# 2020 ANNUAL REPORT OF THE SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) MARINE MAMMAL MONITORING (M3) PROGRAM

**Department of the Navy**
**Chief of Naval Operations**

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| BW | blue whale |
| dB | decibel(s) |
| ESA | Endangered Species Act |
| FW | fin whale |
| GAM | generalized additive model |
| HLA | horizontal line array |
| HW | humpback whale |
| HYW | presumed hybrid blue/fin whale |
| Hz | Hertz |
| ICP | Integrated Common Processor |
| ITS | Incidental Take Statement |
| IUSS | Integrated Undersea Surveillance System |
| LFA | Low Frequency Active |
| LM | Lockheed Martin |
| LOA | Letter of Authorization |
| M3 | Marine Mammal Monitoring |
| MMAP | Marine Mammal Monitoring Program |
| MMPA | Marine Mammal Protection Act |
| NOPF | Naval Ocean Processing Facility |
| SP | sperm whale |
| SURTASS | Surveillance Towed Array Sensor System |
| SW | sei whale |
| TAPP | Tactical Acoustic Intelligence Products Program |
| USNS | United States Naval Ship |

# 1 PURPOSE

The Marine Mammal Monitoring (M3) program is a monitoring component of the Surveillance Towed Array Senor System Low Frequency Active (SURTASS LFA) sonar program. The purpose of the M3 program is to utilize the Navy's fixed and mobile passive acoustic monitoring systems to enhance the Navy's collection of long-term data on individuals and populations of acoustically active marine mammals, principally baleen whales. The M3 program collects underwater acoustic data and uses those data to prepare reports on the behavioral range of acoustically active whales (e.g., calling, singing, and echolocating) and on the influences of anthropogenic activities on whale behaviors. The acoustic data the M3 program observes, collects, and analyzes are electronically archived in a form that can be used for exercise planning, naval operations, system tests, and preparation of environmental compliance documents.

Monitoring and reporting by the M3 program are requirements of the 2019 Final Rule and Letter of Authorization (LOA) under the Marine Mammal Protection Act (MMPA) (NOAA, 2019) and 2019 Incidental Take Statement (ITS) under the Endangered Species Act (ESA) for SURTASS LFA sonar training and testing activities (NMFS, 2019). In accordance with the LOA and ITS requirements, the annual report for SURTASS LFA sonar training and testing activities includes a summary of the M3 program's accomplishments for calendar year 2020. However, this annual report of the M3 program provides a detailed review of the specific tasking and associated task achievements the M3 program has accomplished to date during calendar year 2020.

# 2 M3 PROGRAM

## 2.1 BACKGROUND

Evolving from the Whales '93 and Whales '95 programs, the M3 program collects data from the Navy's Integrated Undersea Surveillance System (IUSS) passive acoustic assets to fill basic knowledge gaps about large whales and to further the Navy's scientific understandings of anthropogenic noise effects on large whales and their acoustic environments. The M3 program became part of the research, monitoring, and reporting program for SURTASS LFA sonar's environmental compliance in 2001 (DoN, 2001). Since then, the M3 program has become a source of unique and highly valuable information and data by which the acoustic activity levels of whales are quantitatively documented and ambient noise level trends are measured over ecologically meaningful spatial and temporal scales under varying ocean noise conditions. The M3 program analysts conduct their data collections, archival, and analysis at the Naval Ocean Processing Facility (NOPF) at Dam Neck.

M3 program's acoustic data are collected to: 1) document occurrence, distribution, and behaviors of acoustically active whale species over ocean basin and decadal scales; 2) objectively assess changes in marine mammal activity levels under normal conditions (e.g., weather, wind, time of year, or time of day) relative to acoustic conditions with varying levels of anthropogenic sources (e.g., seismic profiler[1], naval sonar, shipping, or fishing activities); and 3) assemble a long-term database of ocean environmental data to enable scientifically based evaluations of potential influences on cetaceans or other marine species.

## 2.2 M3 Program History

In the fall of 1992, the U.S. Navy initiated the Whales ’93 program to evaluate the potential of its IUSS for detecting, locating, and tracking whales, as well as determining their seasonal distributions and movements. The three-year Whales ’93 program team collected unprecedented amounts of new information and data on acoustically-active marine mammals in the North Atlantic and North Pacific oceans (Costa, 1993; Watkins et al., 2004; Watkins et al., 2000; Clark and Gagnon, 2002). In 1996, the Whales ’95 experiment began collecting data from eastern Pacific IUSS arrays, which were correlated with ship-based data bioacoustics data collected by a passive towed horizontal line array (HLA) (Clark and Fristrup, 1997; Fristrup and Clark, 1997). Ten years of Atlantic IUSS fixed asset data were analyzed for baleen whale acoustic abundance and trends north and west of Great Britain (Charif and Clark, 2009). The success of these initial research efforts led to the evolution of the M3 program.

## 2.3 Current M3 Program

Since 2002, fixed and mobile passive acoustic monitoring systems in the North Atlantic and North Pacific oceans have been used to acquire annual acoustic data on the sounds produced by several baleen (mysticete) and one toothed (odontocete) whale species. Initially, songs from blue, fin, humpback, and minke whales were detected during extended periods throughout each year, including assumed reproductive seasons. However, as the acoustic expertise of the M3 program team increased and software tools improved, M3 program analysts expanded their research efforts into seasons when these whale species were not necessarily singing (Clark and Gagnon, 2002). Subsequently, M3 program analysts identified calls or transient signals from blue, fin, humpback, and minke whales; sounds from Bryde’s, gray, sei, and Omura’s whales; and echolocation signals from sperm whales.

Their growing bioacoustics proficiency also allowed M3 program analysts to expand their catalog of marine biological sounds that had not yet been identified to species. This collection of unknown biologic sounds includes some signal types from fishes, invertebrates (e.g., sea urchins and diurnal vertical plankton movements), and large whales, some most likely echolocation clicks from diving odontocetes (i.e., species other than sperm whales). By authenticating that a sound source is of biological origin, the M3 program has significantly contributed to the proper identification of marine sounds and sound sources that are not of biological origin.

Another example of insights emerging from the large-scale, long-term data collection of the M3 program is the quantification of annual and inter-annual variation in baleen whale singing behavior. Based on over 17 years of data, M3 program analysts can reliably describe the typical

1 The term “seismic profiler” refers to a vessel operating a seismic airgun array or arrays as part of a geological and geophysical survey, usually to explore for sub-bottom oil and gas but also to conduct basic research.

seasonal patterns of acoustic activities for four species of baleen whales (blue, fin, humpback, and minke whales). Additionally, data from over seven years now provide insights into the seasonal patterns of an additional four species of baleen whales (Omura's, Bryde's, gray, and sei whales) and at least one toothed whale (sperm whale). A large number of sounds, acoustic occurrence counts, and tracks at both the individual- and species-levels have been assembled by the M3 program. This collection of marine mammal acoustic data includes increasingly detailed whale movement patterns that likely reflect breeding, migratory, and possibly feeding behaviors.

Since 2016, as part of 10-day whale counts at eight different locations, spectral ambient noise levels at four frequencies have also been logged. Observations of these environmental data over time have the potential to reveal the interactions and potential influences of anthropogenic and ambient noise sources on large whale behavior. These collected M3 data and the papers generated based on these data provide the Navy with the necessary baseline information to statistically quantify how baleen whale behavior is affected by various factors, such as ocean basin features, water conditions, seasons, time of day, weather conditions, and ambient noise conditions, as well as specific anthropogenic noise conditions (e.g., seismic profiler, shipping, fishing, naval sonar activities). These baseline data and resultant statistics can be of immense value to the Navy and other Federal agencies to address the issue of potential behavioral effects on marine mammals from exposure to Navy sonars and other anthropogenic noise sources (e.g., seismic surveys and vessels).

The M3 program's collected data are classified, as are the data reports and products created by M3 analysts, due to the inclusion of potentially sensitive national security information in the collected underwater acoustic data. The Navy assesses and analyzes the classified data collected from Navy passive acoustic monitoring systems and continues working to make some portion of the data, including that collected by the M3 program, available to scientists with appropriate clearances, and ultimately to the public after appropriate security reviews. The M3 program has had data declassified that led to the preparation and publication of a scientific paper on swimming fin whales and has provided declassified data on Western Pacific gray whale occurrences to an international scientific group.

## 2.4 Regulatory Compliance Requirements

As noted, the 2019 MMPA Final Rule and LOA (NOAA, 2019) and 2019 ESA ITS for SURTASS LFA sonar training and testing activities (NMFS, 2019) require to continue assessing the classified data collected by the M3 program and work toward making some portion of those data, after appropriate security review, available to scientists with clearances. Any part of the resulting analyses by cleared scientists that are deemed to be unclassified after appropriate security reviews are to be made publicly available.

The Navy is committed to continuing to sponsor acoustic monitoring and data collection on marine mammals using its IUSS fixed and mobile passive acoustic monitoring systems. Additionally, the Navy continues to collect ambient noise data and is committed to exploring the feasibility of declassifying and archiving the collected ambient noise data for incorporation into appropriate ocean noise research efforts.

# 3 M3 2020 PROGRAM TASKING AND ACCOMPLISHMENTS

The tasking and range of data the M3 program collects and compiles has increased yearly over the program's duration, especially as the value of the Navy's underwater bioacoustic data to inform our understanding of the distribution, seasonal movements, and behaviors of baleen and sperm whales has been demonstrated and valued. The following is a synopsis of the 2020 (1 January through 30 October 2020) M3 program tasks and accomplishments. The tasking for the M3 program has been determined by the Navy to meet the monitoring and reporting requirements for the M3 program detailed in the LOA and ITS for SURTASS LFA sonar (NOAA, 2019; NMFS, 2019).

## 3.1 REPORTING

The M3 program has submitted three quarterly (calendar year quarters) reports to date in 2020 and will submit a fourth quarter report at the end of the year. The quarterly reports incrementally detail the tasks and associated work accomplished during each three-month period of 2020. This annual report is the overarching synopsis of the M3 program's annual tasking and accomplishments to date in 2020.

## 3.2 M3 DATA COLLECTION AND ANALYSIS

The majority of the M3 program's tasking is related to the collection, recording, and analysis of acoustic data from IUSS sensors, including the SURTASS HLAs.

### 3.2.1 IUSS Hydrophone Data

As part of the long-term collection of ambient noise data, M3 analysts were tasked with increasing the number of hydrophone recordings from the IUSS sensors. However, systematic recording and archiving of hydrophone data have not been possible since 2019 due to the inoperability of the dedicated data recording and collection system. However, in late 2020, this system has been restored to functionality and hydrophone data from IUSS sensors can once again be collected, recorded, and archived.

### 3.2.2 Anthropogenic Noise Sources

The M3 program tracked and assessed data for only one type of anthropogenic sound source, seismic surveys, thus far in 2020. No naval sonar exercises were identified for the M3 program to assess and no scientific/fishery profiling events were detected by the M3 program. The M3 analysts were able to track a seismic survey during 2020.

Additionally, archived, historical whale tracks have been reviewed to locate examples of interactions with vessels so that M3 analysts can begin to identify and examine potential behavioral reactions of whales to such vessel interactions.

#### *3.2.2.1 Seismic Survey Sources*

One seismic survey profiler was tracked thus far in 2020, with 285 positions comprising the track. The M3 program developed a procedure to export the unclassified relative track data of a seismic profiling vessel and a nearby vocalizing blue whale, including the whale's behavioral metrics (Figure 1). M3 analysts were able to track the seismic profiling vessel for multiple weeks. Ambient noise measurements and whale counts were collected in the vicinity of the seismic profiling vessel. Analysis of this tracking data indicated that the blue whale's vocalization or singing rate[2] was highest and swimming speed was slower when the active seismic profiling vessel was furthest away from the whale; as the profiling seismic vessel closed on the blue whale, its swimming speed increased and singing rate decreased.

### 3.2.3 Marine Mammals

#### *3.2.3.1 Marine Mammal Species-specific Vocalization Patterns and Movement Behaviors*

M3 analysts have continued their analysis of baleen whale vocalization and movement pattern analyses that they began with their assessment of fin whale singing patterns associated with swim speed variations (Clark et al., 2019). M3 analysts have compiled the available swim speed and vocalization data for humpback whales. From the data of 436 tracked humpback whales, M3 analysts calculated the mean swim speed for each singing and non-singing humpback whale. Non-singing humpbacks swam significantly faster than singing humpback whales (3.89 versus 1.70 knots, $F_{(1,850)} = 1196.6$, $p < 0.0001$). This finding is consistent with existing literature (e.g., Frankel et al., 1995; Noad & Cato, 2007). Only humpback whales in "full song" were reported as singing by the M3 analysts. Further analyses are planned. A study of singing humpbacks at the beginning and end of the mating season may provide additional information on the behavior of males transitioning into and out of reproductive condition.

#### *3.2.3.2 SURTASS Large Whale Counts*

Since 2018, the M3 program has monitored SURTASS HLA deployments to document the number of deployments, area of operation, wet array time (i.e., the number of hours the SURTASS HLAs were deployed and collecting data), whale holding hours[3], and marine mammal species detected (or held). Five United States Naval Ships (USNS) vessels are equipped with SURTASS HLAs, while only four of those vessels are also equipped with LFA sonar systems (USNS ABLE, EFFECTIVE, IMPECCABLE, and VICTORIOUS); the USNS LOYAL is the fifth SURTASS vessel.

During 2020, daily monitoring of the deployed SURTASS HLAs revealed thousands of hours of marine mammal detections for at least nine different species, and a total of 12,228 wet hours

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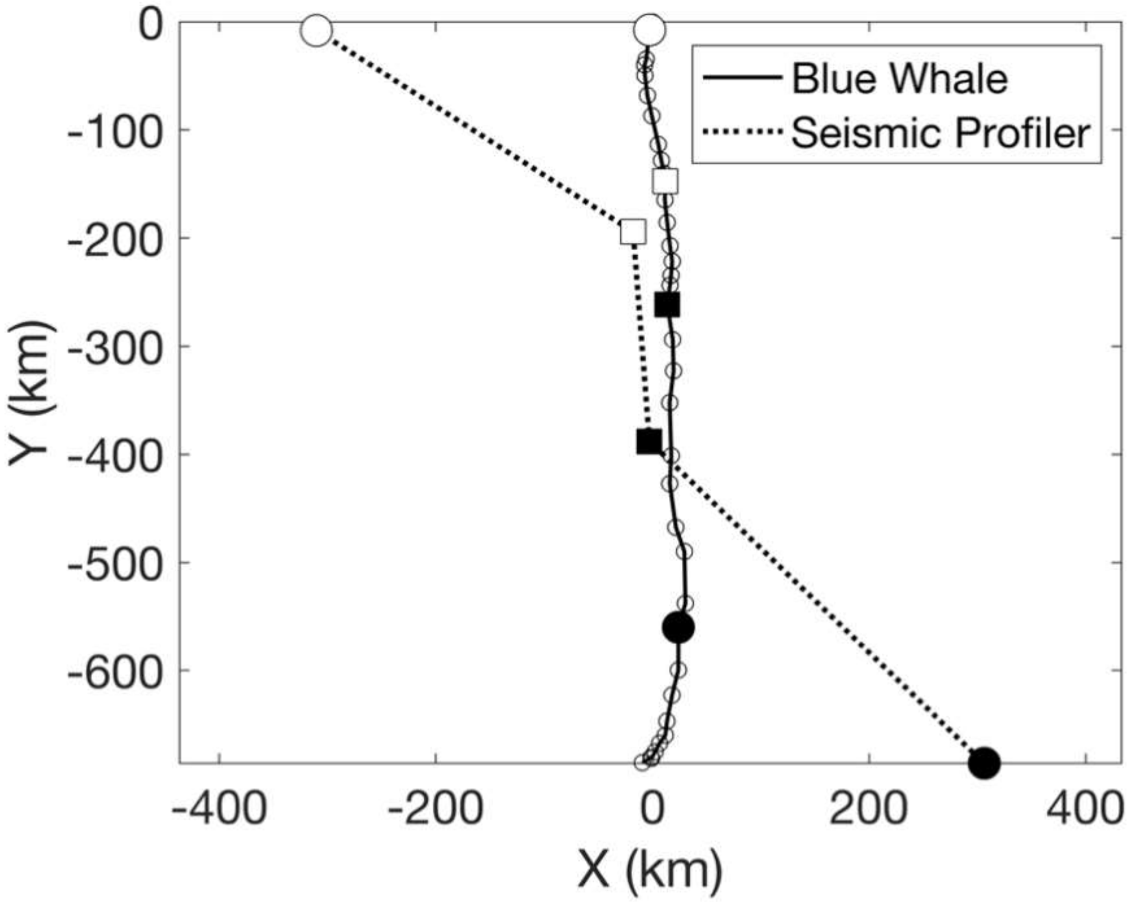
2 Vocalization rate is represented by the number of individual notes a singing whale emits, with a note shown in the collected data as a single frequency sweep and groups of notes forming sequences.

3 "Whale-holding hours" or "whale hours" equal the number of whales held or detected times the number of hours during which the whales were detected. For example, if two fin whales were detected for three hours, the whale holding hours are 6.



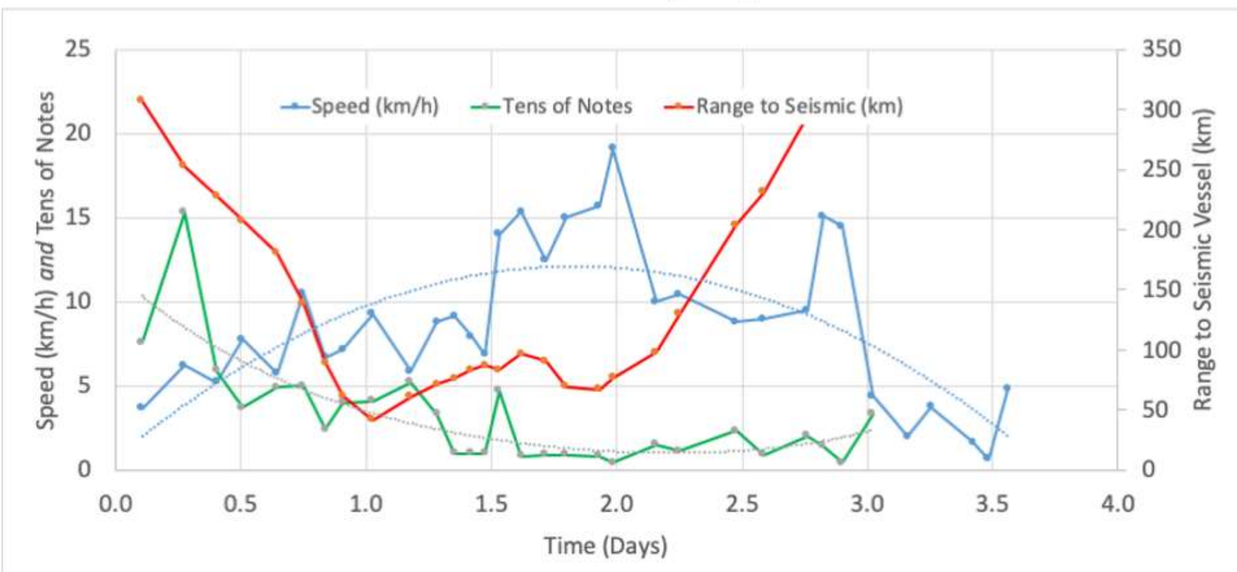




**Figure 1.** ***Top panel*****: Relative positions of a blue whale and a seismic profiler vessel tracked by the M3 program during 2020.** ***Bottom panel*****: Changes in the blue whale's vocalization rate (as indicated by the number of notes in the whales' vocalizations) and swim speed as the seismic profiler vessel approaches and then opens range from the blue whale.**

of SURTASS deployment were documented by M3 analysts, during which a total of 45,555 whale hours were tallied. To protect the national security mission of the SURTASS vessels, each SURTASS vessel has been assigned a random 1 through 5 number, used simply to differentiate the data collected by the M3 program for each vessel.

- **SURTASS Vessel 1**: To date in 2020, SURTASS vessel 1 was deployed to 10 different geographic areas, with M3 analysts documenting 1,701 total hours of array wet time and 1,415 whale hours, during which 219 whales of four different species (humpback, sperm, Omura’s, and Bryde’s whales) were detected.
- **SURTASS Vessel 2**: This SURTASS vessel was deployed to 11 different geographic areas to date in 2020, with M3 analysts documenting 2,587 hours of array wet time and 3,520 whale hours, which represented detections of 556 whales of four whale species (humpback, sperm, Omura’s, and Bryde’s whales).
- **SURTASS Vessel 3**: With deployments to 11 different geographic areas, the SURTASS deployments of vessel 3 resulted in 2,830 hours of array wet time and 13,793 whale hours, with M3 analysts detecting 610 whales identified as seven large and one unknown whale species (sperm, Bryde’s, Omura’s, humpback, sei, blue, fin, and 100-Hertz [Hz] unknown).
- **SURTASS Vessel 4**: To date in 2020, SURTASS vessel 4 was deployed to 11 different geographic areas, during which M3 analysts documented 3,547 hours of array wet time and 20,190 whale hours; 1,109 whales were tallied from seven large whale species (sperm, humpback, Bryde’s, Omura’s, blue, fin, and sei whales).
- **SURTASS Vessel 5**: SURTASS vessel 5 was deployed to seven different geographic areas thus far in 2020, with M3 analysts documenting 1,562 hours of array wet time and 4,636 whale hours, which represented 281 whales identified from four large whale species (sperm, humpback, Bryde’s, and Omura’s whales).

#### *3.2.3.3 North Atlantic Large Whale Counts*

The counts of North Atlantic large whale detected on eight IUSS sensors have been ongoing since 2016. These counts enumerate whales that can be detected on a single sensor for an hour, four times throughout one day every 10 days to capture potential diurnal patterns. The extensive and remarkable dataset of whale counts describe the temporal and spatial trends in abundance of seven cetacean species throughout the North Atlantic Ocean. The ambient noise levels have also been recorded as spectral values at four different frequencies.

Every 10 days during 2020, M3 analysts have conducted counts of seven large whale species detected on eight IUSS sensors (Table 1). This equates to roughly 9 count-days per quarter or 36 count-days per year when large whales are enumerated. On each whale-count day, M3 analysts complete four counts (or one count every six hours) of each of the seven large whale species (blue, Bryde’s, fin, humpback, common minke, sei, and sperm whales). M3 analysts have conducted these whale counts since December 2015, resulting in a wealth of whale demographic data (Figures 2 to 8). Herein, for security purposes, each of the eight IUSS sensors

**Table 1. Total Number of Atlantic Ocean Whales Detected During the Counts Conducted Every 10 Days Between January 1 and October 31, 2020; on Each Count Day, Four Counts of Each of the Seven Large Whale Species Were Conducted.**

| IUSS Sensor | Whale Species | | | | | | | Total Whales Per Sensor |
|---|---|---|---|---|---|---|---|---|
| | Blue | Bryde's | Fin | Humpback | Minke | Sei | Sperm | |
| x114 | 4,051 | 2 | 8,933 | 1,432 | 223 | 137 | 684 | 15,462 |
| x116 | 1,428 | 1 | 9,466 | 942 | 70 | 295 | 1,682 | 13,884 |
| x411 | 1,455 | 0 | 6,744 | 2,694 | 11,979 | 167 | 174 | 23,213 |
| x413 | 1,772 | 199 | 5,347 | 10,927 | 22,323 | 55 | 32 | 40,655 |
| x421 | 2,197 | 0 | 8,475 | 1,559 | 2,617 | 29 | 223 | 15,100 |
| x821 | 3,287 | 0 | 23,108 | 2,471 | 28 | 17 | 798 | 29,709 |
| x1118 | 1,273 | 0 | 2,194 | 338 | 7 | 144 | 103 | 4,059 |
| x8242 | 351 | 0 | 3,073 | 379 | 110 | 12 | 1,285 | 5,210 |
| Total | 15,814 | 202 | 67,340 | 20,742 | 37,357 | 856 | 4,981 | 147,292 |

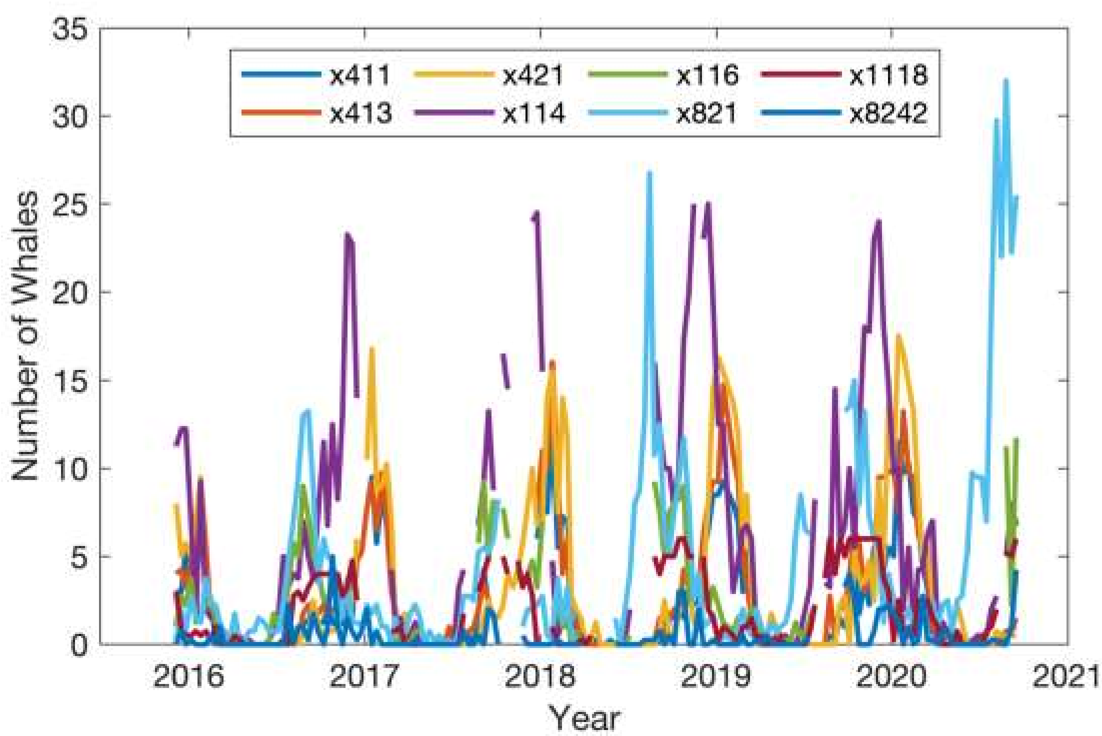



**Figure 2. Number of Blue Whales Counted on Eight Atlantic IUSS Sensors (Colored Lines) Every 10-Days from 2016 Through the Present (October 2020).**

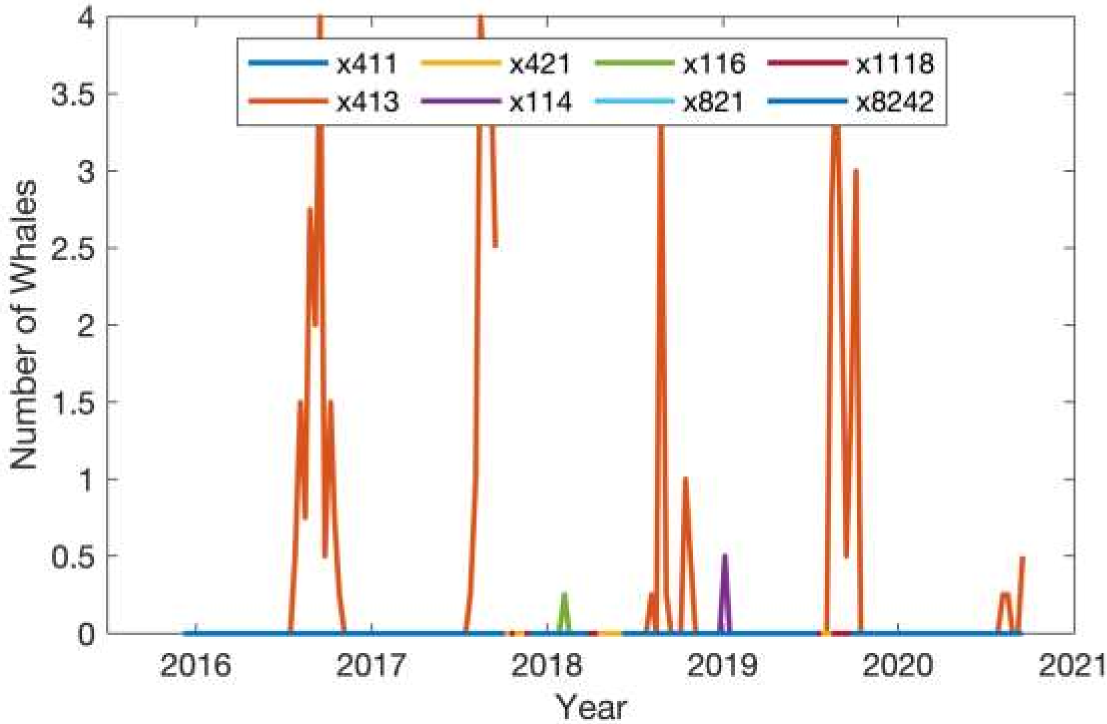



**Figure 3. Number of North Atlantic Bryde's Whales Counted on Eight IUSS Sensors (Colored Lines) Every 10 Days from 2016 Through the Present (October 2020).**

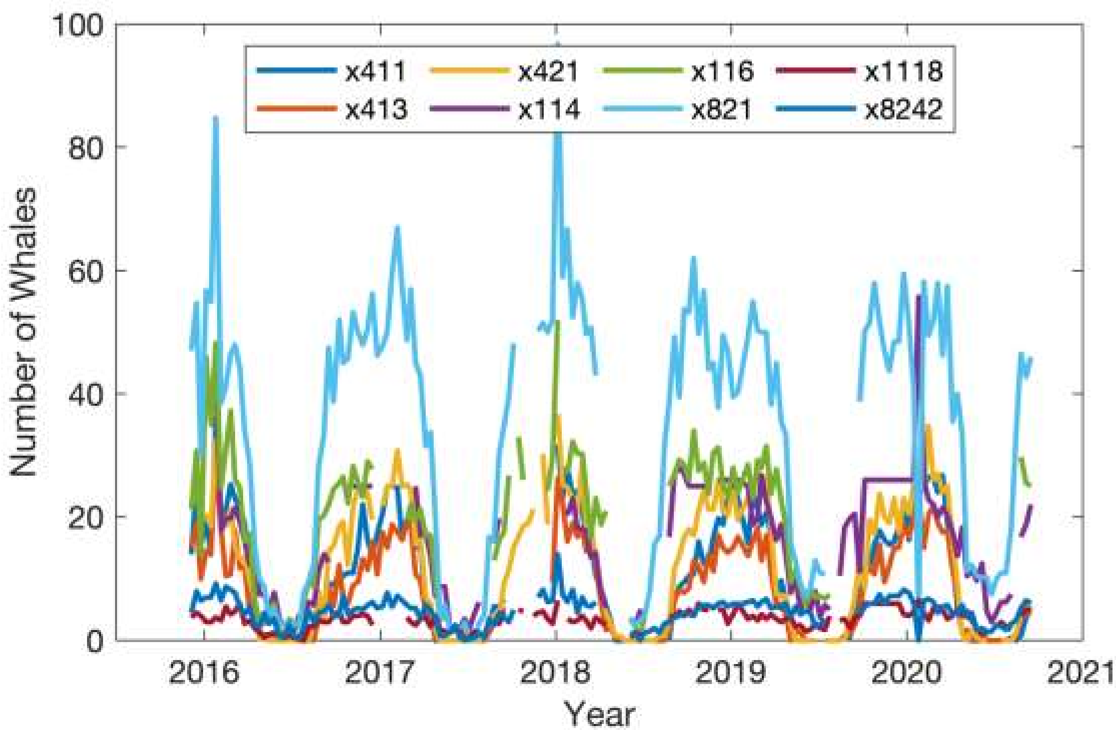



**Figure 4. Number of North Atlantic Fin Whales Counted on Eight IUSS Sensors (Colored Lines) Every 10 Days from 2016 to Present (October 2020).**

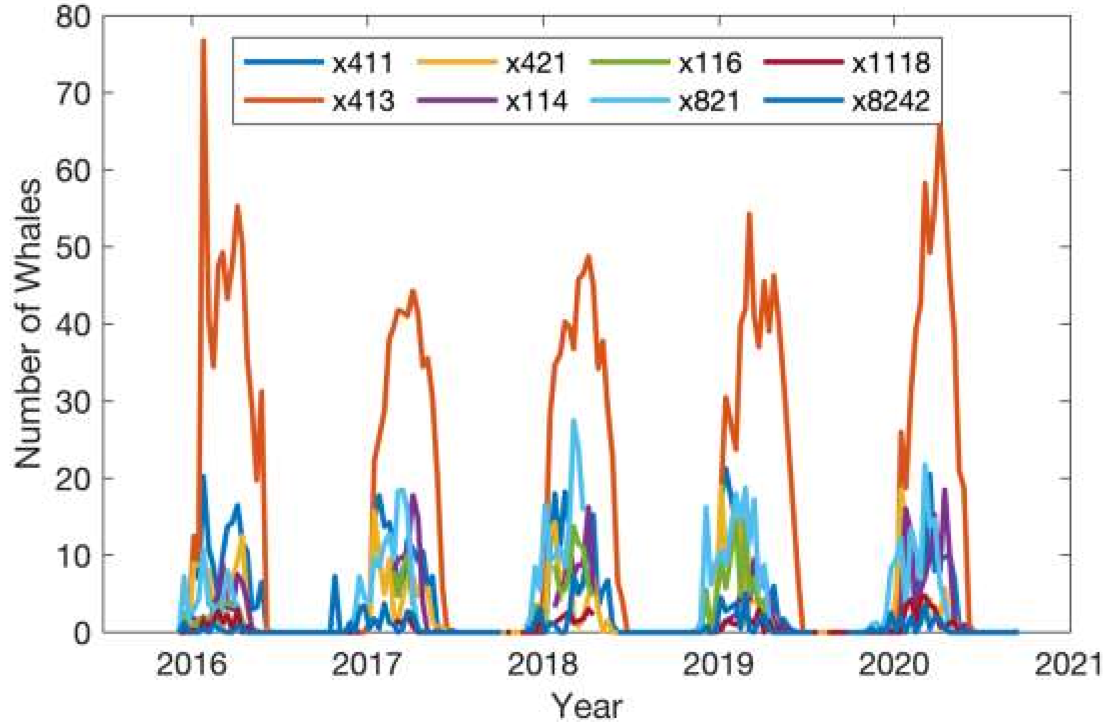



**Figure 5. Number of North Atlantic Humpback Whales Counted on Eight IUSS Sensors (Colored Lines) Every 10 Days from 2016 to Present (October 2020).**

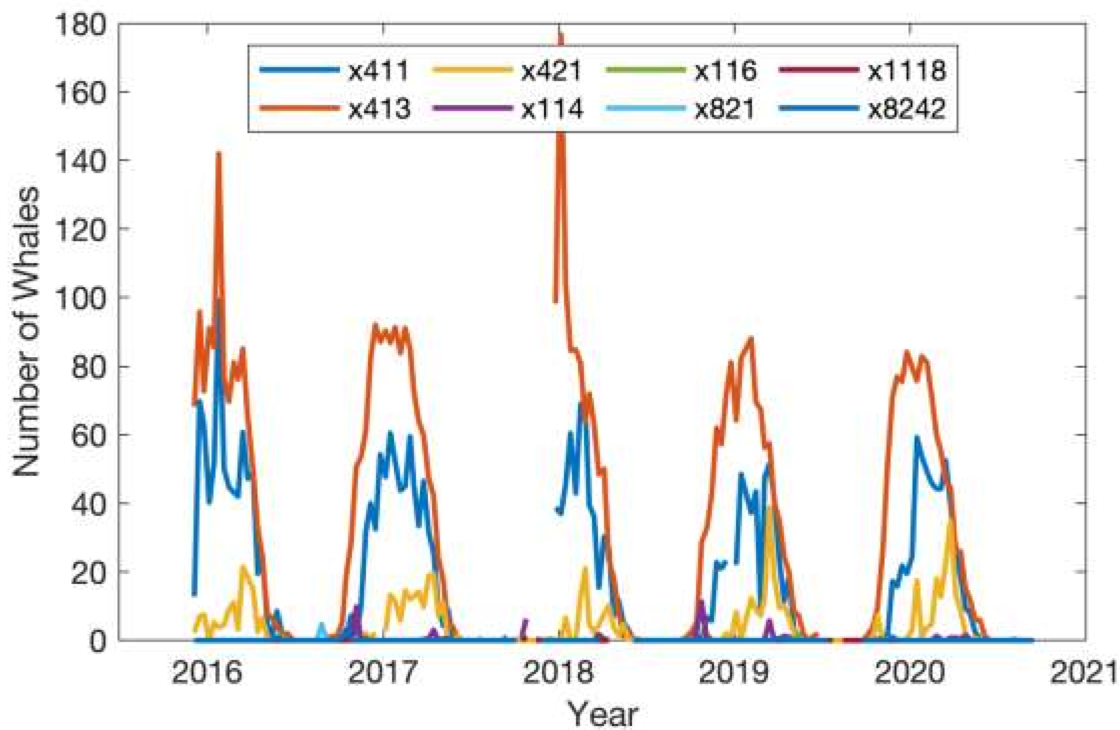



**Figure 6. Number of North Atlantic Common Minke Whales Counted on Eight IUSS Sensors (Colored Lines) Every 10 Days from 2016 to Present (October 2020).**

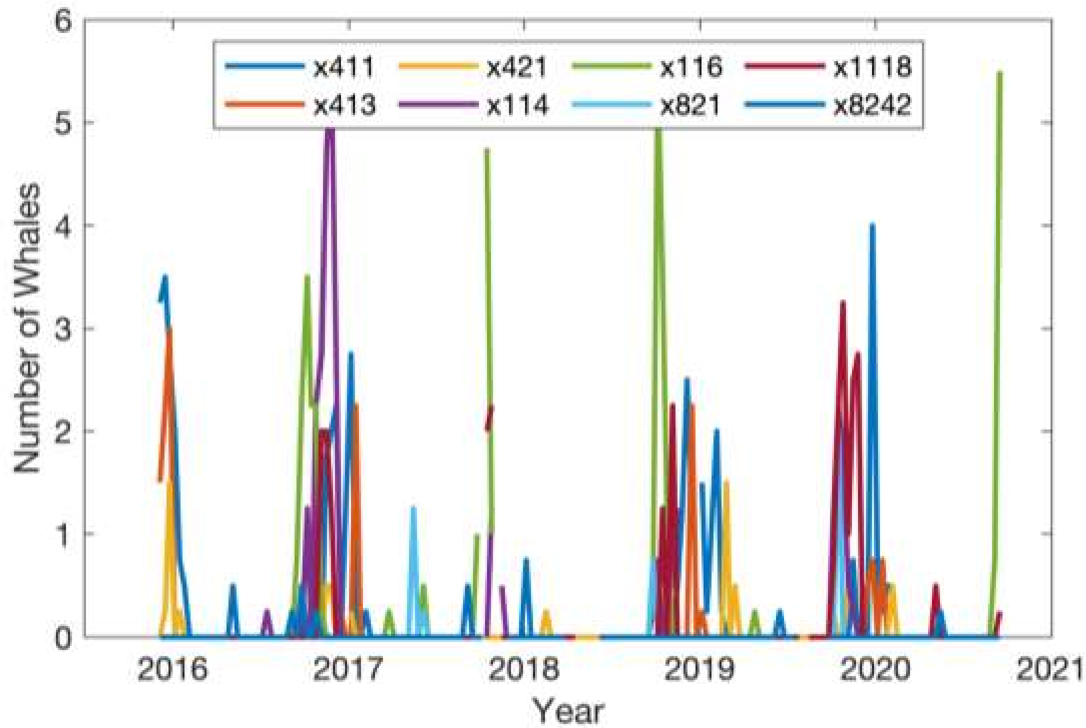



**Figure 7. Number of North Atlantic Sei Whales Counted on Eight IUSS Sensors (Colored Lines) Every 10 Days from 2016 to Present (October 2020).**

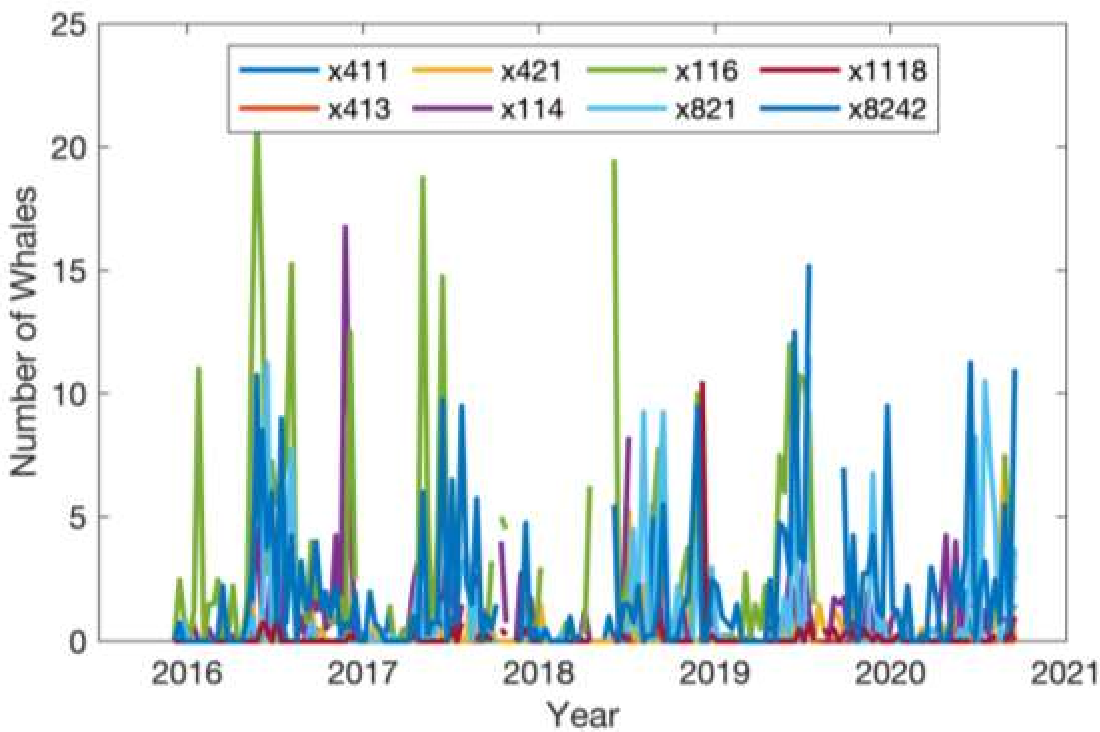



**Figure 8. Number of North Atlantic Sperm Whales Counted on Eight IUSS Sensors (Colored Lines) Every 10 Days from 2016 to Present (October 2020).**

have been assigned a random identification (e.g., x411). To date during 2020, M3 analysts have counted a total of 147,292 North Atlantic large whales representing seven species (Table 1).

- **Power Analysis**

The collection of North Atlantic large whale counts three-times/month, together with ambient noise levels at four different frequencies represents a valuable dataset, but the amount of time needed to collect these data is considerable. A simulation analysis was conducted to evaluate the potential effects of reducing the number of whale count data collected. The first step in the analysis was the assessment of each species separately. The number of counts for each species (count) was the dependent variable. The predictor variables included the hydrophone sensor (station), the date, and the hour of data collection. A Generalized Additive Model (GAM) was used to examine the data. When all seven species were analyzed separately, the variables of station and date were always highly statistically significant, while hour of the day was not. Therefore, the remainder of the analysis focused on reducing the number of counts within a day as opposed to reducing the number of counts within a calendar year.

The next step in the power analysis of large whale counts was to produce the daily mean counts for each hydrophone station using data for:

1) Four whale counts per day
2) A single count per day at each of four time periods: 0000-, 0600-, 1200-, or 1800-hours (or four single counts per day)
3) Two whale counts per day, with one set at times 0000 and 1200 hours and the other at 0600 and 1800 hours.

The resulting mean counts were analyzed using similar GAMs, with predictor values of station and date. The amount of deviance explained by each model was noted (Figure 9). For the plentiful species such as blue, minke, fin, and humpback whales, the difference in the amount of deviation explained does not vary greatly between the different analysis models. For sei, sperm, and Bryde's whales, the variation between the single count results is greater. However, the differences in the deviation explained between models using all count data and the models that relied on only two counts per day appears to be both minimal and stable across species. Therefore, based on this conclusion, the recommendation is that the number of whale-counting periods be reduced from four per day, every 10 days, to only two counts per day, every 10 days. Thus, the number of recommended whale-count days per quarter would remain nine, but the number of North Atlantic large whale counts per quarter would decrease from 36 to 18. While this reduction in data collection is regrettable, the amount of M3 analyst time made available for other tasking is significant.

#### *3.2.3.4 Large Whale Tracks and Recordings*

During 2020, M3 analysts identified and archived numerous recordings and developed thousands of tracks for North Atlantic blue, Bryde's, fin, humpback, minke, sei, and sperm

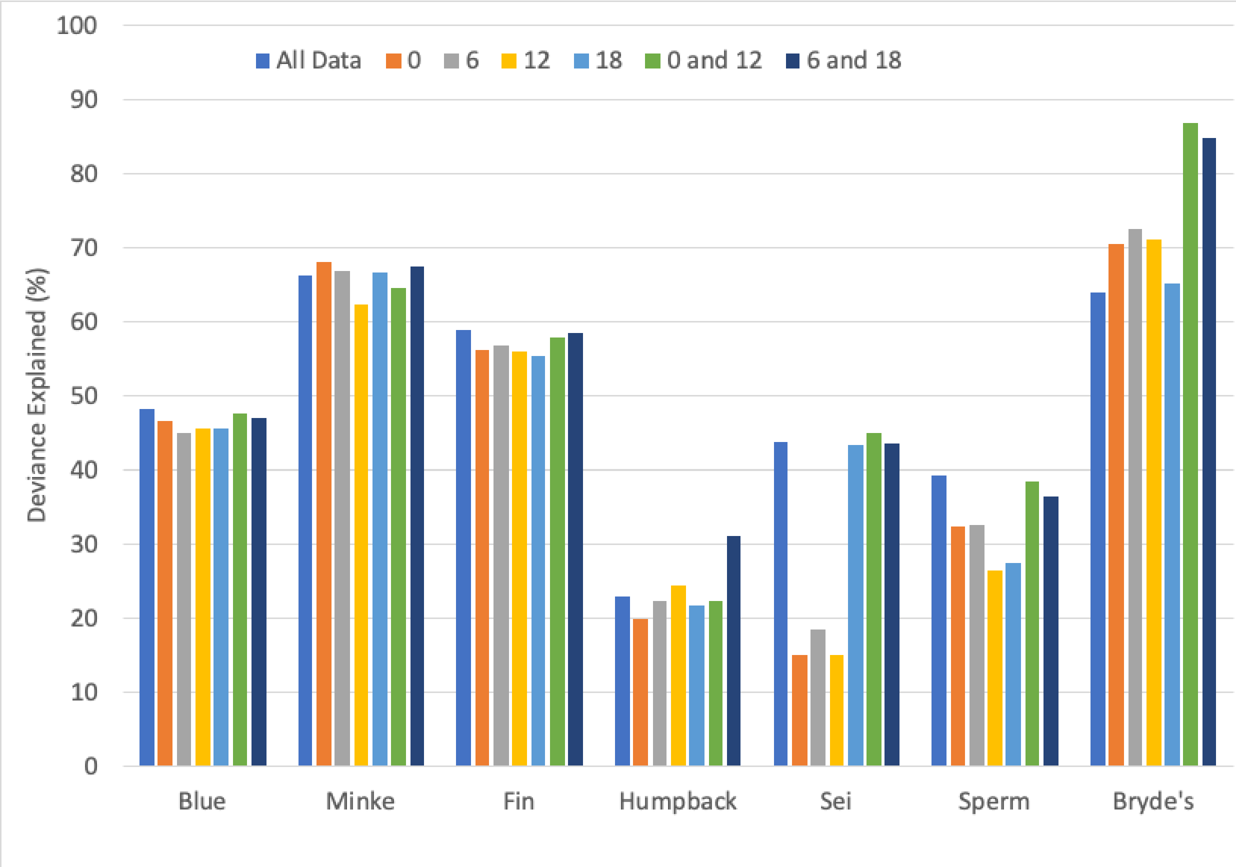



**Figure 9. The amount of deviance explained by GAMs for the analysis of the number of whales detected as a function of hydrophone, station, and date. Results are presented separately for each of the seven large whale species included in the analysis. Within the results for each whale species, the bar furthest left (medium blue) represents the mean values for the four daily whale counts (at four times: 0000, 0600, 1200, and 1800 hours). The next four bars represent analyses run on a single whale count per day (each at one of the time periods). The last two bars (green and navy blue) for each whale species represent analyses run on a mean of two counts per day (one count at times 0000 and 1200 hours and the second count at times 0600 and 1800 hours). Note that the values plotted are the deviance explained by the analyses, not the means themselves.**

whales using the TAPP (Tactical Acoustic Intelligence Products Program). These TAPP recordings and tracks include: 1) songs (blue, fin, humpback, and minke whales); 2) calls (blue, Bryde's, fin, humpback, minke, and sei whales); and 3) foraging clicks (sperm whales) that were recorded throughout 2020.

The recordings and tracks add to the extensive collection amassed from a wide variety of locations and range of behavioral contexts (e.g., foraging during the summer in areas of high prey productivity, migrating movements, or meandering travel throughout an area for weeks at a time). More detailed information follows on the number of recordings and track by species made to date (October) in 2020.

- **Humpback Whales**

To date in 2020, M3 analysts collected 985 acoustic tracks and 4,282 positions of humpback whales in the North Atlantic Ocean (Table 2), focusing on swimming speeds while the whales were and were not singing.

- **Sei Whales**

During calendar year 2020, M3 analysts collected 449 acoustic tracks and 2,974 positions of North Atlantic sei whales (Table 2). These tracking reports provide valuable information on the annual movements, behaviors, vocalizations, and distribution of this rarely observed, largely oceanic baleen whale, Given that the distribution of the sei whale is poorly understood, they are visually difficult to differentiate from either Bryde's or fin whales at sea, exhibit unpredictable occurrence patterns, and occur principally in oceanic regions with only rare occurrence in neritic[4] waters (Jefferson et al., 2015). M3 analysts have refined the process to distinguish sei whale acoustics (most likely calls and not songs) from other vocalizing baleen whales that sometimes emit similar sounds.

- **Blue Whales**

M3 analysts collected 528 acoustic tracks and 5,353 positions of North Atlantic blue whales during 2020. In the North Pacific Ocean, 3 blues where tracked, and 266 positions recorded (Table 2). The capability to acoustically track individual blue whales over long distances provides valuable information on individual whale movement, reproductive behavior, and song variability.

- **Fin Whales**

To date in 2020, M3 analysts have collected 605 acoustic tracks and 3,202 positions of North Atlantic fin whales (Table 2). Several singing fin whales, whose songs had very distinctive features, were detected and tracked over many days. Preliminary analysis of the large dataset and resultant analysis of fin whale singers in the North Atlantic Ocean suggest that no specific breeding area for fin whales exists in the North Atlantic Ocean and that fin whales may breed opportunistically both temporally and spatially.

- **Blue/Fin Presumed Hybrid Individuals**

Six acoustic tracks of four individual whales that are believed to represent hybrid blue/fin whales were tracked in the North Atlantic Ocean with an associated 385 total positions (Table 2). These animals have individually distinct acoustic signals that exhibit characteristics of both typical fin and blue whale signals.

4 The neritic zone is the shallow marine environment extending from mean low water down to about 660-feet (200-meter) water depths that generally corresponding to the continental shelf.

**Table 2. Acoustic Tracks and Geographic Positions of Large Whale Species Detected by the M3 Program from January through October 2020.**

| *2020 Quarter* | | *Acoustic Tracks* | | | | | | *Geographic Positions* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Marine Mammal Species** | *HW* | *SW* | *BW* | *FW* | *SP* | *HYW* | *HW* | *SW* | *BW* | *FW* | *SP* | *HYW* |
| Quarter 1: | North Atlantic Ocean | 857 | 21 | 136 | 191 | 47 | | 3,652 | 117 | 1,957 | 1,117 | 3,652 | |
| Quarter 2: | North Atlantic Ocean | 115 | 46 | 63 | 161 | 209 | | 570 | 278 | 412 | 875 | 1,631 | |
| Quarter 3: | North Atlantic Ocean | 2 | 275 | 250 | 170 | 194 | 4 | 12 | 1,733 | 2,178 | 776 | 1,540 | 236 |
| | North Pacific | | | 3 | | | | | | 212 | | | |
| Quarter 4: (October) | North Atlantic Ocean | 11 | 107 | 79 | 83 | 38 | 2 | 48 | 846 | 806 | 434 | 260 | 149 |
| **Totals (through October 2020)** | | 985 | 449 | 531 | 605 | 488 | 6 | 4,282 | 2,974 | 5,565 | 3,202 | 7,083 | 385 |

* HW=humpback whale; SW=sei whale; BW=blue whale; FW=fin whale; SP=sperm whale; HYW=presumed hybrid blue/fin whale

- **Sperm Whales**

In the North Atlantic, 488 acoustic tracks and 7,083 positions of sperm whales were collected during 2020 (Table 2). Sperm whale clicks were originally thought to be too high in frequency to be detected by IUSS assets, but M3 analysts have concluded that the energy in the lower-frequency bands of sperm whale clicks enable the impulsive, high-intensity sperm whale sounds to be very detectable when they the whales are relatively close to an IUSS sensor.

- **Other Baleen Whales**

No Western Pacific gray whales were detected during 2020. Omura's and Bryde's whales were detected by the eight IUSS sensors during the 10-day counts of North Atlantic large whales but no tracks were generated.

- **Detailed Tracks of Unique Target Whales**

M3 analysts continue to recognize individual, unique whales in the North Atlantic and the North Pacific oceans. Some of these whales have been tracked over a period of at least four years, sometimes as these large baleen whales travel great distances across the ocean basin. These include four nominal blue/fin hybrids in the North Atlantic Ocean as well as the "gap" and "no-gap" whales in the North Pacific Ocean.

#### *3.2.3.5 Acoustic Communication Between Individual Whales*

M3 analyst, Chuck Gagnon, noted and reported the existence of 'chevrons' in fin and sei whale tracks. These chevron tracks show two acoustically active whales approaching each other in space and time. When the two vocalizing whales are in proximity to one another, their observed vocal activity ceases. These unique observations are evidence of the valuable information and insights the M3 program can provide about normal marine mammal communication behavior (e.g. empirical evidence as to the ranges over which acoustic communication occurs. They also provide information on the signal excess required in real-world ocean environments to detect or observe normal social behavior, as well as the potential for anthropogenic activity to mask whale signals and disrupt communication behavior. Observations of these types of chevron whale tracks should be prioritized for further data collection and reporting, with the goal of ultimately publishing these very important insights

Based on the details of fin whale and sei whale chevron tracks as well as the sensor(s) used to record their acoustic signals, the M3 team worked together to model the transmission loss, and thus the detection range and communication behavior between pairs of fin whales and pairs of sei whales. M3 program analysts are working toward getting these acoustic data released or declassified for further analysis and eventual scientific publication.

### 3.2.4 Database Compilation

A new M3 task for 2020 was the creation of a database of songs and calls that included acoustic file examples of each call or song type to enable the documentation of the diversity and variation of calls within species. M3 analysts have worked during this year to compile short example acoustic files recorded from the TAPP system of various large whales, including the hybrid whales and idiosyncratic or unique individual whales that M3 analysts have recognized and followed, some over years. Creation of the call/song database is the next step now that the exemplar acoustic files have been compiled.

M3 analysts continued to populate a new Whale Count and Track database during 2020 that includes tracks and counts of as many as eight large whale species from the North Pacific and Atlantic oceans. This database makes data retrieval and analysis much easier and more efficient. For example, the graphics in this report of the North Atlantic whale counts and ambient noise levels were produced from the track database. Additionally, although the M3 team identified the need for an acoustic database that includes information such as a source's duty cycle, no progress has yet been made to develop this database.

### 3.2.5 Ambient Noise Data Collection and Archival

A long-standing MMPA LOA and Final Rule monitoring and reporting requirement for SURTASS LFA sonar is the collection of underwater ambient noise data from IUSS sensors with the Navy's consideration of the feasibility of declassifying the collected and archived and ultimately making some portion of the data publicly available for input into global ocean noise budgets. The majority of IUSS ambient noise data are cross-spectral matrix (CSM), data which are classified as they may contain national security as well as environmental information. The Navy continues to consider the feasibility of eventually making some portion of these data available.

Due to this ongoing interest and in acknowledgment of the scientific need for additional ocean ambient noise data, M3 analysts have derived ambient noise trend information from the TAPP data collected for their routine whale counts and tracks. As such, North Atlantic ambient noise levels in four frequency bands have been measured every 10 days from eight IUSS sensors since January 2016 (Figures 10 to 17). Note that similarly to the whale count data presented in Section 3.2.2.3 of this report (Figures 2 through 8), for national security purposes, the eight IUSS sensors represented in the ambient noise data have been assigned a random identifier code. Also note that the amplitude values for the ambient noise data are spectral values reported by the Integrated Common Processor (ICP[5]) (1 Hz bandwidth). These unclassified data have not been corrected for any signal processing procedures that are incorporated into the ICP system. Therefore, the values are reported as decibels (dB)/Hz since the absolute values are not known.

The nearly five years of compiled ambient noise data show an annual cycle in ambient noise levels, notably with ambient noise levels dropping from winter to spring. Also notable is that since February 2020 when commercial shipping and recreational cruise travel restrictions related to the COVID pandemic began, the deep ocean ambient noise levels appear to be

5 The Integrated Common Processor (ICP) has the capability to process and display data from all IUSS fixed and mobile underwater systems, taking advantage of automation advancements, array technology improvements, hardware insertions, and the common software components of the Navy's submarine and surface undersea warfare systems.

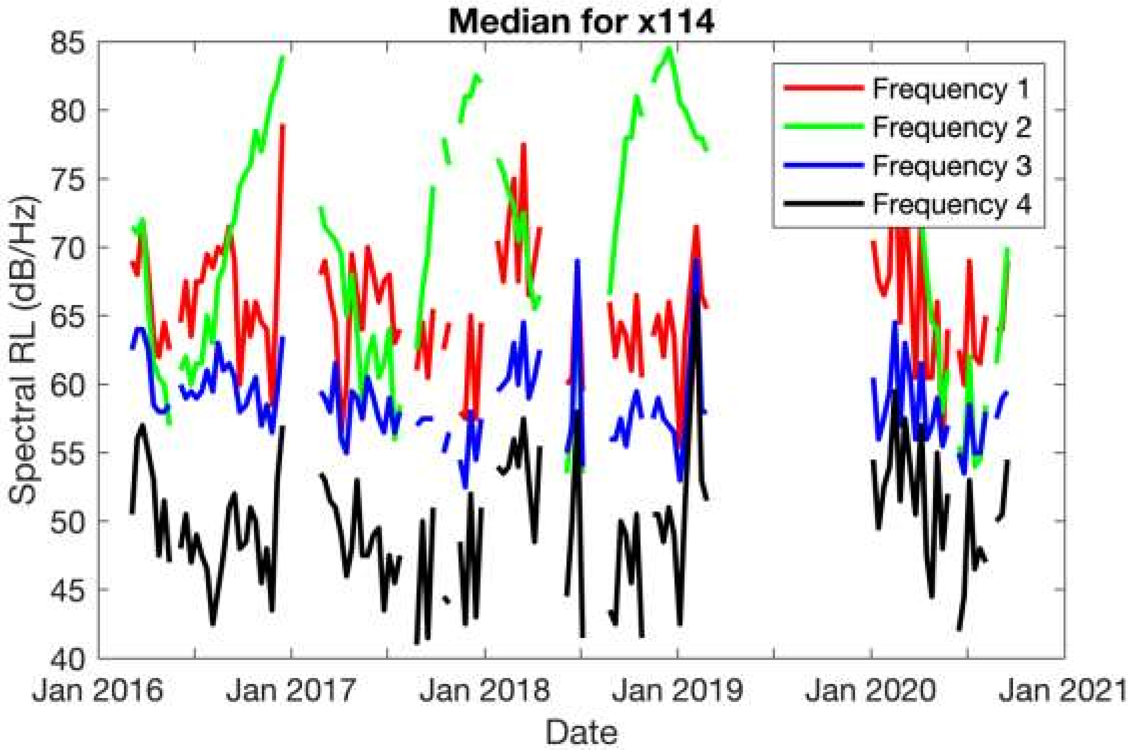



**Figure 10. Trends in the January 2016 Through October 2020 Median Ambient Noise Data at IUSS Sensor x114.**

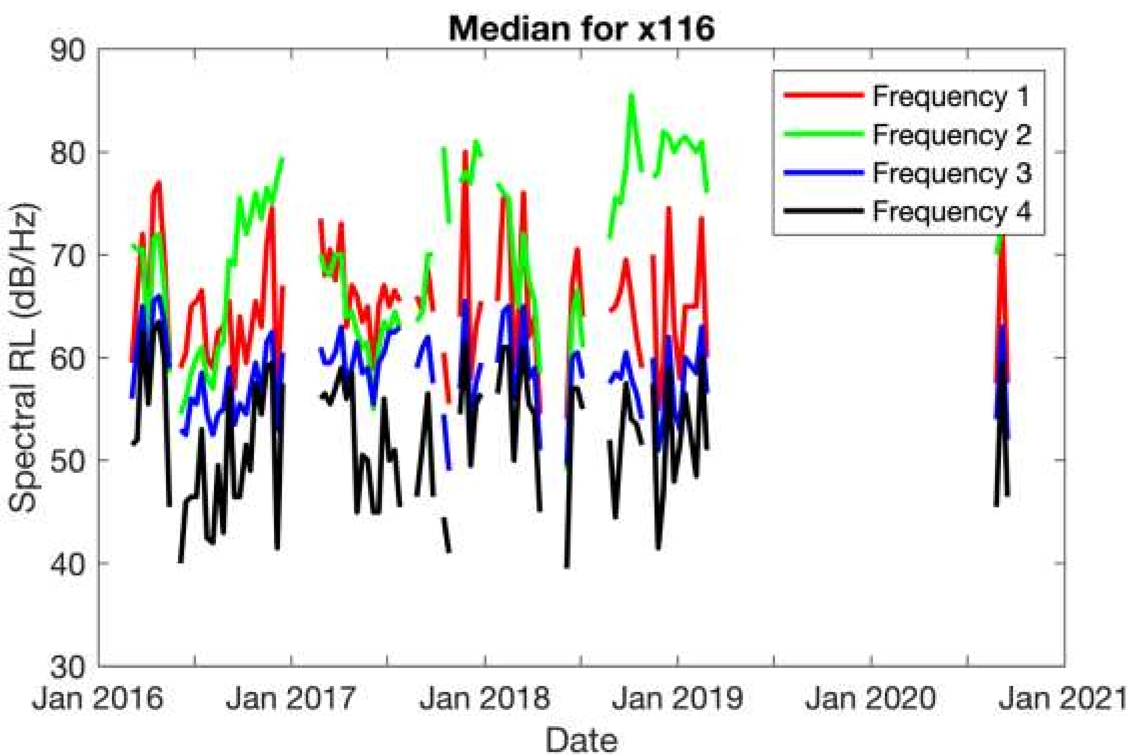



**Figure 11. Trends in the January 2016 Through October 2020 Median Ambient Noise Data at IUSS Sensor x116.**

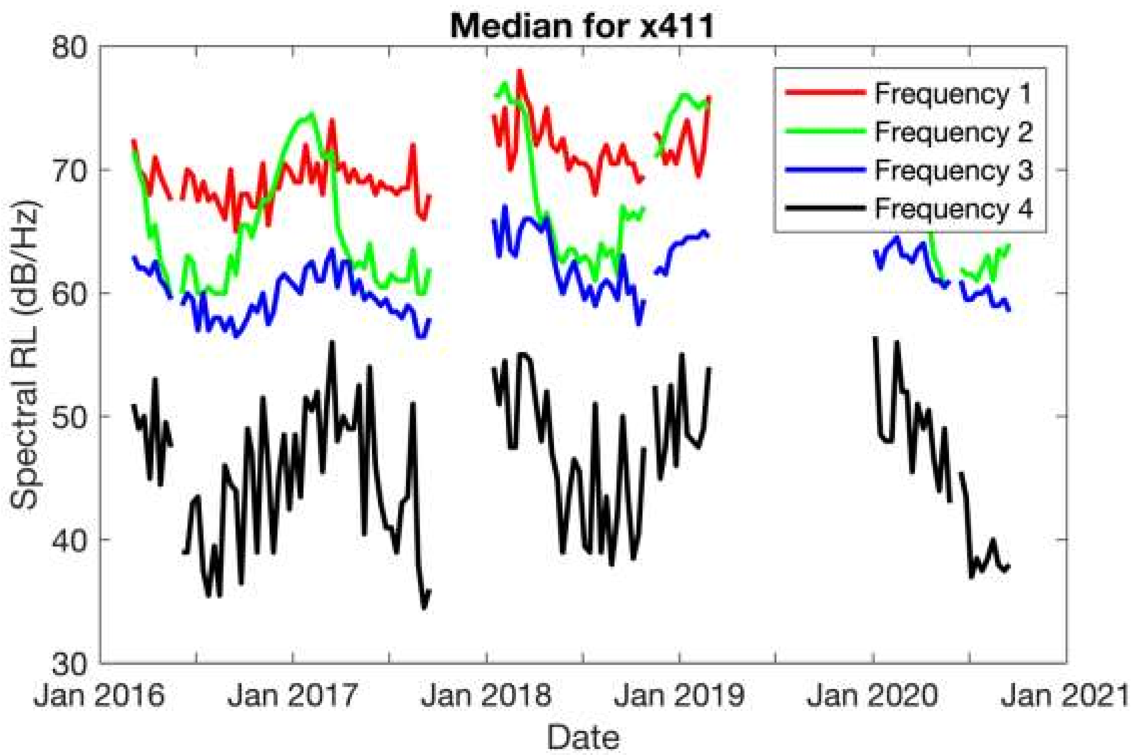



**Figure 12. Trends in the January 2016 Through October 2020 Median Ambient Noise Data at IUSS Sensor x411.**

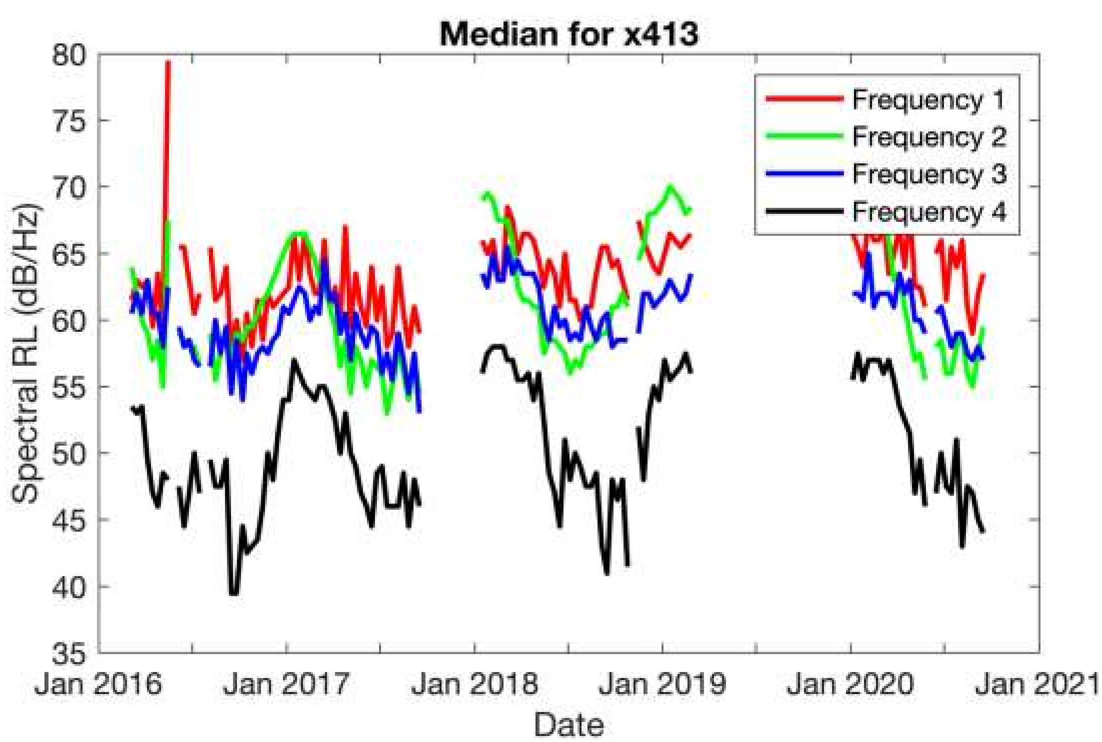



**Figure 13. Trends in the January 2016 Through October 2020 Median Ambient Noise Data at IUSS Sensor x413.**

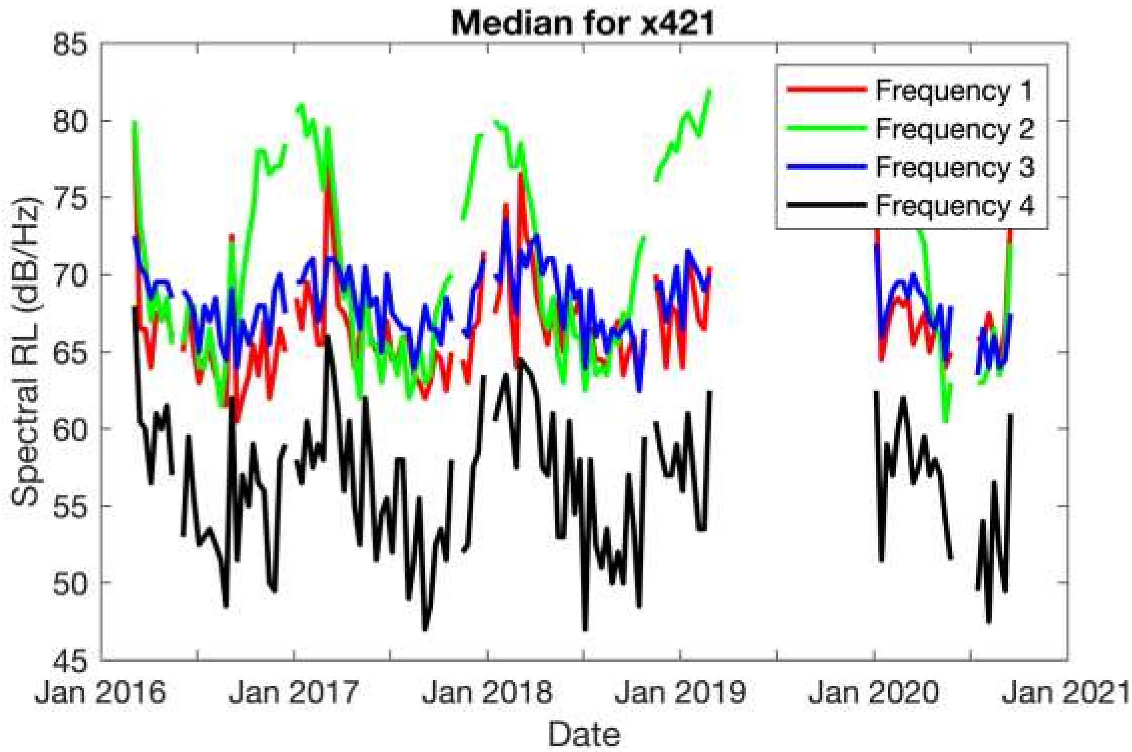



**Figure 14. Trends in the January 2016 Through October 2020 Median Ambient Noise Data at IUSS Sensor x421.**

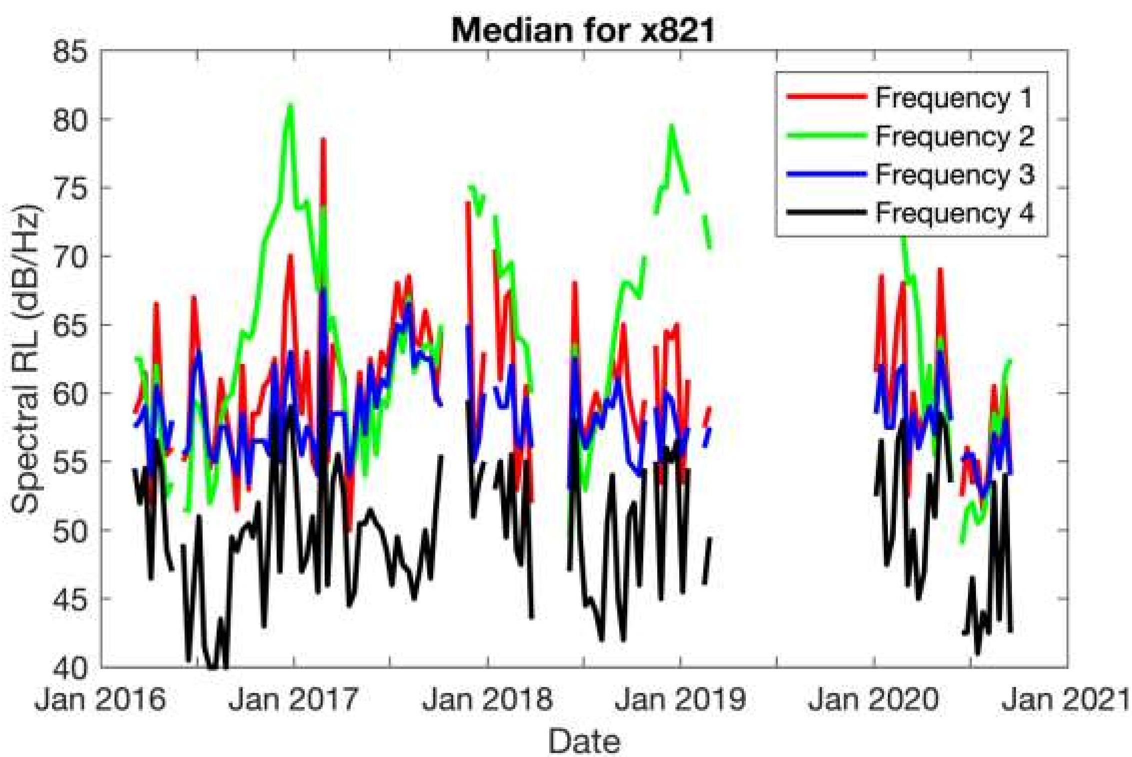



**Figure 15. Trends in the January 2016 Through October 2020 Median Ambient Noise Data at IUSS Sensor x821.**

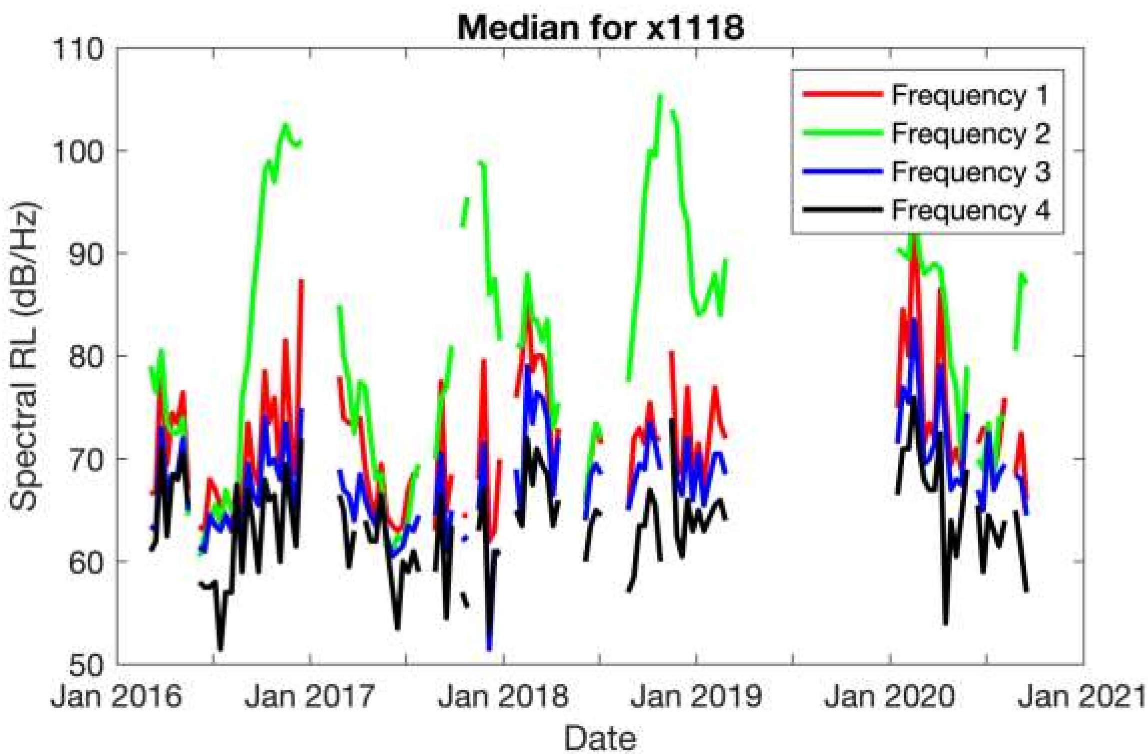



**Figure 16. Trends in the January 2016 Through October 2020 Median Ambient Noise Data at IUSS Sensor x1118.**

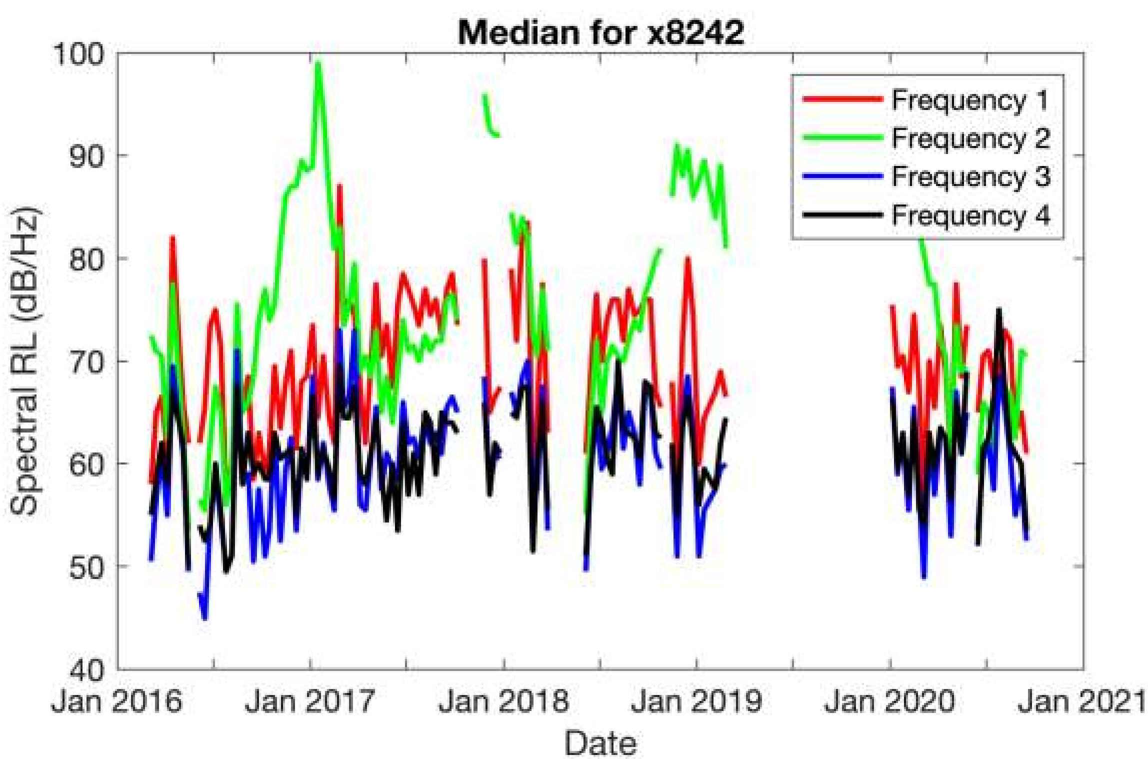



**Figure 17. Trends in the January 2016 Through October 2020 Median Ambient Noise Data at IUSS Sensor x8242.**

unchanged from previous levels. This contrasts the widely reported decreases in ambient noise levels in near-shore waters during the COVID pandemic.

### 3.2.6 NEPTUNE Data

Oceans Network Canada's North East Pacific Time-series Underwater Networked Experiments (NEPTUNE) is the largest of its cabled ocean observatories. Located in the northeastern Pacific Ocean off Vancouver Island, British Columbia, Canada, the NEPTUNE ocean observatory consists of five nodes in an 840-km loop of fiber optic cable on the seafloor that span a wide range of ocean environments, from the coast to deep ocean hydrothermal vent environments. Each node is instrumented with a diverse suite of sensors that enable researchers to study interactions among geological, chemical, physical, and biological processes (Ocean Networks Canada, 2020).

The acoustic data collected by the NEPTUNE observatory are freely available from Oceans Network Canada. The acoustic data can be processed online, or raw .wav files can be downloaded. The M3 team has begun building a list of NEPTUNE hydrophones and associated data availability. Data from NEPTUNE sensors have been used to examine trends in ambient noise data (Thomson and Barclay, 2020).

## 3.3 SCIENTIFIC PUBLICATIONS

Three scientific manuscripts based on M3 data are in progress. The 2016 Marine Mammal Acoustic Pilot Project (MMAPP), for which the M3 program was originally funded by N45, produced a deliverable report. This final report is being updated and re-formatted to prepare it, along with updated data analysis, into a manuscript suitable for submission to a peer-reviewed scientific journal for publication, pending security review.

A second manuscript on the occurrences and movements of Western Pacific gray whales has been outlined and M3 data are being reviewed. Additional independent recordings of Western Pacific gray whales having been requested and received from non-navy sources to amplify the underlying data analyzed in this paper. Additionally, Eastern Pacific gray whale recordings have been downloaded from the Macaulay and Watkins Sound Libraries for comparison with the M3 and other non-navy recordings of Western Pacific gray whales.

The initial steps for a third manuscript, based on humpback whale swimming speeds and related acoustic behavior, such as singing, has begun. M3 analysts have compiled their available humpback whale swim speed and vocalization data from 436 tracked humpback whales. Preliminary analyses of swimming speeds and singing rates are consistent with published literature, but further analysis is needed before any conclusions can be reached.

## 3.4 ACCESSORY TASKS

### 3.4.1 IUSS Sensor Health Checks

M3 analysts conducted daily health checks of the IUSS sensors from which data are collected. The health checks were conducted using the ICP LOFARgrams and Raven software[6] spectrograms of single-hydrophone data. These displays were used to assist the analysts in identifying various IUSS equipment casualties that were not recognized by NOPF operations or maintenance personnel. M3 analysts assisted with the generation of casualty reports on the IUSS equipment casualties identified by the M3 program.

### 3.4.2 Acoustic Display Review

Multiple acoustic displays are reviewed daily (hundreds of thousands over the year) to detect and enumerate the acoustic occurrences and identity of acoustically active marine mammals as well as to identify other unique acoustic phenomena, which were often assumed to be biological.

# 4 M3 PERSONNEL STATUS

The senior M3 analyst, Chuck Gagnon, has chosen to bring his lengthy and illustrious career as a Navy and M3 sonar acoustics expert and submarine and whale tracker to a close. Chuck intends to retire as soon as a replacement can be trained to take over his M3 program tasking, likely in the first half of 2021. A qualified replacement has been identified and is slated to begin working with the M3 program in December 2020.

# 5 FUTURE GOALS OF M3 PROGRAM

Several M3 program plans are infra-structure related, with hardware and software upgrades, an extension of the NOPF building, and the acquisition of additional equipment being top priorities. An expansion and augmentation of the M3 program would be highly valuable, as an expanded capability would facilitate the transition into the scientific community the vitally important data and information on marine mammal movements, distributions, and bioacoustic behaviors that the M3 program has derived from the Navy’s IUSS sensors.

The following are immediate and long-term goals of the M3 Program:

- Increase the number of single-hydrophone inputs and upgrade the Raven software acquisition system to enable recording from one hydrophone for every available IUSS sensor, with the capability of adding additional sensors. This upgraded software and hardware was developed and is already located at Dam Neck NOPF but is currently non-functional to capture single-channel data due to an unresolved software problem

6 Raven is a software program for the acquisition, visualization, measurement, and analysis of acoustics signals.

regarding the storage drives. MAI has brought this issue to the Navy's attention with a request for resolution.

- Expand the collection of movement information on sperm whales. M3 analysts have recently noted that individual sperm whale tracks can be refined to a degree where each whale within a group can be plotted, potentially depicting the spatial foraging requirements of individual whales during migrational movements.
- Use the upgraded NOPF APADS for storage of all CSM data. NOPF APADS was to have been delivered to the M3 program in 2019 but has not arrived. MAI has brought this issue to the Navy's attention with a request for resolution.
- Expand data collection and analysis to include calibrated measurements of received levels of species-specific whale sounds and the calculation of the source levels of individual whale sounds as well as detection ranges. These data are part of the input needed to derive probability of detection functions for passive bioacoustic data. These metrics are essential inputs for estimating acoustic population densities and documenting species-specific sound production rates. Whale density estimates are critical for quantifying the impact of anthropogenic sound on marine mammal populations and stocks.
- Expand data collection and analysis to include calibrated measurements of anthropogenic noise sources (e.g., surface vessels, seismic airgun surveys, fishery/scientific profilers, and naval sonar exercises). This expansion would include calculations of received levels, source levels, and spatial-temporal dynamics of the resultant acoustic environments (i.e., acoustic footprints) generated by different anthropogenic sources under various oceanographic conditions.
- Complete upgrade of the old single-hydrophone Raven acquisition system into the new M3 program space.
- Work within Navy security classification guidelines to have data declassified for inclusion in reports documenting the M3 program's scientific findings with the ultimate goal of submitting these reports/papers for publication in peer-reviewed scientific journals.

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