Attachment 7
Project Completion Report
Project Title: Detering Duck Predation with Underwater Sound

Subaward # O323501
Grant # 2005-38500-16409

PROJECT CODE: **SUBCONTRACT/ACCOUNT NO:**

PROJECT TITLE: Detering Duck Predation with Underwater Sound

DATES OF WORK: March 2008 through April 2011

PARTICIPANTS: Project Coordinator: Erick Swanson
Principal Investigators Cliff Goudey, Dana Morse
Cooperating, Non-funded Participants: Great Eastern Mussel Farms (no longer in business), Aquaculture Harvesters (no longer in business)

REASON FOR TERMINATION: Objectives Completed

PROJECT OBJECTIVES: List objectives as written in approved proposal.

Project Objectives:

1) Re-design the CFER/MCM prototype acoustic duck deterrent buoy to reduce its size and cost.
2) Fabricate nine new acoustic deterrent buoys.
3) Install the buoys at mussel aquaculture farms in mid-coast Maine.
4) Evaluate the buoys during the 2007-2008 duck predation season.
5) Develop an optimal combination of non-lethal deterrents that cost-effectively minimize mussel losses due to duck predation.

Through industry outreach, report the findings of our studies and encourage system commercialization as appropriate.

ANTICIPATED BENEFITS: State how the project will benefit the aquaculture industry either directly or indirectly.

Eider duck predation on cultured mussels is a serious threat to mussel farmers and cause major losses every year. A cost effective program to help minimize losses to eider ducks will benefit the industry.

PRINCIPAL ACCOMPLISHMENTS: Summarize in a concise form the findings for each objective for the duration of the project. Measurement data are to be given in SI units. However, to minimize confusion, a dual system of measurement may be used to express results.

1. Several versions of the buoy have been developed and tested. Small size, up-dated playback system and battery charging via wind chargers have all been evaluated.
2. Four buoys made of steel and fiberglass have been built and tested. Actual cost exceeded projected cost, one buoy was vandalized, and three were sunk in severe winter storms with the loss of battery banks, electronics and wind chargers. Only the underwater speakers and buoy itself were salvageable. Replacing these components resulted in fewer buoys.
3. Four buoys were installed in Blue Hill Bay on three (3) sites for evaluation.

4. When the buoys worked and used as part of a program they were highly effective. Battery changes in rough winter weather were not possible and often left the buoys without power for significant periods prior to the wind charger being installed. Prior to the wind charger being deployed there were no problems with water entering the buoy, even though the buoys were vented.

   With a small Rutland 503 wind charger, the buoys were stable but the 503 was not able to maintain the required voltage and the bearing failed after three months of winter weather. It did extend the time between battery changes.

   The Rutland 913 had more than enough charging capacity but is quite heavy. The system was very effective in normal fall and winter wind conditions maintaining maximum voltage, but all three buoys tested sank in severe high wind and ice conditions in winter. With the bank of batteries in the buoy there is little room. If sea water builds up to cover the bottom battery, which is not very much water, all batteries will short out through the bottom battery causing the bottom battery to explode. With the fiberglass buoy it blew the lid off and the electronics out of the buoy, and the buoy sank. With the steel buoys water entered through the wind charger access apparently due to ice buildup and not in a vertical position, allowing waves to wash over the buoy and wind charger support..

   With a wind charger deployed it appears that the buoy must be absolutely water tight and vertical. The extra weight of the wind charger on top of the buoy allows the 4-6 ft chop to wash over the buoy, and over a three or four day period of a major storm, enough water entered to submerge the bottom battery.

   Modifications have been made and I am convinced a buoy can be made to handle any weather with the 913 wind charger attached, but a successful full winter of testing has not yet happened.

   What we have determined through this development process is as follows:

   a) A chase boat with rockets and bird bangers is the only 100% effective method of keeping ducks away from a submerged long line or other open mussel culture system (rafts may use netting)
   b) A program of playing the sound of the chase boat through underwater sound, a 14 ft aluminum boat moored within the culture site and, in stormy weather, a propane cannon (not a problem for neighbors hi high wind conditions) can be 100% effective hi keeping ducks off the culture site fro up to a week. It is essential that something remain on the site when the chase boat is not there, and the visual effect of a small white boat (our chase boat is white) and the underwater sound of the chase boat works exceptionally well. The appearance of the chase boat on patrol reinforces the buoy/small boat effectiveness, dramatically reducing the number of patrols hi good weather and the buoy and small boat remain effective during extended storms.
   c) The buoy keeps the electronics and batteries relatively warm, 33F, when air temperatures may be near OF. Deploying underwater sound from a steel barge where the electronics and batteries were at ambient air temperatures was unreliable.
   d) The system only works if the batteries are charged, the system requires significant power and battery changes need to be every 10 days if wind charging is not used. When we relied on battery changes, extended periods of the buoy being down occurred. Often there is only one or two days per week that battery changes are possible, and other farm activities may preclude buoy maintenance. Ducks often abandon the site for weeks at a time only to return when you least expect it. If they return during a storm and the buoy is not operating, loses are certain. With the Rutland 913, the buoy's were always fully charged and the system very effective with no duck problems. After the buoy's sank in a major storm, the ducks returned and over tune caused significant losses.

5. The optimum combination of non-lethal deterrents that cost effectively minimize mussel losses to duck predation on our 54 acre site is three(3) white 14 ft aluminum boats and three (3) underwater sound buoys with Rutland 913 wind charger. The wind charger itself produces a visual and sound impact that the ducks are fearful of. The entire deployment is reinforced every time the chase boat patrols and chases off ducks outside the site.

   Rutland produces a 530 which weighs 13 pounds, and the 913 which weighs 23 pounds. The 913 has been a problem in severe whiter storms as the unit is top heavy. The 503 is a better weight but lacks the charging capacity and does not hold up under the most severe weather.

   This winter wo will try an AIR X by Solardyne. It weighs in at 13 pounds, has the output of the Rutland 014 and can handle winds up to 110 mph. It looks like the right turbine for this application.

The wind charger also provides a forth deterrent, the sound created changes with wind speed, and a neon color design can produce a pinwheel effect when turning. Ducks are very determined but simple animlas. The more activity to keep them nervous the less likely they are to explore the site.

The ducks are afraid to land inside the site and often land Y_t mile or so away from the site. They then slowly swim in. Mussels and other food items grow on moorings in a harbor and eiders want to look under our buoys. The underwater sound and the white boats initially keeps them on the outside looking in. Without reinforcement of the chase boat they will be inside the site in 3 to 5 days. With a propane cannon going off every 3 min., at least a week and many never come back. In calm weather complaints regarding the cannon will come from many miles away, but in storms it is not an issue.

Interestingly, the 14 foot aluminum boats we use have never sunk or tipped over in the worst storms. The cannon may be waterlogged at the end of the storm, or encased in ice, but as long as the buoy with the wind charger are still there and operating, we have eliminated duck predation.

IMPACTS: In concise statements (possibly a bulleted list) indicate how the project has or will benefit the aquaculture industry either directly or indirectly and resulting economic values gained (where appropriate).

On our farm we consider these buoys essential to farm operations. It is not possible to keep an employee out there patrolling every day all day. We patrol every morning and afternoon in good weather with the system in place, and stay off the water in severe weather rather than risk equipment and people. There has been interest in this system from other farmers in Maine and Canada.

Once we have a buoy built that can reliably survive an entire winter with a wind charger in place, which I am certain can happen, commercial production of these buoys will then be possible.

RECOMMENDED FOLLOW-UP ACTIVITIES: State concisely how future studies may be structured.

Future studies need to focus on construction details so that these buoys can be deployed in the fall and, with minimum if any service, operate all winter to be removed in the late spring.

SUPPORT: Use the format in the table below to indicate NRAC-USDA funding and additional other support, both federal and non-federal, for the project. Indicate the name of the source(s) of other support as a footnote to the table.

YEAR	NRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2007	$77,918					$77,918	$77,918
2011	$30,083					$30,083	$30,083
TOTAL							

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED: List under an appendix with the following subheadings: *Publications in Print; Manuscripts;* and *Papers Presented.* For the first two subheadings, include journal articles, popular articles, extension materials, DVDs, technical reports, theses and dissertations, etc. using the format of the Transactions of the American Fisheries Society (example below). Under *Papers Presented* subheading include the authors, title, conference/workshop, location, and date(s).Example of Transactions of the American Fisheries Society citation formatBillington, N., R. J. Barrette, and P. D. N. Hebert. 1992. Management implications of mitochondrial DNA variation in walleye stocks. North American Journal of Fisheries Management 12:276-284.

A Sound Idea for Defeating Eider Ducks on Mussel Farms presented by Dana Morse, Maine Sea Grant and published on the internet http://mi.nefsc.noaa.gov/mas30pds/MAS30_Morse.pdf

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PART II

TECHNICAL ANALYSIS AND SUMMARY: Describe the work undertaken and results obtained for each objective. Major results should be presented in detail, including graphs, charts, figures, photomicrographs or other presentations. Methodology should be briefly described and statistical analyses and significance should be included where appropriate. This section of the report should be written with style similar to scientific publication. Reports previously or currently prepared for publication may be submitted as part of this section.

Our experience is that the buoy without the wind charger will handle any weather but is out of operation often because the batters could not be changed. We are exposed to strong winds all winter with only a day or two available to change batteries for weeks at a time. When we get good weather there are other pressing activities that often preclude battery changes. We are convinced that with more refined construction details a buoy can be made that will reliably perform all winter.

The Buoy

We have used steel and fiberglass and by far the preferred material and shape is 12 inch dia. x 8 or 9 feet long fiberglass tube. It is light weight, can easily be handled by one person and fit in a pickup truck. The steel buoy is heavy must be handled by a crane and can not be transported in a pickup.

We used a coupling to hold in a fiberglass bottom, all cemented in place with epoxy. A square steel ballast plate supports the speaker with speaker protection attached to the steel plate.

Calculations for the buoy with batteries were calculated by Cliff Goudey and are as follows:

5.5' draft - 2.5' freeboard

Description	Dimension	Weight	Buoyancy	VCG	Gmom	VCB	Bmom
Spar - 12" BR GRP	12.5" x 1/4" x 8'	55.2	300.0	4.0	221	2.8	825
Top	13" x 1/4" x 3"	3.0		8.0	24		
Bottom	13" x 1/4" x 3"	3.0		0.1	0		
Speaker cage	12.5 x 1/4" x 10"	4.0	3.0	-0.4	-2	-0.4	-1
Cable pipe	3/4" GRP 8'	3.0		4.0	12		
Battery 1		43.5		0.3	13		
Battery 2		43.5		1.0	44		
Battery 2		43.5		1.7	74		
Internal flotation	foam	0.0		0.0	0		
Electronics		7.0		7.7	54		
UW speaker		10.0	5.0	-0.4	-4	-0.4	-2
Light		0.0		0.0	0		
Lift padeyes (2)		1.0		8.0	8		
Wind charger	Rutland 503	15.0		11.0	150		
Steel ballast		87.2	10.9	0.2	17	0.2	2
Sums		318.9	318.9		611		824
				VCG	1.9	VCB	2.6

Wind Turbine

We have used Rutland 913 in the past on another project at the same locations with excellent results, but on the spar buoy the buoy's sank in the most severe weather (wind gust of over 90mph, icing conditions and breaking 4 to 5 ft chop) These same conditions did not affect buoys without the wind charger or the buoys with the 13 pound 503. Keeping the buoy near vertical appears to be the critical factor. The smallest hole to allow water into the buoy will easily flood the bottom battery. There are 3 batteries in a stack, it's a very tight fit, so it doesn't take very much water. When the bottom battery shorts out from the sea water, all three fully charged batteries discharge through the bottom battery, causing it to rupture from the gas pressure. This blew the top off one buoy and ejected the electronics, ripping the wires off.

We are hopeful that the AIR-X will resolve this issue.

The steel spar buoy deployed with a Rutland 913 Wind Charger.

Playback System

The original system used a Nomad digital recorder to play back the recorded underwater sounds through a TOA CA160 12 volt 60 Watt PA Amplifier and a Lubell Labs Inc. LL9816 piezoelectric, dual piston, underwater speaker.

The Nomad was an excellent system but is no longer manufactured. We have replaced it with a Pyle marine radio that will play an SD chip. The desired sounds and silences are transferred to the SD chip and the radio will turn on and off with a timer, playing the recordings at the desired time of day. It is turned off at night to conserve batter power. The speaker is a Lubell Labs Inc. LL9816 piezoelectric, dual piston, underwater speaker.

A number of inexpensive hydrophones and digital recording devices are available to record the underwater sound of the chase boat and service vessel.

Batteries

We have used a variety of sealed AGM batteries and find that for the 12 inch fiberglass buoy, three (3) Optima D34M works well.

Lid

We use a Hand-Tite pipe plug manufactured by R.C. Graham Co. We recommend a strap across the lid when deployed as we have lost several when they buoy sank. We suspect that when water entered through the wind charger wiring or the small 1/8 in top vent (no longer used) the lid blew off from the gas pressure. It only takes 5 pounds of pressure. Had the lid been strapped on it is unlikely the buoy would have sunk.

The tiniest hole in a major storm that last three or four days can let in an amazing amount of water, and that is the condition the buoy must survive.

Deployment

The buoy is deployed from a single pint midway on the side of the buoy from a bridle. The bridle is attached at the bottom and near the waterline. From about 2/3 of the way up from the bottom a line is attached to a float attached to a mooring or in our case, a backline. This provides a horizontal pull on the buoy keeping it deployed in a vertical position regardless of tide and wind.

PROJECT COMPLETION REPORT

SIGNATURE PAGE

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PREPARED BY:

Project Coordinator of Subawardee lk> / " Date