

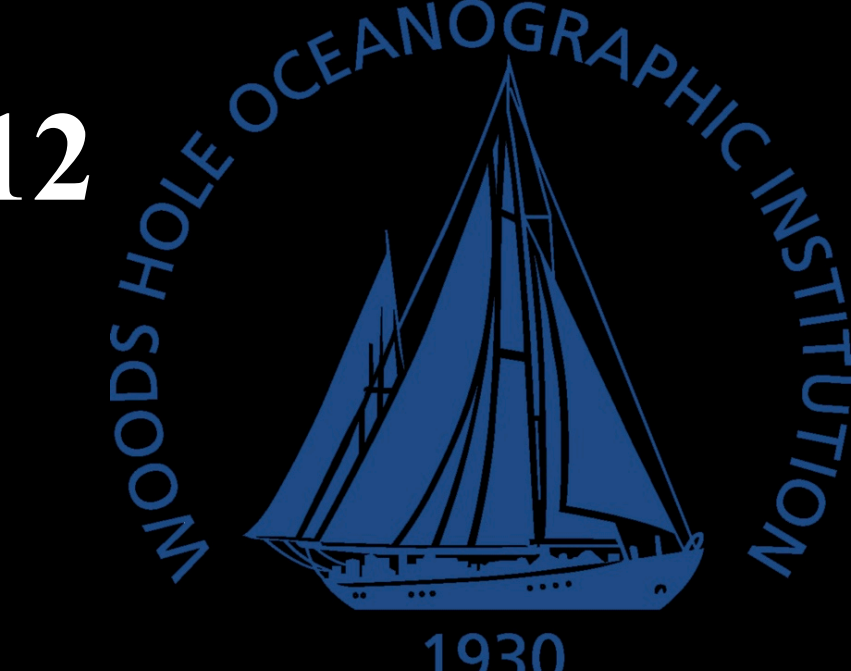


Abundance and vertical distribution of *Squalus acanthias*, Spiny Dogfish, at Stellwagen Bank: daily and interannual patterns from 2008-2012

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Introduction



- Squalus acanthias*, commonly referred to as Spiny Dogfish, is a small coastal shark with a distribution ranging from Florida to Greenland in the Northwest Atlantic Ocean.
- S. acanthias* stocks are at risk to overfishing because sharks mature late in life (6 years male & 12 years female), and have a low fecundity rate [1-5].
- European and Northwestern Atlantic stocks have been severely depleted and overfished, respectively, within the past 10 years and have been listed as Critically Endangered and Endangered by IUCN Red List in 2006 [6, 7].
- To prevent stock collapse, it is important to understand the species' distributional patterns in relation to its environmental components.

STUDY HYPOTHESIS: We hypothesized that *S. acanthias* abundance vary with water temperature because as migratory species, they move north and associate with cooler waters.

Methods

- Sampling was conducted 5-7 days each summer from 2008-2012 from an anchored vessel at the Southwest flank of the Stellwagen Bank (55 m deep, Fig 1).
- Current and temperature measurements of the water column were made with an Acoustic Doppler Current Profiler (ADCP), a temperature mooring, Conductivity Temperature Depth (CTD) casts, and echosounders (120 kHz and 200 kHz).
- The distribution of sharks in the water column was determined from echosounder records of their acoustical traces, and the identity of the traces assessed with an underwater video camera (Fig 2 & 3).
- Echosounder records were subsampled within a 2 minute window at 15 minute intervals and maximum *S. acanthias* densities (Fig 4).
- The temporal vertical distribution and abundance patterns (both daily and annually) of *S. acanthias* collected from 2008-2012 were statistically analyzed in relation to water temperature, time of day, and hours +/- high tide.

Massachusetts Bay, MA (Mass. Bay)

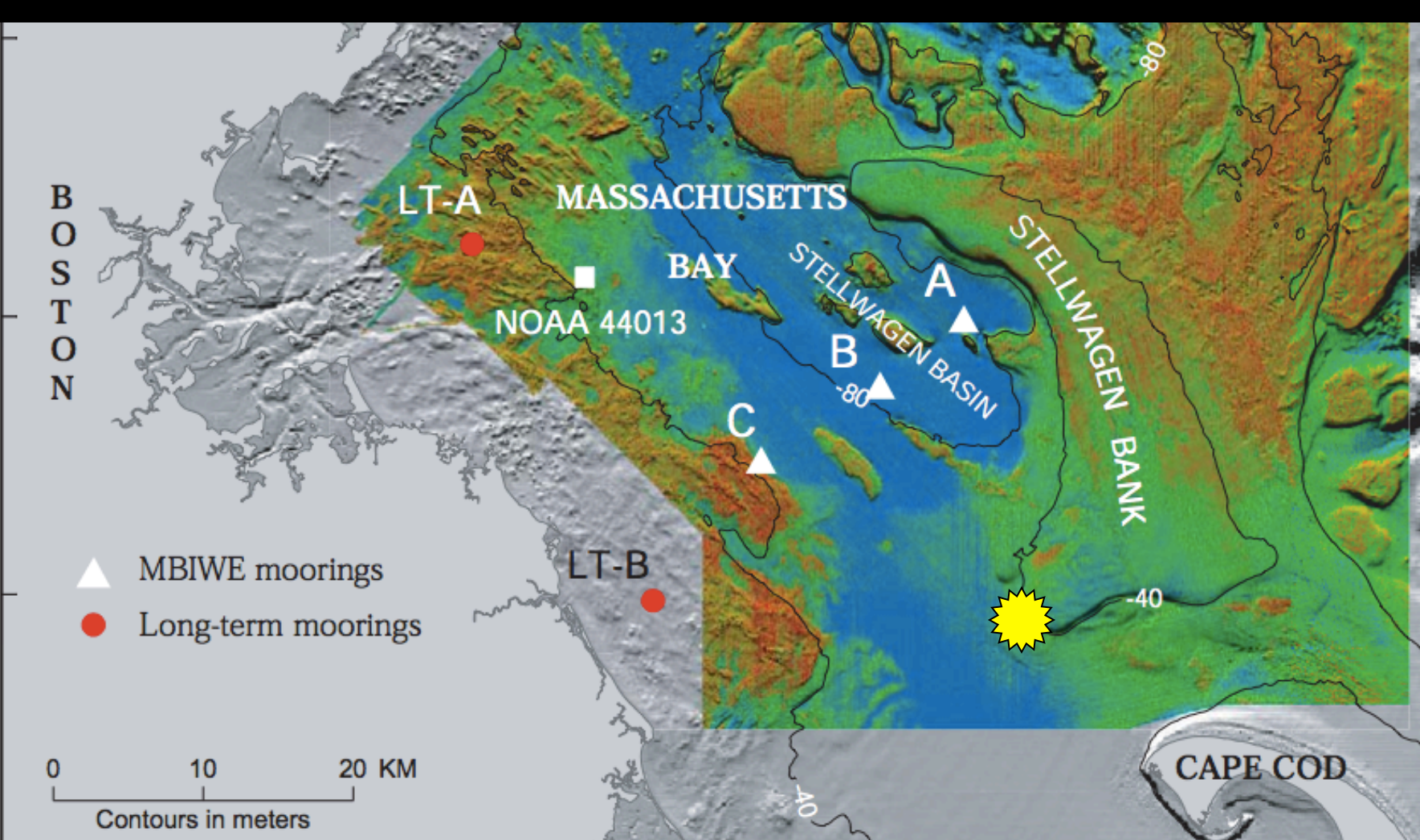


Fig 1: Sample Site at Stellwagen Bank within Mass. Bay, MA.

Trace ID

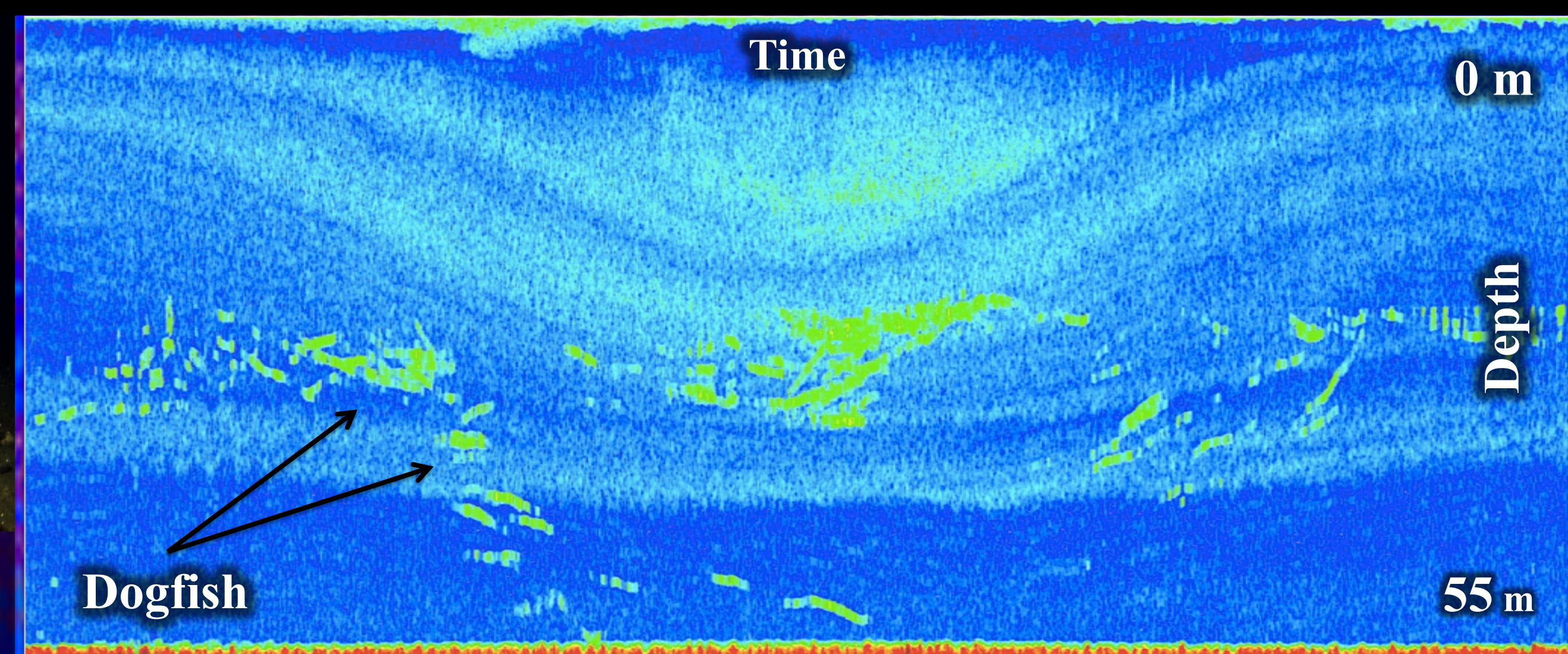


Fig 2: Acoustic Image of an Internal Wave at Stellwagen Bank within Mass. Bay, MA.

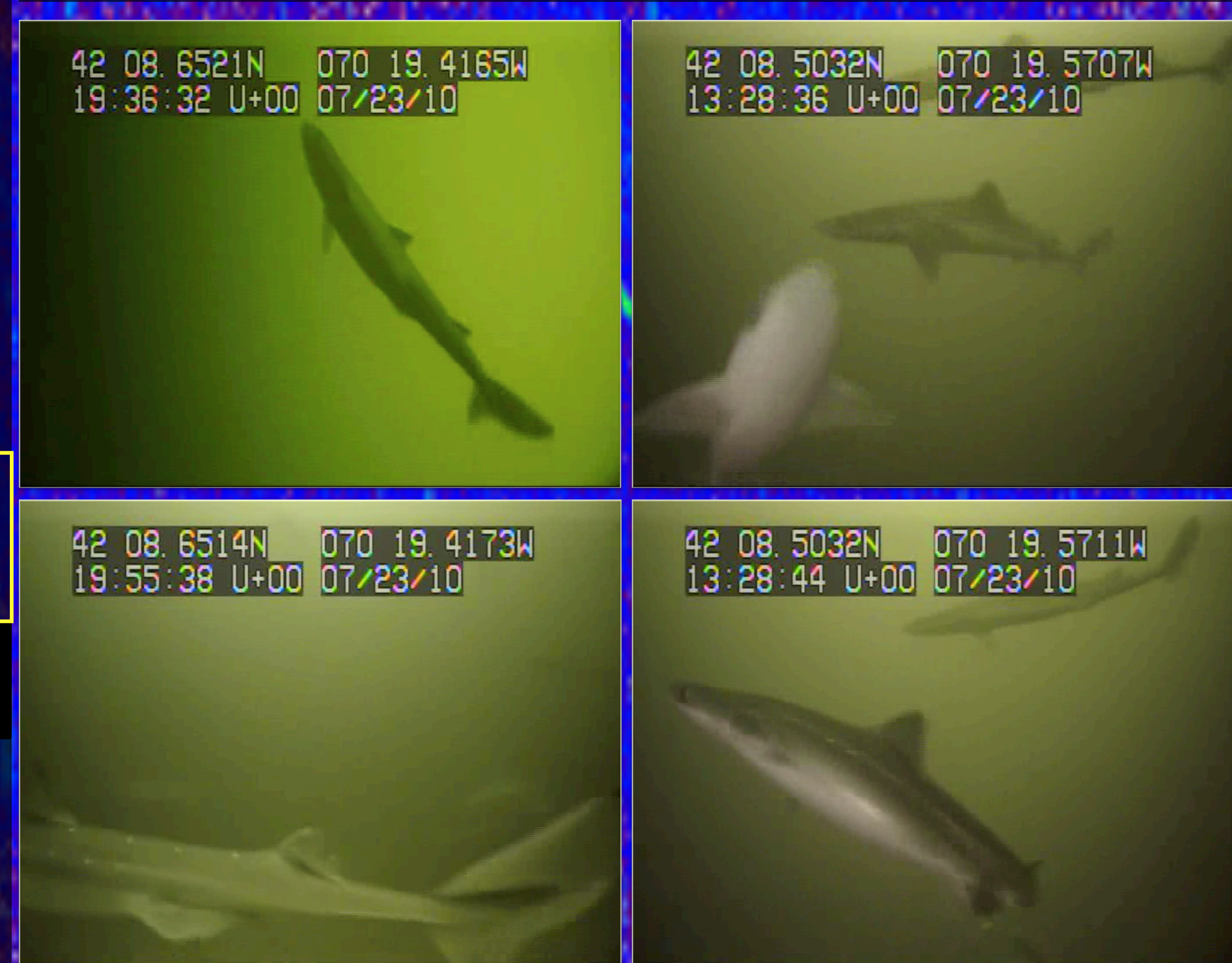


Fig 3: *S. acanthias* trace identity confirmation at Stellwagen Bank within Mass. Bay, MA.

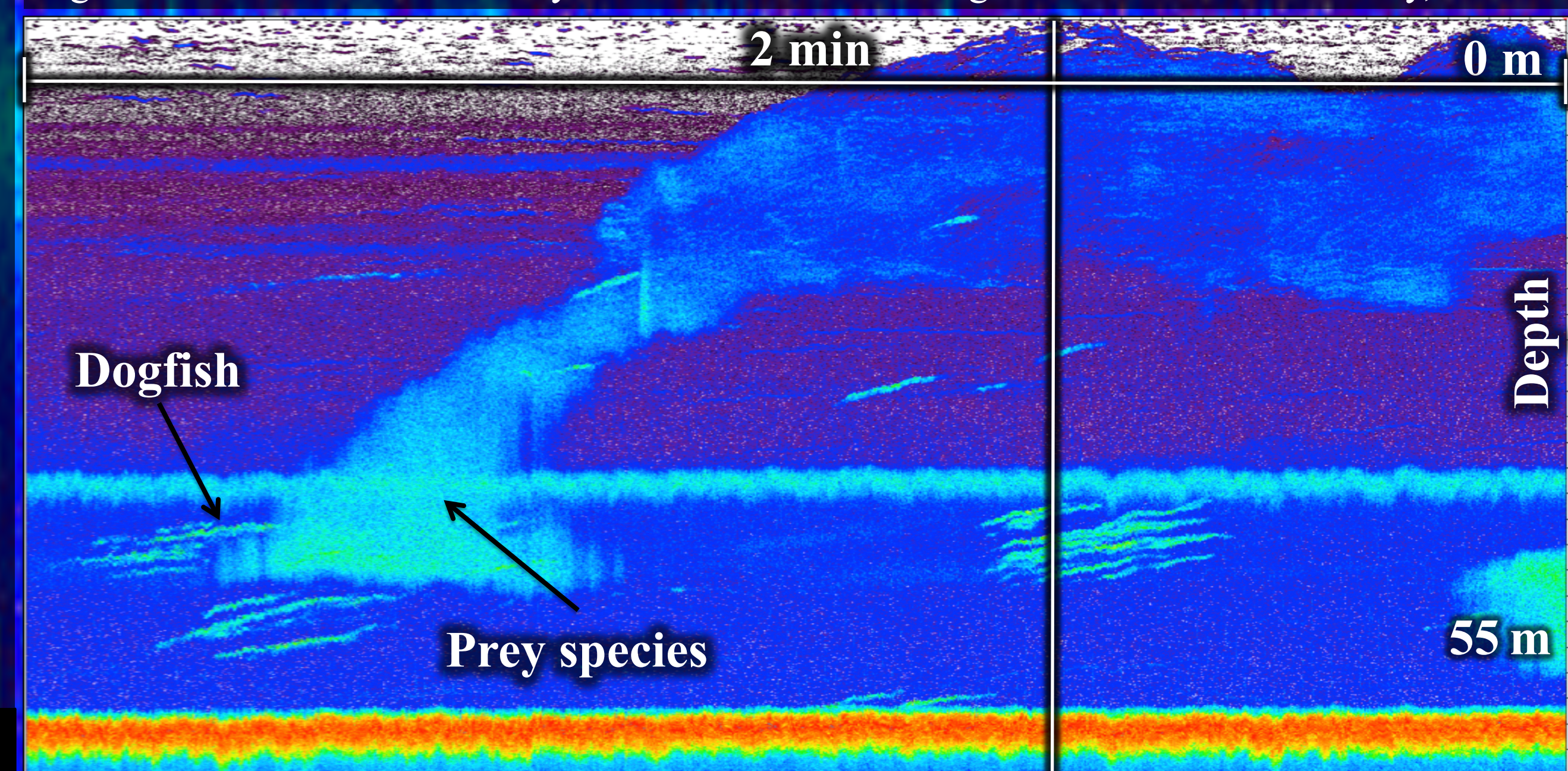


Fig 4: Echosounder subsampling with vertical line at maximum *S. acanthias* abundance.

Results

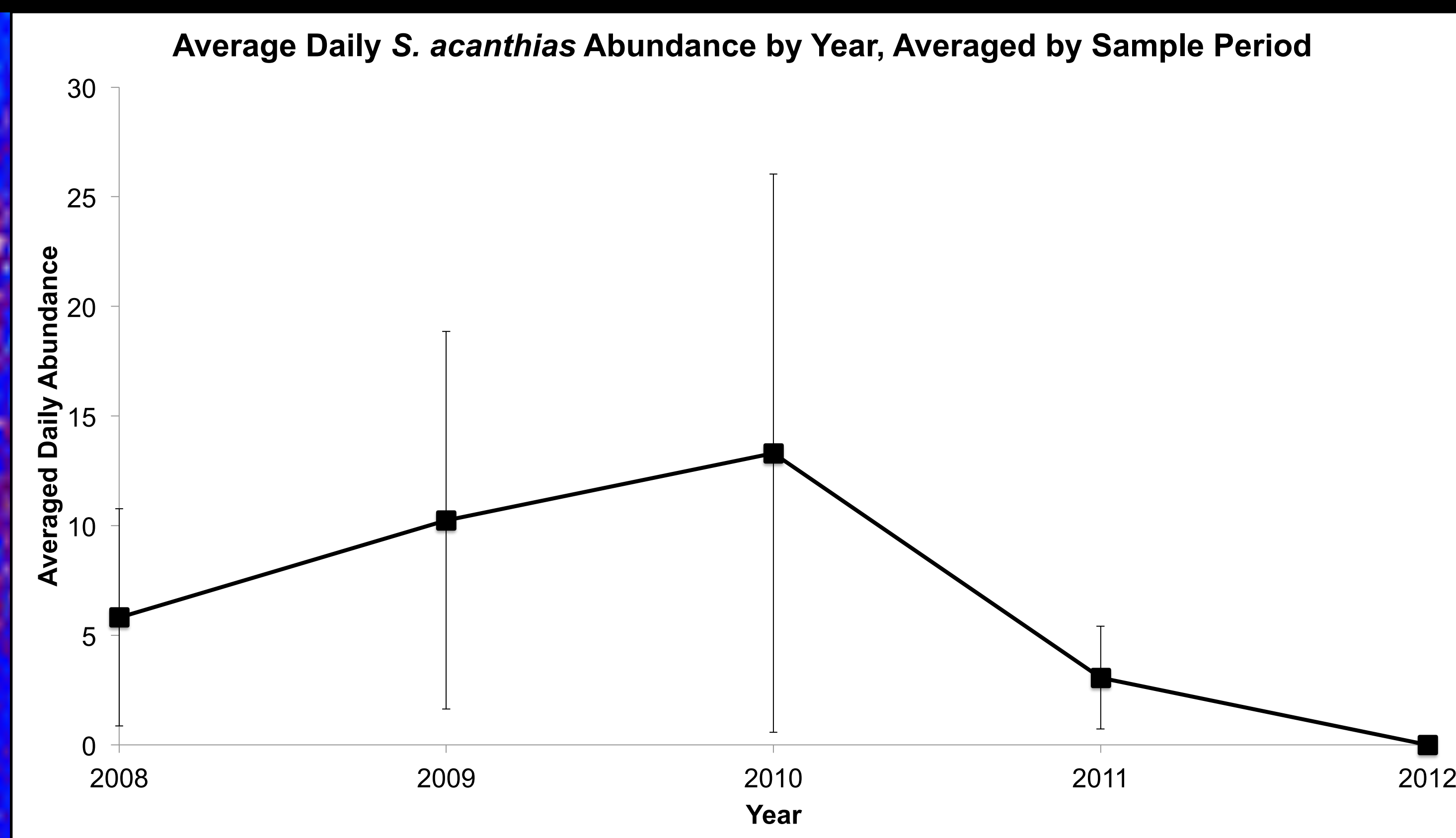


Fig 5: Average (\pm SD) daily *S. acanthias* abundance by year averaged by sample period from 2008-2012.

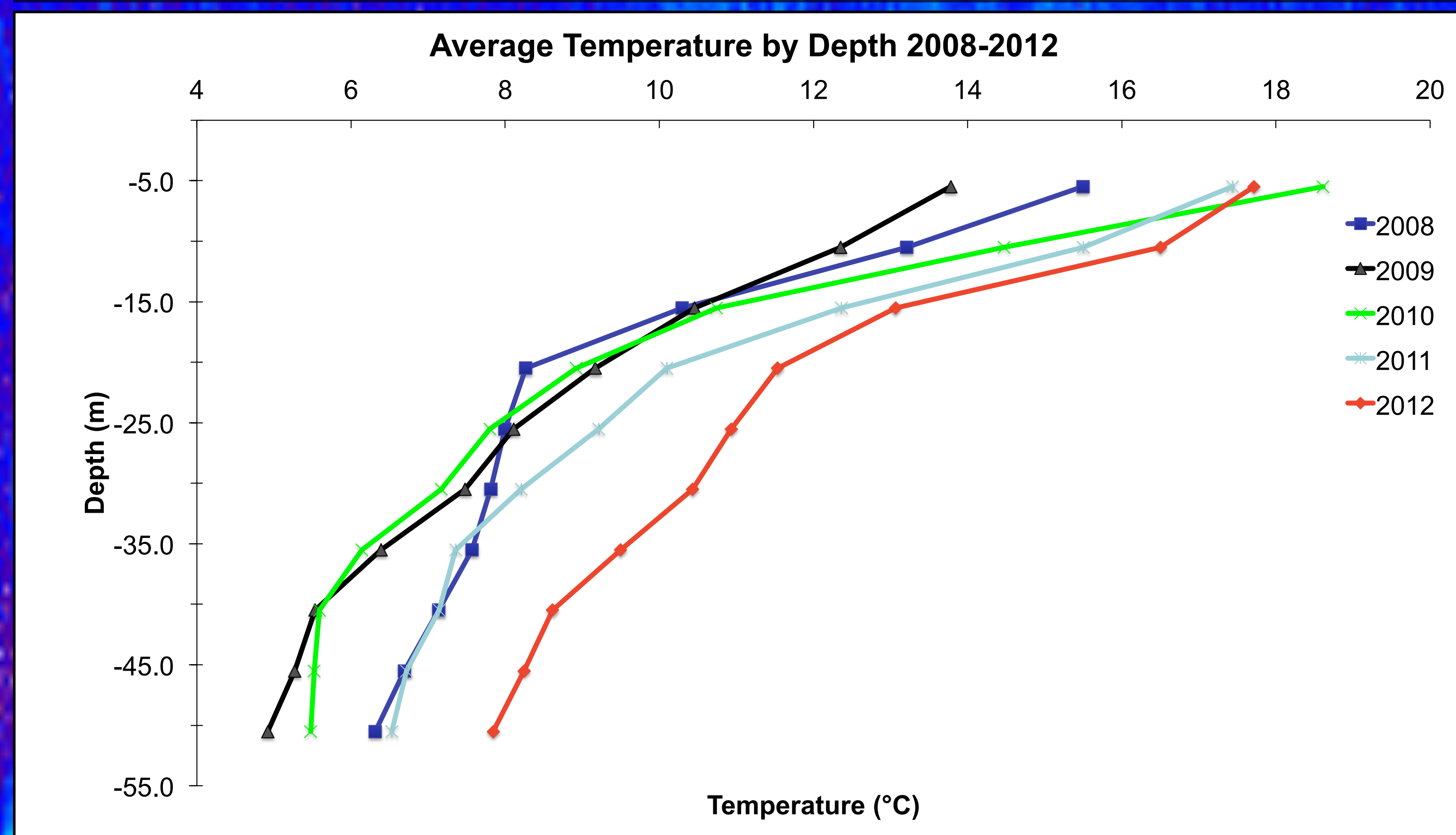


Fig 6: Average (\pm SD) annual water temperature by depth from 2008-2012.

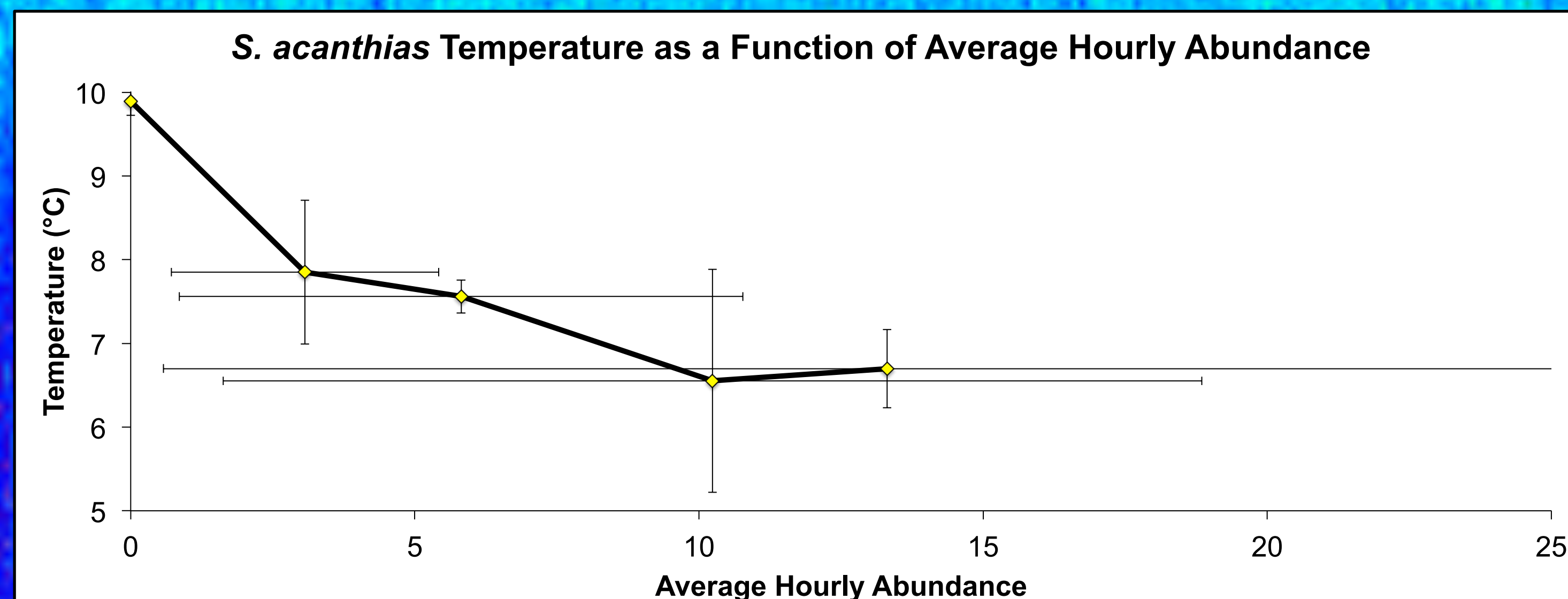


Fig 7: Average (\pm SD) annual water temperature as a function of average (\pm SD) hourly abundance from 2008-2012 (significant at $p < .05$).

Year	Yearly Temperature (°C) between 25-40m		
	Average	stdev	Post Hoc
2008	7.56	0.20	A
2009	6.55	1.33	A
2010	6.70	0.47	A
2011	7.85	0.86	A
2012	9.89	0.17	B
	df= 14	F-Ratio= 7.74	P-value=.004

Table 1: One-Way ANOVA and Games Howell Post Hoc Test results for average water temperature between 25-40 m between 2008-2012.

Year	Average Temperature (°C) between 25-40 m	
	Average	Average Abundance
2010	6.70	13.31
2009	6.55	10.24
2008	7.56	5.82
2011	7.85	3.07
2012	9.89	0.00
	Correlation = -.90	P-value = .04

Table 2: Correlation results for average water temperature at 25-40 m and yearly abundance between 2008-2012.

Conclusion

Temperature and Abundance

- S. acanthias* ranged from 4.4 – 19.8 °C which is similar to the range of $\approx 4 - 20$ °C found in other reports [8, 9].
- Most *S. acanthias* were found at 8.0 ± 2.9 °C. Another study found an affinity to 9 – 15 °C temperatures [9].
- Strong interannual variability in *S. acanthias* abundance was correlated with annual water temperatures at depths between 25 – 40 m ($p < .05$).
- Surface temperatures seem to have no effect on *S. acanthias* abundance.
- No daily patterns were observed.

Vertical distribution

- S. acanthias* ranged from 3.8 – 60 m depth.
- Most *S. acanthias* were found at a depth of 33.2 ± 15.4 m.
- No daily or interannual patterns were observed.

Discussion

- In this study, the average measured abundance of sharks between 25 and 40 m water depth over the past 4 years was negatively correlated with the average measured water temperature at this depth range.
- S. acanthias* have typically been found at water temperatures less than 15 °C, however, this range has been shown to vary with season [8, 9].
- Understanding the movement patterns of *S. acanthias* can be vital in fisheries studies and may be useful to fisheries management agencies to improve estimates of *S. acanthias* abundance.
- While this study is indicative of temporal abundance of *S. acanthias* at Stellwagen Bank from 2008-2012, it may not accurately represent other populations of *S. acanthias*.
- Future observations may include the southern and northern distributional extremes.

Acknowledgements

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Results: Main Findings

- Analysis of 1375 shark acoustic traces and CTD cast data indicated: (1) large interannual variation in shark abundance and water temperature below 25 m, and (2) max *S. acanthias* abundance at 32 m depth.
- Sharks were relatively abundant during 2008-2010 and rare in 2011-2012 (Fig 5).
- Average temperatures were coldest during 2008-2010 and greatest in 2011-2012 with 2012 being significantly warmer than all other years (Fig 6, Table 1).
- Yearly shark abundance and water temperature between 25-40 m showed significant correlation (Table 2, $p < .05$).
- The daily abundance of sharks or their vertical distribution during the day did not correlate with the tide.