Examining the Temporal and Spatial Distribution of Baitfish Species in Bermuda's Coastal Waters

La Distribución Temporal y Espacial de las Especies de Carnada en las Aguas Costeras de Bermudas

Le Répartition Temporelle et Spatiale des Espèces de Poissons-appâts dans les Eaux Côtières des Bermudes

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EXTENDED ABSTRACT

Small pelagic fishes play a vital role in coastal food webs, linking planktonic productivity to fishes and birds at higher trophic levels. These species also have an economic role, as they are exploited by commercial and recreational fishers for use as bait. In Bermuda, baitfish species include the endemic Bermuda anchovy, *Anchoa choerostoma*; Dwarf herring, *Jenkinsia lamprotaenia*; Redear herring, *Harengula humeralis*; Round sardinella, *Sardinella* aurita; Threadfin herring, *Opisthonema oglinum;* and the Reef silverside, *Hypoatherina harringtonensis*. They form large monospecific or multi-species shoals in shallow bays and near-shore waters, with some apparent degree of seasonality that likely reflects the seasonal fluctuations in water temperature associated with Bermuda's location at 32.3°N (Coates et al. 2013). However, despite their ecological and economic importance, the life cycles of these species have not been investigated locally.

Reported landings of baitfish species by Bermuda's commercial fishery have declined since their peak in the 1980s, but have remained relatively stable since 1999. However, it is unclear whether this indicates population declines or altered fishing practices following the banning of fish traps in 1990 (Butler et al. 1993, Smith-Vaniz et al. 1999). Many fishers believe that some of the baitfish species have declined, particularly the larger Round sardinella and Threadfin herring, (Pitt and Welch, *In press*), but there is no fishery-independent data on the relative abundance of any of these species.

Current management measures restrict the size and type of nets that may be used to catch bait, and prohibit net fishing in four bays around Bermuda (see Pitt and Welch, this volume). Here, we describe the annual cycles in the abundance of the various baitfish species in Bermuda's coastal waters, including a first examination of the bays that are closed to net fishing, and build upon this information with a broadscale survey conducted during the period of peak abundance for most species.

Surface and underwater visual surveys of baitfish presence, together with cast net sampling to determine school composition, were conducted approximately weekly for 15 months at 6 bays around the east end of Bermuda. Sites included two of the bays that are closed to net fishing, and four areas where fishing is permitted (Figure 1). The site at Coney Island included a cove and an adjacent causeway area that allowed for the evaluation of small scale spatial variation. Additional opportunistic surveys were carried out at additional sites around the island.

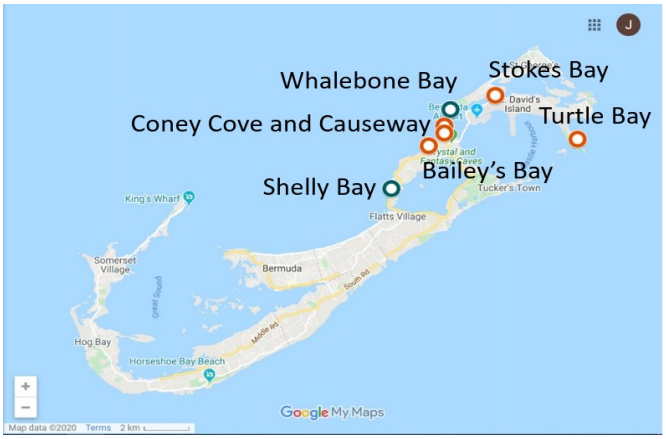

Figure 1. Map of Bermuda showing bays monitored from July 2017 through September 2018. Green circles indicate bays where net fishing is prohibited. Red circles indicate areas open to fishing.

Observations revealed variability in the annual cycles of abundance for the 6 key inshore baitfish species at these study sites, with the greatest species richness found during the late summer and early fall (August through October) (Figure 2). The endemic Bermuda anchovy had the most consistent presence at the most sites through the year. The Reef silverside was observed all year round but was absent from each site for at least several months, although the timing of that absence varied between sites and did not appear to be correlated with the degree of exposure or prevailing level of wave action at any given site. The Dwarf herring was found more consistently in the spring and summer (March through August / September).

Of the large baitfish species, the Redear herring had a relatively consistent presence in Shelly Bay, one of the bays that is closed to net fishing, and was found there almost year round. This species was also found in Bailey's Bay and the Coney Island area during approximately half of the survey months. However, Round sardinella were observed only once at Bailey's Bay and only during August and February in the two areas around Coney Island. Threadfin herring were not observed at any of these sites during this part of the study. Importantly, neither of these latter species considered to be at risk was observed in either of the protected bays that were monitored.

It was also noted that two of the monitored bays had few baitfish except during the fall months. This included Whalebone Bay, one of the two relatively sheltered bays on the north shore that are closed to netting, as well as Turtle Bay, the most exposed of the sites, which opens directly to the southern, windward shore of the island.

Shelly Bay	Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A. cho		1	0	0	0	1	0	0	0	0	0	0	0	0	0
	J. lam		1	0	1	0	0	0	0	0	0	0	0	0	0	0
No netting	H. har		1	1	1	1	1	0	0	0	0	1	1	1	1	1
	H. hum		1	1	1	1	1	1	0	1	1	1	1	1	1	1
	S. aur		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Richness		4	2	3	2	3	1	0	1	1	2	2	2	2	2

Bailey's Bay	Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A. cho	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1
	J. lam	0	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Open	H. har	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
	H. hum	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1
	S. aur	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Richness	2	2	4	3	3	1	3	1	3	3	3	2	3	4	3

Coney Cove	Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A. cho		1		1	0		0	1	1	1	1		1	1	1
	J. lam		1		1	0		1	1	1	0	1		1	1	1
Open	H. har		1		1	1		1	1	1	1	0		0	0	0
	H. hum		1		1	0		0	0	0	0	0		1	1	1
	S. aur		1		0	0		0	1	0	0	0		0	1	0
	Richness		5		4	1		2	4	3	2	2		3	4	3

Coney Causeway	Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A. cho	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
	J. lam	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1
Open	H. har	0	1	1	1	1	0	1	1	1	1	1	0	0	0	0
	H. hum	1	1	0	1	1	0	0	1	0	0	0	0	1	1	1
	S. aur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Richness	2	4	2	4	3	0	3	4	3	3	3	2	3	3	3

Whalebone Bay	Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A. cho		0	0	1	0	0	0	0	0	0	0	0	0	0	1
	J. lam		1	0	0	0	0	0	0	0	0	0	0	0	0	1
	H. har		1	1	1	0	0	0	0	0	0	0	0	0	0	1
No netting	H. hum		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	S. aur		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Richness		2	1	2	0	0	0	0	0	0	0	0	0	0	3

Stokes Bay	Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A. cho		1	1	1	1	1	1	1	1	1	1	1	1	1	
	J. lam		0	0	0	0	0	0	0	0	0	0	0	0	0	
Open	H. har		1	1	1	1	1	1	0	0	1	1	1	1	1	
	H. hum		0	0	0	0	0	0	0	0	0	0	0	0	0	
	S. aur		0	0	0	0	0	0	0	0	0	0	0	0	0	
	Richness		2	2	2	2	2	2	1	1	2	2	2	2	2	

Turtle Bay	Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A. cho		0	0	0	0	0	0	0	0	0	0	0	0	0	
	J. lam		1	0	0	0	0	0	0	0	0	0	0	0	0	
Open	H. har		1	1	1	0	0	0	0	0	0	0	0	0	1	
	H. hum		0	0	0	0	0	0	0	0	0	0	0	0	0	
	S. aur		0	0	0	0	0	0	0	0	0	0	0	0	0	
	Richness		2	1	1	0	0	0	0	0	0	0	0	0	1	

Figure 2. Baitfish species presence / absence at the open (red) and closed (green) monitoring sites from July 2017 through September 2018. *A. choerostoma* red; *J. lamprotaenia* orange; *H. harringtonensis* green; *H. humeralis* blue; *S aurita* indigo. Pale gray = no data. Increasing species richness totals in darker shades of gray.

The data from these monitoring sites drove the timing of a broadscale survey, which was conducted in the fall of 2018 to capture the peak abundance of the most species whilst also recognizing that Dwarf herring, Round sardinella and Threadfin herring would likely be under-represented. Using a drone and vessel-based visual observations, we surveyed approximately 95 km of shoreline, covering long distances per day to get an overview of baitfish presence/absence, school sizes and species composition, while avoiding confounding by movements between surveys. Species composition was validated with net samples and snorkel surveys. A baitfish Abundance Index was developed to help summarise the data visually. The 2-dimensional area of the school (in m^2) was multiplied by a visually assessed density category, where sparse = 1, medium = 2 and dense = 3. In this way, a small dense school could have a similar index value to that of a very large, sparse shoal that represents a similar number of individual fish. For multispecies shoals, the overall index value was pro-rated by the relative proportion of each species as determined by the cast net samples. The index values were then bracketed into 6 scaled categories for visual representation.

Small dense schools of Bermuda anchovy were present in sheltered bays around the island. In contrast, Reef silversides were present in loose shoals along most lee shores. Redear herring were found in the deeper areas of sheltered bays, and juveniles of this species were often found schooling with or below schools of Bermuda anchovy. Dwarf herring were generally found in multispecies shoals at this time of year, and this species was under-represented as their abundance peaks earlier in the year (May—July). Threadfin herring and Round sardinella were the least abundant species in this part of the study as well. Juvenile Threadfin herring were found in multispecies shoals, particularly at the east end of the island. Juvenile Round sardinella were found in only a few, slightly deeper sites, including two eastern sites, two western sites, and one central site on the north shore. However, anecdotal evidence suggests that the adults of these species are more common in deeper inshore areas during the winter months.

Taken together, the data from this study show that the small baitfish species are relatively abundant, although peak abundance occurs at different times of year for the Dwarf herring versus the Bermuda anchovy and Reef silverside. The Redear herring was the most abundant of the larger species, and appears to receive some important protection from the prohibition of net fishing in Shelly Bay. Unfortunately, a number of poaching incidents were observed at this site during the study period. Threadfin herring and Round sardinella were much less abundant than the other species in both the seasonal and broadscale surveys. They were observed mostly in deeper areas, which may be a sign of overexploitation but could also reflect avoidance of warmer shallow waters. This study therefore appears to support assertions regarding declines in these species.

These results also serve to underscore the multispecies nature of baitfish shoals in inshore waters. It is particularly important to note that juveniles of the larger species, including those species whose numbers have decline, were often found shoaling with or underneath the smaller species. This behaviour makes them vulnerable to capture if the smaller species they are shoaling with are targeted by fishers. The likelihood of immature individuals being taken as bycatch is therefore a risk factor for these species.

On a more positive note, anecdotal observations suggest that all baitfish species, including those that are less common, have become more prevalent over the course of this study. Perceived declines in the preceding years may have been related to poor recruitment between 2014 and 2016, when Bermuda experienced severe hurricanes in October of each year.

This greater understanding of the abundance and distribution of baitfishes opens up various management options. Most significantly, these data will be considered during the marine spatial planning exercise currently being undertaken in Bermuda, with the potential for areas that are important for the various baitfish species to be incorporated into a network of representative marine protected areas.

KEYWORDS: baitfish, seasonality, abundance, distribution, Bermuda

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