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A proposed methodology to incorporate ROV length data into red snapper stock assessments

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Abstract

This document outlines a methodology to incorporate ROV obtained length composition data of red snapper into the current stock assessment. Data from four surveys spanning 2005-2012 exist comprising length measurements of 4557 total fish from artificial and natural reefs primarily offshore of Alabama and Florida. No clearly interpretable differences between the length compositions were observed when paired comparisons (same year, season, reef type) were analysed with Kolmogorov-Smirnov tests. Different surveys were then combined within a year and the effect of reef type (artificial or natural) and no clear differences were observed. Hence we deemed that the samples could be combined to produce a single length composition by year and season. Weighting factors were determined by calculating a spatial footprint for each survey relative to the total reef habitat area. These weighting factors are proposed as post-hoc weighting factors (lambdas) to appropriately weight the ROV length composition relative to other length composition inputs.

Introduction

Recently several surveys that use remotely operated vehicles equipped with a laser scales to count and measure fish underwater. These surveys have the benefit being fishery-independent and relatively non-selective with regards to the fish that they sample, in contrast to more size selective sampling gear such as hook and line, traps, etc. This survey gear is also able to sample high relief reef habitat that is often under- or inefficiently-surveyed by capture-based methods.

For this reason, these surveys provide insight into the ambient size structure of the population and insight into the size and relative abundance of fish on artificial or natural reefs that are often under sampled by other survey gear. Incorporating time series of the length composition from these surveys may be valuable to stock assessments.

This paper proposes a methodology to incorporate length composition data from four surveys into the current SEDAR 31 assessments. The first step involves an exploration of the information in each survey and an evaluation of the appropriateness of combining the surveys. Next the surveys are combined into a single length composition matrix for each year. Lastly, advice for appropriately weighting the length composition information in stock assessments is obtained by calculating the total area covered by the surveys as a fraction of the total habitat area.

Materials and Methods

1. *Data sources*

ROV-generated length composition data was available for the years 2005-2007 and 2009-2012 from four different surveys conducted between two labs, described below:

University of West Florida surveys (Patterson et al. 2009)

EELAARS- FWC-funded artificial reef research off Pensacola (2005-2010; sites sampled again in fall 2011 and late winter/early spring 2012). The FWC-funded study was conducted in the Escambia East Large Area Artificial Reef Site (EE LAARS). Twenty-seven study reefs (depth range 27-41 m) among three designs were randomly selected from 125 reefs built by the FWC in spring 2003 but not reported to the public (Fig. 1A). Sites were sampled quarterly from fall 2004 through spring 2010 with either a Videoray Pro3 or Pro4 micro ROV fitted with a red laser scale (two lasers positioned 10 cm apart). A point-count method was employed to estimate fish density; assumptions associated with this method and estimating fish length with the laser scale were tested (Patterson et al. 2009). Fish were tagged through 2007 at 9 study reefs, 9 others served as control sites, and the coordinates of a third set of 9 reefs were reported to the public in spring 2007 to test for fishing effects.

FWRIHab- FWRI-funded project in 2009-10 focused on examining differences in reef fish ecology at natural versus artificial reefs off the Florida Panhandle (but sample sites extending into waters off Alabama). The FWRI-funded project in 2009-10 was meant to be a multi-year effort but that was disrupted by the DHOS. Remotely operated vehicle sampling was conducted at 23 natural and 26 artificial reef sites in the northern Gulf of Mexico (Fig. 1B). Sites were haphazardly chosen through consultation with cooperating charterboat captains. Natural reef sites were sampled with transect sampling (see Fig. 2) and artificial reef sites were sampled either with point count or transect sampling. Sites also were fished with hook and line to test hook selectivity and to provide tissue samples for various analyses. Laser-scaled fish size data from this study are provided under the FWRI Habitat Work tab in the attached excel file.

PostDWOS- Deepwater Horizon Oil Spill (DHOS) sampling of natural reef sites across the same depth and east-west range as the FWRI study. Sixteen natural reef sites were selected from the 2009-10 FWRI-funded study to examine post-DHOS effects of reef fish community and trophic structure (Fig. 1C). These sites have been sampled quarterly with a Videoray Pro4 ROV from fall 2010 to present. Data from this work are provided under the Post DHOS tab in the attached excel file. Artificial reef sites that appear in the data under this tab are eastern and western sites that bracket the EE LAARS reefs we began sampling again in fall 2011 to examine DHOS effects.

Dauphin Island Sea Lab (DISL) surveys (modified from Patterson et al. 2009)-

SMALL FEATURES (Pyramids, Tanks, Chicken Coops, Cement Drums, Rock Outcrops)- The ROV is positioned on the bottom within 5 meters of the target feature. The heading, depth, range to target, GPS position and start time of the video are recorded for the feature. Video is shot for two minutes at the designated heading (in degrees, down current) and then flown to the opposite side of the feature for two additional minutes (on the bottom, within 5 meters of the feature). The second heading and range to feature is recorded (~180 degrees from first heading). If the current is strong the ROV is positioned ~90 degrees from the first heading. Finally, the ROV is positioned ~1 meter above the feature for a slow clockwise 360 degree spin and then video is stopped and the stop time is recorded. Total time for video recording is usually between 7-10 minutes. The ROV is equipped with parallel red lasers spaced 3 cm apart and are used to estimate fish lengths.

LARGE FEATURES (Ship Wrecks, Barges, Rock Ridges, Rock Ledges)- The protocol for large features is to fly a transect down the starboard side of the structure recording heading, GPS position, depth, and start time. After reaching the end of the structure the ROV is positioned to fly back on the port side of the structure and recording heading. The ROV is then flown to the center of the feature (~1 meter above) for a slow clockwise 360 degree spin. The video is then stopped and the time is recorded. In cases where the feature is too large to fly the total length (e.g. large natural bottom features) of a transect, the ROV is flown for two minutes along the right side of the feature (a rock ridge for example). During the first transect start time, depth, GPS position, and heading are recorded. The ROV is then moved to the left side of the ridge and flown back for two minutes in the opposite direction of the first transact (heading and stop time are recorded). Total time for video recording is usually between 7-10 minutes. The ROV is equipped with parallel red lasers spaced 3 cm apart and are used to estimate fish lengths.

2. Exploratory analysis

Initial exploratory analyses consisted of Kolmogorov-Smirnov tests to determine whether 'paired' sets of samples were similar and could be combined or if they had different signals. Paired comparisons were determined as surveys that coincided in the same year, season and on the same reef type (artificial or natural). The artificial and natural reefs were compared within years to determine if they had different length frequencies indicative of a different population size composition.

3. Determining appropriate weighting factors for length composition data.(lambas or external weighting factors for length composition data) from habitat information.

To develop a means to appropriately weight the length composition data relative to the other length composition data sets that we used a GIS dataset to calculate the fraction of hard bottom habitat that these particular datasets applied to relative to the total hard bottom habitat in the Eastern Gulf of Mexico. Hard bottom habitat was assumed to the sum of natural and artificial reef and was determined from with a GIS database compiled by Jo Anne Williams (NOAA-Galveston).

For the Eastern Gulf of Mexico the total available habitat was summed and then the total area covered by each survey was summed. The total area covered by each survey was estimate by a minimum convex polygon placed around the total survey locations. The weight for a given set of samples was then calculated as the fraction of the total habitat covered in each year (Table 2).

The following datasets delineating artificial reefs in the Gulf of Mexico were retrieved and buffered following protocol outlined by Mark Mueller, GMFMC, memo dated 06/8/12:

1) Oil and Gas platforms (platactive_albers_buf44m)
Retrieved from:
http://www.data.boem.gov/homepg/data_center/mapping/geographic_mapping.asp (accessed June 22, 2012)

- Starting with the original dataset of 7,089 records in "8211 (Platforms.e00)". Queried out only the "Active" platforms using the "REMOVAL_DATE" and "REMOVAL" fields. If anything was present in those fields, the records were not exported into the "Active" shapefile. Only 3,228 active platforms remained.
- Buffered using a 44m radius distance using these settings: "FULL" side type, "ROUND" end type, "ALL" Dissolve type.

2) Shipwrecks/Obstructions (Reg8_albers_buf10m, Reg9_albers_buf10m, Reg10_albers_buf10m)

- Retrieved from: Office of Coast Survey's Automated Wreck and Obstruction Information System (AWOIS)" http://www.nauticalcharts.noaa.gov/hsd/AWOIS_download.html (accessed June 25, 2012)

Buffered using a 10m radius distance using these settings: "FULL" side type, "ROUND" end type, "ALL" Dissolve type.

3) State Permitted Artificial Reefs (xxx)

- Retrieved July 17, 2012 from following sources:

  - Alabama: http://www.outdooralabama.com/fishing/saltwater/fisheries/artificial-reefs/
  - Florida: http://myfwc.com/conservation/saltwater/artificial-reefs/export-reef-data/
  - Mississippi: http://www.dmr.ms.gov/marine-fisheries/artificial-reef
  - Louisiana (GCS, NAD83): http://www.wlf.louisiana.gov/fishing/artificial-reef-program
  - Texas: Dr. Brooke Shipley Lozano, personal communication
- Buffered using a 4m radius distance using these settings: "FULL" side type, "ROUND" end type, "ALL" Dissolve type

Natural reef habitat was determined from the following datasets:

usSEABED Data
Point data from usSEABED (gmx_ext, gmx_prs, gmx_clc, gmx_cmp, gmx_fac)(GCS, NAD27)
Retrieved 06/16/12 from http://pubs.usgs.gov/ds/2006/146/htmldocs/data_cata.htm

Marine Substrates, Northern Gulf of Mexico (usSEABED_GOM_Sediments_albers)
- Retrieved 06/25/12 from:
  http://instaar.colorado.edu/~jenkinsc/dbseabed/resources/gsmseabed/griddings/
  Or http://service.ncddc.noaa.gov/rdn/data-atlas/physical/documents/usSEABED_GOM_Sediments.zip
  (usSEABED_GOM_Sediments.shp)
- Polygons with 0.02 decimal degrees resolution (approx. 2 km) originally: GCS, WGS84

Retrieved 06/16/12 from http://pubs.usgs.gov/ds/2005/118/htmldocs/data_cata.htm

USGS Multibeam Mapping
(bath=bathymetry; mos=backscatter)
(http://coastalmap.marine.usgs.gov/regional/contusa/gomex/gloria/data.html):
- DeSoto Canyon 2002 (nthmos, cenmos, sthmos; nthbath, cenbath, sthbath)(Retrieved 07/19/12 from http://geopubs.wr.usgs.gov/open-file/of03-007/data/grids/nthmos.tgz
  - (WGS84, UTM 16N – 8 meter)
- West Florida Shelf 2001 (nmos, cmos, smos; nbathy, cbathy, sbathy)(Retrieved 07/19/12 from http://geopubs.wr.usgs.gov/open-file/of02-005/site/data/nmos.tgz
  - (WGS84, UTM 16N – 8 meter)
- Pinnacles Region 2000 (mos.tgz)(Retrieved 07/19/12 from http://geopubs.wr.usgs.gov/open-file/of02-006/site/data/mos.tgz)
  - (WGS84, UTM 16N – 16 meter)
- Steamboat Lumps 2001 (sbmos; sbbathy)(Retrieved 07/19/12 from http://geopubs.wr.usgs.gov/open-file/of02-005/site/data/sbmos.zip)
  - (WGS84, UTM 16N – 4 meter)
- Selected Areas of Outer Continental Shelf, Northwestern Gulf of Mexico (Retrieved 07/19/12 from http://pubs.usgs.gov/of/2002/0411/data.html) (WGS84, UTM 15N)
  - Stetson Bank 2002 (sbmos; sbbathy)
    - (5 meter)
  - West Flower Garden Bank 1997 (wfmos; wfbathy)
    - (5 meter)
  - East Flower Garden Bank 1997(efbathy; efmos)
    - (5 meter)
  - MacNeil Bank 2002 (mnbathy; mnmos)

    - (4 meter)
  - Bright and Rankin Banks 2002 (brbathy; brmos)
    - (4 meter)
  - Geyer Bank 2002 (gybathy; gymos)
    - (4 meter)
  - Bouma, Rezak, Sidner, and McGrail Banks 2002 (mbbathy; mbmos)
    - (4 meter)
  - Sonnier Banks 2002 (snbathy; snmos)
    - (4 meter)
  - Alderice Banks 2002 (adbathy; admos)
    - (4 meter)
  - Jakkula Bank 2002 (ikbathy; ikmos)
    - (4 meter)
- Multibeam Mapping of the West Florida Shelf, Gulf of Mexico (http://pubs.usgs.gov/of/2002/0005/site/data.html) (WGS84, 8 meter)
  - Northern Region (nbathy; nmos)
  - Central Region (cbathy; cmos)
  - Southern Region (sbathy; smos)

- Bathymetry generated using data from the Chapman 1997 cruise (Retrieved 06/28/12 from http://pubs.usgs.gov/of/1999/of99-589/htm/aview.htm) (UTM Zone 16N, WGS84)
  - awsadutm.shp (awsadchap.shp) Coastline file. Polygon coverage (Source: Arcview sample file)
  - Bath12utm (Bath12geo.shp) Bathymetry. This data was used to generate the contours files found on this CD-ROM. Points. Data Source:National Geophysical Data Center's (NGDC) 1998 Hydrographic Survey CD-ROM Set (Version 4). National Ocean Service (NOS) Hydrographic Data are integrated with the NGDC's GEOphysical DAta System (GEODAS).
  - Chap97utm.shp (Chap97pt.shp) Point file that follows the trackline. Time is included in the attribute table. File was created in Mapinfo and converted to shapefile format using an avenue script.
  - Chapbathutm.shp (Chap97005_bathy.shp) Bathymetry generated using data from the Chapman 1997 cruise. USGS bathymetry. Line. (credit: R. Thieler, USGS Woods Hole)
  - Chaptrkutm.shp (Chap97005_trk.shp) Trackline from the 1997 Chapman cruise. Line. (credit: R. Thieler, USGS Woods Hole)
  - Compmap.tfw (compmapg.tfw) Tiff world file containing referencing information for the composite mosaic of the same name. This file contains ascii text and may be viewed using any text editor.
  - Compmap.tif (compmapg.tif) Composite mosaic image of the West Florida Shelf study area. This tif weighs in at around 110 megabytes. The tfw file of the same name needs to reside in the same directory to be referenced when viewed using the software of choice. Image.
  - Contour10m.shp (cnt10geo_mod) Bathymetric contours at 10 meter intervals generated from NOS bathy data and smoothed by hand. The contours were created using Arcview 3.0a Spatial Analyst with a Nearest Neighbor interpolation method. Line.
  - Hard_bottom_region.shp (Hbtmgeo.shp) Hard bottom region interpreted from the sidescan sonar data. Polygon coverage created using Mapinfo and converted to a

shapefile.
  - High_silt.shp (Hsiltgeo.shp) Silty sand areas determined by backscatter intensity from the sidescan sonar data. Entire sidescan sonarimage classified as either silty sand or medium to coarse sand. Polygon coverage created using Mapinfo and converted to a shapefile.
  - Lowsilt2.shp (Lsiltgeo.shp) Medium to coarse sand areas determined by backscatter intensity from the sidescan sonar data. Entire sidescan sonar image classified as either silty sand or medium to coarse sand. Polygon coverage created using Mapinfo and converted to a shapefile.
  - manmade_region.shp (Mnmadgeo.shp) Features interpreted as possibly manmade (?) objects (trash, shipwrecks, unknowns) from the sidescan-sonar data. These features are small and may not be apparent at the scale the other data sets are viewed. Some zooming in or out may be required. Polygon coverage created using Mapinfo and converted to a shapefile.
  - Outcrop_region.shp (Outcrgeo.shp) Intepretation of high relief outcrop region from sidescan-sonar. File was created in Mapinfo and converted to shapefile format using an Avenue script. Polygons.
  - Pits_region.shp (Pitsgeo.shp). Pits (fish pits?) identified from the sidescan-sonar data. File was created in Mapinfo and converted to shapefile format using an avenue script. Polygons.
  - sedwave2.shp (Sedwvgeo.shp) Sand waves occurring on the shelfbreak. Polygons.
  - profile_loc.shp (profiles.shp) Locations of selected seismic profiles. These profiles are included on this CD-ROM (see seismic.htm). File was created in Mapinfo and converted to shapefile format using an avenue script. Lines
  - shputmmt.met (shapemeta.met) FGDC compliant metadata for the shapefiles listed above.ASCII File.
  - wfsutm (wfs3.shp) West Florida Shelf sediment data. Point coverage generated using ARC/INFO from ascii text, then joined with a dbase file (attributes) and saved as a shapefile.Points.

Seafloor Topography:

Estimated seafloor topography in the Gulf of Mexico is a derived product from SRTM3_PLUS V6.0. Note that the spatial accuracy between land and ocean is different. The elevations in the land are an exact copy of the SRTM30 grid. The resolution is 30 arc second, which is approximately 1 km. However, the ocean data are based on a 1-minute predicted depth grid (approximately 1.85 km or 1 nm resolution). Note: Original datum: Clarke 1866.
Retrieved 06/27/12 from: Isobath_albers
http://gcoos.tamu.edu/products/topography/SRTM30PLUS_files/w98e78n31s18_isobath_selected_5-4000m.zip (vector: Isobath_albers)
http://gcoos.tamu.edu/products/topography/SRTM30PLUS_files/w98e78n31s18_bathy.img (raster: w98e78n31s18_bathy_albers)

U.S. Coastal Relief Model - Gulf of Mexico (GCS, NAD83)
- Multibeam Bathymetry http://www.ngdc.noaa.gov/mgg/bathymetry/multibeam.html
- Western Gulf (western_gom_crm_v1.asc) (http://www.ngdc.noaa.gov/mgg/coastal/crm/data/arc_ascii/western_gom_crm_v1.asc.gz)
- Central Gulf (central_gom_crm_v1.asc)

(http://www.ngdc.noaa.gov/mgg/coastal/crm/data/arc_ascii/central_gom_crm_v1.asc.gz)
- Eastern Gulf (fl_east_gom_crm_v1.asc) (http://www.ngdc.noaa.gov/mgg/coastal/crm/data/arc_ascii/fl_east_gom_crm_v1.asc.gz)

Results

Exploratory analysis

The paucity of 'paired' sets of observations between the four surveys (same habitat type, in the same year and season) makes comparison of the potential differences between the surveys (which may be due to spatial or methodological differences, means that very few direct comparisons of the length frequency distributions can be made (Figure 2). The four that could be made show largely non-significant or non-informative differences due to low sample sizes for one survey (Figure 2) and any differences observed are unlikely to be of utility in determining whether the surveys are appropriate to be combined.

In the absence of definitive information to suggest treating the surveys separately, the survey information was pooled across surveys by year and compared between reef types (artificial or natural) (Figure 3). For the four years that could be compared, two were non-significantly different and in one artificial reefs had larger fish (2009) and in the other natural reefs had larger fish (2011). Hence there was no consistently different pattern between reef type. Given the lack of consistent differences between surveys and reef types we deemed that the data for a given year, survey and reef type could be combined into one dataset.

Calculation of area covered by each survey

The exact calculations are to be determined. The current table is simply a hypothetical placeholder.

Discussion

Overall the lack of significant or clearly interpretable differences between the surveys suggests that they may be combined into a single dataset and applied within the stock assessment as a single 'fleet' or survey, depending upon model structure. It is likely that the selectivity will have to be estimated but that it can reasonably be assumed to non-size selective over the size range that fish are fully recruited to the reef habitat. This is a process that might be age-based and it is possible within SS3 to model both age and size selectivity. In this case we may consider a constant size selectivity and estimating age-selectivity with some strong priors based upon known reef habitat utilization at age for red snapper.

The weighting of this information relative to fishery-dependent and other survey length composition is complicated but proposed method that weights the data by the % of the habitat area that the surveys, in each year, cover is one means. Clearly the data cannot be considered representative of the entire Eastern GOM but, conversely it is also likely that the other data sources do not come from the entire Gulf and are also relatively localized, i.e., length compositions coming from the recreational fishery likely come from similar areas as covered by these surveys.

The benefits of the ROV data are that it is collected in situ, that it is not size-selective and that it is relatively efficient at measuring a large number of fish in areas that are not well represented (artificial and natural reefs) in the current stock assessment data. Including this data should help to incorporate the signals in year class strength seen in these habitat types into the stock assessment.

There does appear to be some evidence of cohort structure and the ROV survey clearly samples fish in the 20-100 mm

Literature cited:

PATTERSON, W.F. III, M.A. DANCE, and D. T. ADDIS. 2009. Development of a Remotely Operated Vehicle Based Methodology to Estimate Fish Community Structure at Artificial Reef Sites in the Northern Gulf of Mexico. Proceedings of the 61st Gulf and Caribbean Fisheries Institute November 10 - 14, 2008. Gosier, Guadeloupe, French West Indies. 265-270.

Table1. ROV Counts of red snapper by year, habitat, survey and season (1,2,3).

	DISL					EELAARS		FWRIHab						postDWOS						total
	artificial			natural		artificial		artificial			natural			artificial			natural			
year	1	2	3	1	2	1	3	1	2	3	1	2	3	1	2	3	1	2	3	
2005						202	250													452
2006						1186	411													1597
2007						770														770
2009								16	28	86	43	34	18							225
2010	4	48	37					71	240		43	94								537
2011	261	71		48	1		20													401
2012						22								44	13	58	199	140	99	575
total	265	119	37	48	1	2180	681	87	268	86	86	128	18	44	13	58	199	140	99	4557

Table 2. Hypothetical table documenting calculations to determine relative weighting factors.

	Total reef habitat (art + natural)	DISL	EELAARS	FWRIHab	postDWOS	Total surveyed	Fraction/weighting factor
2005	1000		200			200	0.2
2006	1000		200			200	0.2
2007	1000		200			200	0.2
2009	1000			300		300	0.3
2010	1000	200		300		500	0.5
2011	1000	200	200	300		700	0.7
2012	1000		200		100	300	0.3

Figure 1. Maps of study reef locations in the northern Gulf of Mexico for A) FWC-funded artificial reef study, B) FWRI-funded reef fish ecology study, and C) Post-DHOS sampling of natural reef sites. Green symbols indicate natural reef locations and yellow symbols indicate artificial reef locations.

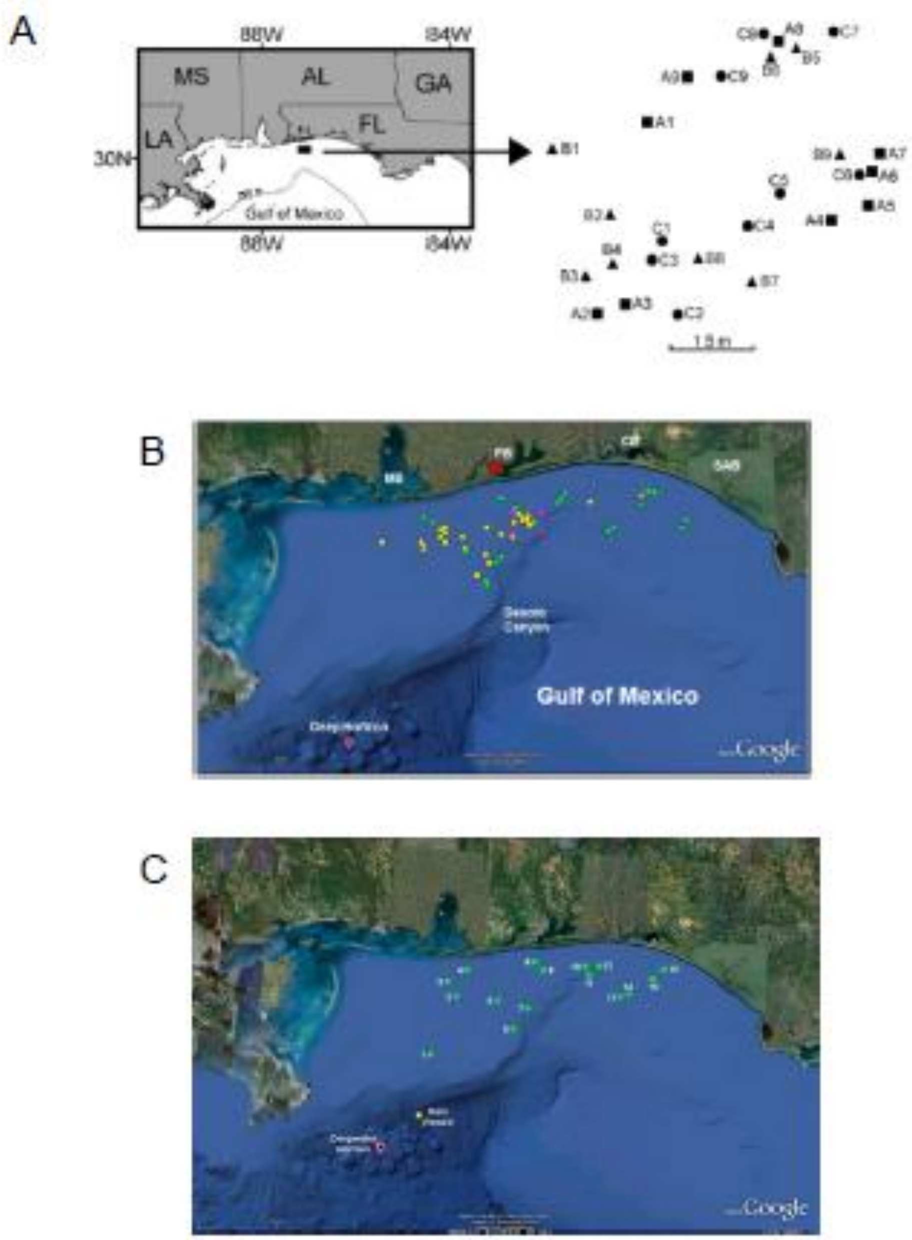

Figure 2. Strictly 'paired' comparisons, length composition in cm.

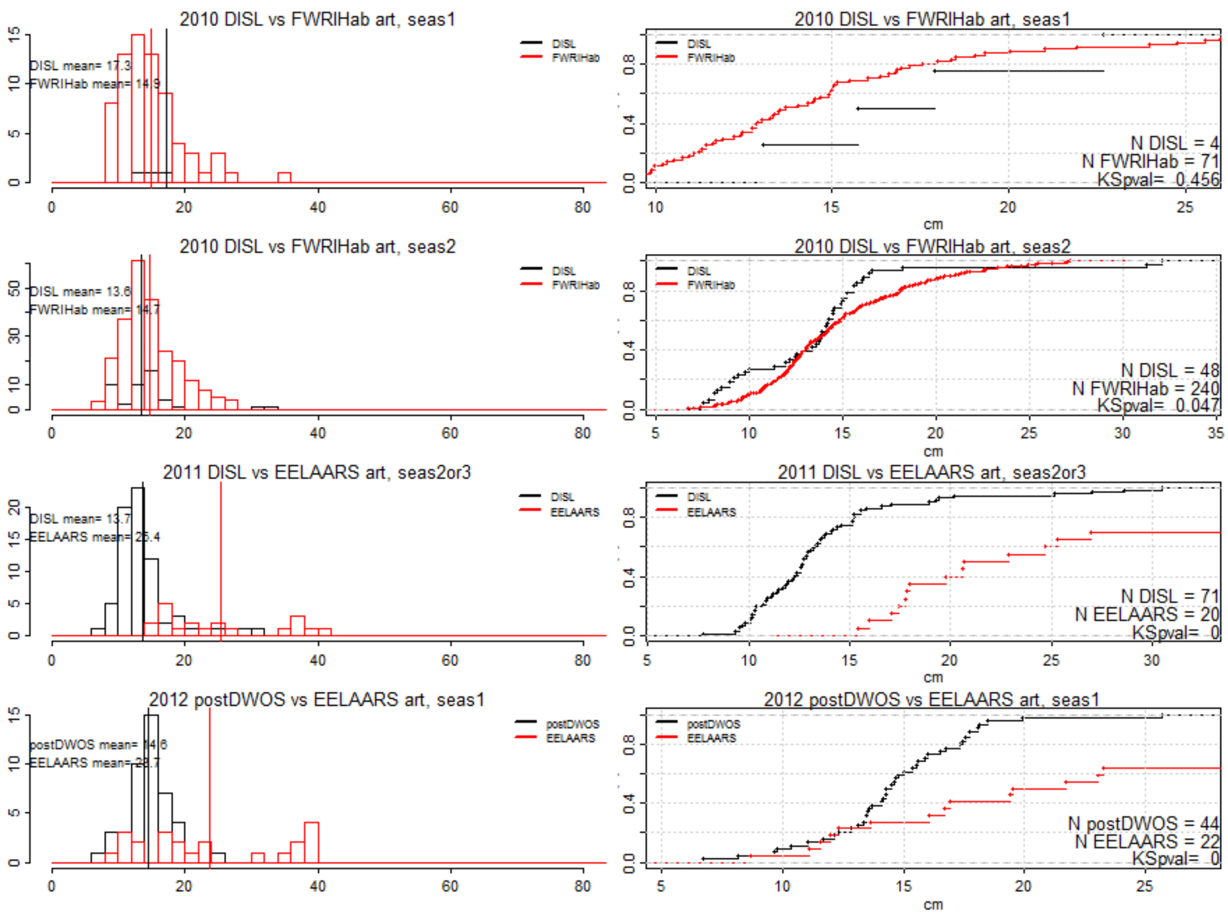

Figure 3. Artificial versus natural, all surveys combined. In 2010 and 2011 there were significantly smaller fish on artificial reefs.

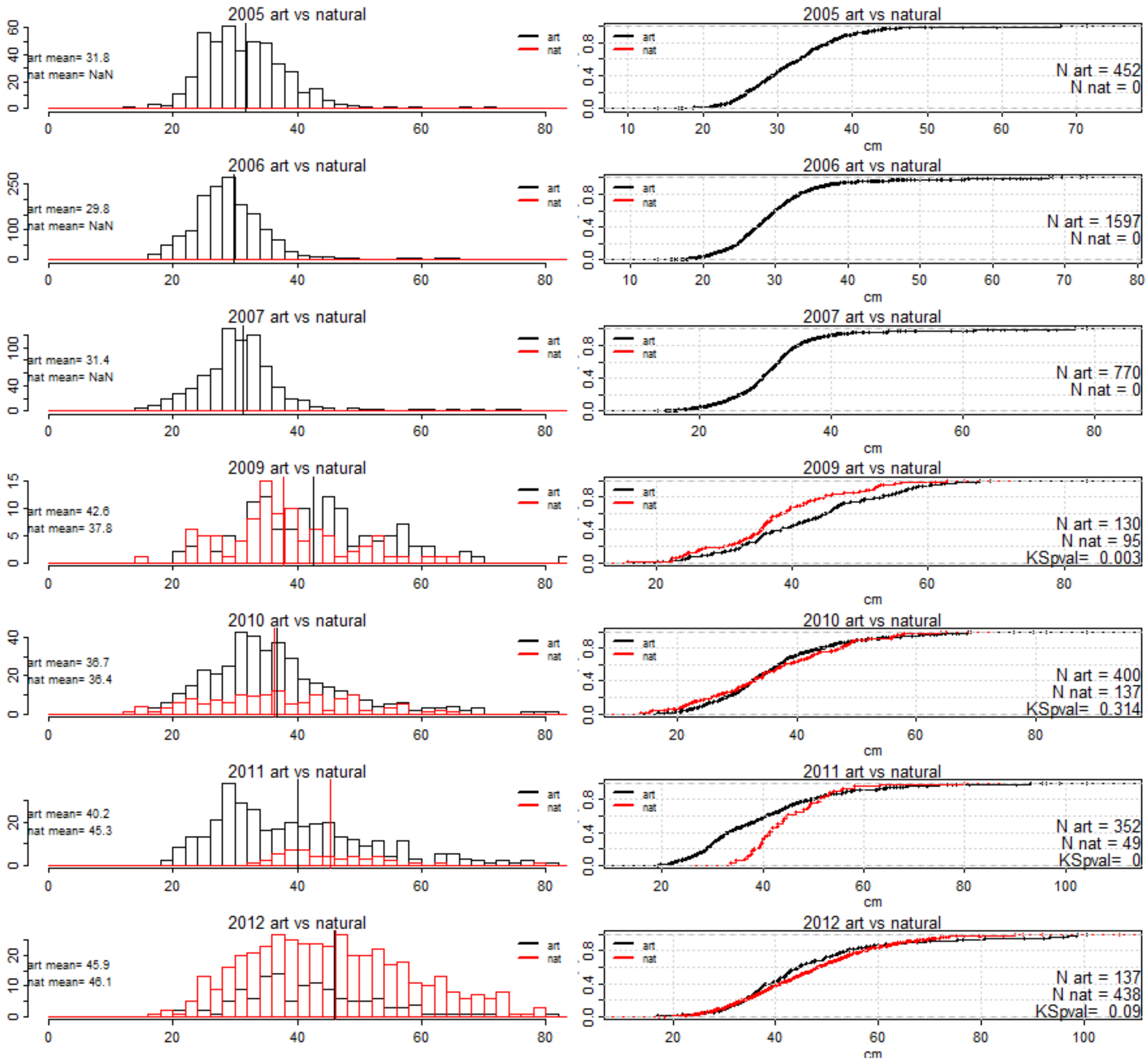

Figure 4. Length composition (cm) by year and season.