾250 mm SL).

When catch records of our drop net system are compared with those of others many sample similarities and differences are seen. Hellier's data demonstrates that drop nets with a smaller mesh size will capture a greater fish biomass when the sample area is kept constant (Hellier 1958). The current drop net design incorporates a 3.2-mm mesh (Table 1). This enables the capture of nearly all small fishes (<150 mm SL) present. Very small species (e.g., *Gobiosoma robustum,* 13-30 mm TL) were not commonly captured using other drop net methods, except in the samples taken by Hoese and Jones (1963) (Table 1). *Gobiosoma robustum* is a common seagreass bed resident from Corpus Christi, Tex., to the Indian River lagoon in eastern Florida (Hoese 1966; Springer and McErlean 1961); therefore, it would not be expected in the samples of Kjelson and Johnson (1973), Kjelson et al. (1975), and Adams (1976). Demersal flatfishes (e.g., *Paralichthys, Etropus, Citharichthys, Symphurus,* and *Achirus*) were captured in drop nets used by Jones et al. (1963), Mosely and Copeland (1969), Kjelson and Johnson (1973), Adams (1976), and our design. Juvenile commercial and sport fishes (15-50 mm SL) caught by the current drop net design were *Cynoscion nebulosus, Lutjanus griseus, L. analis, L. synargris, Albula vulpes, Archosargus probatocephalus,* and *Haemulon parrai. Lagodon rhomboides* was also taken in large numbers (15-145 mm SL), showing densities well over seine estimates. Other authors also found *L. romboides* to be common in their drop net samples (Table 1).

The current drop net system is the only design to use a rigid frame seine and a solid aluminum drop frame in conjunction with 3.2-mm mesh netting. This probably accounts for the goby and flatfish captures and also accurately delineates the sample area. It is possible that the sample area may change due to wind or current effects on falling pursing nets (Table 1; Jones et al. 1963; Kjelson et al. 1975). Disadvantages with the aluminum drop frame are its bulk, limited maneuverability, and operations limited to a level bottom. A collapsible frame or one which can be disassembled may eliminate the maneuverability problem. Moseley and Copeland (1969) indicated that noise and shadows may have affected their samples. We tried to eliminate the shadow effect and noise with as little water surface contact as possible using a tripod which suspended the net over the water with an open center. It may be possible to have vibrations in the tripod apparatus transmitted through the submerged portion of the tripod legs; however, this possibility and its effect is not known. Portable float and portable helicopter drop nets (Table 1) could drop in deeper water (depths of 2.5-4.6 m) than our system (1.2 m). Most other drop net designs require two people to operate. The helicopter drop net requires six while our design requires three. A smaller version of this tripod design would require fewer operators. It takes 60 min to set up, drop, retrieve the sample, and dismantle our drop net without the arbitrary 1 h waiting period. Kjelson and Johnson (1973) and Kjelson et al. (1975) were the only authors to publish operational times and these were 25 min and 15 to 20 min respectively.

The 10-m^2 sample area in the current design is a compromise between maneuverability and sample size. The small sample precludes adequate capture of mobile fishes >150 mm SL. Fishes with a clumped distribution or that form schools will also occur in these drop net samples less frequently than if other gear were used (e.g., seines and trawls). However, to obtain an accurate fish density and biomass estimate in nursery areas or of fish populations in which the adult size is small (e.g., gobioids) the current design has produced adequate samples.

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