Cataloging Biological and Anthropogenic Sounds of the Hudson River at Pier 40

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Abstract

Recently a new development has been utilized for marine science research known as Passive Acoustic Technologies. The purpose of this project is to catalogue biological and anthropogenic sounds for comparison. The comparisons made are between the respective amplitudes and frequencies of anthropogenic and biological sounds. In the summer of 2006, sounds from Pier 40 were recorded twice daily for thirty minutes. After recording was completed, the recorded sounds were then made into spectrograms and oscillograms, measuring frequency and amplitudes vs. time, respectively. After thorough analyses of charted information, conclusions and correlations were found. These results showed that both biological and anthropogenic sources operate at similar frequencies, but the higher amplitudes of anthropogenic sources caused them to drown out or confuse the biological. This project concluded that anthropogenic sounds can have a serious impact on the soniferous organisms at pier 40.

Introduction

As humans, we always use sound all the time. We rely on sound to communicate with one another. Hearing allows us to familiarize ourselves with the environment, especially when there is little or no visual aid to guide a fish. In the Hudson River the only part receiving light is the uppermost layer. Certain organisms such as fish rely on other senses than their eyesight. Later lines, chemo-sensitivity, and hearing all help organisms to find their way in their environments. “When a fish approaches an object, the current pattern is disrupted, changing the pressure distribution in such a way that lateral line receptors may be stimulated.”(Adler, 1975) Therefore, some organisms living in deeper depths rely greatly on hearing, to find their way in the darkness (Wenz, 1962). The most commonly known soniferous fishes of the Hudson include the oyster toadfish, striped cusk eel, and silver perch.

The reason for cataloging bio acoustic and anthropogenic sounds of the Hudson River is to enable us to identify, record, and study marine life. It also allows for us to know the effects of anthropogenic noises on marine life, and if they respond to noise. The best way to create this catalogue is through the use of passive acoustic technology. Although this does not permit visual observation, the recording of marine life does indeed allow us to receive accurate information about the organisms.

Bioacoustic technologies were adapted from inventions used in other braches of science. The Cornell-based bioacoustics spectrogram program Raven, used in our project, was originally created for listening to birds. Marine bioacoustics was originally intended for marine mammals such as dolphins and whales.

Some fish depend on sound for navigation, finding food, mating and expressing aggression (Clark, 2000). There’s an abundance of different sounds in the Hudson River because each organism has its own distinct way of making noise. For example, shrimp have been known to make snapping sounds. Seahorses also create a “pop” when they suck their food through a tube-like snout (Copeia, 1995-1999). There are many contended causes for communication among fishes, some of which have been documented (Clark, 2000). Production of sound has been found to vary, according to the species of an organism and its behavior. Most fish sounds are associated with the swim bladder, which acts as a drum or an amplifier to sound. Fish such as the oyster toadfish have a muscle that vibrates against the swim bladder and the cusk eel creates noise using the swim bladder. Other types of fish create noises by rubbing specific parts of their bodies together. Some rub their bones together to create sound; other fish grind their teeth.

Some recorded bioacoustic sounds have yet to be identified (Rountree, 2002). Dr. Rodney Rountree has made many discoveries surrounding bioacoustics. Dr. Rountree, works in Amherst, Massachusetts during the fall. He has recorded the calls of many biological sources; the oyster toadfish, and the striped cusk eel. (Mann, D. A., Higgs, D, Tavolga, W.N, and Dr. Popper, have recorded many other species, including the domino damselfish, *D. albisella,* two separate species of toadfish, *O. beta* and *S. astrifer*, silver perch, *B. chrysoura*, gafftopsail catfish, *B. marinus*, spotted sea trout, *C. nebulosus*, and the black drum, *P. cromis*.) D. Mann has also recorded the Damselfish's famous "signal jump" on video, with a hydrophone accompaniment, finding a loud chattering as it performs the "jump." Others such as D. Mann, and Dr. Popper, have done similar research in bioacoustics, which we plan to study and compare with the current work of this team.

Methods & Materials

Water Chemistry

Daily recordings of water quality data were taken from the Lilac (a stationary steamboat located at the north side of Pier 40) at approximately 11:15 am for sixteen days, between the dates of July 17 and August 11. A water sampling device called a Kemmerer was used to obtain water from the Hudson River to test the water chemistry parameters. The water was then poured slowly into a clean bucket. Dissolved oxygen, salinity, pH, turbidity, and temperature were measured using the materials from a water chemistry test kit. The purpose of this was to check for any abnormalities in the water. All marine scientists, while conducting experiments, collect these hydrodynamic parameters.

Trapping Fish

Traps were also checked each morning. Twenty minnow traps and four crab pots were deployed and checked daily for marine animals around the perimeter of the Lilac. The majority of organisms caught in the traps, starting with the most common, were blue crabs, toadfish, butterfish, American eels, and white perch. All fish caught were measured in centimeters from the tip of the nose to the tip of their tail. This measure is called total length. Crabs were measured from claw to claw as well as from one side of their carapace to the other, which is called carapace length. All marine organisms were then returned back to the Hudson River.

Audio-Visual Documentation

For one hour each morning and afternoon, from July 17 to August 11 2006, sounds beneath the surface of the Hudson River were captured and recorded using a portable hydrophone (AQ-15 series with fifteen meters of cable), a tape recorder, and a set of small speakers(which enabled us to listen to the sounds while recording). A camera (Nikon Cool Pix 5000) was used to photograph boats that passed, and each boat was later associated with its corresponding sound. When a sound was heard, data on it was written down, including length of time, the tape counter for when the sound started, the source, and the distance of the source from where the hydrophone was in the water. Using the GPS receiver (Garmin GPS 60), the exact latitude and longitude was recorded, though the accuracy increases if more than four satellite signals were received at one time. Once recordings were completed for the designated time period, the hydrophone was rinsed with fresh water to keep any particle buildup from affecting future recordings.

Data Analysis

After the end of the sixty-minute recording session, the sounds recorded were uploaded to a computer. With the tape recorder plugged into the computer, the program *Raven* was opened and the captured sounds were divided up for easier filtering. When each segment was ready to be saved, it was labeled in a specific manner so that it could easily be found for future reference. If one sound in particular was isolated, such as a toadfish call or a boat motor, it was saved as its own sound file.

Discussion

Results show that many anthropogenic sounds such as boats, jet-skis, and ferries operate at similar frequencies to the animal sources that were recorded, such as the oyster toadfish and the striped cusk eel. Although these anthropogenic sounds operate at the same frequencies as the biological, they operate at much higher amplitudes. Amplitude was recorded in kU (kiloUnits), showing relative differences in volume. Although many factors affect the kU reading (i.e.: distance from source, recording volume, input volume), it can still be seen that anthropogenic sounds such as the engine of a boat or the creaking of a dock are much louder then the call of a cusk eel or toadfish. This higher amplitude may not only muffle or confuse the soniferous fish of the Hudson River, but also could change their behavior.

Bioacoustic sounds are often muffled by most anthropogenic sounds. The toadfish, which makes noise at frequencies between 100 and 900 Hz, could be confused by certain anthropogenic sounds such as a fireboat, which operates at frequencies ranging from 100 Hz to 1550. The cusk eel, emitting noise between 1200 and 2400 Hz, could be confused by other anthropogenic sources with similar frequency ranges such as a revving boat engine, which emits sounds at a range of frequencies ranging from 100 to 2800 Hz.

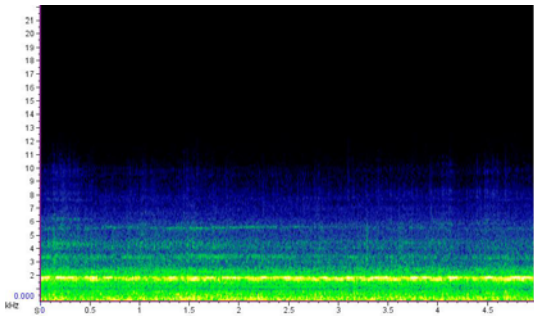
Fish use their sense of hearing and their ability to make noise for many purposes, such as navigation, feeding and the spawning process. If a toadfish were to hear a boat horn that sounded similar to another toadfish, this could possibly disturb the toadfish's lifestyle and confuse it. Toadfish are extremely territorial, and may attempt to oust invaders upon hearing a misleading boat horn. The fish may then be attempting to remove the threat of a nonexistent invader instead of productive activities like reproducing or searching for food. The cusk eel uses sounds for similar purposes, and the same negative effects apply. Since almost all anthropogenic sounds are much louder than the bioacoustic ones, the sounds made by the fishes cannot be heard. When two toadfish or two cusk eels try to communicate for purposes such as mating or navigation, they may no longer be able to hear each other over the sound of the boats and docks, making it difficult to communicate and function as a group. If the fish are drowned out or misled by the man-made sounds, it could prove difficult for them to survive in the Hudson.

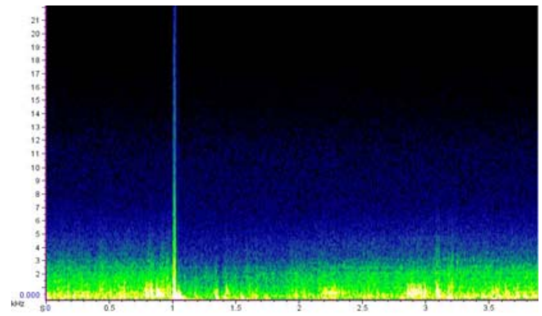
Even if all possible information about man-made and animal sounds were to be recorded, such knowledge is useless if not properly applied in a way that would be highly beneficial to the Hudson's aquatic life. Accounting for the fact that the volume of single boat is so great, as a group the volume would be increased dramatically. When all of these boats pass by in succession the volume could be damaging, if not deafening. If this is the case, laws should be passed to limit the amount of boat traffic allowed at one time, thus giving fish a chance to flee the area before the pressure is increased. The pressure generated is the power emitted from the amplitude. The reason for the loud frequencies of these boats should be furthered studied, to see if there is a practical way to lower the frequencies. Sounds emitted from boats are due to their motors, a solution could potentially be as simple as requiring mufflers.

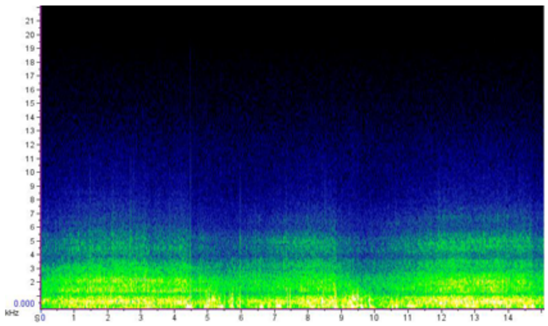
Marine communication has been going on forever, but not many people were aware of the extent of communication among fishes. There should be studies on the effects of amplitudes on the motor skills of fish. In the future, shipping companies, commercial fishermen, and pleasure boaters should be educated on the effects of their boat motors on the fishes of the Hudson River and other areas. Scientists should further study the exact effects of anthropogenic sounds on biological sources so accurate information can be distrusted. Once these people are educated, there can be an invention or an improvement in boat motors making them silent while remaining efficient. Scientists should also create studies that will reveal all kinds of communication between marine organisms, including all the effects on the biological sounds. The companies that rely on marine transportation should take measures to protect the environment; they should introduce motors that operate at lower amplitudes to their boats. Another piece of future work would be one utilizing passive acoustic technologies. Such technology can be used to take surveys of the residing fish species of the Hudson River to be able to know what species live in the river.

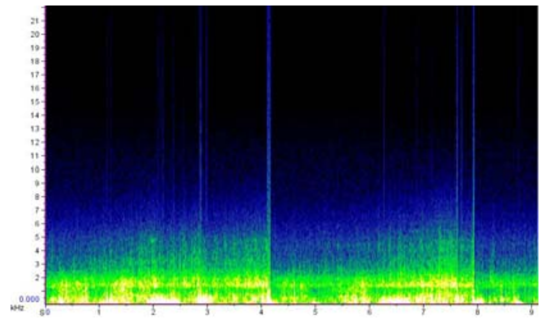
Results

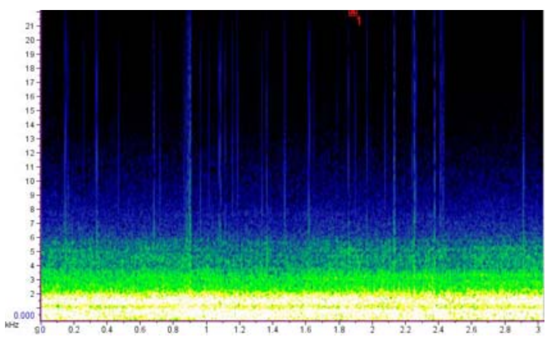
Spectrograms

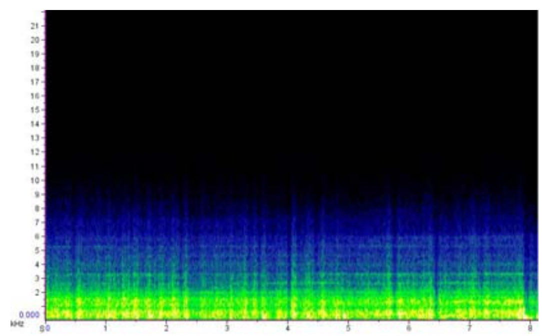

Circle Line

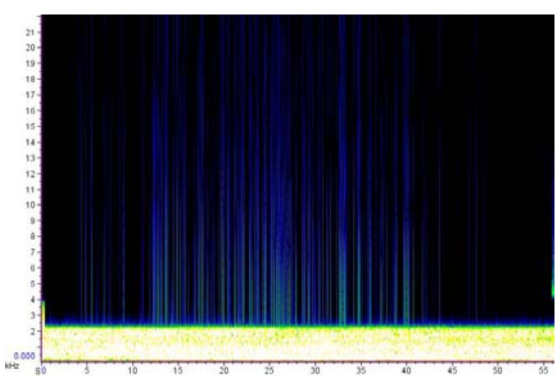

Creak

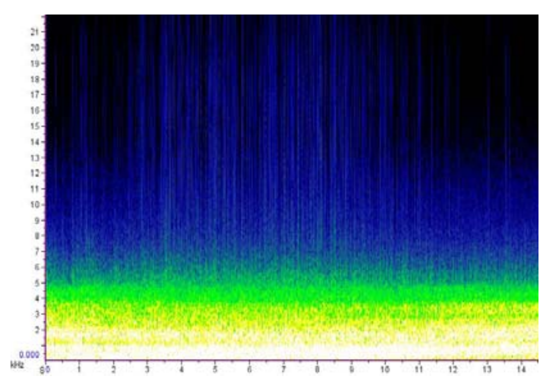

Cusk Eel

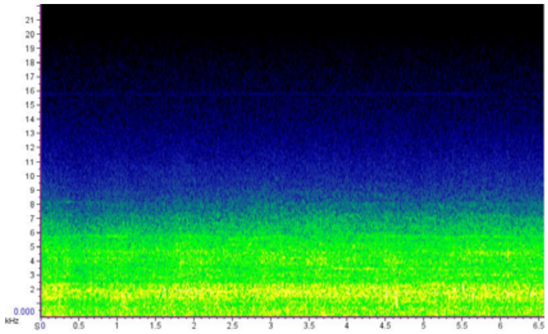

Dock


Ferry

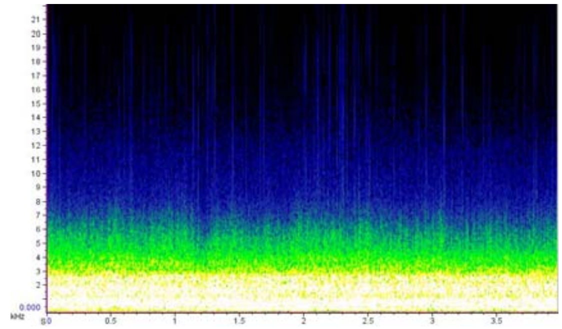

Fireboat


Jetski

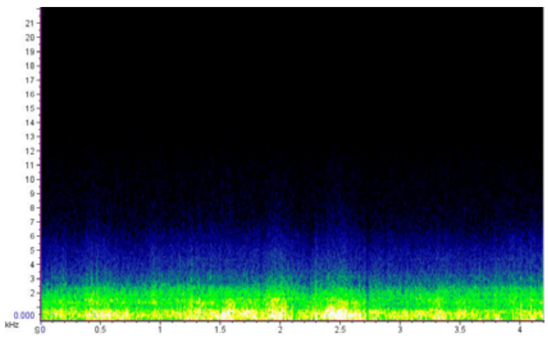

Motor Boat



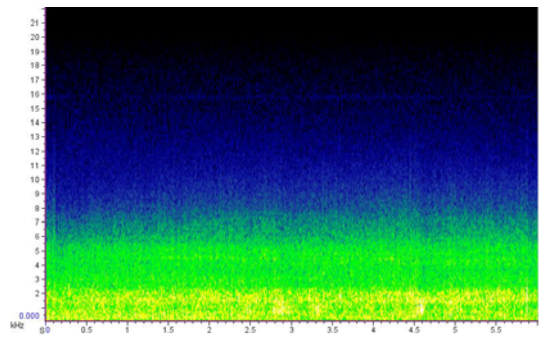
New York Water Way Boat



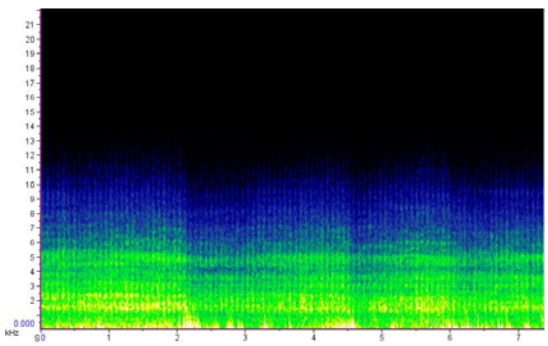
Revving Engine



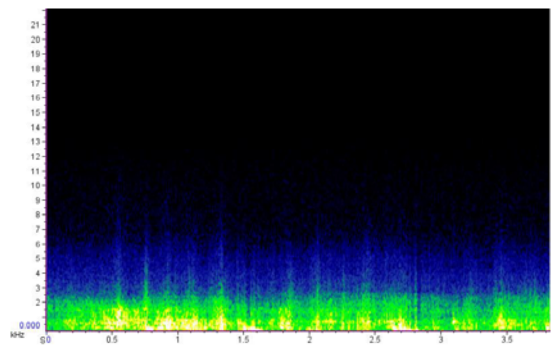
Toad Fish



Tug Boat



Water Taxi



Zephyr

The spectrograms were analyzed, showing that anthropogenic sources emit higher amplitudes than biological sources do, making them louder.

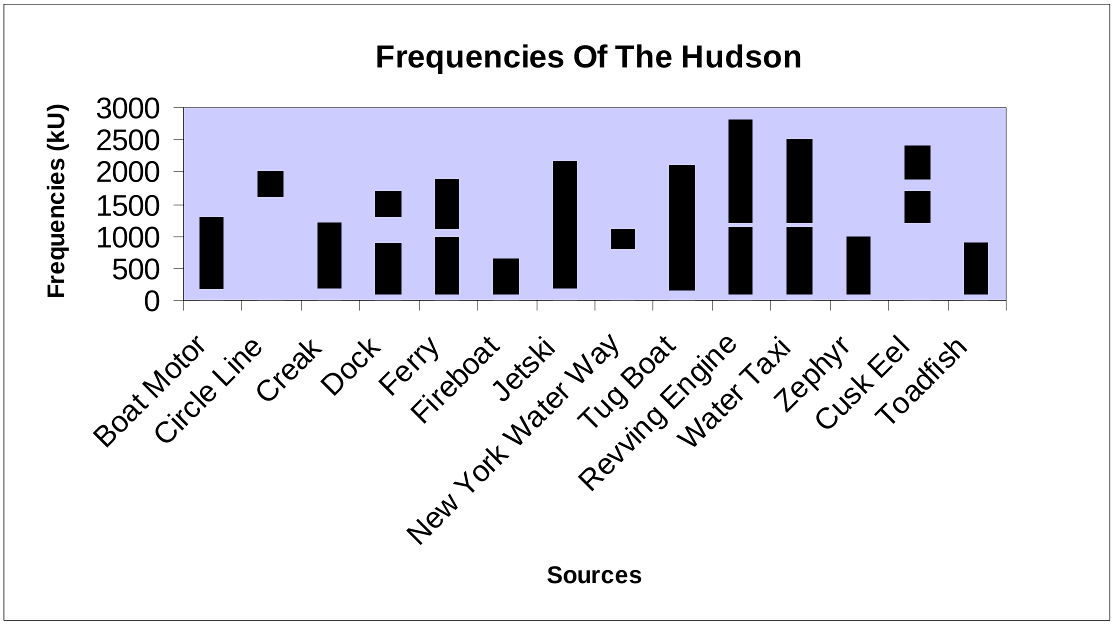


Figure 1

In Figure 1, it is shown that anthropogenic and biological sounds emit similar frequencies making them have similar pitches

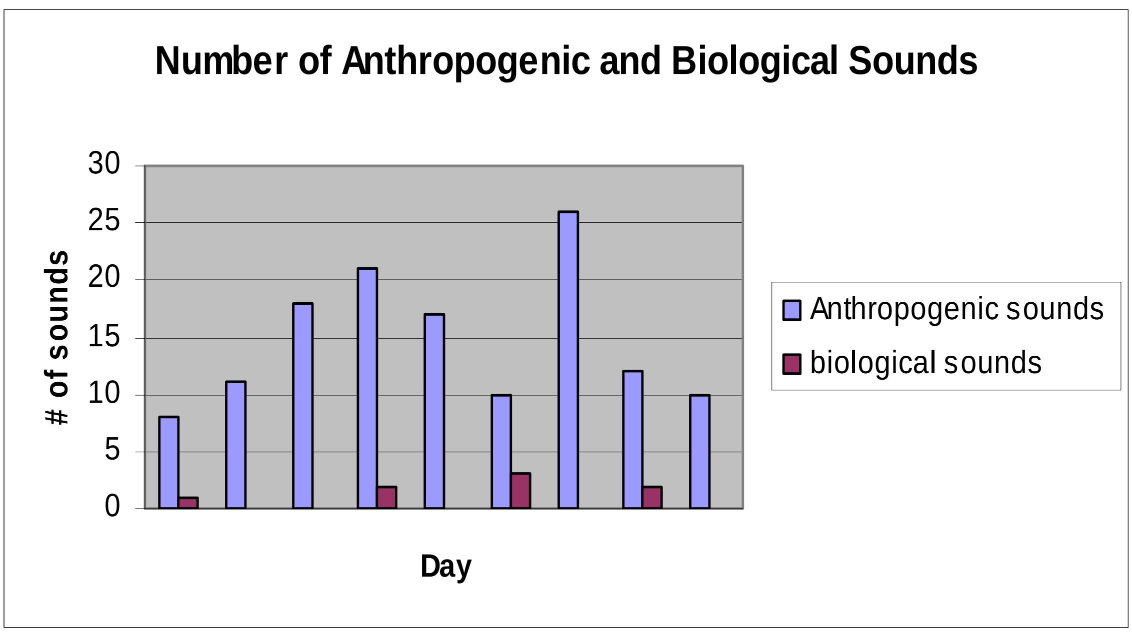


Figure 2

Figure 2 shows that compared with the number of anthropogenic sounds there was a relatively few biological sounds.

WATER TEMP	AIR TEMP.	SALINITY	D.O.	TURBIDITY	Ph
26	24	20	6.8	0.85	7.7
21.5	27	19	4.5	0.7	7.7
25	33	18	6	0.7	7.5
26	37	17	5	1.07	7.6
24	32	20	7.2	0.9	7.7
23	30	20	7.9	1.4	7.8
25	29	28	6.2	0.9	7.3
25	29	19	5.2	1.1	7.6
25	36	21	5.7	1.14	7.5
30	32	16	6.2	1.5	7.7
27	43	14	1.4	1.4	7.7
25	42	16	8	1.2	8
23	36	22	7.6	1.4	8.1
23	41	23	6	1.6	8
23	28	24	6.3	0.9	8

Figure 3

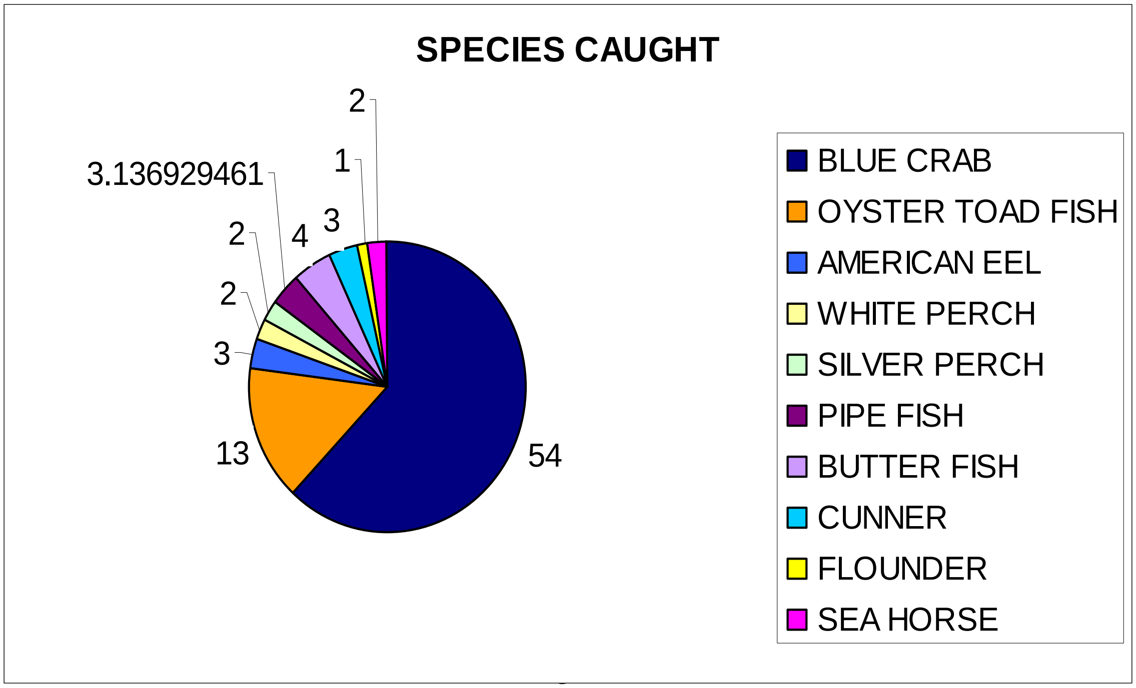


Figure 4

Figure 3 is a chart of water quality data that was recorded daily. Figure 4 is a pie chart of the overall amount of species caught daily with the traps that were set up. Trapping and water testing was done daily to verify consistency in the Hudson River.

Conclusion

Upon completion of this project, it can be concluded that anthropogenic and bioacoustic sounds operate at similar frequencies. It has also been discovered that anthropogenic and bioacoustic sounds are indeed emitted, and capable of being recorded in the Hudson River. As stated earlier in the paper, it was understood that frequency is the number of sound waves passing a given point in a given amount of time. Frequency relates to pitch. The higher the frequency, the higher the pitch of a sound. Since both types of sounds had similar frequencies, they also had similar pitches. However, according to the spectrograms in the results, it can be seen that anthropogenic sounds have higher amplitudes than bioacoustic sounds. Amplitude is the size of a sound wave passing a given point. The higher the amplitude, the higher the power of the sound is. Power, being the pressure generated by the amplitude, is perceived as loudness. Therefore the higher the amplitude, the louder a sound is. Although anthropogenic sounds have higher amplitude than bioacoustic sounds, both can operate at similar frequencies. This means anthropogenic sounds could potentially confuse fish and even go so far as to change their natural behavior.

The general public may be unaware to the extent of how the high amplitudes emitted by boats in the Hudson can be. These high amplitude sounds may cause fish to lose their hearing and possibly change their daily behavior. Future research will make people aware of this problem.

In the future, shipping companies, commercial fishermen, and pleasure boaters should be educated on the negative effects of their boat motors. Once boaters are educated, an improvement in boat motors that could make them silent yet still efficient. People that rely on marine transportation should take measures to protect the environment because if the ecosystem is damaged, then a subject of certain studies will no longer be available. These studies could potentially discover information that will help humans or organisms from other areas.

A damaged ecosystem can also create problems unknown at this time, so the old expression “it’s better to be safe than sorry” would certainly apply.

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