Sea Grant
University of Southern California

The Impact of Intense Recreational Fishing Pressure on Spawning Aggregations of Barred Sand Bass (Paralabrax Nebulifer) off the Los Angeles Metropolitan Area

By

Larry G. Allen, Ph.D.

USCSG-TR-05-2010

University of Southern California
Los Angeles, CA 90089-0373

Technical Report

EXECUTIVE SUMMARY

- We tested the feasibility of using an innovative approach that will prove to be an extremely valuable technique for all future stock assessments of coastal pelagic species off southern California. We conducted a hydroacoustic (sonar) assessment of barred sand bass standing stock (abundance and biomass) using high resolution split beam sonar verified by both rod and reel sampling over sonar targets and underwater video observations. Simply put, we plan to visually identify conspicuous acoustic targets, identify these targets with both rod and reel sampling and underwater video towed by the research vessel. Once a target is verified (e.g., as an aggregation of barred sand bass), its target strength can be related quantitatively to abundance and biomass.

- The feasibility phase of this study was conducted over five days in July (peak spawning months for barred sand bass) of 2010 over the 20-30m depth contour at Huntington Flats. Each day the sampling, area was easily determined by the positioning of the sport fishing fleet including Commercial Passenger Sportfishing Vessels (CPFVs) and private vessels targeting sand bass from San Pedro, Long Beach and Newport Beach. As many as 12 total CPFVs and 35 private vessels were observed fishing this same area on each of the four days of hydroacoustic sampling in July 2010.

- Hydroacoustic transects were conducted on July 15, 16, 22, and 23, 2010 aboard the *RV Yellowfin* using a leased, high resolution, split beam sonar unit, the *Biosonics DT-X*. This sonar unit came interfaced with an on-board, laptop computer loaded with the necessary software for sonar imaging and GPS location (BioSonics Visual AnalyzerTM). Ten to twelve randomly placed, replicate, sonar transects (defined as regions) were run each day on the Huntington Flats. GPS readings were recorded continuously over the entire cruise track for each day. On shore, the complete BioSonics data files were transferred into state-of-the-art Echoview ® 4.90 software files for full analysis of target identification, spatial location, target frequency analysis, target strength, and, ultimately, integration of target numerical density and biomass with defined regions of the daily cruise track.

- The BioSonics transponder was calibrated in situ the research vessel on July 2, 2010 using the metal, acoustic calibration sphere provided with the unit (mean dB = -41.5). Acoustic targets were verified by both rod and reel sampling and underwater video. Specific target strengths were verified *in situ* for barred sand bass and Pacific mackerel by tethering freshly caught specimens from a hook-less ganion with one kg weight and passing the apparatus through the sonar cone under the transponder mounted to the port side of the research vessel in three separate trials.

- Initially, rod and reel sampling was the primary means of target species verification. When suspected sonar targets were identified, the "stop" was marked using paper buoys. Many of these stops yielded barred sand bass as the primary species captured followed by Pacific mackerel. Barred sand bass collected in these aggregations on July 22nd had a mean size (290 mmSL) and weight (572 g). Overall, 8-10 anglers aboard the *RV Yellowfin* captured 212 barred sand bass by this method with the daily totals as follows: July 15 – 0, July 16 – 10, July 22 – 157, and Jul 23 – 45.

- On July 22 and 23, 2010, specimens of both barred sand bass and Pacific mackerel were collected by rod and reel and tethered to a hook-less ganion. This apparatus was lowered into the sonar cone along the port side of the research vessel and staged at several depths while the Biosonics unit continuously recorded. These activities served to accurately calibrate the range, frequencies, and mean target strengths of both species that were numerically dominant in the sampling area.

- Utilizing sonar recordings of the targets verified by rod and reel sampling and tethering as well as by underwater video (see below), mean target strength of barred sand bass was determined to be -35 dB while Pacific mackerel averaged -45 dB and northern anchovy, -51 dB.

- Approximately three hours of video recording conducted on July 23, 2010 yielded four successful video verifications of sonar targets. The first successful verification occurred between 1054 and 1056 hours when first a school of northern anchovy and then a loose aggregation of barred sand bass were detected by both sonar and the video camera which was towed 10 m behind the sonar cone. Three additional video target verifications of barred sand bass in the water column occurred at 1127, 1332 and 1345 hrs the same day. Videos files of all four successful verifications are provided on the CD accompanying this report (courtesy of Erica Jarvis, California Department of Fish and Game).

- The ultimate goal of this feasibility study was to determine whether this methodology can accurately estimate standing stock of barred sand bass in the well established spawning aggregation area off Huntington Beach, CA. The answer to that question is a resounding **"YES".**

- Estimated barred sand bass abundances varied between 16.8 and 239.8 bass per hectare over the four days of assessment. At 0.5 kg each, this corresponded to a range of standing stock between 8.4 to 120 kg per hectare. The highest densities were encountered on July 16, 2010 when most sonar marks were large groups of fish which resulted in a large standard error of the estimate.

- This method also allowed us to estimate the abundances of the other two common species in the area, Pacific mackerel and northern anchovy. Pacific mackerel were the second most abundant species captured by rod and reel and averaged between 15 and 261 fish per hectare over the four sampling days. At 0.25 kg per fish, this corresponds to between 3.8 and 65.4 kg/ha. Sonar estimation of their abundance in the study area ranged between only about 6 and 225 fish per hectare (0.4 and 11.3 kg/ha).

Introduction

The barred sand bass (*Paralabrax nebulifer*) has become one of the staples of the near shore recreational fishing fleet of southern California, an area that is populated by more than 20 million people. Since the late 1970s, the barred sand bass (commonly referred to simply as "sand bass") has consistently ranked among the top five species in the southern California marine recreational fish catch. From 2000-2003 sand bass ranked first or second in the recreational fishery off southern California only being supplanted once by Pacific (=chub) mackerel during that time.

However, since the year 2004 catches of barred sand bass have fallen off precipitously. This valuable marine resource is the target of a highly directed fishery on spawning aggregations, mostly by lower income urban fishers who can afford a modest price for a boat ticket. The impact of the intensive fishing on this critically important species off the heavily urbanized coasts of Los Angeles and Orange counties is totally unknown.

The major sand bass fishing sites in the Southern California Bight include the Silver Strand, Del Mar, San Onofre, the Huntington Flats, the inshore portion of northern Santa Monica Bay off Pacific Palisades, Santa Monica, and the Ventura Flats. Estimates of annual barred sand bass landings from all sport fishing activities (shore, pier, private boat, and Commercial Passenger Fishing Vessels, CPFVs) from 1980 to 2006 averaged 822,000 fish and ranged as high as 2,122,000 in 1988. Between 1988 and 2002 catches remained relatively stable with peaks in 1989 (1,296,000), 2000 (1,130,000), and 2002 (1,062,000). By 2008 and 2009, annual catches in southern California waters had fallen off to 130,000 and 106,000 fish (Figure 1). From 1980 on, CPFVs and private boats have taken the vast majority of sand bass while fishing the summer spawning aggregations (Figure 2). As fishing effort targeting barred sand bass has increased, concern has been voiced that the stock is becoming over-exploited. The recent decline in catches in this major recreational fishery is cause for great concern.

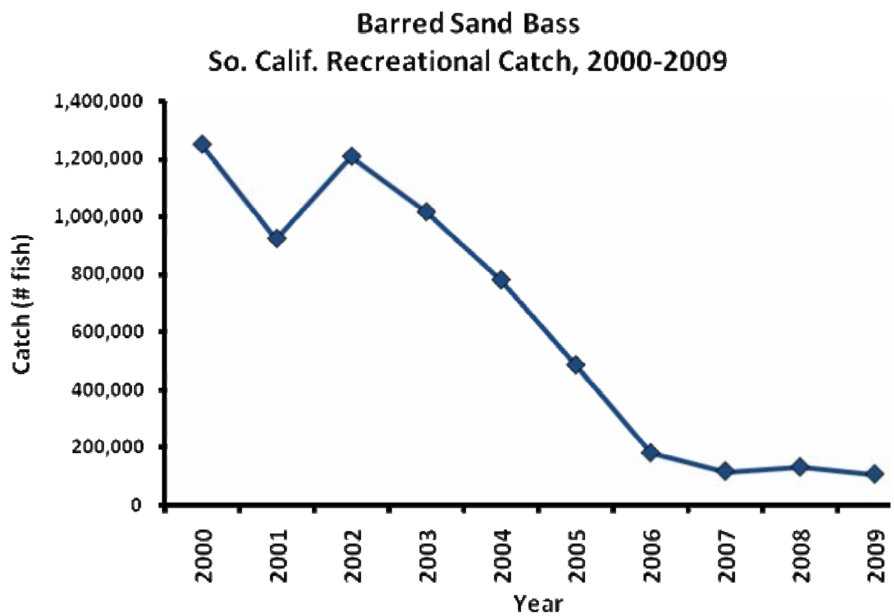


Figure 1. Total catch of barred sand bass from southern California for 2000 to 2009. (data source: MRFSS & CRFS: http://www.recfin.org).

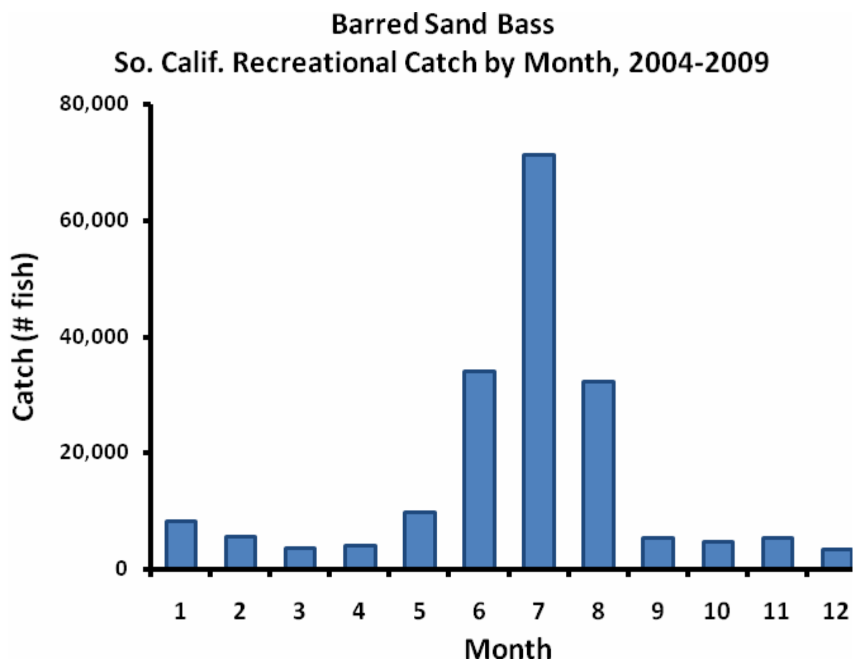


Figure 2. Total catch of barred sand bass from southern California by month for 2004 to 2009. (data source: CRFS: http://www.recfin.org).

The barred sand bass (*Paralabrax nebulifer*) is a common species in the nearshore marine environment off southern California. Together with the kelp bass (*Paralabrax clathratus*) it forms more than 90% of the general "rock bass" recreational catch in the first half of this decade (Frey 1971; Oliphant 1990). Barred sand bass ranges from Santa Cruz, California south to Magdalena Bay, Baja California Sur, including Guadalupe Island (Miller and Lea 1972), occupying a variety of different habitats including kelp beds and sand flats on the open coast to inland harbors and bays. They are a benthic; relatively sedentary fish, which are rarely, found more than 3 m above the substrate, closely associated with the interface between bottom structure and sand (Turner *et al*. 1969, Feder *et al.* 1974, Larson and DeMartini 1984). Barred sand bass are oviparous, broadcast spawners that breed from April to August with a peak in July (Love *et al* 1996a). They tend to form large breeding aggregations over soft bottom areas between 15-30m during their spawning season. Their eggs and larvae are pelagic, drifting in open water, and juveniles appear in shallow water from late summer to early winter (Love 1991). In barred sand bass, 50% of males matured at 219mm, and 50% of females matured at 239mm. Males mature between the ages 2 and 4 and females mature between the ages 2 and 5 years (Love *et al.* 1996a; Allen and Hovey 2001).

The barred sand bass is a warm temperate member of the family Serranidae and one of the three species of *Paralabrax* in southern California. Many species of the family Serranidae (sea basses) have specialized reproductive strategies. Some species are protogynous hermaphrodites and hence spend the early part of their lives as females and later change sex to conclude their lives as males. Oda *et al.* (1993) suggested that barred sand bass, like its sister species, the spotted sand bass (*P. maculatofasciatus*) might be protogynous hermaphrodites (Allen et al. 1995, Hovey and Allen 2000), however Hovey *et al.* (2002) demonstrated that barred sand bass taken from breeding aggregations were, indeed, gonochores with very few transitional individuals examined.

Very little is known about the behavior of barred sand bass with regards to breeding aggregations. Therefore, it is not surprising that we know almost nothing about the impact of fishing on aggregations of barred sand bass. Based on work throughout the world, fish spawning aggregations while being very important to local populations and economies, are not resilient to even moderate fishing pressure (Sala *et al*. 2003, Sadovy 2005, Sadovy and Domeier 2005).

The principle goal of this proposed research is to examine the impacts of the intense fishing pressure on barred sand bass populations during these spawning aggregations. In order to accomplish this, we will first need to develop a reliable method of estimating abundance (standing stock) of sand bass in these aggregations, which occur over relatively deep (20-30 m) coastal waters. Once standing stocks are accurately estimated, the impact of fishing pressure on the abundance over time can be determined.

The specific goal of this feasibility study is to seek answers the basic question:

1) Can we accurately determine the standing stock of barred sand bass in the aggregation area?

Methods and Materials

We tested the feasibility of using an innovative approach that will prove to be an extremely valuable technique for all future stock assessments of coastal pelagic species off southern California. An accurate assessment of standing stock of the spawning aggregations of barred sand bass required the development of this novel sampling technique. These breeding aggregations occur in open water over relatively deep sandy bottoms (20-30m) about 3-5 km offshore at specific locations. Water clarity is usually limited in these areas with underwater visibility rarely exceeding 3-5m. The combination of depths, diffuse aggregations spread over several kilometers, and limited visibility render underwater visual surveys by SCUBA divers impractical and necessitate the development of new, non-visual assessment techniques. We proposed to test the feasibility of conducting a hydroacoustic (sonar) assessment of barred sand bass standing stock (abundance and biomass) using high resolution split beam sonar verified by both rod and reel sampling over sonar targets and underwater video observations. Simply put, we plan to visually identify conspicuous acoustic targets, identify these targets with both rod and reel sampling and underwater video towed by the research vessel. Once a target is verified (e.g., as an aggregation of barred sand bass), its target strength can be related quantitatively to abundance and biomass.

The feasibility phase of this study was conducted over five days in July (peak spawning months for barred sand bass) of 2010 over the 20-30m depth contour at Huntington Flats. These locations are within the historic fishing grounds for barred sand bass off Los Angeles and Orange counties from which 10s of thousands of sand bass are taken daily during peak fishing season (Figure 3). Each day the sampling area was easily determined by the positioning of the sport fishing fleet including Commercial Passenger Sportfishing Vessels (CPFVs) and private vessels targeting sand bass from San Pedro, Long Beach and Newport Beach. As many as 12 total CPFVs and 35 private vessels were observed fishing this same area on each of the four days of hydroacoustic sampling in July 2010 (Figure 4). The study required five ship days (one day of preliminary sampling) and the participation of the *R/V Yellowfin* crew (3), the P.I., two compensated field assistants, and 2-4 rod and reel volunteers.

Hydroacoustic transects (Figure 5, 6) were conducted on July 15, 16, 22, and 23, 2010 aboard the *RV Yellowfin* using a leased high resolution, split beam sonar unit, the *Biosonics DT-X*. This sonar unit came interfaced with an on-board, laptop computer loaded with the necessary software for sonar imaging and GPS location (BioSonics Visual AnalyzerTM) (Figure 7). Ten to twelve randomly placed, replicate, sonar transects (defined as regions) were run each day on the Huntington Flats area specifically between what is called "Sand Bass Junction" (Love et al 1996b) and "Bolsa Chica Artificial Reef (BCAR aka Izor Reef). GPS readings were recorded continuously over the entire cruise track for each day. On shore, the complete BioSonics data files were transferred into state-of-the-art Echoview ® 4.90 software files for full analysis of target identification, spatial location, target frequency analysis, target strength, and, ultimately, intergration of target numerical density and biomass with defined regions of the daily cruise track (Figure 8). The Echoview software was leased for a two month period.

The BioSonics transponder was calibrated in situ the research vessel on July 2, 2010 using the metal, acoustic calibration sphere (Figure 9) provided with the unit (mean dB = -41.5). Acoustic targets were verified by both rod and reel sampling and underwater video. Specific target strengths were verified *in situ* for barred sand bass (Figure 10) and Pacific mackerel (Figure 11) by tethering freshly caught specimens from a hook-less ganion with one kg weight and passing the apparatus through the sonar cone under the transponder mounted to the port side of the research vessel in three separate trials. Video verification of targets was conducted on July 23, 2010 in collaboration with personnel from the Marine Region of the California Department of Fish and Game (CFG). CFG personnel provided and operated a Deep Blue Pro Color Underwater Video Camera (Figure 12) which was towed via cable at 8-10 depth off the port stern quarter of the *Yellowfin*.

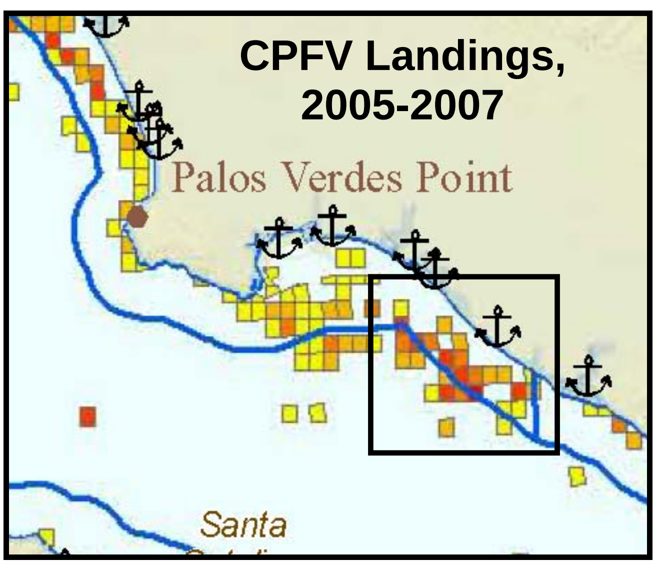


Figure 3. Commercial Passenger Fishing Vessel (CPFV) landings (Mean CPUE) and by location (microblocks) of barred sand bass throughout southern California from 2005-2007 (source: MLPA South Coast Regional Profile 2009). Inset rectangles delineate the "Huntington Flats" area.

Figure 4. CPFVs and private vessels fishing at “Sand Bass Junction” off Bolsa Chica, CA, 16 July 2010 (top) and 22 July 2010 (bottom). As many as 12 total CPFVs and 35 private vessels were observed fishing this same area on each of the four days of hydroacoustic sampling in July 2010.

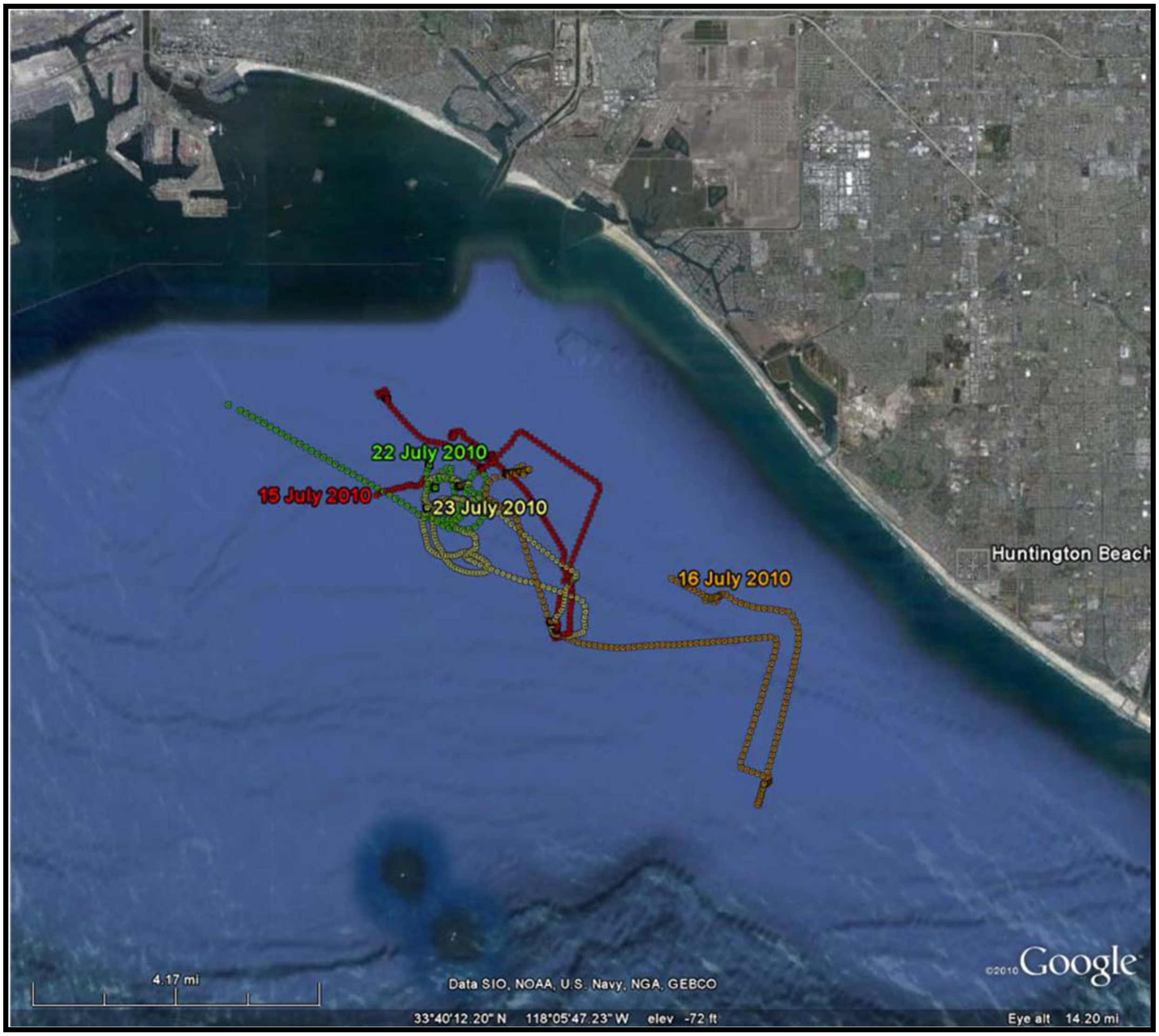
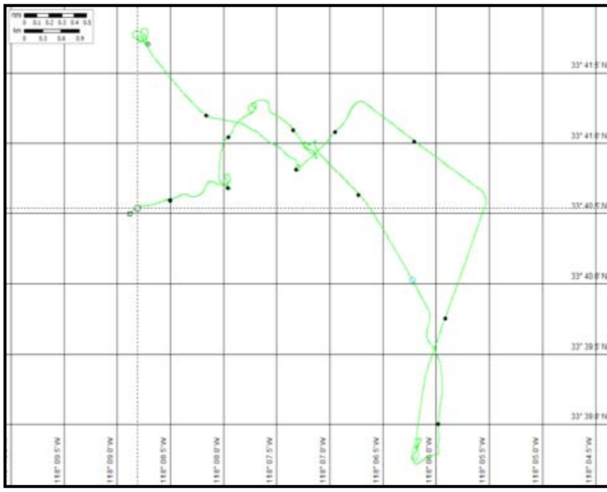
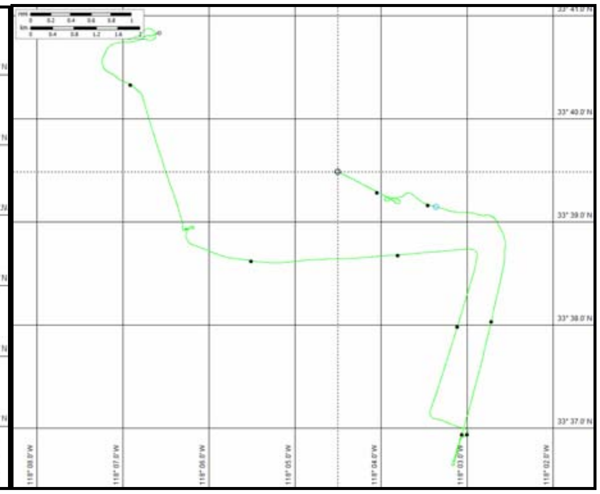


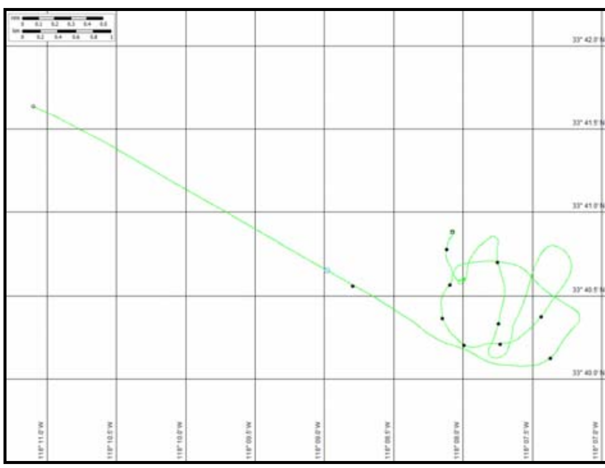
Figure 5. Tracks for sampling cruises off Huntington Beach, CA in July 2010 as recorded by Biosonics unit.



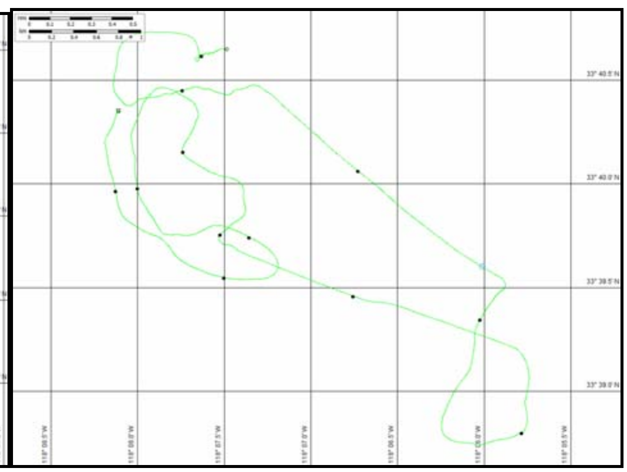
Cruise Track 15 July 2010



Cruise Track 16 July 2010



Cruise Track 22 July 2010



Cruise Track 23 July 2010

Figure 6. Individual tracks for sampling cruises off Huntington Beach, CA in July 2010 as recorded by Biosonics data interfaced with Echoview platform. Black dots indicate regions defined as hydroacoustic transects for analysis of fish density while the research vessel was traveling.

Figure 7. BioSonics DT-*X* unit with hydrophone (top), RV Yellowfin (middle), and BioSonics transducer unit mounted to by retractable boom to the port side a midship of vessel (bottom).

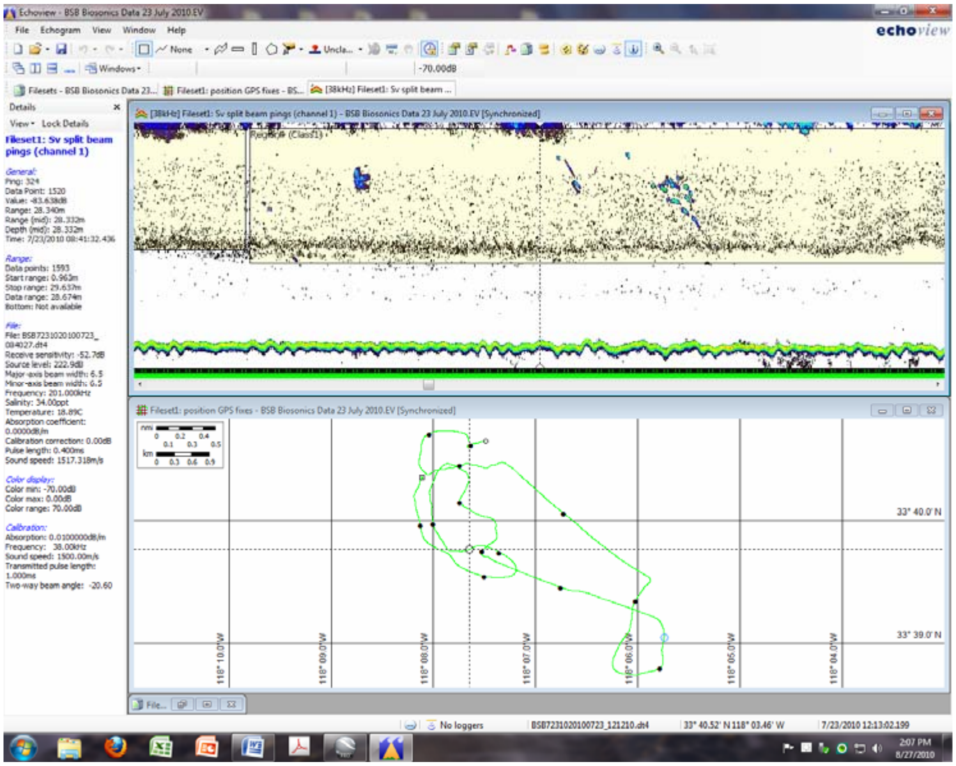


Figure 8. BioSonics DT-X sonar and GPS position readout in Echoview software platform.

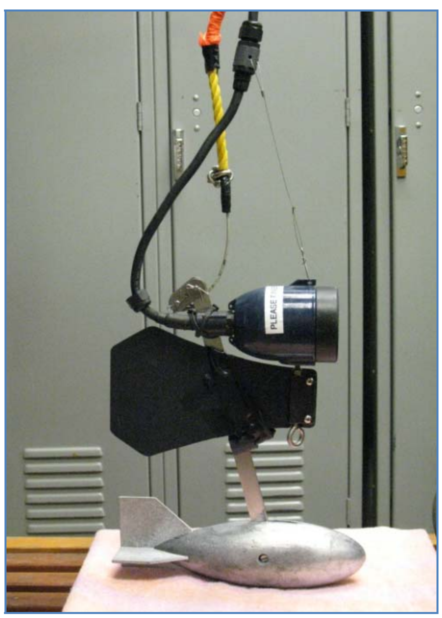


Figure 9. Deep Blue Pro Color Underwater Video Camera Pro Package. Video Output: Composite NTSC (PAL Optional) Focus: Fixed 1 inch to focal infinity; Resolution: 520 TV Lines; CCD: 1/3" Sony Super HAD II; Camera Weight: 1.2lbs water / 2lbs air (Dive weight can be added); Depth Rating: 800ft standard; Weight with 50ft Cable: 10lbs.

Results

Target Strength Calibration

Calibration Sphere

On July 2, 2010, the acoustic calibration sphere provided with the BioSonics DT-X system was deployed at 5 and 8m using a fishing rod for system calibration (Figure 10). The target strength of was -41.5 dB matched the factory specifications for depth and water temperature very closely. Therefore, no offset was necessary before analysis of sonar data.

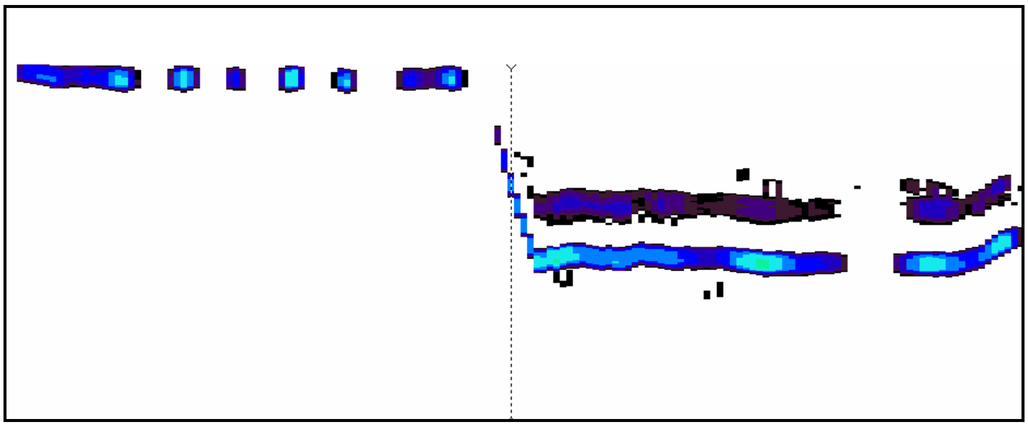


Figure 10. Sonar recording of Acoustic Calibration Sphere on trial 2 July 2010 (mean dB = -41.5).

Target Verification

Rod and Reel Sampling of Sonar Targets

Initially, rod and reel sampling was the primary means of target species identification (Figure 11). When suspected sonar targets (Figures 12-14) were identified, the "stop" was marked using paper buoys. The research vessel then circled around on the spot where weighted lures and live baits (northern anchovy) were quickly lowered to the target depth. If barred sand bass were initially caught, the vessel's anchor was deployed to thoroughly sample the spot (Figure 15). Many of these stops yielded barred sand bass as the primary species captured followed by Pacific mackerel. As top in the morning of July 22 was productive enough for a representative sample of barred sand bass to be weighed and measured (Figure 16) to determine the mean size (290 mmSL) and weight (572 g) of the fishes in these aggregations. Overall, 8-10 anglers aboard the RV Yellowfin captured 212 barred sand bass by this method with the daily totals as follows: July 15 – 0, July 16 – 10, July 22 – 157, and Jul 23 – 45.

Figure 11. Rod and reel (fishing) operations – SCMI staff aboard the RV Yellowfin and volunteer, professional fishing guide, Mike Gardner, at Huntington Flats 23 July 2010.

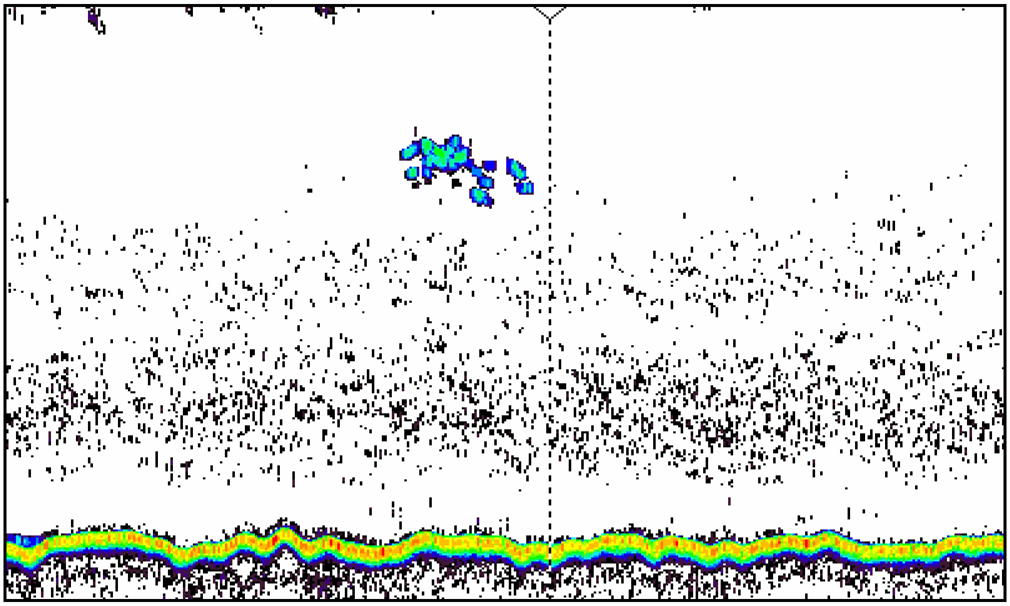


Figure 12. Sonar target initiating "stop" for rod and reel verification. Mark verified as barred sand bass aggregation in water column by rod and reel sampling (6-10 m depth); 22 July 2010.

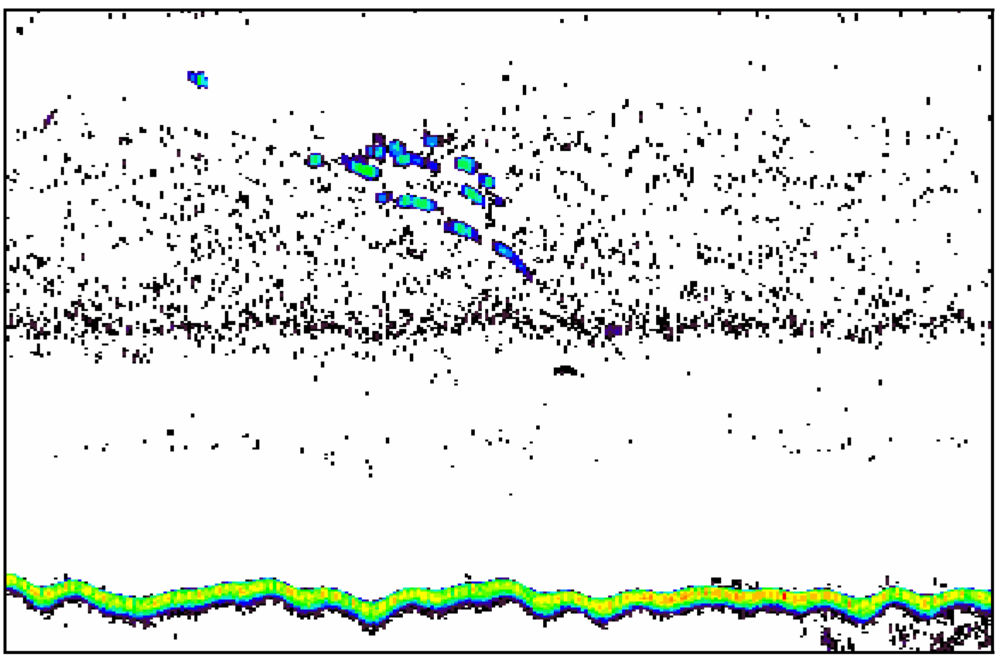


Figure 13. Barred sand bass aggregation (verified by underwater video; 23 July 2010 1055 hrs).

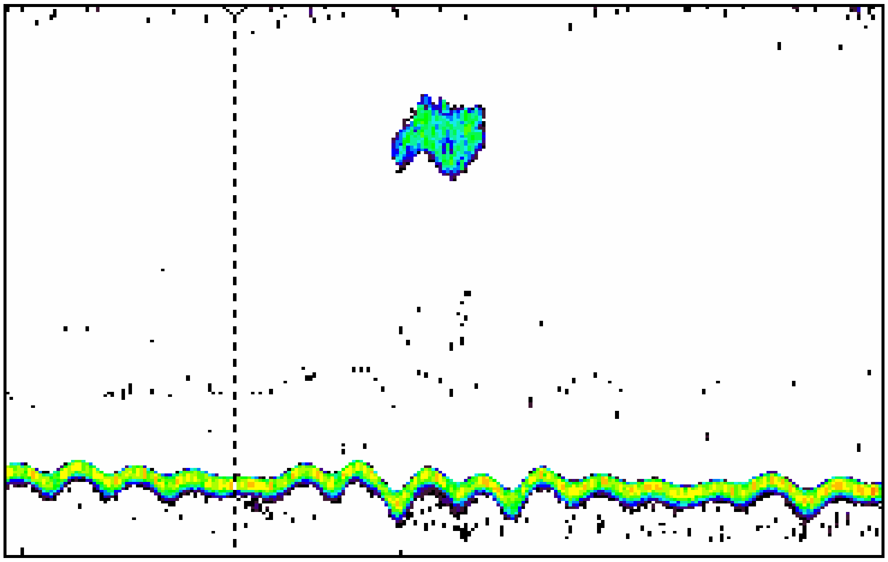


Figure 14. A presumed barred sand bass spawning ball; 16 July 2010 1010 hrs (5-10 m depth).

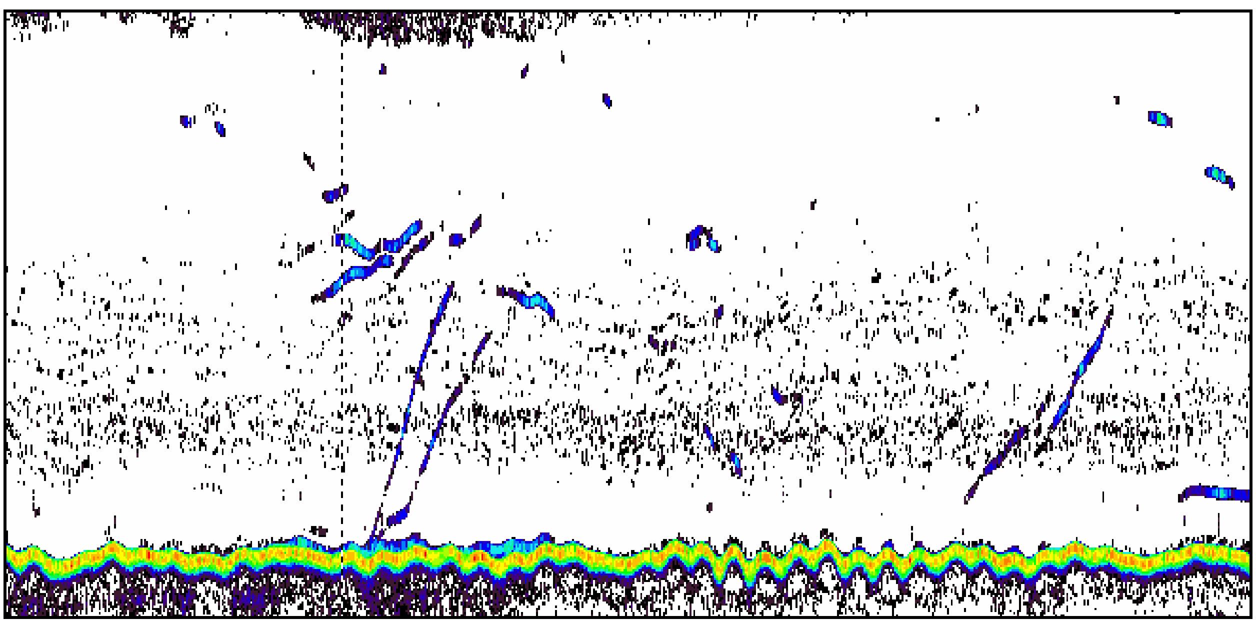


Figure 15. Barred sand bass sonar marks on anchor 22 July 2010 during fishing verification stop in which 48 sand bass were taken on rod and reel by 10 anglers aboard the *RV Yellowfin*.

Figure 16. SCMI staff fishing aboard the *RV Yellowfin* (top left) and displaying representative barred sand bass captured during early sonar "stop" on suspected barred sand bass sonar marks; 22 July 2010.

Figure 17. California Department of Fish and Game staff biologists, Heather Gliniak (left), Erica Jarvis (middle), and the P.I., yours truly (right), displaying barred sand bass captured at various sonar "stops" off Huntington Beach, 23 July 2010.

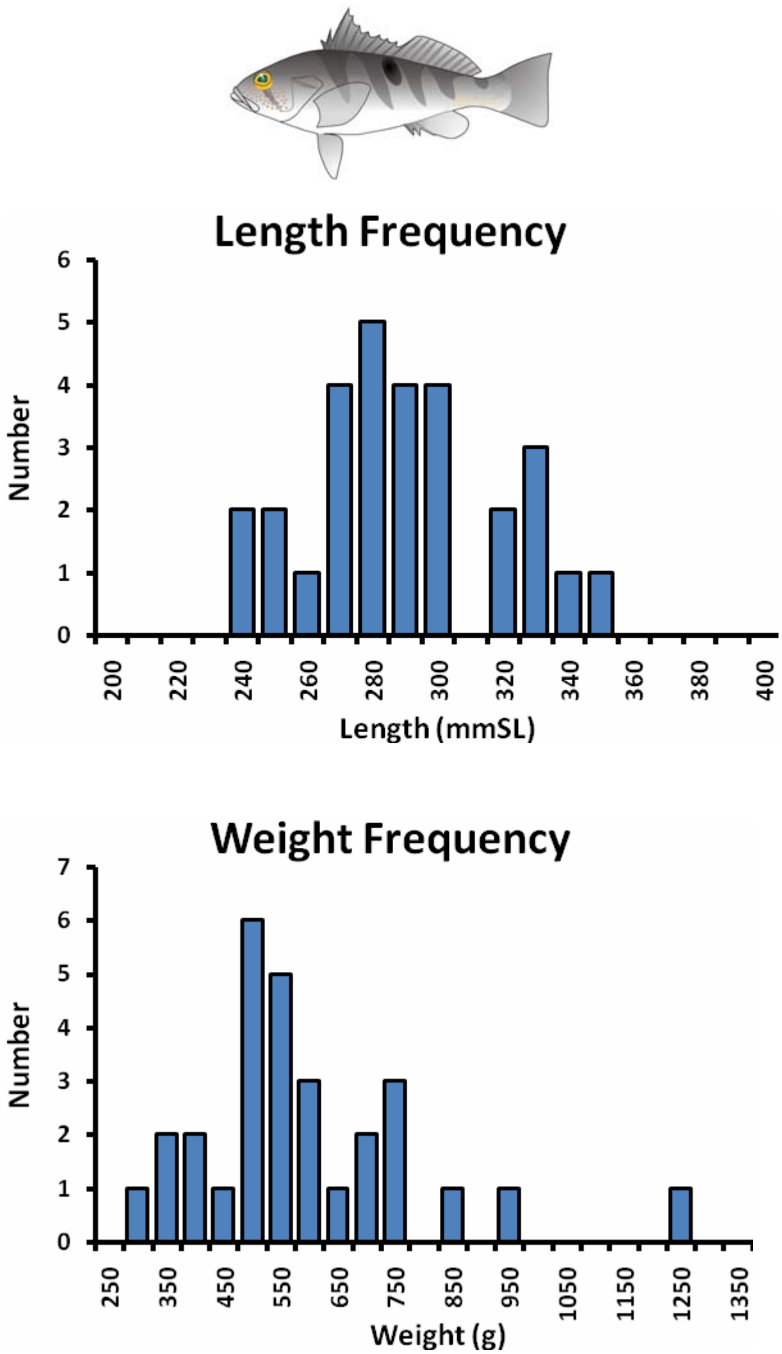


Figure 18. Results of length (mmSL) (top) and weight frequency analyses (bottom) of a representative sample of barred sand bass taken from the first target "stop" on 22 July 2010 from 0830 to about 1030 hrs.

Tethered Target Species - Barred sand bass (*Paralabrax nebulifer)* and Pacific mackerel (*Scomber japonicus*)

On July 22 and 23, 2010, specimens of both barred sand bass (Figure 19) and Pacific mackerel (Figure 20) were collected by rod and reel and tethered to a hook-less ganion. This apparatus was lowered into the sonar cone along the port side of the research vessel and staged at several depths while the Biosonics unit continuously recorded. These activities served to accurately calibrate the range, frequencies, and mean target strengths of both species that were numerically dominant in the sampling area.

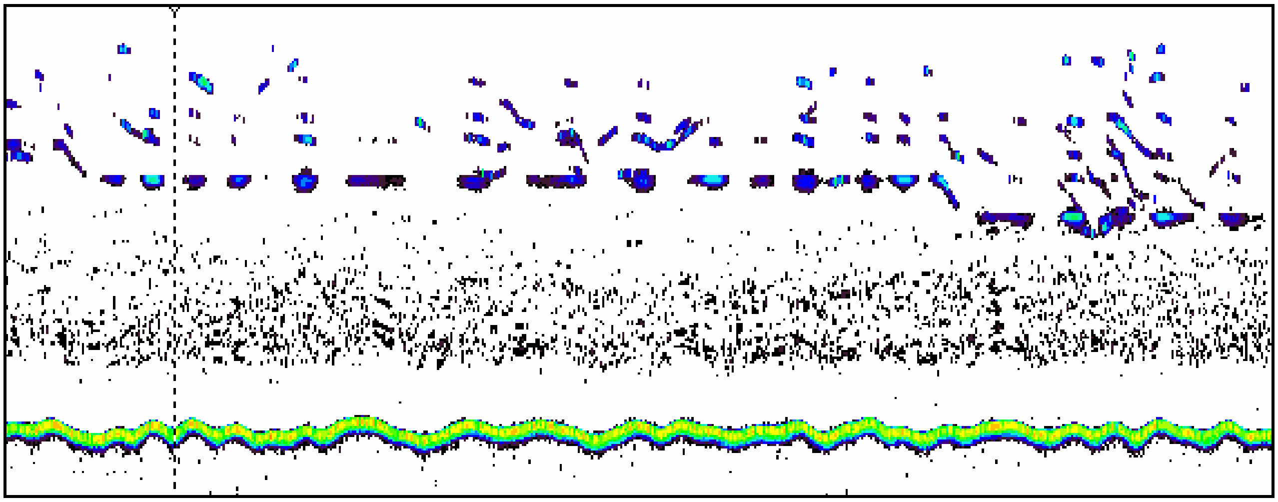


Figure 19. Sonar recording of tether apparatus; 22 July 2010; (top to bottom) three barred sand bass and 1 kg weight.

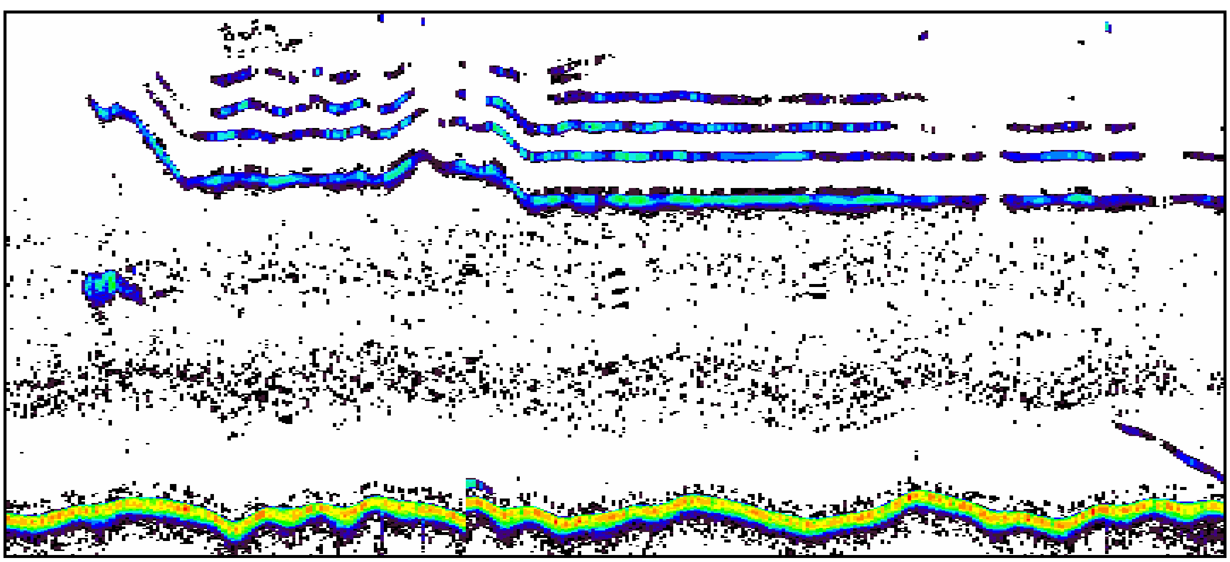


Figure 20. Tether apparatus; 23 July 2010; (top to bottom) one Pacific Mackerel, two Barred Sand Bass and 1 kg weight.

Target Strength Frequency Determination

By utilizing sonar recordings of the targets verified by rod and reel sampling and tethering as well as by underwater video (see below) mean target strength of barred sand bass was determined to be -35 dB by this method while Pacific mackerel averaged -45 dB.

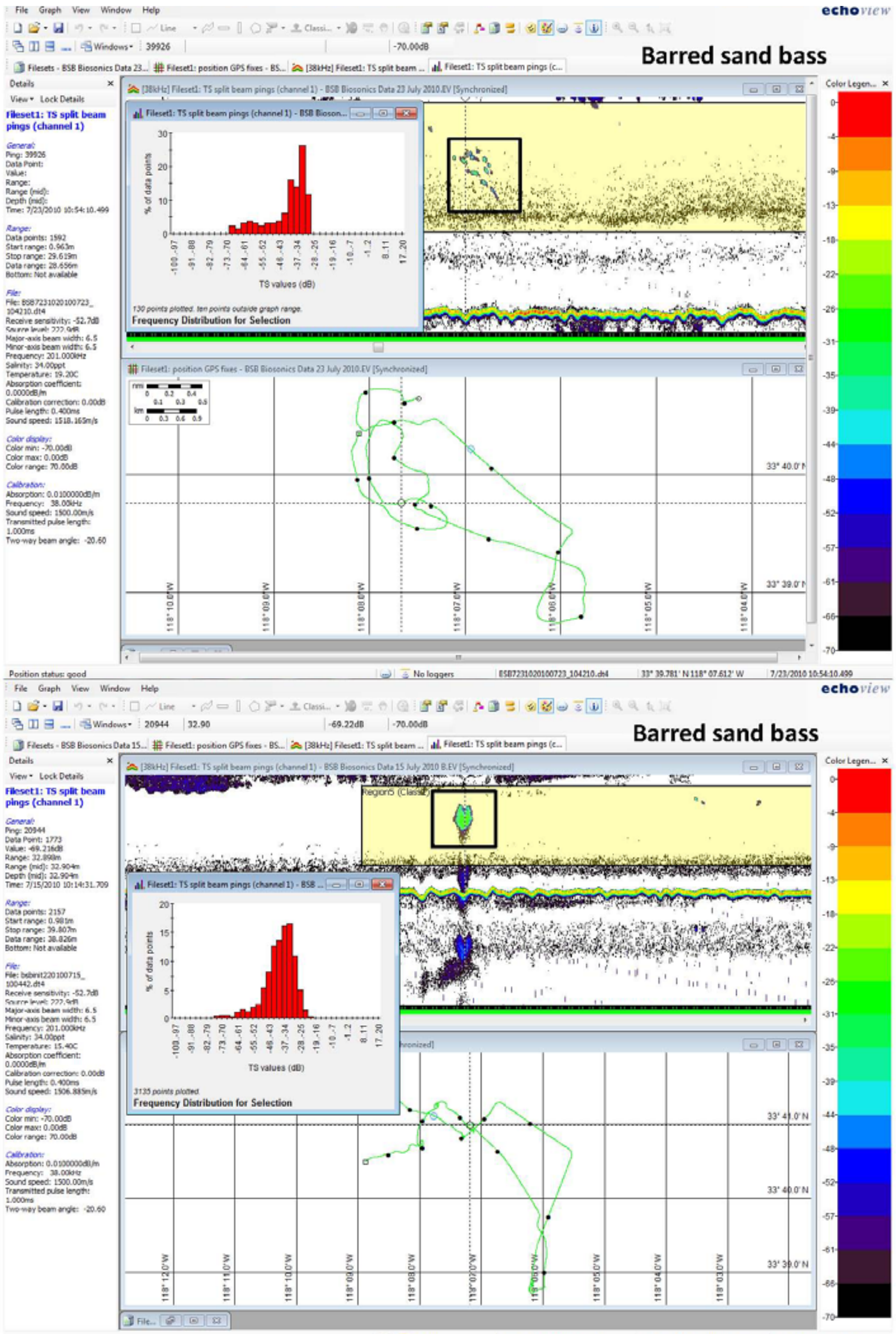


Figure 21. Echoview platform view of sonar record and GPS position of two aggregations of barred sand bass with target strength frequency analysis superimposed for both cases. Modes and means for barred sand bass consistently centered around -35 dB in all cases.

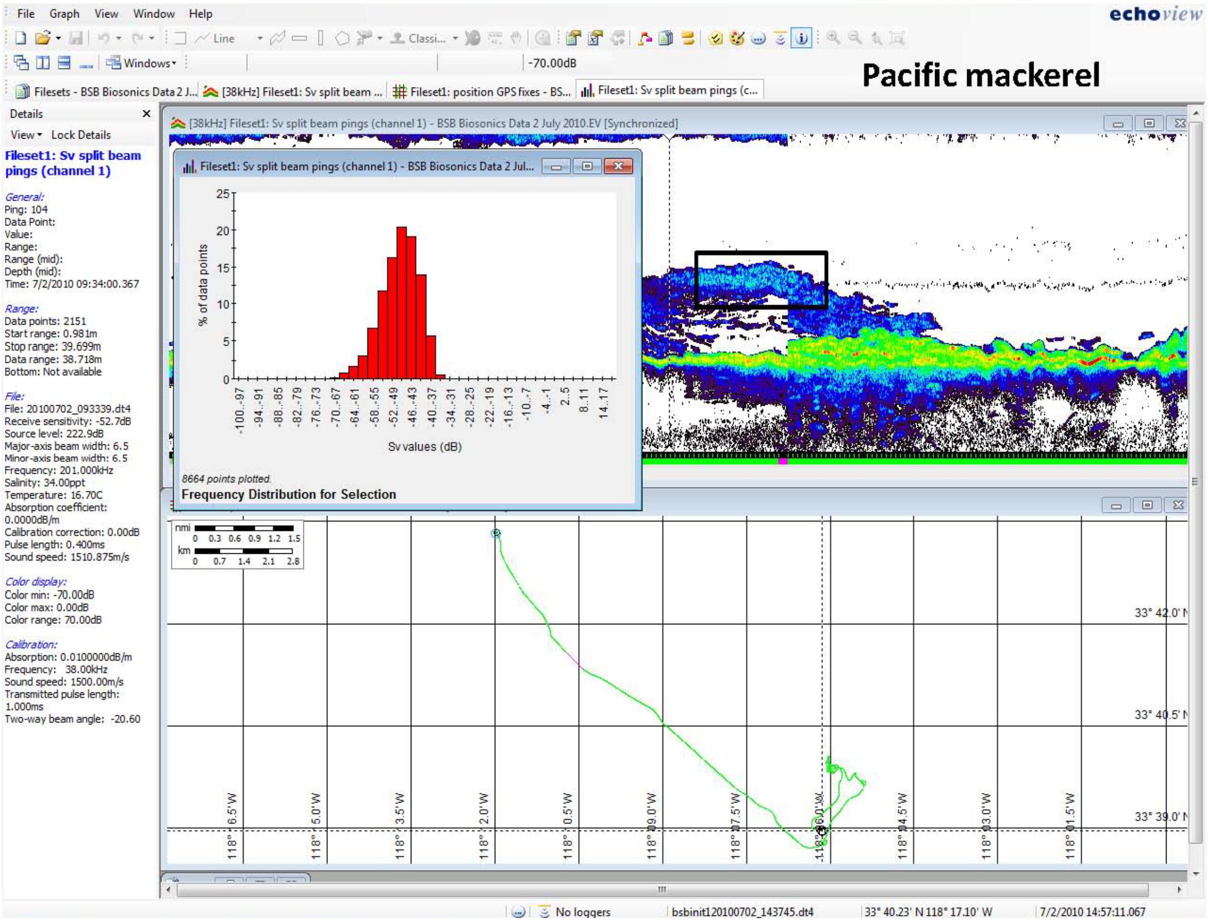


Figure 22. Echoview platform view of sonar record and GPS position of a large aggregation of Pacific mackerel with target strength frequency analysis superimposed for both cases. Modes and means for Pacific mackerel consistently centered around -45 dB in all cases.

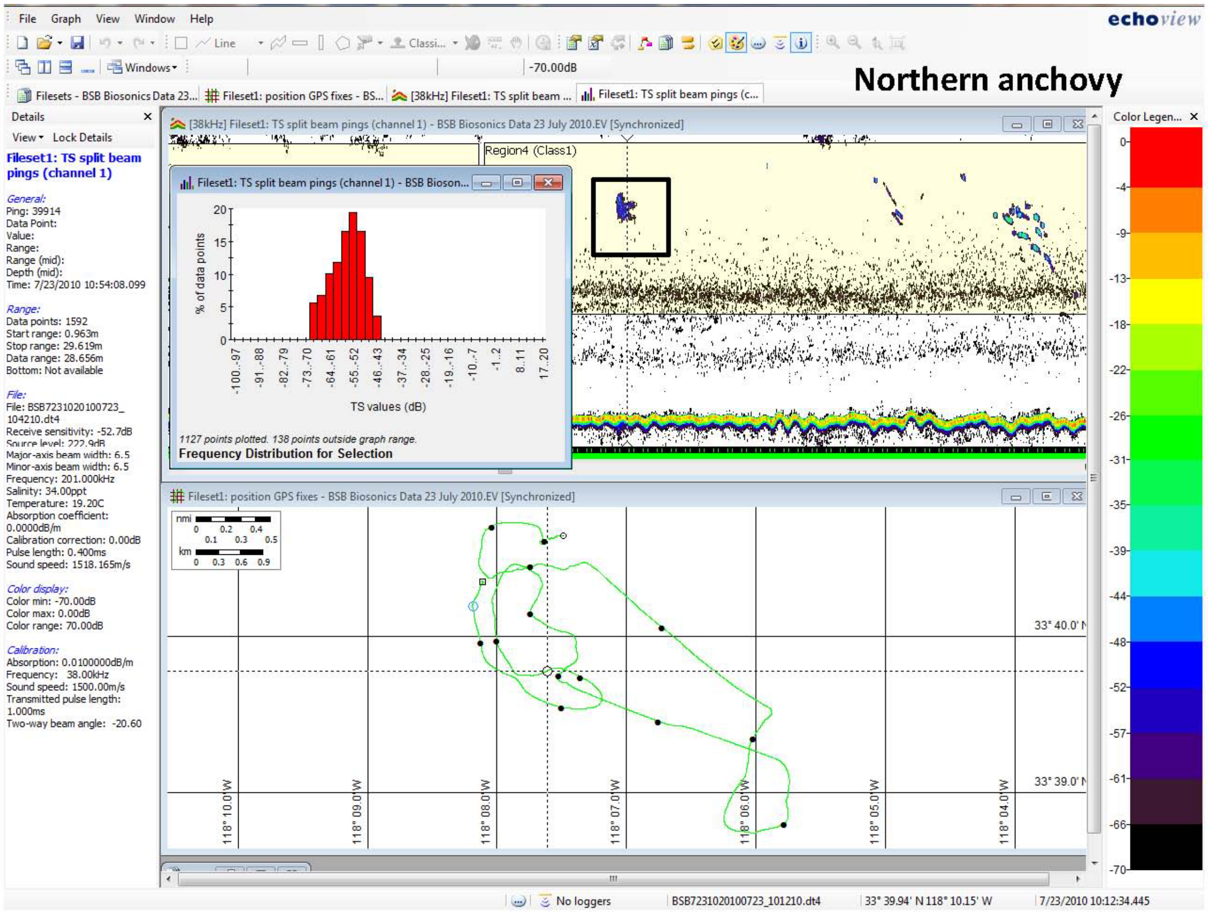


Figure 23. Echoview platform view of sonar record and GPS position of a school of Northern anchovy (*Engraulis mordax*) verified by underwater video (see next section) with target strength frequency analysis superimposed for both cases. Modes and means for northern anchovy consistently centered around -51 dB in all cases.

Video Verification of Targets

Approximately three hours of video recording conducted on July 23, 2010 yielded four successful video verifications of sonar targets. The first successful verification occurred between 1054 and 1056 hours when first a school of northern anchovy and then a loose aggregation of barred sand bass were detected by both sonar and the video camera which was towed 10 m behind the sonar cone (Figure 25, 26). Videos files of all four successful verifications are provided on the CD accompanying this report (courtesy of Erica Jarvis, California Department of Fish and Game).

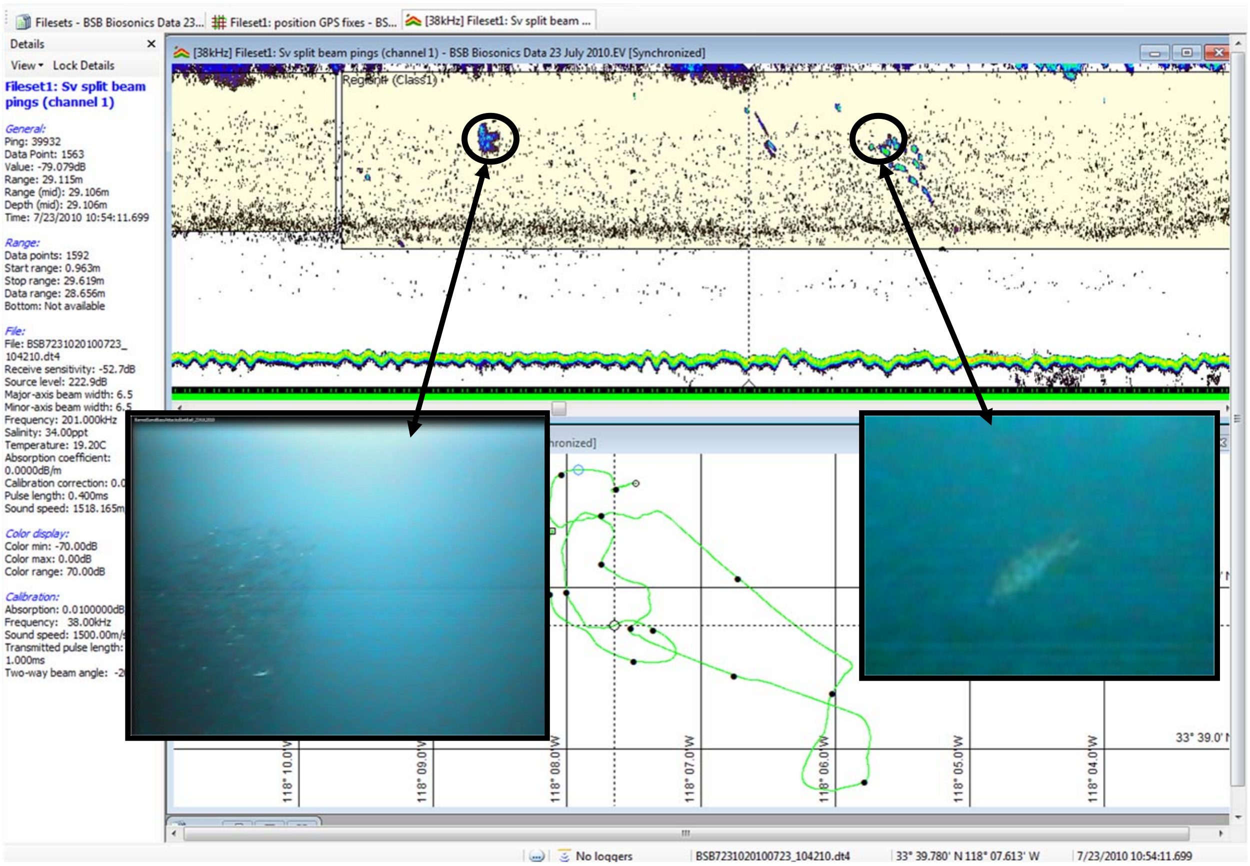


Figure 25. Echoview platform view of sonar record and GPS position of a school of northern anchovy (left) and an aggregation of barred sand bass (right) with enlarged still frames from video camera towed 10 m behind the superimposed for both cases; 23 July 2010; 1054-1056 hrs.

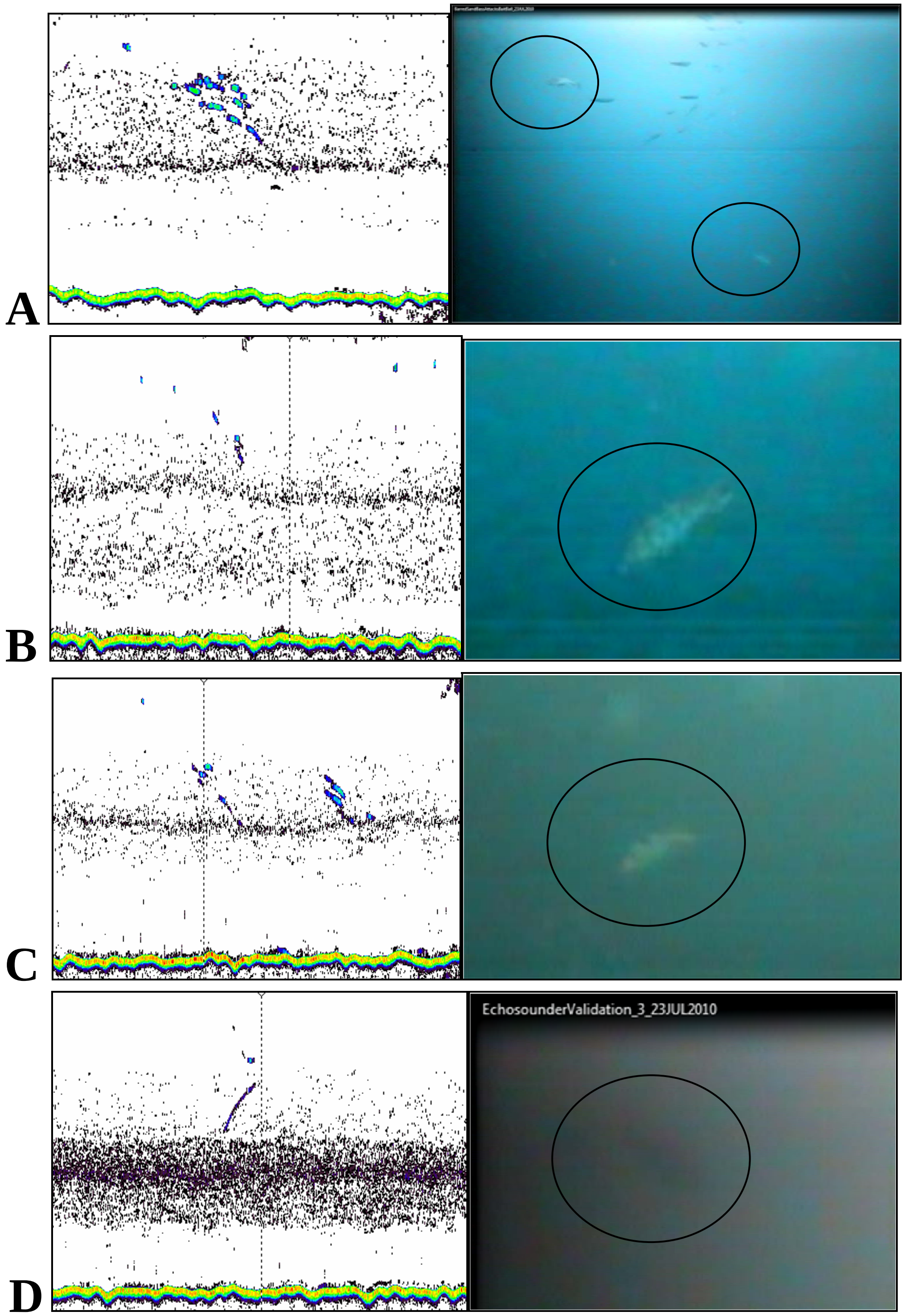


Figure 26. Sonar recordings (left) and corresponding enlarged still frames (right) from video camera towed 10 m behind the sonar cone on July 23, 2010. A) an aggregation of barred sand bass associated with a "bait ball" at 1056 hrs; B) a single barred sand bass at 1127 hrs; C) a single at 1332 hrs; and D) another (faint) single at 1345 hrs. Targets can be seen much more clearly on video clips (attached).

Hydroacoustic Estimation of Numerical Density and Biomass

The ultimate goal of this feasibility study was to determine whether this methodology can accurately estimate standing stock of barred sand bass in the well established spawning aggregation area off Huntington Beach, CA. The answer to that question is a resounding "YES". Actually, with the verified target strengths, these methods coupled with the BioSonics and Echoview software interface made it possible to estimate the abundance of all three common fish species, barred sand bass, Pacific mackerel, and northern anchovy (Figure 27-29) occurring in the sampling area.

Figure 27. Barred sand bass (-35 dB)

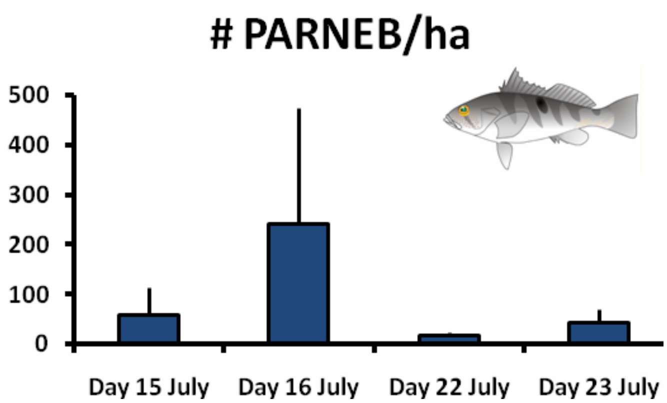
Figure 28. Pacific mackerel (-45 dB)

Figure 29. Northern anchovy (-51 dB)

Estimated barred sand bass abundances varied between 16.8 and 239.8 bass per hectare over the four days of assessment (Figure 30). Averaging 0.5 kg each, this corresponded to a range of standing stock between 8.4 to 120 kg per hectare (Table 1). The highest densities were encountered on July 16, 2010 when most sonar marks were large groups of fish which resulted in a large standard error of the estimate. The reason for this grouping behavior is unknown, however, this behavior occurred a full day after a noticeable upwelling event on July 15, 2010 when the surface water temperature fell to 15.9 ^{o}C. Sea surface temperature had returned to 18.0 ^{o}C by the morning of July 16th. Coinciding with this temperature drop, both rod and reel sampling aboard the research vessel and the sport fishing catch for the CPFV and private boats in the area of Huntington Flats were markedly depressed. Interestingly, the day of the highest catches of sand bass was July 22nd was corresponded to the day of the lowest standing crop estimates for sand bass in the water column.

Table 1. Numerical and Biomass Densities of Barred Sand Bass (PARNEB)

	# PARNEB/ha	2SE
Day 15 July	58.02	55.07
Day 16 July	239.85	232.41
Day 22 July	16.78	7.74
Day 23 July	43.91	25.55
	kg PARNEB/ha	**2SE**
Day 15 July	29.01	27.53
Day 16 July	119.92	116.20
Day 22 July	8.39	3.87
Day 23 July	21.96	12.78



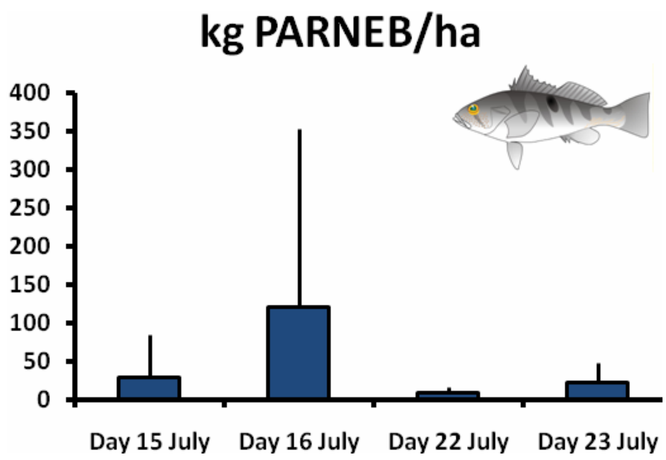


Figure 30. Mean numerical density (#fish/ha -top) and standing stock (biomass density – kg/ha) of barred sand bass for four days in July 2010 over the Huntington flats area as determined using BioSonics hydroacoustic transects. Error bars denote 2SEs from the mean of between 10 and 12 transects for each cruise date.

In addition to standing stock estimates for barred sand bass, this method also allowed us to estimate the abundances of the other two common species in the area, Pacific mackerel and northern anchovy (Table 2). Pacific mackerel were the second most abundant species captured by rod and reel and averaged between 15 and 261 fish per hectare over the four sampling days. At 0.25 kg per fish, this corresponds to between 3.8 and 65.4 kg/ha (Figure 31). Northern anchovy are obligatory schooling fishes that represent the major forage species in the water column. Sonar estimation of their abundance in the study area ranged between only about 6 and 225 fish per hectare (0.4 and 11.3 kg/ha). These small groups may well only represent the uneaten "chum" from the numerous sport fishing vessels in the area over this time period.

As seen in the barred sand bass daily estimates above, the stocks of both mackerel and anchovy were notable higher on July 16th, probably for the same reason. The rapid decrease and subsequent increase in surface water temperature may have promoted tighter schooling behavior in both species.

Table 2. Numerical and biomass densities of barred sand bass (PARNEB), Pacific mackerel (SCOJAP), and northern anchovy (ENGMOR).

	# PARNEB/ha	# SCOJAP/ha	# ENGMOR/ha
Day 15 July	58.02	70.57	28.23
Day 16 July	239.85	261.65	225.31
Day 22 July	16.78	15.18	7.99
Day 23 July	43.91	22.69	6.59
	kg PARNEB/ha	**kg SCOJAP/ha**	**kg ENGMOR/ha**
Day 15 July	29.01	17.64	1.41
Day 16 July	119.92	65.41	11.27
Day 22 July	8.39	3.79	0.40
Day 23 July	21.96	5.67	0.33

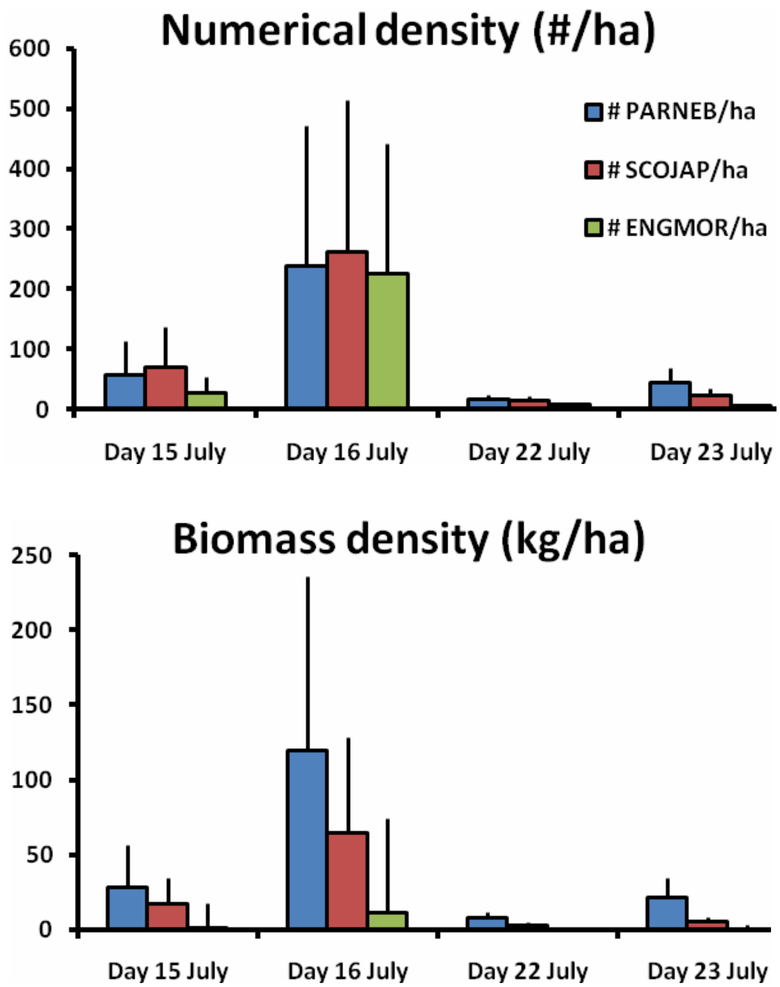


Figure 31. Mean numerical density (#fish/ha) and standing stock (biomass density – kg/ha) of barred sand bass, Pacific mackerel, and northern anchovy for four days in July 2010 over the Huntington flats area as determined using BioSonics hydroacoustic transects. Error bars denote 2SEs from the mean of between 10 and 12 transects for each cruise date.

REFERENCES:

Allen, L.G., T.E. Hovey, M.S. Love, and T.W. Smith. 1995. The life history of the spotted sand bass (*Paralabrax maculatofasciatus*) within the Southern California Bight. Calif. Coop. Oceanic Fish. Invest. Rep. 36:193-203.

Allen, L.G. and T.E. Hovey 2001. Barred Sand Bass. *In:* Leet, W.S., C.M. Dewees, R. Klingbeil, E.J Larson (eds). California's Living Marine Resources: A Status Report. Calif. Dept Fish Game, U. C. Agri. Nat. Res. Pub. SG01-11, 592 pp.

DeMartini, E.E. 1987. Tests of ovary subsampling options and preliminary estimates of batch fecundity for two *Paralabrax* species. Calif. Coop. Oceanic Fish. Invest. Rep. 28:168-170.

Feder, H.M., C.H. Turner, and C. Limbaugh. 1974. Observations on fishes associated with kelp beds in southern California. California Department of Fish and Game, Fish Bulletin 160. 144p.

Frey, H.W., ed. 1971. California's living marine resources and their utilization. California Department of Fish and Game Marine Resource Agency 148p.

Hovey, T.E. and L.G. Allen. 2000. Reproductive patterns of six populations of the spotted sand bass, *Paralabrax maculatofasciatus* from southern and Baja California. Copeia 2000: 459-468.

Hovey, C. B., L. G. Allen, and T. E. Hovey 2002. The reproductive pattern of barred sand bass *(Paralabrax nebulifer*) from southern California. CalCOFI Reps. 43: 174-181.

Larson, R.J., and E.E. DeMartini. 1984. Abundance and vertical distribution of fishes in cobble-bottom kelp forest off San Onofre, California. U.S. Fishery Bulletin 82:37-54.

Love, M.S., A. Brooks, D. Busatto, J. Stephens, and P.A. Gregory. 1996a. Aspects of the life history of the kelp bass, *Paralabrax clathratus*, and the barred sand bass, *P. nebulifer*, from the Southern California Bight. U.S. Fishery Bulletin 94:472-481.

Love, M. S., A. Brooks and J. R. Ally. 1996b. An analysis of commercial passenger fishing vessel fisheries for kelp bass and barred sand bass in the southern California Bight. Calif. Fish Game. 82:105-121.

Miller, D.J., and R.N. Lea. 1972. Guide to the coastal marine fishes of California. *California Department of Fish and Game, Fish Bulletin* 157. 249p. (addendum added 1976).

Oda, D.L., R.J. Lavenberg, and J.M. Rounds. 1993. Reproductive biology of three California species of *Paralabrax* (Pisces: Serranidae). Calif. Coop. Oceanic Fish. Invest. Rep. 34:122-131.

Oliphant, M. 1990. Recreational fishery. In: Review of some California fisheries for 1989. California Cooperative Oceanic Fisheries Investigations Reports 31:9-21.

Sadovy, Y. 2005. Trouble on the reef: the imperative for managing vulnerable and valuable fisheries. Fish and Fisheries 6: 167-185

Sala, E., Aburto-Oropeza, O., Paredes, G., and Thompson, G. 2003. Spawning aggregations and reproductive behavior of reef fishes in the Gulf of California. Bulletin of Marine Science 72: 103-121.

Sadovy, Y., and Domeier, M.L. 2005. Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. Coral Reefs 24: 254-262

Turner, C.H., E.E. Ebert, and R.R. Given. 1969. Man-made reef ecology. Calif. Fish Game, Fish. Bull. 146. 221 p.