Abundance, Distribution and Diversity of Chesapeake Bay Fishes: Results from CHESFIMS (Chesapeake Bay Fishery Independent Multispecies Fisheries Survey)

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BACKGROUND

The potential for biological interactions and technical interactions within traditional single species management has motivated the development of multispecies approaches. Houde et al. (1998) reported the recommendations of a workshop to explore the utility and advisability of adopting multispecies approaches in Chesapeake Bay. An important conclusion of the workshop was the development of coordinated, baywide surveys to estimate key species abundances and to provide biological data on both economically and ecologically important species that are currently lacking (Houde et al. op. cit.). The workshop recommended that these surveys should permit the estimation of the temporal and spatial dynamics of key predator-prey relationships and trophic interactions (Houde et al. op. cit.).

Several fishery-independent surveys for the assessments of important fish and shellfish stocks in the Chesapeake Bay are currently ongoing but their study design and spatio-temporal coverage limits their applicability for exploring the multispecies question directly. From 1995 - 2000, a baywide investigation of biological production potential and its temporal and spatial variability was conducted. The objectives of TIES (Trophic Interactions in Estuarine Systems) research were broad and not focused solely on fish. Nevertheless, fish were sampled consistently using midwater trawls throughout the program=s duration. Species abundances, diversity, size and biomass distributions were analyzed (Jung 2001).

OBJECTIVES

The TIES data form a foundation on which our **Ches**apeake Bay **F**ishery-**I**ndependent **M**ultispecies **S**urvey (CHESFIMS) builds, thereby representing an ongoing 7-year survey of the abundances and key trophic interactions in the Chesapeake Bay fish community. CHESFIMS includes two key survey elements. A broadscale component seeks to survey the bentho-pelagic fish community, focusing on young (juveniles, and yearling) fishes in the mainstem of Chesapeake Bay, thereby extending the TIES database. In a second component, we have initiated a survey of the shallow shoal areas not covered by TIES. These complemented surveys will yield an integrated estimate of the abundance, diversity, distribution and trophic status of economically and ecologically important members of the Chesapeake Bay fish community. Here we summarize results from CHESFIMS= first year, and provide indications of how the survey will be developed subsequently.

METHODS

Broad Scale Survey

Three broad scale surveys were conducted in 2001, from 30 April - 5 May (CF 0101), 16 - 23 July (CF 0102) and 24 September - 1 October (CF 0103) (Table 1). All surveys were conducted from the University of Maryland Center for Environmental Science=s R/V Aquarius. Samples of the fish community were collected from between 15 - 48 stations (Table 1). At each station we profiled the water column using a Seabird SBE 25 CTD profiler. Subsequently, a midwater trawl (18-m^2 mouth opening, 6-mm cod end mesh, as in the TIES program) was deployed in a single, oblique stepped tow. The net was fished for two minutes in each of ten depth zones distributed throughout the water column from the surface to the bottom. The nominal tow duration was 20 minutes, however, the actual deployment time was recorded. The section of the tow conducted in the deepest zone sampled epibenthic fishes close to or on the bottom. The remaining portion of the tow sampled pelagic and neustonic fishes. All survey deployments were conducted between 19:00 and 07:00 to reduce problems with gear avoidance and to take advantage of the diurnal distribution patterns of pelagic fish species.

Raw processing of net hauls was conducted on board the vessel. The total catch at each station was weighed. Fish were identified to species and total weights for individual species were recorded. Samples of length and weights of individual fish were taken for up to 30 randomly selected individuals of each species. Fish were then frozen whole, or preserved in ethanol, depending upon size for subsequently analysis in the laboratory. In the laboratory, identifications, lengths and weights were confirmed. Subsequently, stomachs and otoliths were dissected from individual fish for diet and age analysis. Stomach contents were flushed and identified to the lowest taxanomic level possible. Sizes and weights of subsamples of prey were quantified. No age analysis has yet been conducted.

Shoal Survey

The shoal survey was conducted as a stratified random survey. The survey area included shallow waters (< 5 m) from the MD line (approximately 37.5^{o}N) to 38.5^{o}N (below the mouth of the Choptank River). The strata for the pilot study were chosen to minimize travel time, and thus support the collection of data from a fairly large number of stations for the fixed budget. The four shoal survey strata were:

Table 1. Summary of sampling and results (mean ± SE) from 2001 broadscale surveys				
		Survey		
		CF0101	CF0102	CF0103
Dates		April 30 - May 5	July 16 -23	Sept 25 - 29
Number of Stations		31	48	15
Average CPUE (fish/haul)	Lower	63.4±22.21	1418±346.2	3280
	Mid	14±3.41	1745±586.6	9002±656
	Upper	63.66±48.45	1586±525.3	2814±1165
	Overall	49.9±14.91	1535±274.8	5639±563.4
Average CPUE (g/haul)	Lower	2179±1198	3197±1136	6361
	Mid	250.4±81.89	1054±372	8546±430.5
	Upper	6466±4884	4021±2155	3027±1294
	Overall	2044±878.7	2654±720.6	5957±568.2
Total N^{o} S		27	29	26
Average Diversity (N^{o}. Species)	Lower	5.31±3.01	6.05±1.77	10
	Mid	3.6±1.89	5.35±2.23	5±0
	Upper	4.66±3.44	5.66±2.87	5.88±2.31

Stratum 1 - from the mouth of the Patuxent River to 38^{o}25'16" N; the stratum was divided into six equal length sections, and one station was randomly selected in each longitudinal section.
Stratum 2: Shallow Eastern Shore waters between 37.54 ^{o}N (below Smith Island) and 38.03^{o}N (above Smith Island). The region of this stratum includes one broadscale survey fixed transect and MDNR blue crab survey stations. Total stratum area 346.2 km^2; 33 stations sampled.
Stratum 3: Shallow Eastern Shore waters between 38.03^{o}N and approximately 38.22^{o}N (the north side of the Patuxent R.). This region includes a transect from the mainstem survey and MDNR blue crab stations. Total stratum area 617 km^2; 56 stations sampled.
Stratum 4: Shallow Eastern Shore waters between 38.22^{o}N and 38.32^{o}N (below the Choptank R.). Total stratum area 64.4 km^2; 8 stations sampled.

Six minute tows were conducted at each station using a16› bottom trawl. We used the same trawl and trawling procedure as for the blue crab trawl survey for compatibility. All fish and crabs in the catch were identified by species, counted, measured and weighed. Environmental data such as air temperature, surface and bottom water temperature, salinity, dissolved oxygen, water clarity and wind conditions were recorded.

RESULTS

Broad Scale Survey

The first survey (CF0101) sampled 31 stations baywide and collected 1,452 fish (total weight ~ 67 kg). The second survey (CF0102) sampled 48 stations baywide, collecting 75,336 fish (total weight ~ 130 kg). The final survey sampled on 15 stations, mainly in the mid- and upper-Bay. Poor weather during the scheduled survey period prevented sampling of more stations. Despite this lower effort, 73,619 fish (total weight ~76 kg) were collected.

Patterns and distributions of diversity and abundance varied among the three surveys. The total number of species caught in each survey was approximately constant (Table 1). .The average diversity of the fish community at each station increased slightly between spring and autumn. In general, the average diversity was higher in the lower-Bay region reflecting the increased diversity of marine ecosystems (Table 1). Average catch per tow increased over the three surveys (Table 1). However, within surveys the distribution of abundance changed. In April (CF0101), the abundance in the mid-Bay region was approximately one fifth of the abundance in the other two regions (Table 1). In the summer survey, abundance was equal in all regions (Table 1). Yet, by autumn, the pattern of abundance had shifted so that fish in the mid-Bay region were almost three times more abundant than in the other regions (Table 1). Similar patterns were evident in biomass (Table 1).

Bay anchovy (*Anchoa mitchilli*) dominated the catches during all cruises (Fig. 1). Bay anchovy catches increased from 16.45 fish.tow^{-1} in April, to 1,458 fish.tow^{-1} in July and peaked at 4,871 fish.tow^{-1} in September. However, estimates for September may be inflated because we were unable to sample the lower-Bay stations at which anchovy abundances were likely lower. The seasonal pattern of catches of bay anchovy reflects the underlying biology of this species (Kimura et al. 2000). In the spring survey, the highest catches of anchovy were taken in the lower Bay. In these regions, anchovy averaged 70.28 mm TL (range 33-94 mm TL). In the summer cruise, the center of anchovy distribution had moved slightly northward (Fig. 2), and the length range had broadened (15 - 99 mm TL, average = 38.27 mm TL). The average length of anchovy was lowest in the mid-Bay region. The abundance and both minimum and maximum sizes were higher in the upper Bay region, reflecting the northward migration of newly recruited bay anchovy. We cannot infer fully the distribution of anchovy in autumn, due to the weather-induced reduction of sampling in the lower bay. However, the available data are consistent with a general

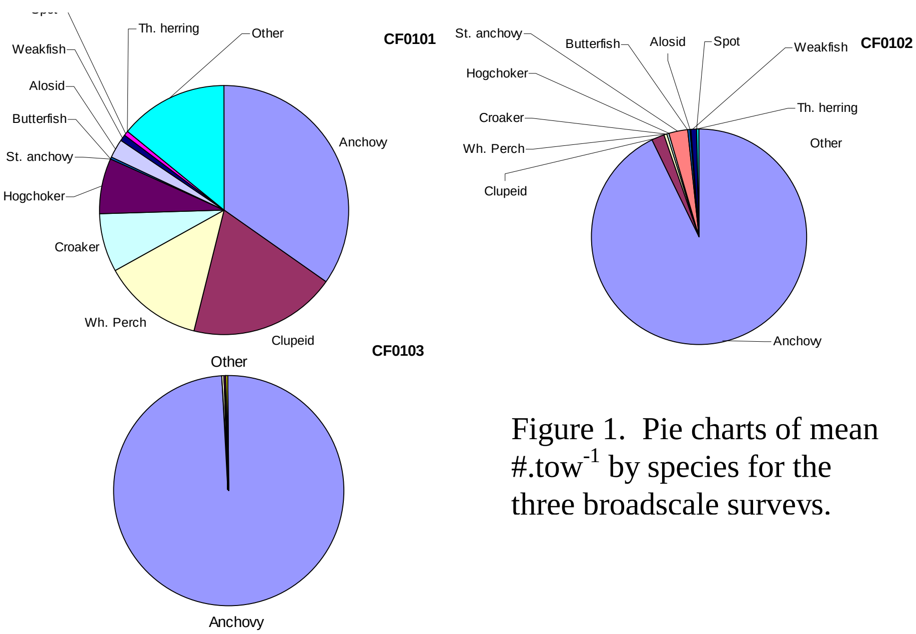

Figure 1. Pie charts of mean #.tow^{-1} by species for the three broadscale survevs.

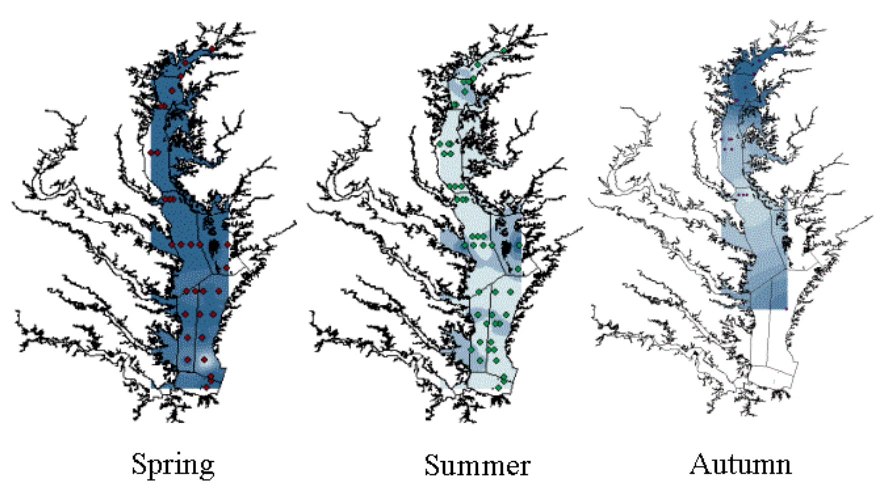

Figure 2. Distribution of bay anchovy (#.tow^{-1}). Lighter colors indicate higher concentrations

northward migration of young-of-year anchovy.

Young of year clupeids were the second most abundant fishes in both the spring and summer surveys (Fig. 1). Average catches of this species group during these surveys were 9.03 and 28.31 fish.tow^{-1} in spring and summer respectively. Young of year clupeids were only collected in the lower- and mid-Bay stations in the spring. In the summer, young of year clupeids were present in all three regions. Fish were smaller on average in the lower Bay than in either the mid- or upper-Bay. Only two fish were caught in the autumn survey; one each in the mid- and upper-Bay regions. Both fish were greater than 77 mm TL.

White perch was the 3rd, 5th and 2nd most abundant species in our collections in the spring, summer and autumn surveys (Fig. 1). In all surveys, white perch was collected only at upper-Bay stations. In the spring, the average CPUE was 11.23 fish.tow^{-1}. The average length of white perch was 192 mm TL (range 67-297 mm TL). By summer, white perch abundance had increased (95.4 fish/tow), but average size had decreased (186.7 mm TL, range 5 - 262 mm TL) due to recruitment of young of year to the survey gear.

Sciaenids were also common in catches (Fig. 1). In springtime, the sciaenid catch was dominated by croaker (*Micropogonias undulatus*), which was the 4th single-most abundant species at that time. The average CPUE for croaker was 3.516 fish.tow^{-1}, with the majority of catches being taken in the lower-Bay. In this region, the average size of croaker was 270.3 mm TL (range 270 - 283 mm TL). By summer time croaker CPUE increased to 4.79 fish.tow^{-1}, but its rank abundance was reduced to 7th. The average size of croaker was relatively unchanged from springtime, but the size range increased greatly (31 - 366 mm TL), because of recruitment of young of year croaker to the gear. Only three croaker were collected in the autumn survey, due principally to the reduced spatial coverage of that survey. Weakfish (*Cynoscion regalis*) were seasonally abundant in survey catches in summer (1.4 fish.tow^{-1}) and autumn (4.9 fish.tow^{-1}). In springtime, weakfish abundance was concentrated in lower- and mid-Bay stations, and was comprised of relatively large weakfish (184 - 286 mm TL). Young of year weakfish recruited to the survey gear in summer (size range = 21 - 303 mm TL), and were more evenly distributed among regions. This relatively broad distribution was maintained in the autumn.

We combined CHESFIMS abundance data for the three of the most common species with the historical TIES data (Fig. 3). The composite time series for bay anchovy indicates a strong increase in autumn abundance over the period 1995 -

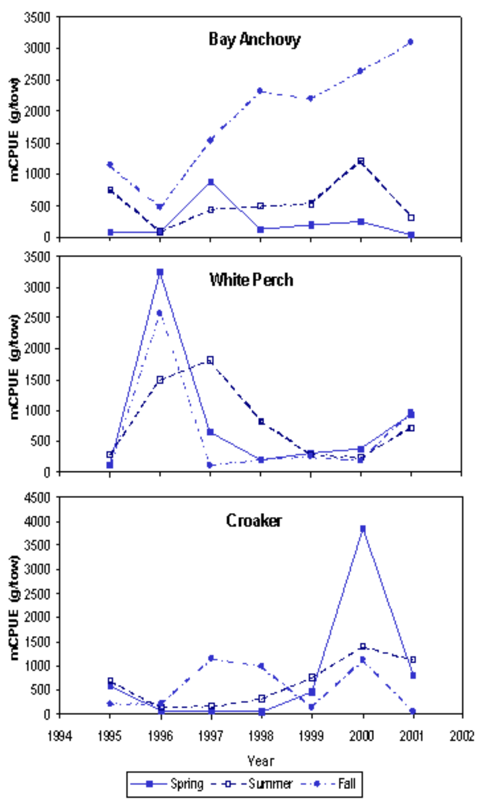

Figure 3. Time series of abundance of bay anchovy, white perch and croaker from TIES and CHESFIMS surveys

2001. The Atlantic croaker and white perch time series exhibit complementary patterns. White perch was most abundant early in the time series; Atlantic croaker is most abundant in the latter years of the time series.

We collected specimens for dietary analyses on all three surveys. To date we have dissected and analyzed the resultant data only for the springtime cruise. Data analysis is ongoing.

Shoal Survey

Abundances were highly variable from month to month (Table 2). Indices of abundance were highest in July and lowest in May. Catches were an order of magnitude higher, even greater for some species, in July than in May. September catches remained high for most species and were even greater than July catches for some species such as the blue crab.

Within each month, abundances were also variable between strata (Table 2). The Pocomoke Sound stratum contained the highest catches among the four strata during all sampling periods. Catches were lower in the Tangier Sound but remained much higher than the Choptank and Calvert Cliffs strata. Catch estimates in the Choptank and Calvert Cliffs strata were usually low or controlled by one catch. For example, one Calvert Cliffs trawl in May caught over 1000 bay anchovy but a total of only 25 anchovies were caught in the remaining five trawls, resulting in a high variance of the mean catch per tow.

Species composition also changed from month to month and from strata to strata. In May, catches mostly comprised of bay anchovy, blue crab (*Callinectes sapidus*), hogchoker (*Trinectes maculatus*), and northern sea robin (*Prionotus carolinus*). July catches were also dominated by bay anchovy, but weakfish and spot (*Leiostomus xanthurus*) were also abundant. Anchovy abundance declined in September but still comprised a large amount of each trawl along with Atlantic croaker and blue crab. The Choptank and Calvert Cliffs strata were dominated by only a few species, in some cases only two different species were caught in a particular strata. There was anywhere from 15 – 19 different species caught in the Tangier and Pocomoke Sounds over the course of the sampling season.

a.)

May	**July**	**September**
Bay Anchovy	Bay Anchovy	Croaker
Blue Crab	Weakfish	Blue Crab
Hogchoker	Hogchoker	Bay Anchovy
Northern Sea Robin	Spot	Weakfish

b.)

May	**July**	**September**
Blue Crab	Blue Crab	Blue Crab
Summer Flounder	Weakfish	Spot
Hogchoker	Bay Anchovy	Summer Flounder
Bay Anchovy	Spot	Croaker

Table 3. Summary of a.) the most frequent species by month and b.) highest species biomass by month. Species are listed in order, from high to low.

Length-frequency distributions were calculated for the six most abundant species for the entire sampling period. Bay anchovy sizes changed similarly patterns observed in the broadscale survey data. The average size of anchovy in May was 66 mm TL. The average size declined to 44 mm TL. In July, larger fish were still noticeable however. The growth of smaller fish was apparent in September with a small shift in size (mean 48mm). There was wide range of smaller blue crabs (mean 66.9mm) caught in May, with most under the legal size of 127mm. The catch shifted to moderate and large crabs in July; the average size was 93mm, and about a third of the catch was greater than 127mm. There was a decrease in the mean size of crabs in September to 83mm even though there was a high frequency of crabs larger than 127mm. This was due to the appearance of large numbers of young of the year crabs (CW < 60 mm), leading to a bimodal distribution of crabs. There were few weakfish caught in May, and those that were caught were large in size compared to the other sampling periods. The mean size of weakfish in May was 226mm. Weakfish abundance increased dramatically in July with the appearance of the young-of-the-year. The mean size in July was 78mm. There was a slight shift to larger size weakfish in September with a mean size of 81mm. The size distribution of hogchoker was approximately normal in May (average = 87 mm TL, range 35 – 155 mm TL,). A similar distribution was observed in in July but with a slight increase in the mean (92 mm TL). The September size distribution was bimodal with a small (< 55mm) and larger (> 86mm) mode. The size distribution of summer flounder was bimodal in all three surveys, with a large (> 300mm TL) and a group of smaller flounder that steadily increased in size throughout the sampling period from 150mm in May to 225mm – 300mm by September. Finally, there was no clear pattern to the size of spot caught, with a wide range of fish from 20 – 211mm.

CONCLUSIONS

In the first year of CHESFIMS we completed three broadscale and three shoal surveys and met and exceeded the project goals. The results from the different surveys provide a solid foundation from which to address important questions relevant to multispecies management.

1) Our surveys provide apparently reliable indices of abundance and distribution of ecologically and economically important finfish species in Chesapeake Bay. Of note, is that these surveys provide the reliable, baywide estimates of bay anchovy abundance, a previous unsurveyed species. Though not exploited itself, bay anchovy is an important prey item for many economically important piscivores (Hartman and Brandt 1995). Consequently, the availability of an index of abundance will be an important component of future multispecies fisheries models. Not only do our surveys provide an accurate index of anchovy abundance and recruitment, but they also provide important baywide recruitment indices for several species including Atlantic croaker, weakfish, anadromous clupeids and probably white perch.

2) Our sampling will provide important information on the trophodynamics of key components of the Chesapeake Bay fish community. As regional agencies begin to explore multispecies management models, such as ECOPATH / ECOSIM, the need for diet data, collected coincidentally with abundance estimates will become acute. A full assessment of the utility of the dietary information provided by CHESFIMS awaits completion of the laboratory analysis of preserved samples. It is important to note that preserved TIES samples are also available for analysis and offer the potential to greatly broaden the potential inferences regarding dietary patterns.

3) On going efforts with regard to statistical analysis of the data offer the opportunity to optimize current survey designs. These efforts are an important component of our work. Knowledge of the relative efficiency of alternative stratification schemes, spatial distribution and sampling intensity will be important if multispecies surveys are to become a routine feature of the assessment of the Chesapeake Bay fish community.

LITERATURE CITED.

Hartman, K. J. and S. B. Brandt. 1995. Predatory demand and impact of striped bass, bluefish, and weakfish in the Chesapeake Bay: Applications of bioenergetics models. Can. J. Fish. Aquat. Sci. 52: 1667-1687.

Houde, E. D., M. J. Fogarty and T. J. Miller. 1998. Prospects for multispecies management in Chesapeake Bay: A workshop. STAC Publication 98-002. Chesapeake Research Consortium, Edgewater, MD.

Jung, S. 2001. Spatial and temporal variability of fish biomass in the Chesapeake Bay. University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory

Kimura R., D. H. Secor, E. D. Houde and P. M. Picoli. 2000. Up-estuary dispersal of young of year bay anchovy in the Chesapeake Bay: inferences from microprobe analysis of strontium> Mare. Ecol. Progr. Ser. 208:217-227