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Evaluation of video and acoustic index methods for assessing reef-fish populations

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Since 1991, the National Marine Fisheries Service (NMFS) has used a video camera/trap system to assess the relative abundance of reef fishes in the Gulf of Mexico occurring on natural hard-bottom substrata at depths between 9 m and 110 m. The relative index of reef-fish abundance resulting from these annual Gulf-wide surveys is based on counts of fish recorded during a 1 h set of a video camera on the bottom. During the 1993 reef-fish survey, a total of 115 reef sites were sampled with a video camera and fisheries acoustic system. Video data were used to identify fish species distributed above the bottom. Off-bottom fish included snappers (Lutjanidae), groupers (Serranidae), and amberjacks (*Seriola* spp.), species of interest to commercial and recreational fisheries. Correlation between total off-bottom taxa abundance and volume backscatter was low ($r=0.41$, $n=115$). The low correlation may be caused by differences in the area sampled by the video camera and acoustic systems at each site. The low correlation limits the use of acoustic data as an auxiliary variable in a combined video-acoustic estimator.

Key words: fisheries acoustics, reef fish, video camera.

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Introduction

A fishery-independent survey to assess the relative abundance of reef fishes on natural hard-bottom substrata lying between 9 m and 110 m in the Gulf of Mexico is conducted annually under the Southeast Area Monitoring and Assessment Program (SEAMAP) by the National Marine Fisheries Service (NMFS) in cooperation with the states of Mississippi and Alabama. Surveys to assess reef-fish abundance are difficult because of the diversity and mobility of fishes found on reef habitats, as well as the cryptic nature and behavior of some species (Sale and Douglas, 1981). Methodologies that employ SCUBA divers are not practical because of the depth range sampled. We are, therefore, limited to remote-sensing techniques that employ video cameras that can be rapidly deployed and retrieved from depth. A video camera/trap system that is non-destructive to sensitive reef habitats and relatively non-selective of reef-fish species was first employed in 1991. Fisheries acoustic sampling of reef sites was added to the survey design in 1993 in an attempt to offset some of the shortcomings of video census techniques. In this paper, we examine the feasibility of assessing reef-fish populations in the Gulf of Mexico by video and acoustic estimates of reef-fish abundance.

Methods

Video observations were conducted during daylight hours with a Hi-8 mm video camera in an underwater housing mounted at a height of 25 cm above the bottom on a baited, single-funnel fish trap (2.13 m long by 0.76 m square). Fish within a 90° field of view can be identified to a range of 5 m from the camera. Each video tape, of approximately 1 h duration, was examined separately by two viewers who identified all fish to the lowest possible taxonomic level while enumerating them. Discrepancies between the two viewers were resolved either through discussion among the viewers,

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Table 1. Frequency of fish occurrence 0.5 m or more above the bottom.

Common name	Scientific name	n	f	100 (Fn^{-1})
Lizardfish	*Synodus* spp.	8	0	0.0
Wrass	Labridae	134	5	3.7
Small sea bass	*Serranus* spp.	10	10	9.5
Parrotfish	Scaridae	36	6	16.7
Butterflyfish	*Chaetodon* spp.	94	33	35.1
Damselfish	Pomacentridae	70	33	47.1
Angelfish	Pomacanthidae	119	58	48.7
Grouper	Epinephelinae	102	66	64.7
Snapper	Lutjanidae	79	55	69.6
Triggerfish	*Balistes* spp.	58	49	84.4
Amberjack	*Seriola* spp.	91	83	91.2

n = number of stations where observed, f = number of stations where fish were observed above the bottom.

or by a simultaneous third review of the tape by both viewers.

A BioSonics Model 102 echo-sounder with a 120 kHz dual-beam transducer (7°/16°) mounted in a V-fin towed body was used to sample reef sites. Acoustic volume backscatter data were collected using a pulse width of 0.3 ms and a transmit rate of 2 pings s^{-1}, with the V-fin towed 10 m below the surface. A total of four or five parallel 185 m transects centered around the reef site were sampled at a speed of 1.8–5.5 km h^{-1}, with the video/trap gear deployed during the first or second pass. Volume backscatter was determined at each reef site and compared with video estimates of fish abundance using a product-moment correlation coefficient.

Acoustic detection of fish targets depends on their height above the dead zone, which was estimated as 0.5 m at a range of 100 m (Johannesson and Mitson, 1983). When the 1993 video tapes were viewed, each species was classified as ‘‘above the bottom’’ if, at any time during the 1 h set, individuals were estimated to be at least 0.5 m above the bottom. The rationale for this criterion was that if any individuals of a species spent any time above the dead zone, there was a likelihood they would be acoustically detected. The overall probability of any species being classified as off-bottom was estimated as the frequency of sites where it occurred above the bottom.

Results

The video/trap gear and acoustic system sampled 115 reef sites during the 1993 survey. A total of 148 identifiable fish taxa plus unidentified fish were observed on video tapes. Frequency of occurrence above the bottom was estimated for only those taxa that were observed at a minimum of five sites (Table 1). Data indicate that many species associated with natural hard-bottom features have a chance of being acoustically detected. Important commercial and recreational species such as groupers (Epinephelinae), snappers (Lutjanidae), triggerfish (*Balistes* spp.), and amberjacks (*Seriola* spp.) occurred off-bottom at 65% to 91% of the sites where they were observed. Other taxa – lizardfish (*Synodus* spp.), wrasses (Labridae), small sea basses (*Serranus* spp.), parrotfish (Scaridae), butterflyfish (*Chaetodon* spp.), and damselfish (Pomacentridae) were rarely found greater than 0.5 m above the bottom. Taxa were classified as off-bottom when they occurred above the bottom at greater than 50% of the sites where they were observed.

There was only a weak correlation between video estimates of off-bottom taxa abundance and volume backscatter estimated as mean volts squared (v^2) (Fig. 1). The product-moment correlation coefficient was 0.408 ($n = 115$, $p_\alpha = 0.001$).

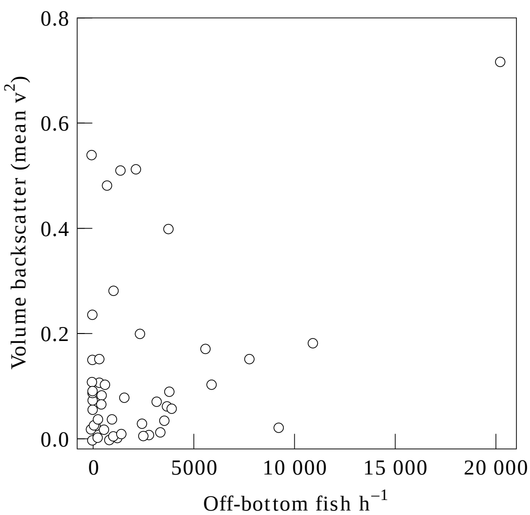

Figure 1. Scatterplot of the video (off-bottom fish h^{-1}) and acoustic volume backscatter (mean volts squared, v^2) estimates of reef fish abundance ($r = 0.410$; $n = 115$).

Examination of species-composition data provides insight into factors causing the low correlation between abundance estimates. At sites where the acoustic estimate was very high relative to the video estimate, species composition was dominated either by amberjacks, or by wrasses and damsel fishes. When wrasses and damsel fishes dominated, jacks (Carangidae) were also present. The discrepancy between the two abundance estimates at these sites may have resulted from ensonification of a school of amberjacks or other jacks passing the site, but out of the camera's view. At sites where video abundance estimates were high relative to acoustic estimates, species composition was dominated by damsel fishes, wrasses, parrot fishes, and unidentified small fishes; taxa that are found within 0.5 m of the bottom. At several of these sites, vermilion snapper (*Rhomboplites aurorubens* Cuvier) comprised greater than 73% of the fish observed, which probably inflated the video estimate of abundance due to multiple counts of the same individuals since vermilion snapper typically school around the video/trap gear.

Discussion

Use of acoustics along with a video camera produces two complementary estimates of reef-fish abundance. Video data provide species identifications and estimates of abundance that may vary with water clarity. Acoustic data offer the advantage of an abundance estimate not influenced by visibility. Initially, acoustic data were to be used as auxiliary information with video data in a combined ratio estimate of abundance. This idea was predicated on close correlation between the video and acoustic estimates of abundance. Comparisons did provide useful insights into relative strengths and weaknesses of each method. Video observations yield precise and consistent species identifications, but also repeated counts of schooling species and a limited view of the reef sites. The acoustic system yields an areal estimate of abundance but no species-specific information and is limited to only those species that consistently occur off-bottom.

The correlation between video and acoustic abundance estimates may be increased by modification of sampling gear and methodology. The volume sampled with a single stationary video camera can be increased, and multiple count problems may be mitigated by the use of more than one camera at a site. We have devised a multiple camera gear that consists of four orthogonally mounted cameras that provide nearly a 360° field-of-view, thereby increasing reef area viewed and allowing us to account for fish schooling around the gear. Multiple fish counts could also be minimized by use of a video index for maximum number of fish that is weighted by the duration of each occurrence when it is viewed (Ellis and DeMartini, 1995). We plan to continue our efforts to make video and acoustic data spatially more comparable by reducing the area ensonified around the video gear. These aforementioned methodological refinements will lead to the best estimate of reef-fish abundance available.

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