A Versatile and Inexpensive Method for Training and Testing Observers Conducting Underwater Visual Censuses Requiring Size Estimates

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ABSTRACT

Underwater visual-based population monitoring programs that include the collection of size-structure information of the organisms surveyed require that observers collecting this data are able to accurately estimate the recorded size parameter. Training and testing of observers conducting size estimates during underwater visual surveys have traditionally employed very simple linear artificial targets of known dimensions or more complex and costly life-sized models of the organisms surveyed. As part of its efforts to monitor reef fish populations in the Florida Keys, the Florida Marine Research Institute has developed a new visual target type that is inexpensive to build, easy to maintain and deploy in-situ, and allows for almost infinite variability in target image size as well as accurate representation of species-specific visual aspects. These new targets are created by placing images of organisms photocopied onto waterproof paper between two sheets of Plexiglas. A large variety of sizes can be generated from the same original image by using the photocopier to reduce or enlarge copy size. Teflon bolts and wingnuts are used to hold the two Plexiglas sheets together around the inserted images. Targets are deployed in the field using an anchor and float arrangement. New observers can be trained and tested with the images before collecting program data, and experienced observers retested on a regular basis. This new target system, which should overcome the estimation biases associated with the use of simple linear target systems without incurring the high expenses of constructing solid, lifelike models of the organisms surveyed, should be tested and evaluated more thoroughly for its applicability as a training tool.

KEY WORDS: visual surveys, underwater size estimation, visual census training and testing

INTRODUCTION

Underwater visual censuses are an efficient, nondestructive way to observe and assess populations of aquatic organisms, and are now widely accepted and used by fish biologists in particular (Jones and Thompson 1978, Bohnsack and Bannerot 1986, Clarke 1986, Bortone et al. 1989, Russ 1989, Smith 1989). Many fisheries managers use visual censuses as a tool to estimate species length-frequency distributions and abundance in monitoring programs (Thresher and Gunn 1986, Alcala and Russ 1990, Kulbicki and Wantiez 1990, Roberts 1995, Dixon 1997, Wantiez et al. 1997). When implementing visual-based population monitoring programs in which size structure data is collected, it is crucial that the observers collecting these data (usually SCUBA divers) are trained to accurately estimate the size parameter of individuals (often total length) which is recorded. *In situ* testing of size estimation skills underwater can serve to improve the ability of observers to accurately conduct visual surveys by identifying individual size estimation biases that can then be eliminated with practice. Studies have shown that by training and testing underwater observers with known-size visual targets, size estimation accuracy for most taxa increases in a relatively short amount of time (Bell et al. 1985, Mille and Van Tassell 1994, Thompson and Mapstone 1997).

Traditionally, the known-size artificial targets used to train and test divers in size estimations have been either lengths of simple rods or tubes (Bell et al. 1985) or specially constructed life-sized models of target organisms (Rooker and Recksieck 1988, Mille and Van Tassell 1994). Simple elongate targets, while inexpensive, will not assist observers in recognizing (and correcting for) errors and biases associated with estimating sizes of complex-shaped organisms. Bell et al. (1985) found that divers trained to accurately estimate lengths of PVC pipe experienced difficulties transferring this skill to fish length estimation. Species-specific, two-dimensional or three-dimensional models are more realistic and can provide more useful training and testing aids, but constructing a large number of them can be cumbersome and expensive. Large numbers of visual targets are desirable because observers are less likely to memorize model sizes when they are trained and tested on a repeated basis using the same set of targets.

In view of the problems with the previously used underwater visual survey methods for developing and testing observer size estimation skills, the Fisheries-Independent Monitoring program at the Florida Marine Research Institute has developed a new visual target system to be used in the training and evaluation of our divers. Our visual target system is inexpensive and simple to build, easy to maintain and deploy in the field, and allows for almost infinite variability in target size and provides species-specific targets for each organism that is being monitored. Herein we describe the construction of this visual target system and illustrate it's use in our sampling program, and discuss it's economy, simplicity, and applicability. Although we developed this system in order to train and test SCUBA divers conducting length estimations of reef fish species, it is applicable with little or no modification to most underwater visual sampling programs which require observer estimations of size parameters of aquatic organisms.

MATERIALS AND METHODS

Our new underwater visual targets are created by placing drawings or photographs of organisms (in our case, fishes) photocopied onto waterproof paper between two sheets of Plexiglas (Figure 1), and rigging these sheets with a weight and float arrangement that allows them to be deployed in the field (Figure 2).

Figure 1. Target images are placed between Plexiglas sheets.

Construction of the targets is relatively simple and requires a minimal amount of materials and labor and few tools (Table 1). The specific materials listed are those available in our area, but substitutions can be made to adapt to most local markets.

To construct each target, we use a table saw fitted with a Plexiglas blade to cut two equal sized pieces of Plexiglas from a 121.9 cm x 248.9 cm (48" x 98") sheet of Palsun 0.32 cm (1/8") Plexiglas. Plexiglass frames of various sizes are used to prevent observers from using the frame size as an aid to estimate target image size. Holes are drilled a few centimeters from each corner of the two pieces of matching Plexiglas in order to fasten the pieces together with nylon nuts and bolts. One or two additional securing bolts placed near the center of the Plexiglas pieces are required when building a target larger than about 45 cm x 60 cm.

Our file of target images was created by photocopying drawings or pictures of local reef fish species from various sources onto waterproof paper. A variety of target image sizes are created for each species by are enlarging or reducing the image during the copying process. Excess paper is trimmed from around each image so that it will appear realistic underwater and allow an unobstructed view of the background around the target. To assemble the target arrays, the fish images are placed between a pair of matching Plexiglas pieces of appropriate size before bolting them securely together (Figure 1). To prevent paper images from slipping, a spacer made from a small piece of felt is added under the reverse side of the image. Multiple images can be placed within a single Plexiglas frame.

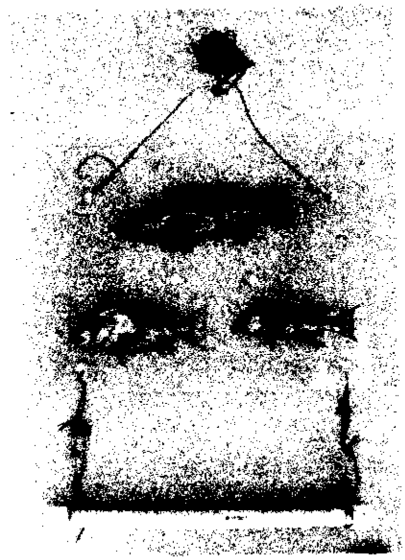

Figure 2. Visual target array with component parts labeled.

Our target arrays are deployed underwater in the field by suspending the Plexiglas frame above the bottom using a weight and float arrangement. Our weights are constructed by cutting pieces of polyvinylchloride (PVC) pipe into the lengths appropriate for the target arrays, filling with sand, and sealing on both ends with PVC slip caps glued in place with PVC cement. A piece of nylon twine is tied to each end of the filled PVC pipe and also to a stainless steel longline clip. The longline clips are attached to loops of nylon twine tied securely to each of the bottom corner bolts of the Plexiglas pieces (Figure 2). The pipe weight should be rigged so that the target array will float in a natural position when suspended in the water. PVC sponge net floats of appropriate size to suspend the target array perpendicular to the bottom are attached to the top of the target by using additional nylon twine and longline clips. Our completed target arrays are designed to be negatively buoyant with the target images suspended in the water column near the bottom, but positively buoyant float and weight combinations could be used to suspend arrays beneath surface buoys, or arrays could be attached to fixed structures attached to the bottom or in the water column.

We have used our target arrays for both generalized diver training and formal testing under simulated visual survey conditions. During training, the arrays are (marked with a surveyor's tape) and record estimated total lengths and species identification of each target image in each array, and also record their estimate of the distance from the transect line to each array. This simulates the transect surveys that we normally employ during regular censuses. Additional targets are also set around a nearby stake, to which the diver proceeds and then conducts a simulated stationary point count (Figure 3), recording the same estimates and species identifications as during the simulated transect survey. We test new divers' length estimation skills before any training or practice, and retest after approximately six weeks of training. Training includes practice with measuring sticks, paired-count comparisons with experienced divers, and estimating the lengths of live fish that are then captured and measured. Tests are given to experienced divers semi-annually to maintain the reliability of our visual length data and to help observers identify and correct biases that they may have developed.

RESULTS AND DISCUSSION

The underwater visual target system we have developed is inexpensive and easy to construct, very durable, and much more versatile than previously reported target systems. In addition, since the target arrays are easy to deploy in the field and very flexible as to target images and deployment mechanics, this system could be adapted to a variety of projects which require underwater visual species identifications and size estimations. While our primary intent in developing the system was to assure accurate estimation of total fish lengths during underwater visual population surveys, we found the system also functioned well to verify species identifications and the ability of divers to accurately estimate distances.

The availability and afford ability of materials for constructing sophisticated underwater visual target systems may be a constraint in some isolated field-based laboratories or developing countries, so we designed our targets to be constructed from easily obtained, relatively inexpensive, durable materials. The estimated cost of our largest target array (45 cm x 60 cm frame) is $21.57 (Table 1), but target frames can be smaller and therefore less expensive. Plexiglas and waterproof paper represent the majority of each target array's cost ($15.40 of the total cost of $21.57 for one 45 cm x 60 cm target array), but because these and all of the other materials used were chosen specifically for their resistance to damage by water, corrosion, and ultraviolet light, a long useful life may be expected. Other examples of durable products used include non-corrosive nylon bolts, stainless steel longline clips, and PVC weights and floats. These visual target systems can sustain high use in rugged conditions and last indefinitely with minimal care, thereby obviating construction costs for replacements.

Table 1. List of materials and approximate costs for constructing seven large (45 cm x 60 cm) target arrays for underwater visual size estimation training. Prices are quoted from local vendors in the Florida Keys during 1999.

	Price per Unit	Number of Units Required	Price per Target	Price for 7 Targets
Weights				
PVC Pipe Schedule 40 (1")	$ 2.22/ 10 ft.	1.5 ft. per target	$ 0.32	$ 2.22
PVC Slip Cap (1")	$ 0.30 each	2 per target	$ 0.60	$ 4.20
PVC Cement (8 oz.)	$ 2.55/ bottle		$ 0.10	$ 2.55
Sand (50 lb. Bag)	$ 2.96/ bag	1.5 lbs. per target	$ 0.08	$ 0.56
Target				
Plexiglas	$94.88/ sheet	7 targets per sheet	$13.55	$ 94.88
(1/8" x 48" x 96")	$ 0.28 each	(assorted sizes)		
Nylon Bolt (¼" x 1½")	$0.40/ pair	5 per target	$ 1.40	$ 9.80
Nylon Wingnut (¼")	$36.89/ box	5 per target	$ 1.00	$ 5.20
Waterproof Paper		5 sheets per target	$ 1.85	$12.95
(100 sheets/box)				
Buoyancy				
Assorted PVC sponge floats	$ 0.75/ float	1 or 2 per target	$ 1.25	$ 8.75
Spool of Twine (325 ft.)	$ 2.30/ spool	avg. 6 ft. per target	$ 0.04	$ 0.28
Longline Clips (10 per bag)	$ 4.60/ bag	3 per target	$ 1.38	$ 9.66
		Total estimated cost:	$21.57	$151.05

Figure 3. Layout target arrays over bottom to simulate transect and point count underwater visual surveys.

Despite an almost negligible cost per individual target image, the use of species-specific graphic representations allows divers to train and test with images that have all of the same distinct body shapes and markings characteristic of the individual species included in actual surveys. Suspended over the substrate, the photocopies can in fact appear very lifelike to approaching divers. The capability to produce numerous photocopies with a large range of sizes from the same image eliminates the possibility of observers becoming familiar with individual targets through repeated exposure. We minimize the potential for the divers becoming familiar with the dimensions of the Plexiglas frames used in the target arrays by varying both their size and shape and constantly changing the fish images used in each array. In addition, the floats, clips, PVC pipe, nuts and bolts used to construct the arrays can be purchased in various sizes, and can be varied on individual frames between uses to reduce chances of these items providing cues to dimensions.

Carefully controlled comparison studies would be required to thoroughly evaluate the effectiveness of our target system to eliminate or minimize the reported biases associated with underwater visual training and testing methods using simple elongate visual targets, or to establish the relative effectiveness of the use of the two-dimensional silhouette images used in our system as opposed to three-dimensional models. While these studies are beyond our current resources, we believe that based on practical considerations alone, our system offers an excellent compromise between accepting the biases introduced by shape differences between simple linear objects and living organisms (as well as shape differences between different species of organisms) and the costs of constructing solid, lifelike, two- or three-dimensional models. Our system has proven to be highly effective in the application for which we developed it, i.e. testing and training SCUBA divers making total length estimations of reef fish populations. A very significant improvement in length estimation of target images has been documented for our new observers after only a short training period utilizing both our model system and estimations of the sizes of real fish. Figure 4 illustrates the results of a typical new observer who was tested with models before any practice or experience and then retested after about a dozen training dives over a six-week period. Accuracy in assigning targets to correct size classes improved from 40% to 89% after training. In conclusion, we believe our new underwater visual target system is a practical and versatile tool for the training and periodic testing of observers required to make size estimations of aquatic organisms in their natural environment, especially for multi-species, visual survey-based population monitoring programs such as ours. The system is inexpensive, easy to use and maintain, and yet provides the ability to employ a large variety of realistic target images and sizes without incurring the high labor costs required to generate solid models of target organisms. Its potential as a training and testing tool for conducting underwater visual censuses warrants further testing and evaluation.

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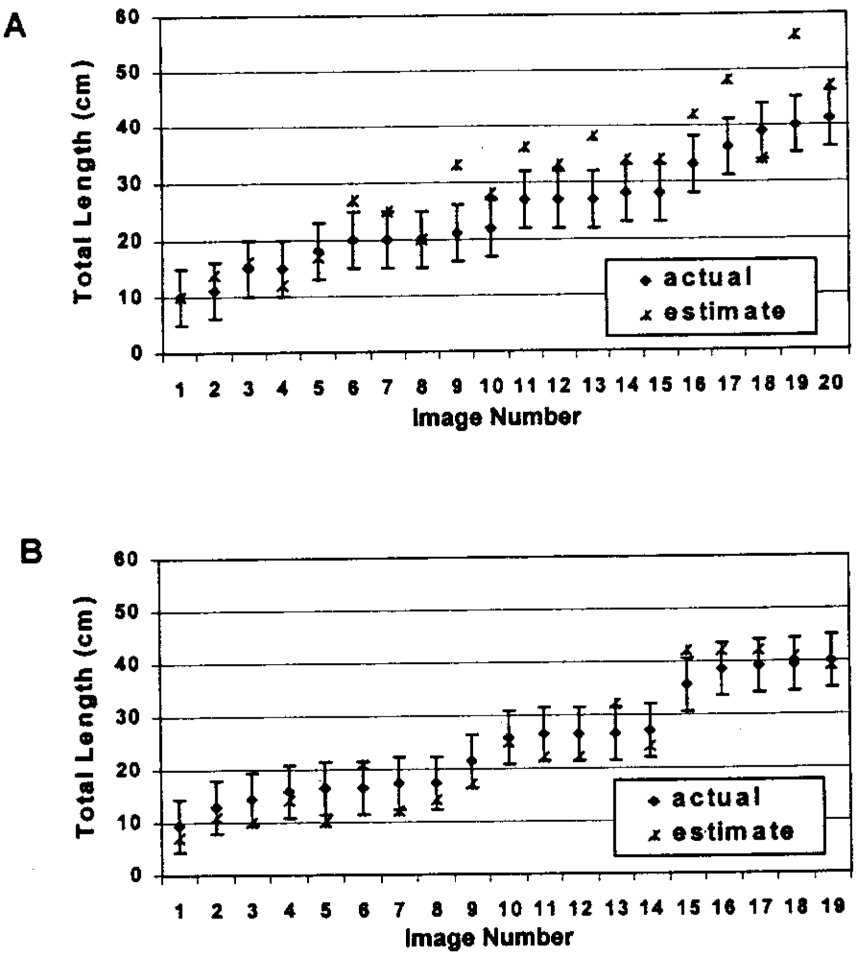

Figure 4. A diver's estimate of lengths plotted with the actual image sizes (A) prior to and (B) following training. Error bars represent +/- 5 cm from the actual size, designated as the acceptable range for our visual census program. Forty percent of the diver's size estimates in the initial test were within the acceptable range. Following a short training period, the diver's estimation accuracy increased to 89%.

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