AN UPDATE AND REVIEW OF THE SOUTHERN ST. LAWRENCE ACOUSTIC INDEX OF ATLANTIC BLUEFIN TUNA ABUNDANCE (2017-2018)

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SUMMARY

For the most part the GSL acoustic time series has been consistent with BFT catch-per-unit-effort, however, recent updates (2017-2018) suggest a significant decline in BFT that does not appear to be consistent with CPUE. Here we investigate data editor, vessel, and herring as factors that may be contributing to the lower index values. Results suggest that the recent index values do not appear to be related to the variables under investigation but that it may be negatively impacted when herring biomass falls below a threshold of 0.25 kg/m2. We recommend that the index value for 2018 not be included in this year's index aim to collect additional evidence to help confirm the cause of the decline.

RÉSUMÉ

Dans l'ensemble, la série temporelle acoustique du GSL était conforme à la prise par unité d'effort du thon rouge; cependant, des mises à jour récentes (2017-2018) suggèrent un déclin significatif du thon rouge qui ne semble pas être conforme à la CPUE. Le présent document examine l'éditeur de données, le navire et le hareng comme facteurs pouvant contribuer à la baisse des valeurs de l'indice. Les résultats suggèrent que les récentes valeurs de l'indice ne semblent pas être liées aux variables étudiées, mais qu'elles peuvent avoir un impact négatif lorsque la biomasse de hareng tombe en dessous d'un seuil de 0,25 kg/m2. Nous recommandons de ne pas inclure la valeur de l'indice pour 2018 dans l'indice de cette année afin de recueillir des preuves supplémentaires permettant de confirmer la cause du déclin.

RESUMEN

En su mayoría, la serie temporal acústica del golfo de San Lorenzo ha sido coherente con la captura por unidad de esfuerzo del atún rojo, sin embargo, recientes actualizaciones (2017-208) sugieren un descenso significativo de atún rojo que no parece ser coherente con la CPUE. En este documento se investigan el editor de datos, el buque y el arenque como factores que podrían estar contribuyendo al descenso de los valores del índice. Los resultados sugieren que los valores recientes del índice no parecen estar relacionados con las variables que se están investigando, pero que el índice podría verse negativamente afectado cunado la biomasa de arenque cae por debajo de un umbral de 0,25 kg/m2. Recomendamos que el valor del índice para 2018 no se incluya en el índice de este año con el fin de recopilar evidencias adicionales para ayudar a confirmar la causa del descenso.

KEYWORDS

Acoustics, fishery independent data, Bluefin tuna

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1. Introduction

In 2016, a fishery independent index of abundance was developed for Atlantic Bluefin tuna (ABFT) in the Gulf of Saint Lawrence (GSL) region (Melvin *et al*., 2017). DFO has undertaken these surveys since the 1990's in the Baie-des-Chaleurs region of the GSL using, for the most part, the same vessel, acoustics, and survey design. In 2017, ICCAT accepted this fishery-independent index of abundance for the 2017 stock assessment, where data from 1994 to 2016 were used (Melvin and Minch, 2018). This index greatly supports the stock assessment by providing fishery-independent data and has been broadly similar to the trend in the GSL fishery dependent catch-per-unit-effort (CPUE). In recent years (2017-2018), however, the index suggests that ABFT abundance has declined sharply, unlike the trend in the fishery based indicator (Minch, 2019). This decline has prompted questions surrounding factors that may be contributing to the recent index values, such as a change in data editors, survey vessels and a decline in herring biomass.

In recent years there have been a number of different individuals analyzing the acoustic data, however a primary analyst has always been used to verify the estimate and this analyst was replaced. Consequently, the target detection skill of these analysts were reviewed. In addition, the southern GSL herring stocks has been in decline for a number of years, and given that herring are a primary food source for tuna when they enter the GSL, it was necessary to determine if the decline may cause ABFT to move to regions with higher aggregations of prey. Lastly, the survey, which followed a random stratified parallel design since 1993, has been undertaken using the same vessel and methodology until 2015 when hardware and vessel changes began to occur. Quantifying the effects of these changes was also reviewed.

The objectives of the report were to provide an update to the acoustic index using data from 2017 and 2018 and to investigate if the differences in primary data editors, changes in herring biomass and vessels impacted the estimate of the number of tuna identified across depth, stratum and survey start time.

2. Methods

2.1. Survey Vessel

A random stratified parallel design survey of southern GSL herring biomass established in 1993 has been undertaken using the same vessel and methodology until 2015. While the survey covers the Baie-des-Chaleurs, Gaspésie, and P.E.I. regions of the Gulf of Saint Lawrence, P.E.I was not surveyed in recent years, due to the inability to safely dock the boat, and thus P.E.I was excluded from the index. Within the Gulf of Saint Lawrence not all transects within strata were surveyed annually, and thus only strata that were consistently surveyed (14 strata) were used for the index (**Figure 1**). In 2015, the acoustic hardware changed from HDPS to Simrad EK60. Additionally, in 2016 the survey vessel (Creed) was changed from a catamaran to the single-hulled fishing vessel the Perley. As such, there may have been changes in the quality of the survey data especially if the replacement vessel increased the level of vessel-induced noise and affected the feeding response of tuna on herring. In 2016, the Creed underwent a refit and returned to service in 2017, however, in 2018 the Creed was replaced midway through by the Perley. It should be noted that during all surveys where the Creed collected acoustic data, the Perley was always used as a fishing vessel to validate the presence of herring for the survey. For more information on the survey design and data analysis refer to Minch (2019).

2.2. Variables under investigation

Echoview files for 2017 were edited by a former and current primary reader and their counts and target selection were compared. Also, the current reader re-edited the 2018 files. Both readers applied the same methodology to target identification to insure consistency of results. All data editing and processing were consistent with past practices (Melvin *et al.*, 2017).

To contrast the effect of vessels on tuna counts, we compared acoustic data for consecutive survey years (2015 Creed versus 2016 Perley) when Bluefin tuna counts were observed to be high. We also compared tuna counts during low index years (2018 Creed versus 2018 Perley) (**Figure 2**). Detections of tuna and herring were compared across categories (High:Creed versus High:Perley and Low:Creed versus Low:Perley) by transect and depth categories (0-100 meters). Finally, the observed tuna counts and herring biomass for each vessel were compared with respect to transect start time.

3. Results

A total of 40 tuna were identified in 2017, while only 14 were identified in 2018. Following the recommendations and edits of the primary reader, the total number of tuna for 2017 was finalized at 44 and 9 respectively for 2017 and 2018 (**Table 1**). The updated abundance index values are 0.053 for 2017 and 0.007 for 2018. The value for 2017 is slightly higher with the corrections 0.046 versus 0.053 while the value for 2018 is slightly lower with the changes 0.0008 versus 0.0007 (**Table 2**). The trend in herring biomass does not appear to correspond to the trend in the acoustic index until 2017 (**Figure 3**). Both vessels had similar ranges of detection for high and low index years when comparing the number of tuna targets over depth. (**Figure 4**). The same trend was observed for herring biomass over depth in high and low index years when surveyed by both vessels (**Figure 5**). The number of tuna identified at the transect level in NE, NW and SE Miscou was similar for high index years when surveyed by both vessels (**Figure 6**). Tuna targets were identified across all transect start times when surveyed by both vessels (**Figure 7**).

4. Discussion

Upon review of the updated acoustic index by the Bluefin tuna Working Group, the group discussed whether the marked decline in the observed count of Bluefin tuna in 2017 and 2018 could be a function of a decline in herring biomass, changes in survey design or editing practices. Review of the 2017 survey values was completed by the former primary reader and a second review of the 2018 survey values was conducted by the current primary reader. This reanalysis resulted in index values for 2017 and 2018 that were not very different from the previously published index values. This suggests that the editing protocols are sufficient to produce consistent Bluefin tuna counts between the former and current primary readers.

Since the 2000's the southern GSL herring stocks have been steadily declining, but only recently has there been a corresponding decline in Bluefin tuna counts. In fact, Bluefin tuna counts have been increasing between 2000 and 2016 while herring biomass has been in decline. Consequently there does not appear to be evidence of a functional relationship between changes in herring biomass and Bluefin tuna counts, however, it is logical that Bluefin tuna will occur in an area once herring biomass has exceeded a threshold amount. This threshold appears to occur around 0.25 kg/m^2.

Vessel changes in recent years were suspected to be contributing to the decline in the index because the replacement vessel, the Perley (used in 2016, 2018) is a single hull style fishing vessel and is known to be noisier than the catamaran style Creed. It was also expected that depth would impact the number of ABFT identified in a transect when surveying with the Perley since typically coastal shallow waters might cause more vessel avoidance from the Perley. Although it was expected that the noisier Perley would cause vessel avoidance behavior by tuna or herring, the results did not conclusively demonstrate that the vessels affected the Bluefin tuna counts across transects in either high and low index years or over depth. We also investigated transect location, and transect start time for a bias between vessels and potential relationship with the number of tuna identified in transects and found none. These results align with a review of vessel avoidance in supposedly noisy and quiet vessels which suggests that "quiet" vessels still cause vessel avoidance and may not be as "quiet" as once suspected, as there are other stimuli that may be responsible for avoidance such as visual cues and the ship bow wave (De Robertis and Handegard, 2013).

Consideration was given to the fact that the acoustic survey in the Baie-des-Chaleur area covers only a small fraction of the southern Gulf of Saint Lawrence and whether the declines in herring and Bluefin tuna that were observed are indicative of the true state of either stock. Given that the fishery dependent indicator for the entire sGSL did not demonstrate a sharp decline in CPUE in recent years, it is possible that the decline in the acoustic index reflects a local phenomenon. Investigations into the potential causes and duration of the decline in the Baie-des-Chaleur area will continue.

Although the current protocols for data editing appear sufficient, additional effort will be dedicated towards the review and development of standardized, objective (and potentially automated) operating procedures across Canada through involvement with the Small Pelagics and Acoustics Working Group. While there was not sufficient evidence to demonstrate a vessel effect, there are plans in place to conduct a comparative acoustic survey involving the Perley. The Creed is no longer operational and it is scheduled to be replaced with another acoustically silent vessel, consequently the comparison will be made between the Perley and the new vessel. Future work will also review the potential to use acoustic data from other Atlantic regions to develop indexes covering a greater proportion of the ABFT distribution in Eastern Canadian waters and discuss adding an acoustic survey component to existing ecosystem surveys. For the present, however, it is recommended that current and future Bluefin tuna counts based on the acoustic survey in the Baie-des-Chaleurs should be reviewed by the Bluefin tuna Working Group for inclusion in the index when the annual southern GSL herring biomass estimated from the survey is less than 0.25 kg/m^2.

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Table 1. A comparison of primary readers performance using average # tuna/km and stratum area weighted average # tuna/km (SAW).

Primary Reader	Year	# of strata	# of tuna targets	SAW abundance	2*SE	CV
Current	2017	14	40	0.046	0.0042	0.019
Former	2017	14	44	0.053	0.0020	0.007
Current	2018	14	14	0.011	0.0008	0.013
Current 2	2018	14	9	0.007	0.0005	0.013

Table 2. Descriptive statistics for the acoustic Bluefin tuna index of abundance using average # tuna/km and stratum area weighted average # tuna/km (SAW).

Year	# of strata	# of transects	SAW abundance	2*SE	CV	VESSEL
1994	14	118	0.026	0.0134	0.275	CREED
1995	12	100	0.034	0.0085	0.135	CREED
1996	14	118	0.067	0.0123	0.098	CREED
1997	14	110	0.038	0.0084	0.119	CREED
1998	14	120	0.042	0.0169	0.213	CREED
1999	14	103	0.035	0.0078	0.12	CREED
2000	14	108	0.019	0.005	0.138	CREED
2001	14	115	0.037	0.01	0.145	CREED
2002	12	78	0.02	0.0067	0.186	CREED
2003	10	119	0.036	0.0098	0.144	CREED
2004	14	137	0.038	0.0051	0.071	CREED
2005	14	147	0.051	0.0052	0.054	CREED
2006	13	116	0.062	0.0086	0.073	CREED
2007	14	124	0.042	0.0103	0.131	CREED
2008	14	142	0.034	0.0049	0.076	CREED
2009	13	120	0.057	0.0096	0.09	CREED
2010	14	139	0.065	0.0051	0.042	CREED
2011	14	135	0.05	0.0075	0.08	CREED
2012	13	126	0.1	0.0126	0.065	CREED
2013	14	138	0.056	0.006	0.057	CREED
2014	14	133	0.076	0.009	0.063	CREED
2015	14	100	0.075	0.0138	0.098	CREED
2016	14	73	0.088	0.019	0.01	PERLEY
2017	14	100	0.053	0.002	0.007	CREED
2018	14	134	0.007	0.0005	0.013	CREED/PERLEY

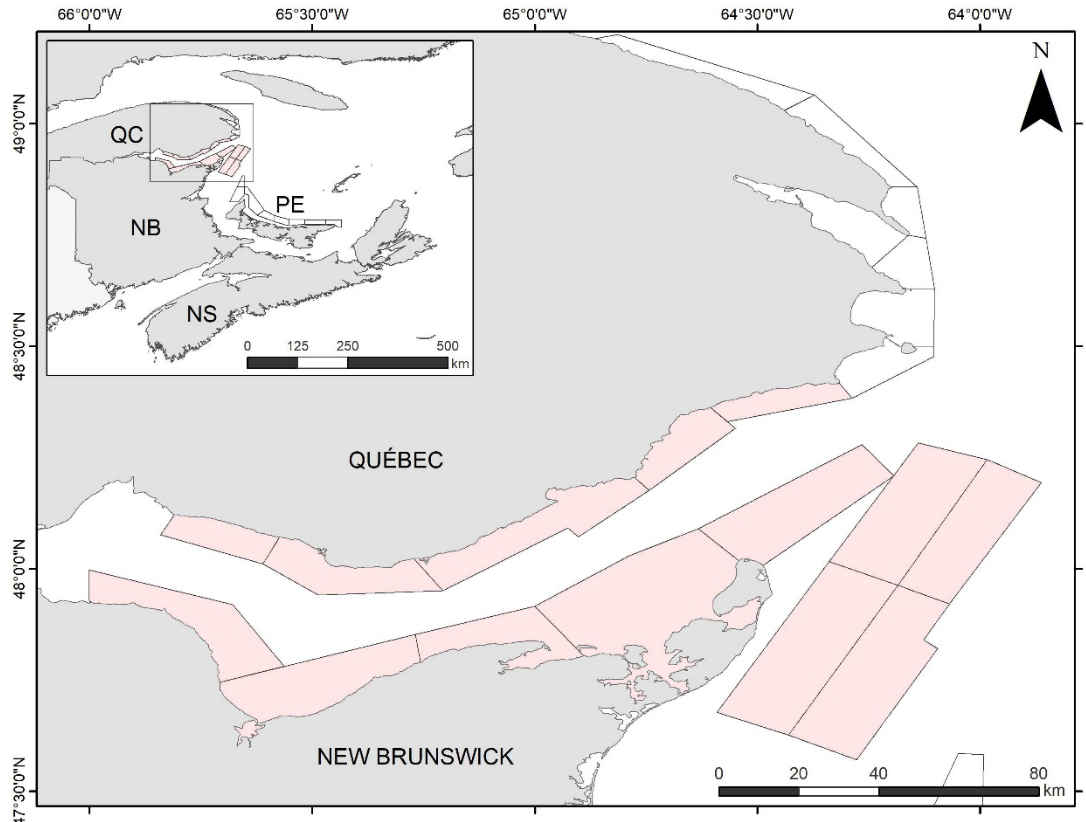

Figure 1. Map of survey area in the southern Gulf of Saint Lawrence Baie-des-Chaleurs. Boxes in pink represent strata that have been included in the acoustic index; boxes in white have not been consistently surveyed over the years and have been omitted from analysis.

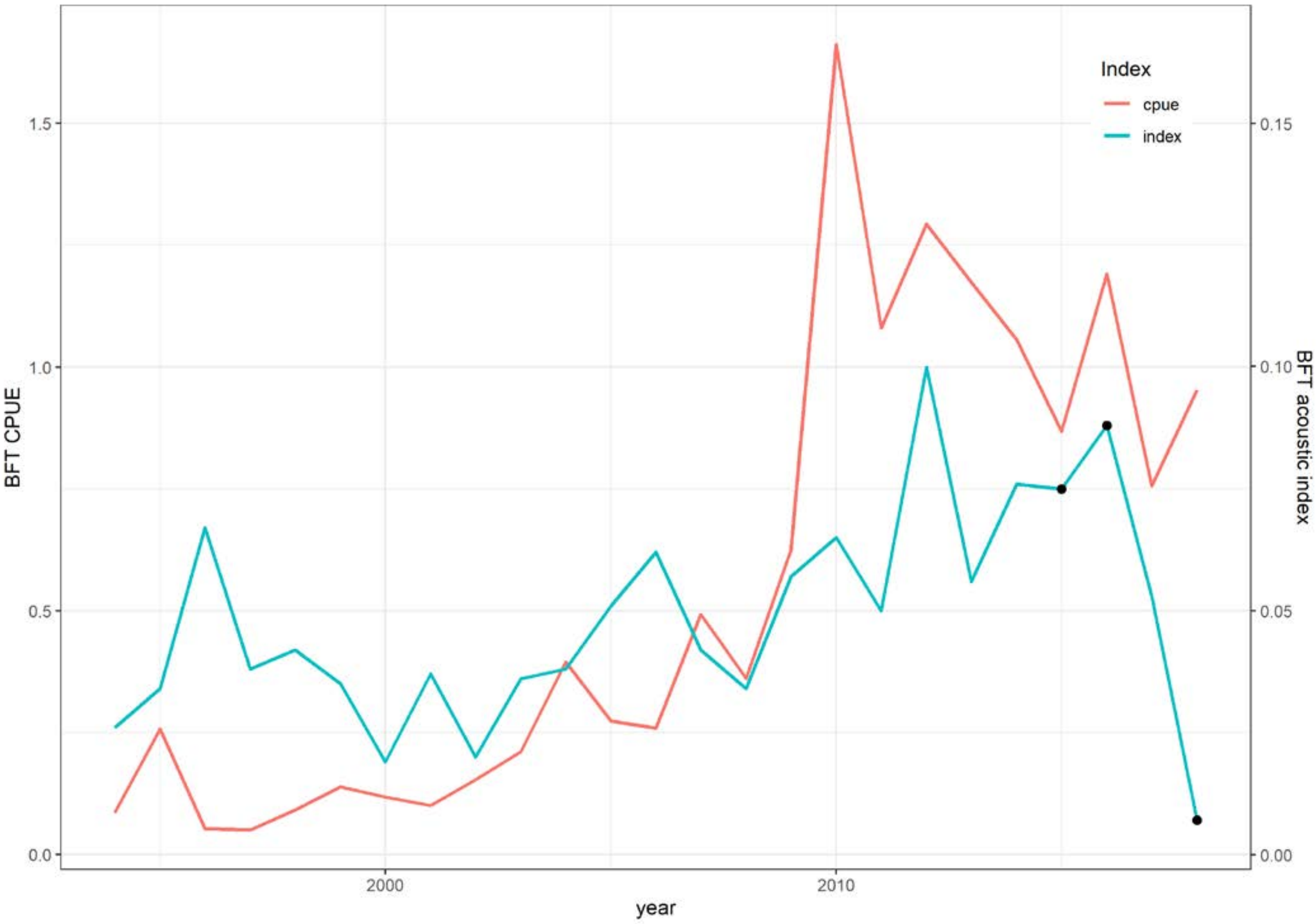

Figure 2. Atlantic Bluefin tuna abundance time series using fishery dependent CPUE (Hanke, 2019) and fishery independent acoustic data (stratum area weighted average # of tuna/km) for the Gulf of Saint Lawrence and Baie-des-Chaleur, respectively. Black dots indicate years where transect level data were used in this report to compare vessels (Creed (2015, 2018) and the Perley (2016, 2018)).

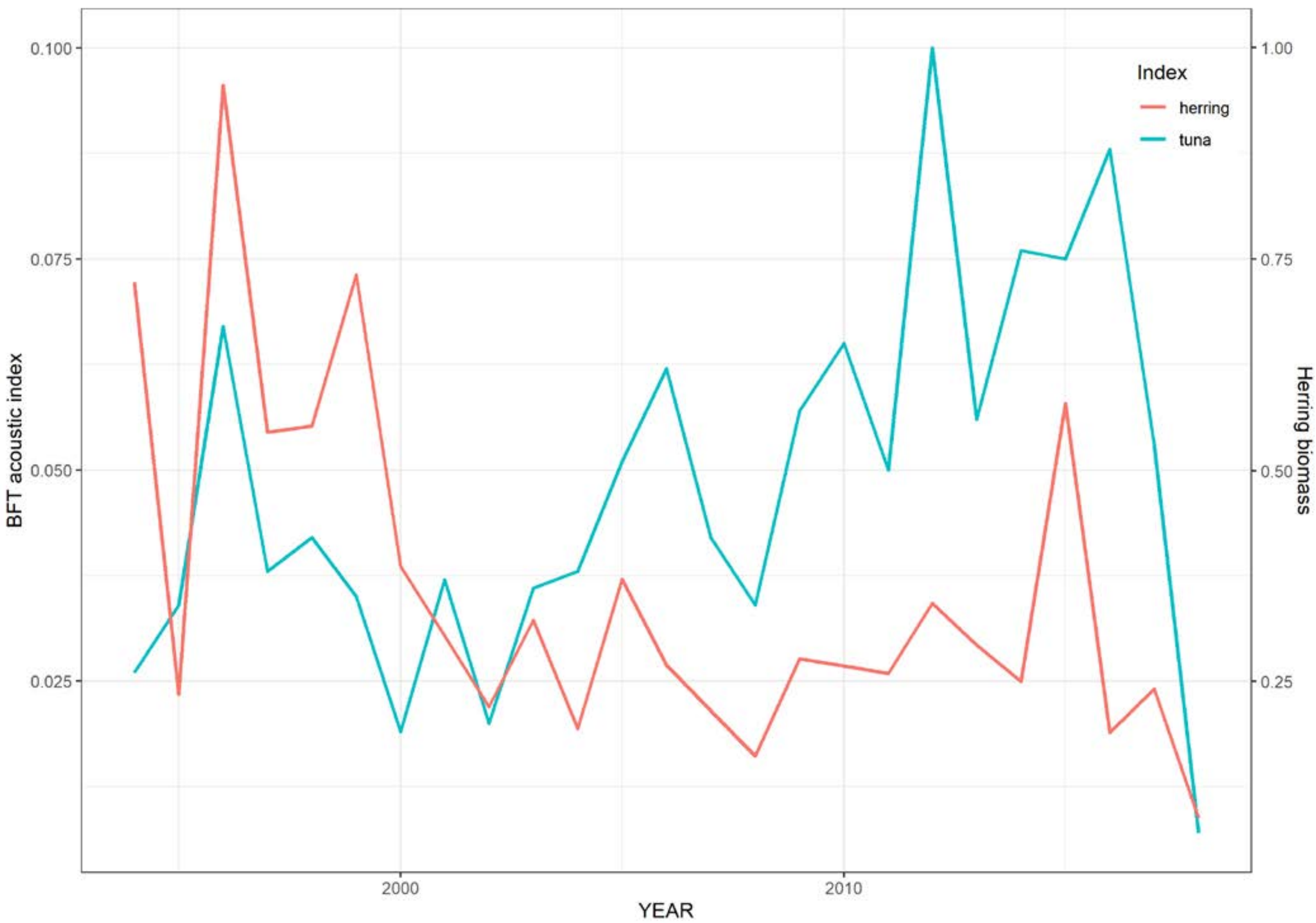

Figure 3. Acoustic Gulf of Saint Lawrence survey data including Atlantic Bluefin tuna abundance (stratum area weighted average # of tuna/km) and herring biomass (kg/m^2) (Turcotte *et al.*, 2020).

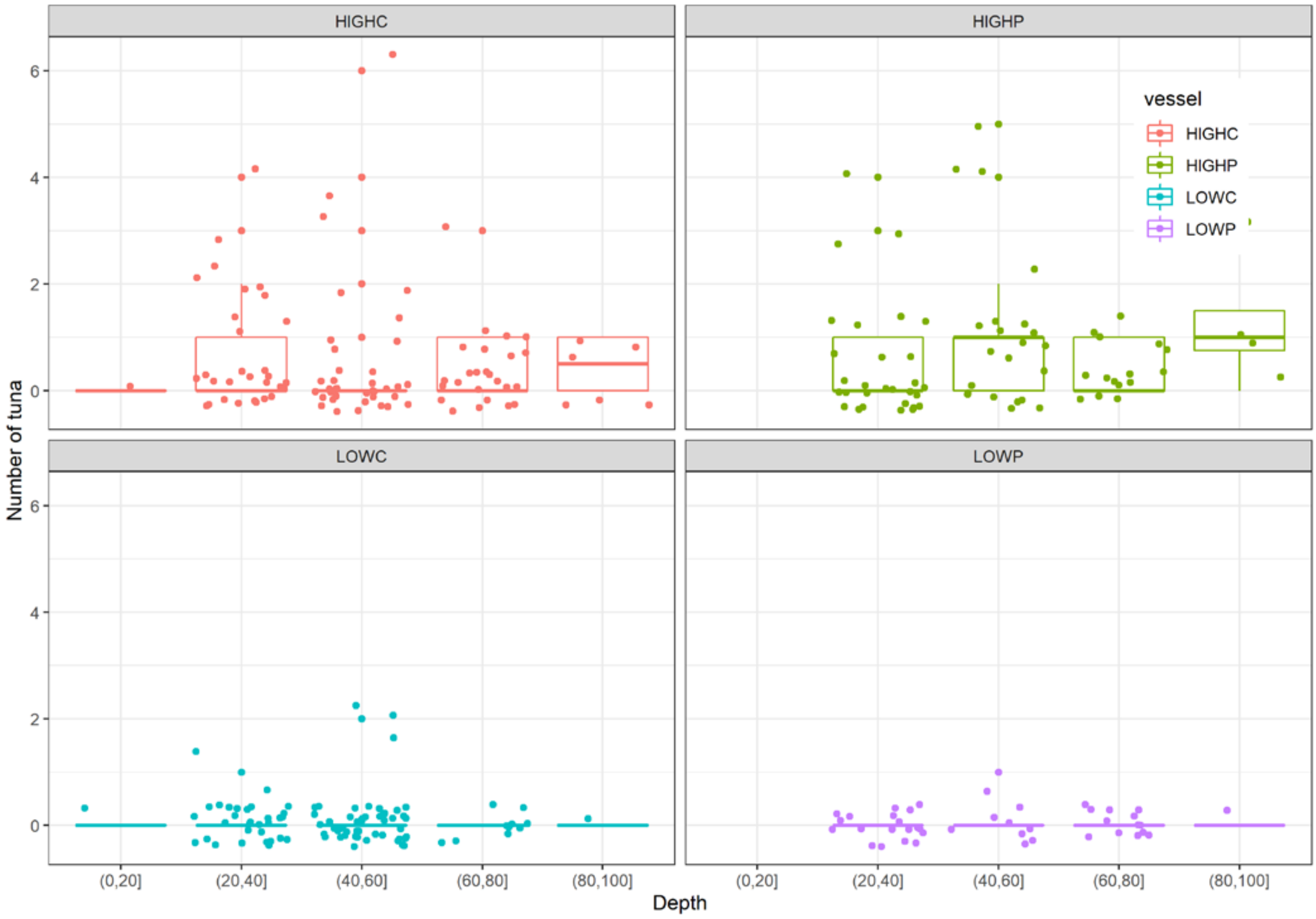

Figure 4. Trends in transect level Bluefin tuna counts across average transect depth bins (0-100 meters) for high and low index years by vessel (HIGHC/P=high ABFT index value observed by Creed, 2015, and Perley, 2016; LOWC/P=low index year, 2018, for both Creed and Perley).

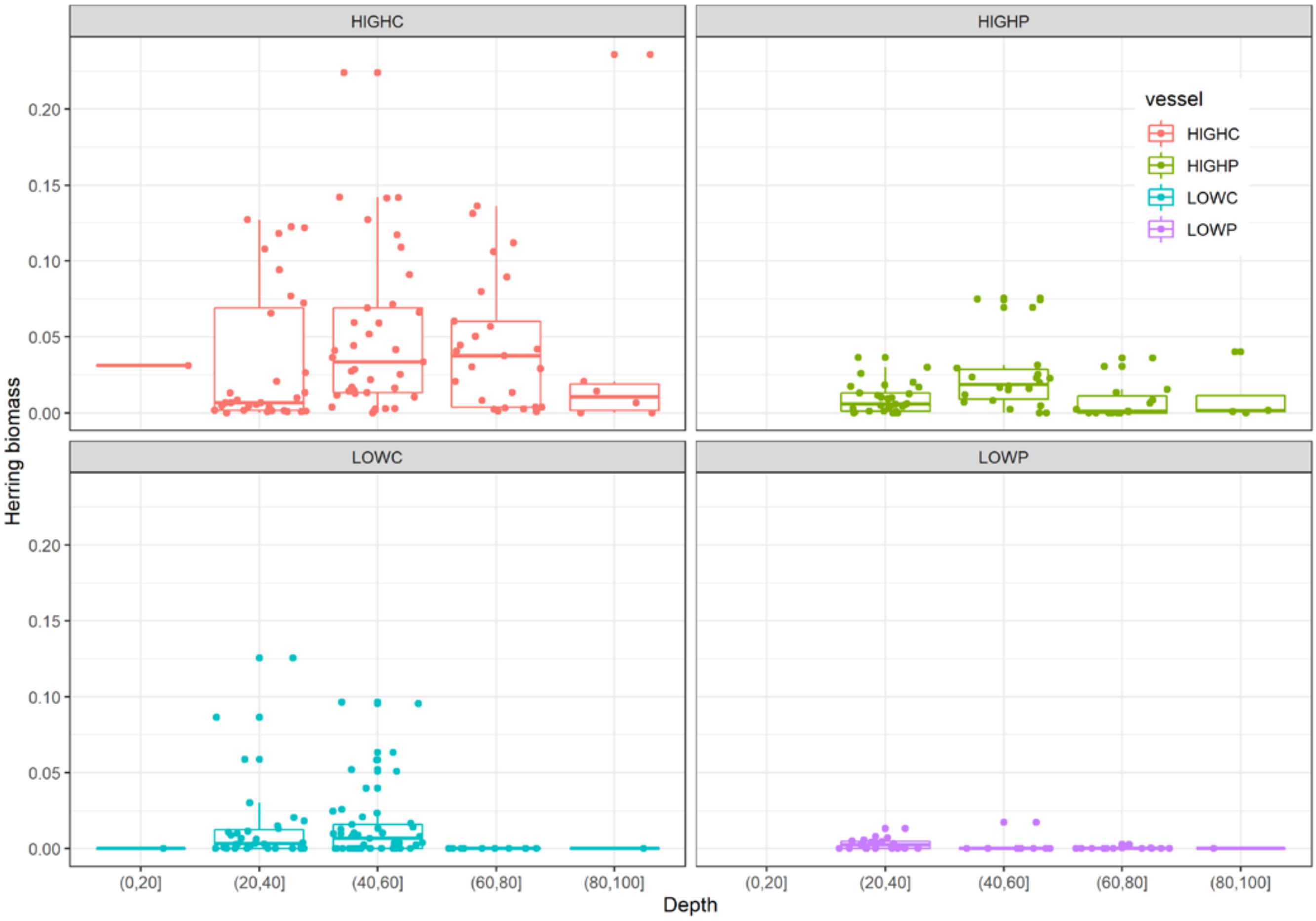

Figure 5. Trends in transect level herring biomass across average transect depth bins (0-100 meters) for high and low index years by vessel (HIGHC/P=high ABFT index value observed by Creed, 2015, and Perley, 2016; LOWC/P=low index year, 2018, for both Creed and Perley).

Figure 6. Trends in transect level Bluefin tuna counts across survey strata for high and low index years by vessel (HIGHC/P=high ABFT index value observed by Creed, 2015, and Perley, 2016; LOWC/P=low index year, 2018, for both Creed and Perley).

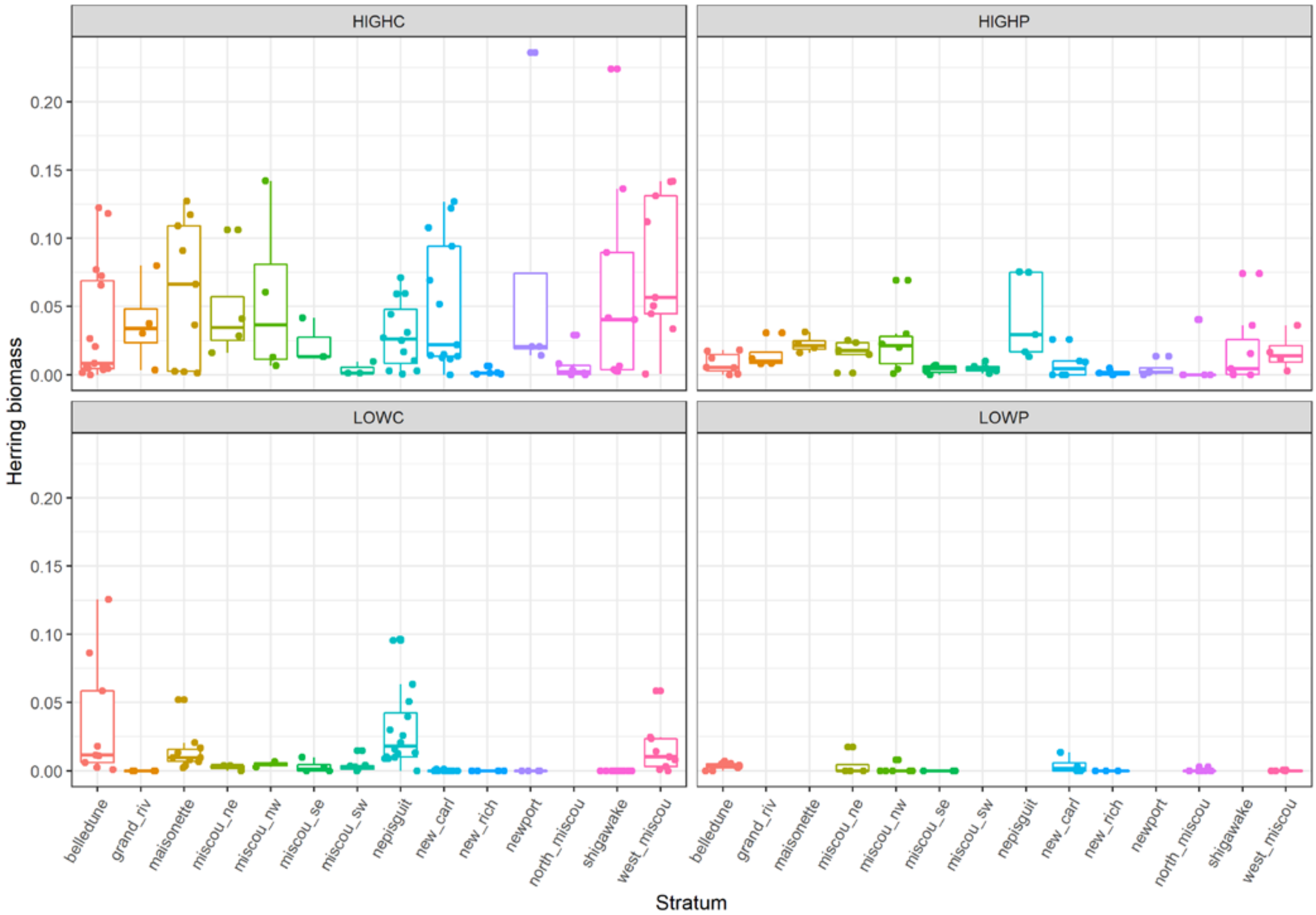

Figure 7. Trends in transect level herring biomass across survey strata for high and low index years by vessel (HIGHC/P=high ABFT index value observed by Creed, 2015, and Perley, 2016; LOWC/P=low index year, 2018, for both Creed and Perley).

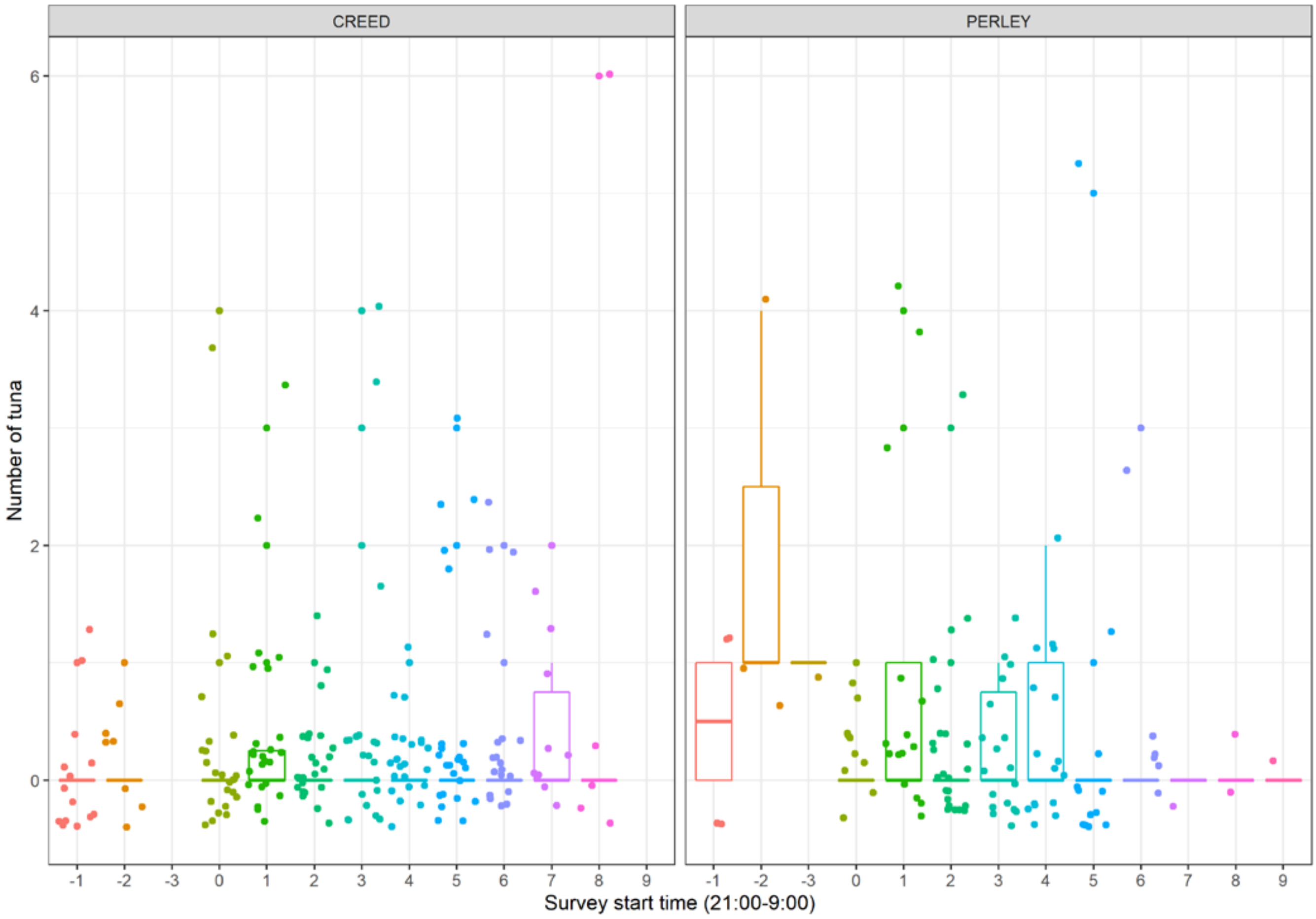

Figure 8. Trends in transect level Bluefin tuna counts across survey start time (21:00-9:00) for the Creed and Perley.