FINAL REPORT

Proof-of-concept for off the shelf technology to identify acoustic signature to detect presence of manatee(s)

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EXECUTIVE SUMMARY

Lampl Herbert Consultants (LHC) was one of six contractors selected to receive a grant from the Florida Manatee Avoidance Technology Grant Program. Lampl Herbert Consultants' proof-of-concept project was awarded under the category entitled "Technology designed to alert boaters to the presence of manatees to enable boaters to avoid manatees without changing the behavior of the animals."

The project mission was to develop a passive listening system that included signal recognition software to detect manatee vocalizations utilizing a commercially available hydrophone and a portable computer.

The manatee detection algorithm included signal-processing schemes for filtration, spectral analysis, normalization, and noise shrinkage. After these initial signal-conditioning tools were utilized, a rule-based system is used to score the harmonic structure of the signal to determine the presence of manatee. The software should receive signals sampled at or above 44.1 kHz with 16 bits or performance will be significantly reduced. Frequencies up to approximately 18 kHz are utilized.

The field acquisition system was based on a single 6050C ITC hydrophone (30 Hz to 75 kHz) and a small computer. Data was read into the computer though a microphone input and digitized by the computers built in sound card analog to digital converter (ADC) at 44.1 kHz with 16-bit mono. The primary software development tool to process field data was MATLAB. The MATLAB Data Acquisition Toolbox was used to collect the data from the computers sound devise.

The field demonstration was performed in the water behind the Florida Marine Research Institute in St. Petersburg, Florida. Manatee recordings were amplified and transmitted by USF owned hardware. Receive hydrophones were placed in the water at ranges of five and then ten meters. During the field demonstration, the algorithm performed well with both the data provided by Dr. Tom O'Shea and the test data produced by USF. The demonstrated capability of detection in adverse ambient noise environments provides optimism toward system capabilities in real-world very high noise environments. This technology study indicates that manatee detection with very low false alarm rates should be obtainable.

Proof-of-concept for off the shelf technology to identify acoustic signature to detect presence of manatee(s)

INTRODUCTION

In 2001, the Florida Legislature appropriated $200,000 in the Marine Resources Conservation Trust Fund (MRCTF) to fund research projects that directly address the problem of collisions between manatees and watercraft and seek to reduce collisions using technological solutions.

Lampl Herbert Consultants (LHC) was one of six contractors selected to receive a grant from the Florida Manatee Avoidance Technology Grant Program Attachment 1). Lampl Herbert Consultants' proof-of-concept project (Attachment 2) was awarded under the category entitled "Technology designed to alert boaters to the presence of manatees to enable boaters to avoid manatees without changing the behavior of the animals."

The project mission was to develop a passive listening system that included signal recognition software to detect manatee vocalizations utilizing a commercially available hydrophone and a portable computer. The listening system was developed for Lampl Herbert Consultants, Tallahassee, Florida, by the Navy's Coastal Systems Station (CSS) in Panama City, Florida, through a Cooperative Research and Development Agreement (CRADA) in place between CSS and the Coastal Operations Institute, Inc. of Panama City, Florida.

Lampl Herbert Consultants is the primary contractor and served as the Project Director. Coastal Systems Station (subcontractor) was the technical consultant and Coastal Operations Institute (subcontractor) served as the technology transfer group. Attachment 3 maps the team.

The work plan focused on three aspects:

1. Software development (development of the algorithm software).
2. Hardware development (related to integrating the algorithm software with a commercial-off-the-shelf (COTS) hydrophone and laptop computer).
3. Field Demonstration

SOFTWARE DEVELOPMENT

Library of Manatee Vocalizations

LHC and CSS produced a two-CD catalog set of manatee vocalizations to serve as a reference library of manatee vocalizations for use by contractors/ researchers engaged in the Manatee Avoidance Technology Project.

The catalog set was based on approximately 100 hours of manatee vocalization previously recorded on analog tapes using a high quality, H-56 Navy hydrophone. Dr. Tom O'Shea recorded the tapes from 1981 to 1984, while he was affiliated with the Sirenia Program at the University of Florida. The analog tapes were converted to digital format and were cataloged into the following categories; calf-cow interactions, frightened or disturb, noise, nursing, or miscellaneous. The recordings were collected at SeaWorld, Orlando and various locations in South Florida. The recordings from SeaWorld were cataloged by observed distance on the voice tracks. During the cataloging procedure, selected vocalizations were analyzed and the results were compared to analysis done at the time of original recording.

Additional digital recordings of manatee vocalizations were gathered by other researchers. At the beginning of the project, the primary source of manatee vocalizations was scheduled to come from Dr. David Mann of the University of South Florida (USF). However, the manatee vocalization data was not obtained or released before the algorithm development was performed because U.S. Fish and Wildlife permits required for recording manatee vocalizations had not been approved. At this stage in the project, the recordings from the O'Shea data remain the basis for the LHC development work.

Propagation of Acoustic Energy from Manatee Vocalizations

The acoustic energy structures revealed in the recordings of Dr. O'Shea were extremely useful for the development of manatee detection algorithms. Unfortunately, little useful calibration information was available to accurately determine the source levels produced by manatee vocalizations. This lack of information, along with the lack of range information in most of the recordings, makes detection range analysis quite difficult and imprecise. Unfortunately the recordings and information provided by USF did not alleviate this deficiency. Calibration information and accurate manatee ranges during recording are required. Aspect angle to the manatee may also be of importance.

Algorithm Software Development

The primary source for manatee vocalizations for algorithm development came from the *Manatee Vocalization - Catalog of Sounds*. CSS developed an expert system manatee detector from the manatee vocalizations based on time/frequency decomposition using short-time Windowed Fourier analysis.

The manatee detection algorithm includes signal-processing schemes for filtration, spectral analysis, normalization, and noise shrinkage. After these initial signal-conditioning tools are utilized, a rule-based system is used to score the harmonic structure of the signal to determine the presence of manatee.

The Processing Steps for Manatee Detection Algorithm:

(1) Retrieve data from the preamplified hydrophone via the sound card auxiliary input on a computer.

(2) Digitally high pass filter the data to remove any low frequency noise from distant boat traffic and 60 Hz energy received.

(3) Perform Welch periodogram estimates of the signals power spectrum during overlapped time windows of length typical of most manatee chirps.

(4) Perform a signal normalization scheme in the frequency domain for each spectrum.

(5) Perform several iterations of a noise shrinkage algorithm.

(6) Perform resonance set extraction, marking resonance numbers and levels over the range of base frequencies of typical manatee vocalizations.

(7) Score the resonant structure of the signal by looking at the dominant resonance numbers, total number of significant resonant components, and the strength of the each resonance.

(8) If the score is greater than a threshold, the algorithm software will signal "Manatee Detected."

(9) Return to Step 1.

The software should receive signals sampled at or above 44.1 kHz with 16 bits or performance will be significantly reduced. Frequencies up to approximately 18 kHz are utilized.

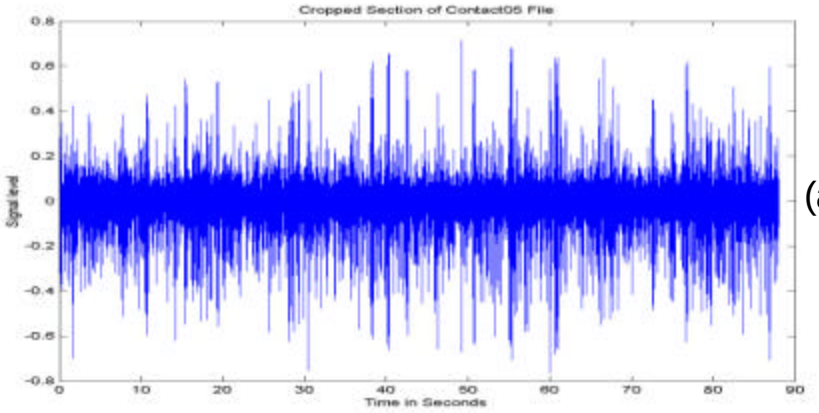
Background Noise Collection and Integration into Software Testing

Background noise sources were recorded to help support the software development and testing. The noise sources included snapping shrimp, splashes, fish, and various size boats recorded in St. Andrews Bay, from CSS

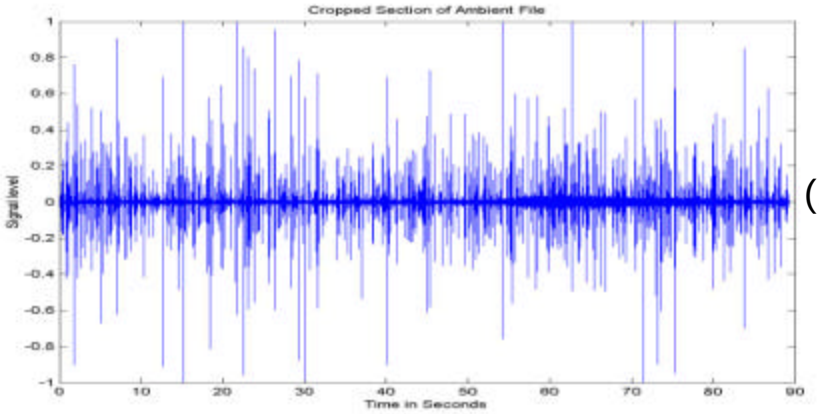
property. Additionally, bottle nosed dolphin vocalizations were collected by Gulf World Marine Park, Panama City, Florida and provided to CSS. During the early stages of the software development and testing, some dolphin "whistle" vocalizations were found to be very similar in base frequency to manatee "chirps" but generally their signal was longer in duration and had a different resonant structure than most manatee vocalizations. The lack of resonance structure found in dolphin chirps is utilized for discrimination, and thus reduces false alarms that may be produced by dolphin activity. The normalization scheme, noise shrinkage algorithm, and signal structure discrimination methodologies appear to be a very effective means of reducing false alarms and allowing the reduction of the threshold when the detector is subjected to the types of recorded noise sources. The manatee detection software was tested with recordings evolved from summing the various background sources with attenuated versions of the manatee recordings.

Figure 1 shows one set of test inputs. Figure 1a shows a portion of a cow-calf contact file where the two manatees are communicating in the wild. According to Dr. O'Shea, during at least one portion of this recording the cow and calf are separated by approximately 10 meters. The signal to noise ratio of this file is fairly high and some of the vocalizations are clearly visible in this time domain display. Figure 1b is the time domain display of background noise taken from Saint Andrews Bay, Panama City, Florida. This background noise includes snapping shrimp throughout, a small boat passing and changing speed, splashing, and toadfish sounds. The boat's closest position of approach occurs around 62 seconds into the file when its' range to the hydrophone is approximately 10 meters. The time sequence in figure 1a was multiplied by .06 and summed with the time sequence in Figure 1b. The result was then amplified slightly and recorded to a wav file. Some clipping occurred but should be inconsequential. The time series of Figure 1c looks like an amplified version of the time series in Figure 1b because the signal level of the time sequence in Figure 1a was reduced well below that of the time sequence in Figure 1b before the summation process.

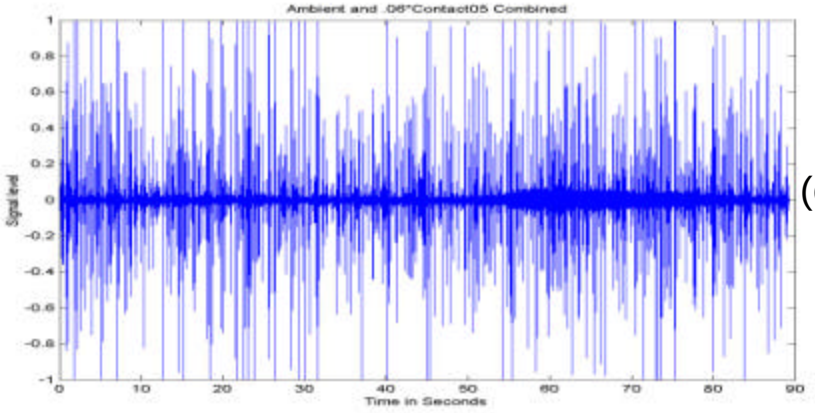
FIGURE 1: ONE SET OF TEST INPUTS



(a)



(b)



(c)

Figure 2 illustrates the results of the signal processing at various stages of the detection procedure for a high signal to noise ratio case. The figure is extracted from the processing of the time series in Figure 1a and contains one manatee vocalization just before the eleven-second mark. Figure 2a displays a snippet of the high pass filtered data's spectrogram. Figure 2b displays the same data after the normalization processing and Figure 2c displays the output of the noise shrinkage algorithm.

FIGURE 2: SIGNAL PROCESSING AT VARIOUS STAGES

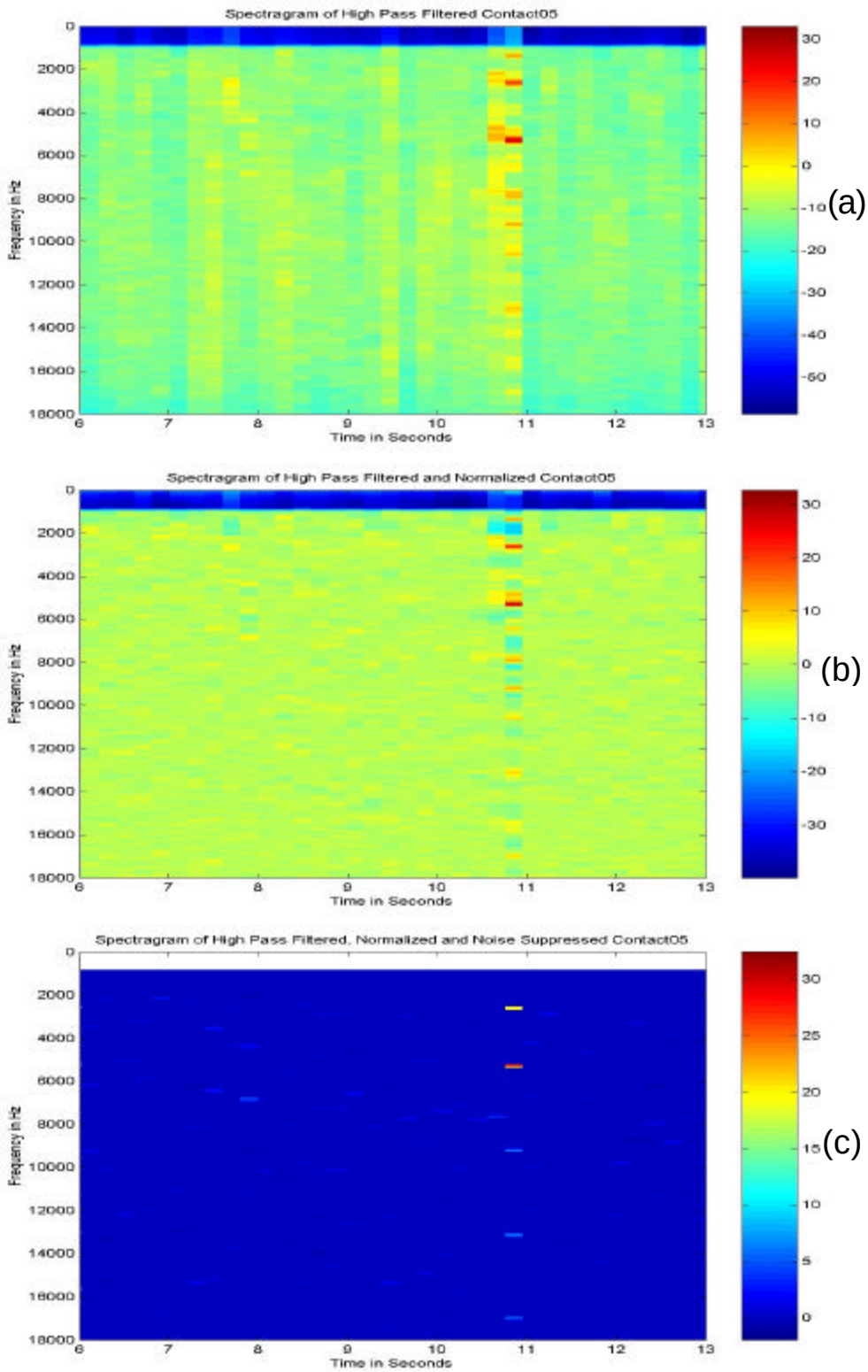
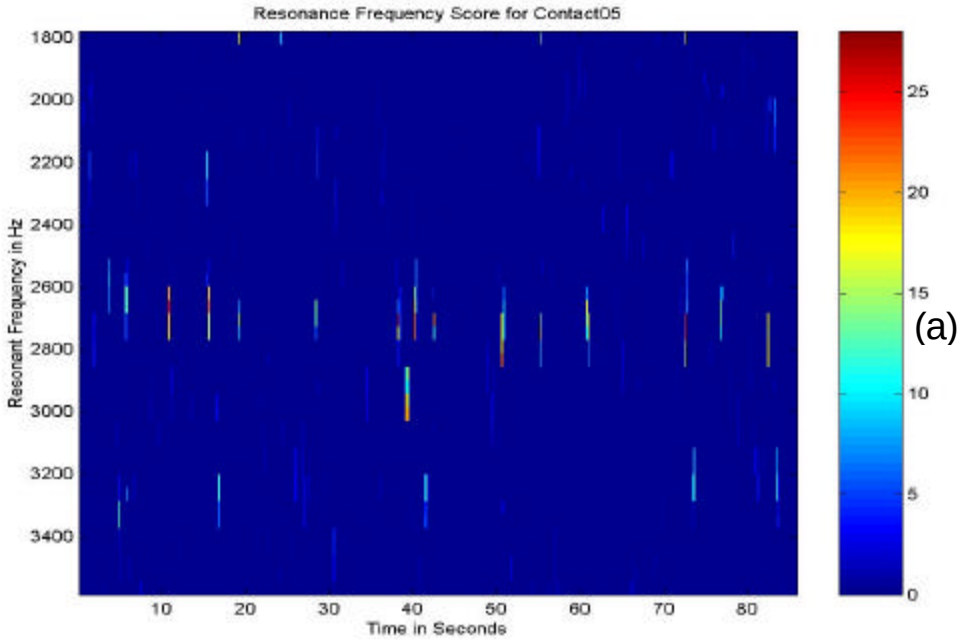
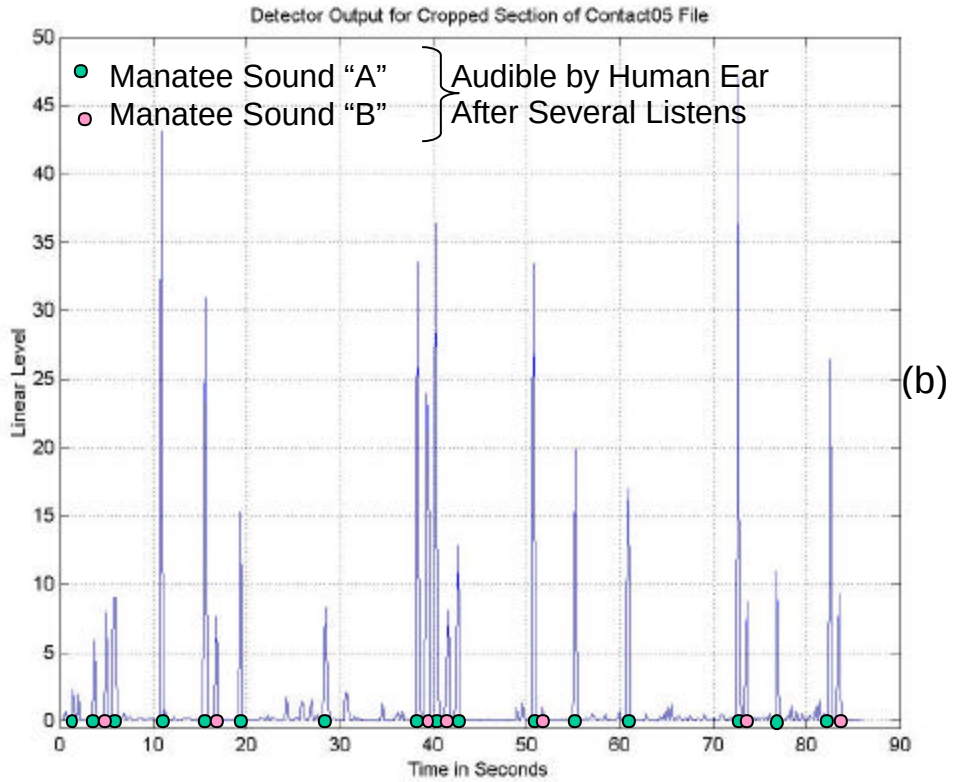


Figure 3a displays the resonance frequency structure score versus resonance frequency for all time windows throughout the time history. Figure 3b displays the manatee detector output that is derived by taking the sum of the resonant frequency structure scores for each time window. An attempt at displaying ground truth was also attempted in Figure 3b. The recording used was listened to many times and the audible manatee vocalizations were marked along the X-axis. An attempt to separate the vocalizations of the two manatees was also performed with the human ear. A couple of the marked vocalizations are very faint and were barely sensed by the human ear. There is also some confusion related to the noise between 25 and 30 seconds into the file. When listening at very high volumes faint distant manatee like sounds appear to possibly exist during this time period.

For this example, Figure 3b shows that all but the first audible vocalization in the recording would alarm the system with even a simple stationary threshold level of three with zero false alarms. An adaptive time varying threshold algorithm would be preferred though, as long as enough averaging time without manatee vocalizations is available for initialization.

FIGURE 3: RESONANCE FREQUENCY STRUCTURE SCORE VERSUS RESONANCE FREQUENCY





Figures 4 and 5 illustrate the same identical processing stages when the input signal is the time series of Figure 1c, where the signal to noise ratio is very small. Figure 5b is marked to show the passing of a small fishing boat and the vocalizations of a fish. The boat was approximately 16 feet in length and had an outboard motor. Near its' Closest Point of Approach (CPA) the boat increased its' RPM level. At CPA the boat's range was estimated to be 10 to 15 meters. The fish based sounds were also loud. As stated earlier, snapping shrimp sounds occur throughout the recording and are at a significantly high level.

The time series in Figure 1c was played through a speaker system and an individual with limited previous experience with this particular file but knowledge of manatee vocalizations was asked to identify the audible vocalization times. The recognized times are marked in Figure 4b. With the added noise, many of the original vocalizations were no longer audible and some of those that were audible were much less recognizable. Of the twenty-three original known vocalizations, sixteen were recognized by the listener.

Figure 4 demonstrates the utility of the normalization and noise shrinkage algorithms. In Figure 4a, the manatee signature is not recognizable unless the viewer knows of its' location. The normalization process output of Figure 4b shows how along with normalization, the broadband energy of each spectrum is reduced without significantly attenuating the manatee vocalization. This process also helps to reduce the detectors' output variance. The noise shrinkage algorithm results illustrated in Figure 4c did a very good job of reducing the noise and extracting the manatee vocalization for this high noise case. Although it appears that the noise shrinkage algorithm has degraded some of the harmonic structure of this manatee vocalization, the noise is almost completely annihilated.

If the threshold were again set manually to three, ten detections would have occurred. Detections would have come from each of the two manatees. The detector exceeded the value of three for eight of the sixteen audible vocalizations, and two of the inaudible vocalizations. No false alarms would have occurred for this threshold level.

Note: For the remainder of this paper a normalization value different than the one in the above example is utilized. Thus, the scale of this example does not correspond to the one utilized in the system performance analysis of later sections.

FIGURE 4

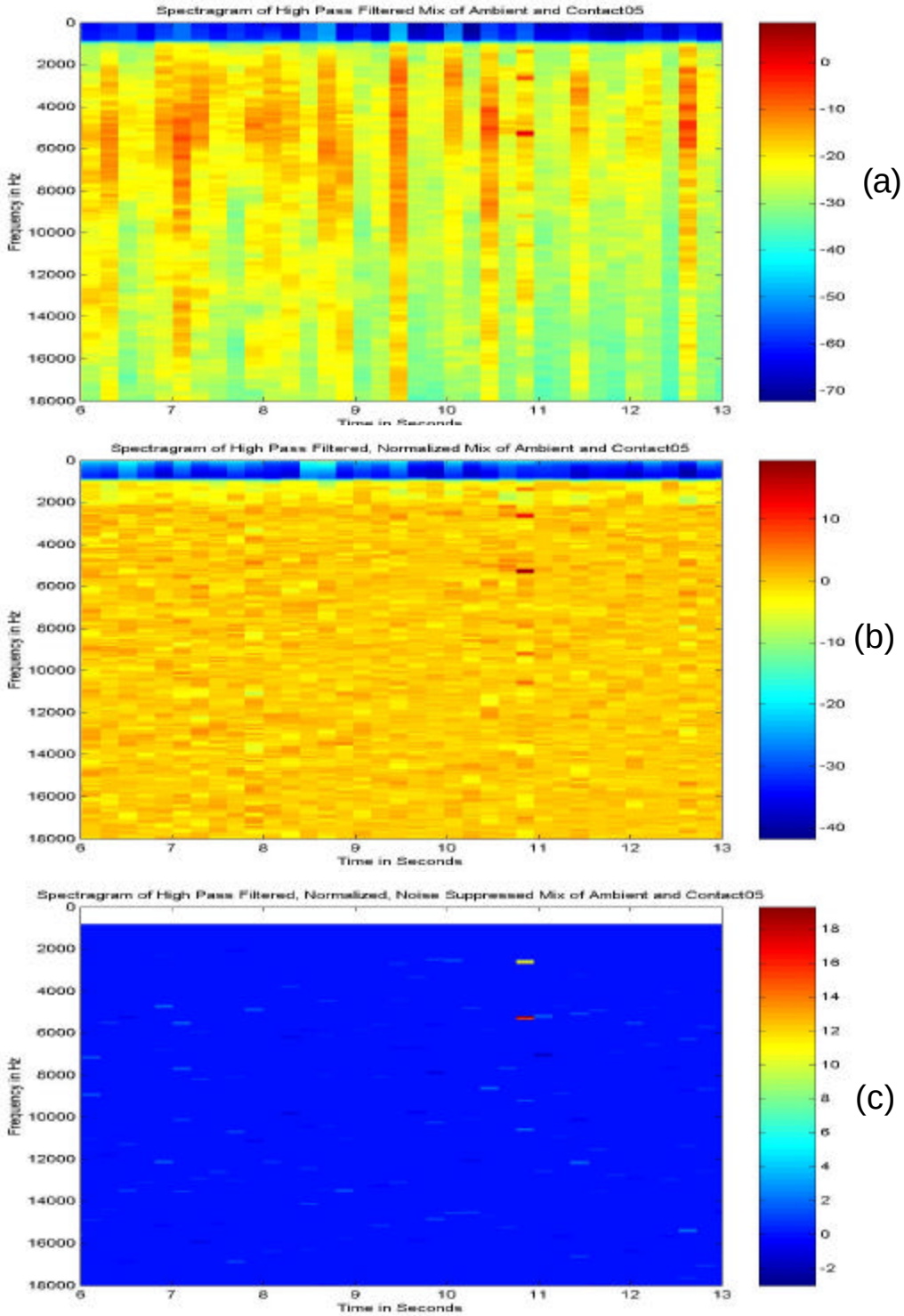
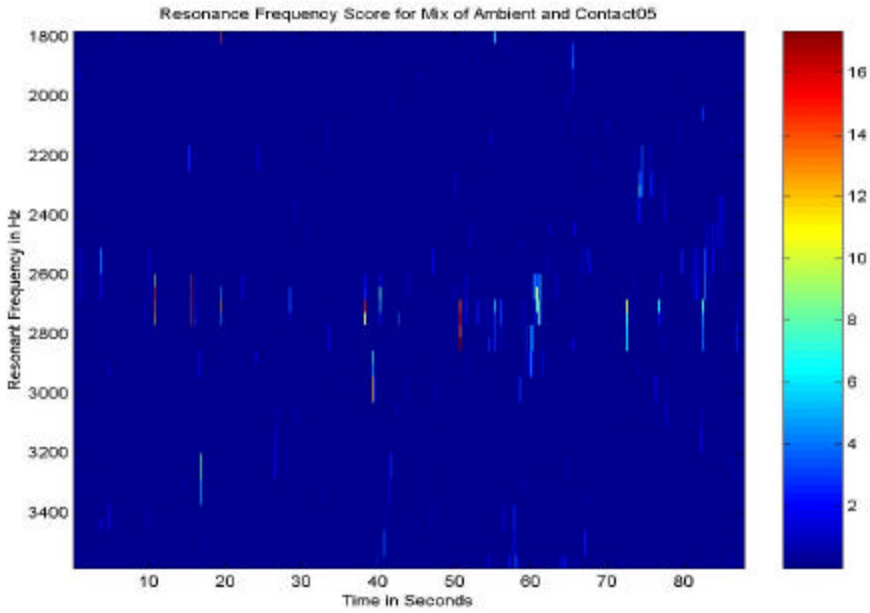
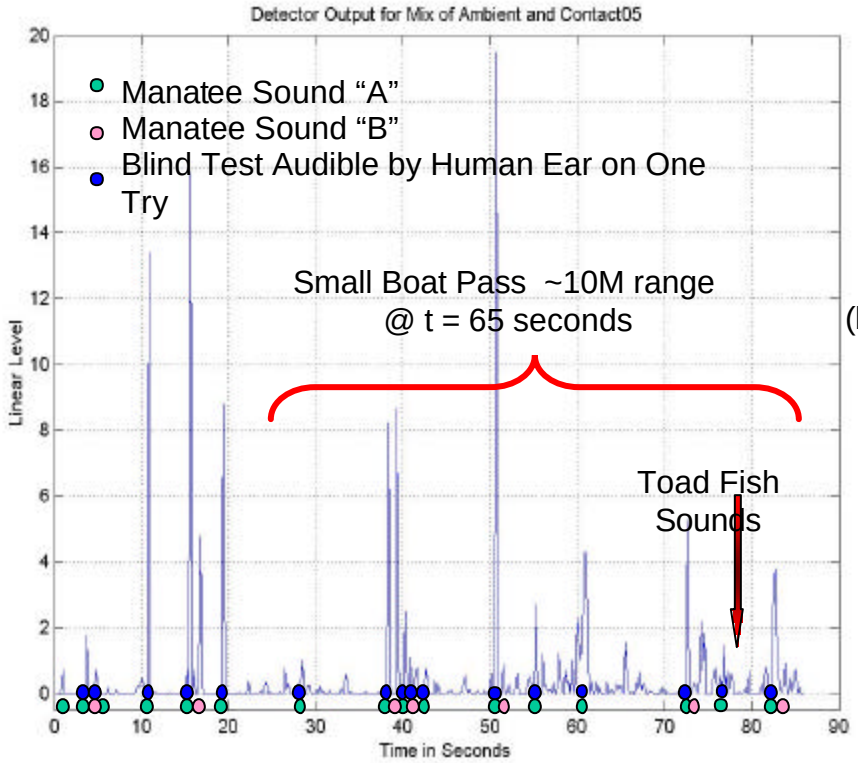

Spectragram of High Pass Filtered Mix of Ambient and Contact05
Frequency in Hz
Time in Seconds
(a)
Spectragram of High Pass Filtered, Normalized Mix of Ambient and Contact05
Frequency in Hz
Time in Seconds
(b)
Spectragram of High Pass Filtered, Normalized, Noise Suppressed Mix of Ambient and Contact05
Frequency in Hz
Time in Seconds
(c)

FIGURE 5


Resonance Frequency Score for Mix of Ambient and Contact05
Resonant Frequency in Hz
1800
2000
2200
2400
2600
2800
3000
3200
3400
10
20
30
40
50
60
70
80
Time in Seconds
16
14
12
10
8
6
4
2

(a)


Detector Output for Mix of Ambient and Contact05
Manatee Sound "A"
Manatee Sound "B"
Blind Test Audible by Human Ear on One Try
Small Boat Pass ~10M range
@ t = 65 seconds
Toad Fish Sounds
Linear Level
Time in Seconds
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
70
80
90

(b)

HARDWARE DEVELOPMENT

The field acquisition system was based on a single 6050C ITC hydrophone (30 Hz to 75 kHz) and a small computer. Data was read into the computer though a microphone input and digitized by the computers built in sound card analog to digital converter (ADC) at 44.1 kHz with 16-bit mono.

Processing of Field Data

The primary software development tool was MATLAB. The MATLAB Data Acquisition Toolbox was used to collect the data from the computers sound devise. A MATLAB loop acquires acoustic data and then processes it before repeating. This process results in the loss of some data while processing is being performed. The computational demand is not very high and if threads were used in the 'C' programming language a computer would have no problem performing both data collection and processing in parallel within real time with no data losses.

Non-real time analysis was also available to operate on prerecorded files. When prerecorded data is analyzed, no data is lost and a better estimate of system potential is derived.

DEMONSTRATION AND TESTING

Processing of USF Test Data Files

Two environment recordings of manatee vocalizations, produced by the University of South Florida, were attenuated and superimposed onto the recordings to provide test sets with different background noise levels. This data was provided to test systems and as an example of what to expect for the final field test demonstration. The wav files were 16-bit mono, 48828 samples per second files.

The environmental background noise files were named "QuietBN.wav" and "LoudBN.wav". "Loud.wav" and "Quiet.wav" consist of these background noise files with superimposed manatee vocalizations. The manatee vocalizations appeared as thirty five distinct events over the duration of the file. Most of the events are single manatee chirps while a few contain multiple closely spaced chirps.

The files provided were analyzed by both the real-time and wav file input MATLAB software. The real-time system was implemented by playing the

recording on a CD player and inputting the sound into the sound card of the analysis computer. The two algorithms are identical except in the way the data is read in and the real time MATLAB looping which results in data loss. Thus the results of the wav file input program are more significant and indicate the potential performance of the algorithms.

First, the background noise files were analyzed for false alarm potential. Twice the output of the detector reached a peak value of around .55 with the input file "QuietBN.wav". The peak detector output produced from the file "LoudBN.wav" was less than .35. Thus, no false alarms would be produced by either file if the threshold were set at 0.6 or above and a total of two false alarms would occur if the threshold was set at 0.5. Each file was approximately 180 seconds in duration.

The files "Loud.wav" and "Quiet.wav" were then analyzed for detection performance. Table (1) illustrates the event detection percentage for various thresholds for each file. For a threshold level of 0.6, 85.7% of the manatee chirp events were detected in the file "Quiet.wav" and 40% were detected in "Loud.wav".

Table 1

Threshold, T	T=0.5	T=0.6	T=1.0	T=1.2
Quiet.wav	85.7	85.7	82.9	80
Loud.wav	42.9	40.0	31.4	20

Processing of CSS Noise Files

Almost thirty minutes of noise was recorded in St. Andrews Bay, Panama City Florida. This data was utilized in the illustrated example discussed previously and consisted of shallow water bay background. As mentioned previously the data included sounds from snapping shrimp, splashes, fish, and various size boats at very close ranges. This data was analyzed for false alarms by applying it as input to the manatee detector. Four samples of the output reached a level above 0.5 while once the level exceeded 0.6. The peak detector output level over the entire data set was 0.63.

Field Test Demonstration

The field demonstration was performed in the water behind the Florida Marine Research Institute in St. Petersburg, Florida. Manatee recordings were amplified and transmitted by USF owned hardware. Receive hydrophones were placed in the water at ranges of five and then ten meters. Received signals were analyzed in real time and recorded for future studies. Although the signals were sufficient

to demonstrate the ability to detect manatee vocalizations acoustically, they were not suitable for accurate system capability analysis.

An attempt to normalize the transmitted manatee chirp signal levels was made by normalizing the RMS power of manatee recordings over the total chirp duration. Unfortunately, the signals being normalized did not contain manatee chirps only. Many of the files were corrupted by large noise levels. This noise heavily influenced the estimated manatee chirp power. Also, when the signals were amplified and transmitted, so was the recorded noise. Quite often this transmitted noise level exceeded that of the environment.

Also, many of the manatee chirps in the original data provided by Dr. O'Shea contained frequency components in the 1 to 3 kHz region. These harmonic components did not appear in the demonstration. Often the first harmonic appears in this frequency range and is one of the most powerful components.

During the live demonstration the real time system was operated. For the 5 meter distance 44, 45 and 48 out of one hundred transmissions were detected in three runs for a threshold of 0.6. For the same three runs 29, 28, and 21 detections occurred with a threshold of 1.0. For the 10 meter distance 30 detections occurred for the threshold of 0.6 while 11 occurred for the threshold of 1.0. Since only around 80% of the data was actually processed by the real time MATLAB algorithm, one should expect about 20% better performance than this for a production detector using this algorithm.

Four sets of recorded field test data were made available by USF. The first three sets were recorded when the receive hydrophone was at a distance of five meters while the fourth file was recorded at 10 meters range.

The first data set was a calibration test started at 11:37. During this test 3 sets of manatee chirps can be heard by listening to the recording. A total of 50 manatee vocalizations were transmitted over a 300 second period. The second data set was a calibration test started at 12:00. This test consisted of 100 manatee chirp transmissions over a 327 second period. The third data set was a version of the 5 meter demonstration test and included 100 manatee vocalizations over a 337 second period. The last data set, a version of the 10 meter demonstration test also consisted of 100 manatee vocalizations over a period of 430 seconds.

Table 2 lists the detection performance in percent of chirps detected for the four runs at four different threshold settings. Again, these results are only for demonstration purposes and do not accurately portray the system's capabilities since the signals were corrupted with amplified noise and were missing components. Another notable result of the analysis was that over the entire

duration of all four files not one false alarm occurred even for the lowest threshold of 0.5.

Table 2

Threshold, T	T=0.5	T=0.6	T=1.0	T=1.2
1137 Caltest	94%	86%	86%	86%
1200 Caltest	91%	89%	81%	75%
5 meters	68%	65%	55%	52%
10 meters	42%	37%	21%	17%

CONCLUSIONS AND RECOMMENDATIONS

Although the signal levels transmitted in the demonstration were often well above the ambient noise levels experienced, the transmitted signals characteristics as well as the amplified and transmitted noise heavily influenced the results of the experiment. This and a lack of calibrated data availability, prevent an accurate estimation of system capabilities in terms of detection probabilities versus range and environmental conditions.

Currently, the algorithm performs well with both the data provided by Dr. Tom O'Shea and the test data produced by USF. The demonstrated capability of detection in adverse ambient noise environments provides optimism toward system capabilities in real-world very high noise environments. This technology study indicates that manatee detection with very low false alarm rates should be obtainable. The question of most concern is at what ranges will these detections occur.

Also, since the multiple algorithms derived from this and other grants produce promising detection performance, fusion could be used to combine these detectors. If the different detectors attempt to utilize somewhat statistically independent phenomena to perform, the combination of algorithms could enhance detection significantly. For detectors where the output distributions of signal plus noise and noise only cases are unimodal, and a positive deflection occurs when manatees are present, this fusion could easily be performed with an adaptive Fisher discriminant algorithm.

ATTACHMENT 1:

Manatee Avoidance Technology Grants Awarded[1]

Ranking	Bidders	Amount Requested	Funding allocated FY 01/02 & 02/03
1	University of South Florida	$40,270.00	$40,270.00
Passive acoustic detection of manatee sounds to alert boaters: Propose to design a system that detects the presence of manatees by passively detecting their vocalizations and incidental sounds and using this information to alert boaters through a warning system.			
2	Hubbs-SeaWorld Research Institute	$154,675.00	$70,000
Design for a Manatee Finder: sonar techniques to prevent manatee-vessel collisions: Propose to do comprehensive study to develop sonar technology to localize manatees and inform boaters of their presence called a Manatee Finder. Work will include determining whether manatees react to sonar signals.			
3	Nova Southeastern University	$6,911.00	$6,911.00
Boater manatee awareness system: Propose to design an infrared detection system to determine the number of manatees in a semi-enclosed area by detecting their exhalations in order to alert boaters to the number of animals in the area and eventually monitor of boater speed zone compliance.			
4	University of Florida	$30,000	$15,305.00
A system for warning boaters of the presence of manatees: Propose to analyze sounds produced by manatees to identify a unique signature for the species and demonstrate in the field that this unique sound signature can be isolated successfully from the high ambient background noises commonly present. This baseline research will allow the PI's to then apply for funds to modify existing naval submarine-detection technology.			
5	Lampl-Herbert	$103,400	$77,500.00
Proof-of-concept for off the shelf technology to identify acoustic signature to detect presence of manatee(s): Propose to use existing electro-acoustic technology to identify a manatee vocalization signature to be used in a software driven sensor array to identify manatees in congested waterways. This would later be used to develop warning devices for boaters.			
6	W. Randolph Warner	$190,216.00	$90,016.00
Manatee proximity locater: Propose to develop voice recognition software for manatee vocalizations called the Manatee Proximity Indicator. When a predetermined vocalization is received and recognized, a signal sequence is then activated which will alert boaters.			

[1] http://floridamarine.org/features/view_article.asp?id=14362

ATTACHMENT 2:

LAMPL HERBERT CONSULTANTS, INC.

REVISED SCOPE OF WORK FOR MANATEE AVOIDANCE TECHNOLOGY PROPOSAL TO THE FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

Revised 12/28/01

Lampl Herbert Consultants (LHC) submitted a proposal in October 2001, for manatee avoidance technology in response to a request for proposal from the Florida Fish and Wildlife Conservation Commission (FWC). The proposal was revised in mid-December 2001 at the request of the FWC to reflect preliminary changes to the budget and to provide additional technical details on the tasks to be performed in the proposal. The information provided below represents a second revision to reflect the final negotiated budget and to provide a Scope of Work.

MISSION

The mission of this project is to develop a passive sonar system that includes signal recognition software to detect manatee vocalizations utilizing a commercially available hydrophone and a portable computer. The sonar system will be developed for Lampl Herbert Consultants, Tallahassee, Florida, by the Navy Coastal Systems Station in Panama City, Florida, through a Cooperative Research and Development Agreement (CRADA) in place between CSS and the Coastal Operations Institute, Inc. of Panama City, Florida. The sonar system will be field tested in a proof-of-concept demonstration at a location and field setting arranged by the Florida Marine Research Institute.

TECHNICAL DETAILS

Lampl Herbert Consultants' work plan focuses on 1) the development of software (algorithm) to detect the presence of manatees in a specific area 2) configuration of the software with a commercial-off-the-shelf (COTS) hydrophone and laptop computer and 3) demonstration of the equipment and software in a two-day field test in Florida. The LHC project team will participate in a joint field demonstration organized by FWC. The FWC agrees to provide 1) manatee signature database at the commencement of the contract and 2) field support that will include boats, divers, and other personnel as may be required for verification of the presence of manatees during the field test.

Algorithm Development:

The main element of this project will be the development of the algorithm to process signals from the manatee vocalizations in the wild. The algorithm will be developed based on the manatee signature database provided by the FWC. The algorithm development will be conducted for Lampl Herbert Consultants by the Navy Coastal Systems Station (CCS) personnel and will take about two person-months over a 60-day period. CSS plans to extract classification features from the manatee vocalizations/signals based on time/frequency decomposition (using either wavelets or short-time Windowed Fourier analysis). Other options that may be tried include classifiers such as Multi-Variate Gaussian, K-Nearest Neighbor, Multilayer Perceptron Neural Nets, and Support Vector Machines.

Preliminary Processing Steps for Manatee Detection Algorithm:

(10) Apply Anti-alias filter before digitizing hydrophone signal.

(11) Digitize 10 seconds worth of data.

(12) Check energy level (if too low, then assume no detection and return to Step 1).

(13) Perform time-freq decomposition and extract classification features.

(14) Run classification features through classifier and generate a score, which indicates the degree of Manatee-likeness.

(15) Integrate score with previous scores.

(16) If integrated score is greater than a threshold, algorithm software will signal on laptop "Manatee Detected."

(17) Return to Step 1.

Field Equipment for Data Collection:

The field acquisition system will be based on a single 6050C ITC hydrophone (30Hz to 75 KHz). An existing laptop with an upgraded PCMCIA card (samples at 500 KHz (12 bits)) will be used to run the algorithm software to process the field data.

Processing of Field Data:

Software will be developed by CSS prior to the field test to identify manatee vocalizations from background noise. The primary development tool will be a MATLAB data acquisition toolbox (software) that will be used with a Laptop/PCMCIA card. The acoustic data will be fed into the Laptop and into MATLAB in real time for the field demonstration.[2]

TIMETABLE

FWC contracts with LHC:	By January 15
Project start date:	January 15
FWC provides manatee signature database to LHC:	January 15
One-day project meeting between FWC and LHC:	Between January 15 and January 18
Configure field equipment:	January 15 to February 15
Develop software:	January 20 to March 20
Two-day field demonstration[3]:	Between April 10 and May 20
Monthly progress reports To FWC:	February 15 March 15 April 15 May 15
Submit draft report to FWC	May 15
Submit final report to FWC:	June 15

[2] The field data can be saved as a foundation for the development of a simulation; however, the development of a simulation exceeds the scope of this proposal.

[3] Dates based on agreement between Fish and Wildlife Conservation Commission and Lampl Herbert Consultants.

BUDGET DETAIL

The budget is provided in lump sum components based on project areas as detailed below.

Project Technical Direction	$ 4,500
Signature Database – provided by FWC	$ -0-
Development of Algorithm	$ 27,000
Development of Field Equipment	$ 10,000
Proof-of-Concept In-Situ Field Demonstration	$ 14,000
Project Management and Documentation	$ 22,000
Project Budget	**$ 77,500**

ATTACHMENT 3:

Project Team		
Affiliation	**Personnel**	**Title**
Lampl Herbert Consultants Tallahassee, Florida Prime Contractor	Thomas Herbert, PhD	Project Director
	Gregory Hitz	Project Manager
Coastal Systems Station Panama City, Florida Subcontractor	Clint Mayo	Technical Director
	Chris Sermarini	Software Development Manager
	Gerry Dobeck	Software Development Consultant
	Bob Manning	Software Development Consultant
	Mike Sandlin	Hardware Development Manager
	John Hansel	Hardware Development
	Todd Bowden	Field Demonstration
Coastal Operation Institute Panama City, Florida Subcontractor	David Artman, PhD	Executive Director