Kimberly Franklin (00:00):
Hello, my name is Kimberly Franklin. I was a researcher at the Oceanography Department at Dalhousie University. And today I will be presenting using sonobuoys and visual surveys to describe North Atlantic Right Whale calling behavior in the Gulf of St. Lawrence. This work was done in collaboration with colleagues from NOAA Northeast Fisheries Sciences Center and the Anderson Cabot Center for Ocean Life at the New England Aquarium.

New Speaker (00:25):
Passive Acoustic Monitoring, or PAM, is just that, passively listening and monitoring sounds. PAM is an excellent tool for monitoring right whales because they're quite vocal. Right whales make three main types of calls upcalls, mid-frequency tonal calls, which will be referred to as "tonal calls" in this presentation, and gunshots, which are shown in these three images. The images are spectrograms, which are visual representations of sound. On the x-axis is time and on the y-axis is frequency. The color denotes amplitude or loudness. Starting with upcalls, this call type is made by all individuals of all ages and sexes in all habitats. Next, are tonal calls, which are thought to be made by focal females in surface active groups. And finally, gunshots, which are thought to be made by males. But for PAM to work, it requires right whales to produce a call.

New Speaker (01:18):
When and why right whales produce any of these calls is an active area of research. As I mentioned previously, we know some things about the individual call types, but ultimately their calling behavior varies and depends on biological and environmental contexts. For instance, individual calling rates are highly variable and calling characteristics can convey individual and age specific information, which can change as an individual ages. This means that each call produced is variable in its own way and has the potential to be identified to a single whale. Also, whale behavior context matters. There is evidence that more calls are produced during surface activities and traveling and less calls when foraging or resting. Right whale calls are also known to vary in response to noise in the environment and in each of their well studied habitats. All these factors contribute to right whale calling behavior being highly variable and greatly influenced by their surroundings and contexts.

New Speaker (02:16):
To understand right whale calling behavior, both visual and acoustic observations are needed. A few studies have conducted visual-acoustic research in their summer foraging and socializing habitats such as the Bay of Fundy, Roseway Basin, and the Gulf of Maine. But their calling behavior context has yet to be explored in the Gulf of St. Lawrence habitat.

Kimberly Franklin (02:37):
This brings us to the objective of our study. We wanted to quantify how right whale calling varies with respect to the number of whales observed, their sex and behavior, and day of year in the Southern Gulf of St. Lawrence. But more specifically, to find out what influences call rates and if calling rates can be used to predict the number of whales observed.
New Speaker (02:58):
To do this, we needed to collect simultaneous visual and acoustic data. Visual data was collected by NOAA aerial surveys in collaboration with DFO in the Southern Gulf of St. Lawrence. When three or more right whales were seen and the observers knew that they would be staying in the area for an hour or more, they began collecting the acoustic data. The acoustic data was collected using expired sonobuoys, which are disposable drifting hydrophone systems made up of a hydrophone, a transmitter, and a buoy with an antenna where the sounds underwater are transmitted to a receiver on the plane. The sonobuoys were deployed from the plane at about half a kilometer to a kilometer away from the sighted whales and had a recording life of up to eight hours, although most systems stopped after three hours.

Kimberly Franklin (03:44):
This is the big picture of what a typical day on the water looked like. We have the plane photographing and visually observing the whales with a sonobuoy in the water transmitting the sounds produced by the whales back to the plane.

New Speaker (03:59):
Overall, 37 sonobuoys were deployed from June to August in 2017, 2018 and 2019 in the Southern Gulf of St. Lawrence. On the map here, the deployments from 2017 are represented by circles, in 2018 by triangles, and 2019 by squares. The blue color gradient refers to the different bathymetric depths. Most sonobuoys were deployed in and around the Shediac Valley with a few more deployed more Northeast in 2019, and a few more Southeast in 2017. The data from all the years were combined as a Kruskal-Wallis test indicated no variation among the three years.

New Speaker (04:38):
There was a total of eight variables collected from this work. The sonobuoys collected the audio data, which produced the acoustic variables, upcall rate, tonal rate, and gunshot rate. These call rates are the number of calls detected per hour of recording. From the plane we have the visual variables, whale count, which is the number of whales seen in and around the deployment, the male to female ratio, which is the number of males divided by the number of females per deployment, and the socializing and forging rates, which are the number of times each of these behaviors were observed per hour of the deployment. And lastly, we have our time variable, which is represented as a numerical count of the day of year and is referred to as "day of year."

New Speaker (05:22):
Now for the results. Here, we have a scatter plot showing call rates for each of the call types for each deployment over time. Day of year is on the x-axis and call rate is on the y-axis. Each call type is represented by a different color. Upcalls are white, gunshots are blue, and tonals are brown. All three call types increased toward the end of the study period in August. This trend shows that upcalls increased as gunshot and tonal calls increased rather than remaining consistent over time. Also, this is the first known report of a temporal trend seen in right whale tonal calling. And lastly, the arrows on the
Using sonobuoys and visual surveys to characterize North Atlantic right whale (*Eubalaena glacialis*) calling behavior in the Gulf of St. Lawrence

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graph illustrate days where no upcalls were detected, but either gunshot and/or tonal calls were detected.

New Speaker (06:08):
Here we have a scatter plot with the behavior rates compared to day of year for each of the 37 deployments. The x-axis is day of year and the y-axis is behavior rate. Foraging behavior is shown in purple and socializing behavior is shown in yellow. We see that foraging rate, or the purple dots, progressively decrease throughout the study period while the socializing, or yellow dots, increase.

New Speaker (06:35):
This scatter plot shows whale count over time, where the x-axis is the day of year, and the y-axis is the number of whales observed during the deployment. There appears to be a very weak increase of whales observed throughout the study period.

Kimberly Franklin (06:52):
This is a Spearman rank correlation matrix. It is just another way to show the data, specifically, the correlations between all the variables. All the variables are listed at the top and then repeated again down the diagonal. The correlation between two variables is shown at the intersection. An x over the correlation means that it was not significant or that the p-value was greater than 0.05. The blue color indicates a positive correlation and the orange to red color indicates a negative correlation for the significant comparisons. I would just like to point out a few interesting things here. First, day of year was significantly well correlated with the call types and behaviors and weekly with whale count, which we saw in the scatter plots. Next, foraging rate had negative correlations with all the call rates, socializing rate, and day of year. And finally, all the call rates were significant and positively correlated with each other.

Kimberly Franklin (07:49):
Now to answer our two main questions. For the first question, "What influences call rates?" a negative binomial regression model was created and composed of all the visual variables and day of year, and was applied to each of the three call types. All these regressions then underwent an AIC stepwise selection process to determine which variables were most important to that call type. For upcall rates, socializing and whale count appeared to be the main drivers of this call type. For gunshots, it was strictly day of year. And for tonal rates, it was day of year and the male to female ratio.

Kimberly Franklin (08:29):
For the second question, "Can calling rates be used to predict the number of whales observed?" a simple linear regression model was created to compare each call type rate and day of year to whale count. None of the call types were related to the number of whales seen, only day of year was related to this variable.

New Speaker (08:51):
In conclusion, call rates increased from June to August for all call types. This is also the first known report of a temporal increase in right whale mid-frequency tonal calling. Upcalls were occasionally produced more frequently when gunshots and tonal calls were produced in larger quantities. There was a few deployments where no upcalls were detected, but other call types were. This suggest that PAM may not be the best at detecting whale presence at fine timescales, but can be improved if other call types are considered. Calling rates were negatively associated with foraging and positively with socializing. And finally, calling rates were too variable to provide reliable count estimates of observed whales. All in all, some behaviors, such as socializing, may be reliably inferred from acoustics alone, and PAM could be more than a presence only tool.

New Speaker (09:44):
We would like to thank all those who helped in supporting and providing feedback for this work. And thank you for listening. I look forward to your questions and comments at the conference.