Environment and Natural Resources Trust Fund (ENRTF)
2010 Work Program

Date of Report:
Date of Next Progress Report:
Date of Work Program Approval:
Project Completion Date: June 30, 2013

I. PROJECT TITLE: Bioacoustic traps for the management of the round goby

Project Manager: Allen F. Mensinger
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Location: *The Duluth-Superior Harbor and Lower St. Louis River, St. Louis County, Carlton County, Duluth*

Total ENRTF Project Budget:	**ENRTF Appropriation**	**$175000**
	Minus Amount Spent:	**$0**
	Equal Balance:	**$175000**

Legal Citation: ML 2010, Chap.[____], Sec.[____], Subd._____.

Appropriation Language:

II. PROJECT SUMMARY AND RESULTS:

The round goby is an invasive fish that is rapidly spreading throughout the Great Lakes. It outcompetes native fish and is negatively impacting the benthic fish community. Its ability to spawn throughout the spring and summer in contrast to native fish, which only spawn once per year, is one reason for its success. Therefore, by interfering with the gobies' reproductive cycle, its expansion would be stopped or delayed. As male gobies use sound to attract females to the nest, we plan to develop a bioacoustic fish trap to capture female round gobies throughout the spawning season. We will first develop a sound library of the fish's calls to determine the correct calls to use. We will then test these sounds and different trap designs in a laboratory setting to optimize attraction and capture efficiency. Finally, we will deploy these bioacoustic traps in the Duluth - Superior Harbor to test their efficacy under field conditions. The technology could be used as an early warning system to alert fishery managers of new goby investigations, to block the spread of the goby at key check points, and potentially to eradicate new or small populations of the invasive fish.

III. PROGRESS SUMMARY AS OF:

IV. OUTLINE OF PROJECT RESULTS*:*

RESULT 1: Round Goby acoustic library

Description: Multiple hydrophones will be placed throughout the Duluth Superior Harbor to record the sounds of the round goby. As fish vocalizations may be temperature and seasonally dependent, it is important to have an entire spawning season (May through September) of sounds. This will allow the sounds to be adjusted throughout the season in future years to optimally attract female gobies.

Summary Budget Information for Result 1:	**ENRTF Budget:**	**$52000**
	Amount Spent:	**$ 0**
	Balance:	**$ 52000**

Deliverable	Completion Date	Budget
1. An acoustic library of sounds emitted by the round goby in the field at various temperatures	6/30/2011	$52000

Result Completion Date: 6/30/2011

Result Status as of 12/31/2010:

Result Status as of 6/30/2011

Final Report Summary:

RESULT 2: Round goby sound attraction

Description: Underwater speakers will be placed in large (2 meter diameter) tanks in the laboratory. The round goby sounds (from result 1) will be played to female gobies. We will determine the optimal sound parameters (frequency, calling rate, amplitude) for round goby attraction.

Summary Budget Information for Result 2:	**ENRTF Budget:**	**$53000**
	Amount Spent:	**$ 0**
	Balance:	**$ 53000**

Deliverable	Completion Date	Budget
1. Acoustic sound files of the best sounds to attract the round goby in the laboratory.	June 30, 2012	$53000

Result Completion Date: June 30, 2012

Result Status as of December 31, 2011

Result Status as of: June 30, 2012

Final Report Summary:

RESULT 3: Round goby bioacoustic traps

Description: Minnow traps will be modified into round goby bioacoustic traps that include an underwater speaker and large holding area. The traps will be placed throughout the Duluth-Superior Harbor and St. Louis River. Round goby sounds (result 2) will be played throughout the breeding season and the number female gobies captured will be compared to control traps (without sound).

Summary Budget Information for Result 3: **ENRTF Budget:** **$53500**
Amount Spent: **$ 0**
Balance: **$ 53500**

Deliverable	Completion Date	Budget
1. To develop a fish trap that will attract the round goby via sound recording developed in the result 1 and 2.	June 30, 2013	$53000

Result Completion Date: June 2013

Result Status as of December 31, 2012:

Result Status as of June 30, 2013

Final Report Summary:

RESULT 4: Dissemination/publication of results

Description: All the results of the study will be published in peer reviewed publications. The round goby sound library will be placed on the PI's (Mensinger) web site and will be available for free download. Mensinger and the graduate student will present the results at the appropriate state, regional and national meetings. Mensinger also will be available to consult (at no charge) for the appropriate end users of this technology such as local, state and federal agencies including the DNR. The bioacoustic traps will be provided at cost to any interested party or agency in the state of Minnesota

Summary Budget Information for Result 4: **ENRTF Budget:** **$17000**
Amount Spent: **$ 0**
Balance: **$ 17000**

Deliverable	Completion Date	Budget
1.Peer reviewed manuscripts, website (sound library) and presentations will be produced based on results 1,2 and 3.	June 30, 2013	$17000

Result Completion Date: June 30 2013

Result Status as of June 30, 2011

Result Status as of December 31, 2011:

Result Status as of June 30, 2012:

Result Status as of December 31, 2012

Result Status as of June 31, 2013

Final Report Summary:

V. TOTAL ENRTF PROJECT BUDGET: ***175,000***

Personnel: $ 154,100

PI Allen Mensinger Has 9 month appointment at University of MN Duluth one month summer salary is requested for 3 summers 75% salary, 25% fringe	$ 35,000
graduate research assistant 50% time, 36 months, 58% salary, 42% tuition/fringe	$109,000
Undergraduate research assistant 3 month summer stipend (2 summers) 75% salary, 25% fringe	$10,600

Contracts: N/A

Equipment/Tools/Supplies: $ 18600

equipment	supplier	number	Cost per unit	Total
hydrophones	TBD	5	300	1500
speakers	Underwater sound	10	350	3500
amplifiers	WPI	2	300	600
Data acquisition systems	TBD	2	2500	5000
Fish traps	Aquatic Eco systems	20	~12	250
Supplies for making hydrophone stand, mounting speakers and modifying fish traps such as lumber, steel and PVC pipe	Home depot			2000
Gas for boat	various			1000
Electronics	Radio Shack			1000
Electronic storage device	Best Buy	1	250	250
Large aquaria	Red Ewald	2	500	1000
Water Chiller	Aquatic Eco systems	1	2000	2000
Test kits	Aquatic Eco systems			500
Total				$18,600

Acquisition (Fee Title or Permanent Easements): N/A

Travel: $ 1800

Travel by car with boat trailer to field sites. 2 spawning seasons (for sound library and traps). 80 miles rt per week. 20 weeks per year. @0.55/per mile

Additional Budget Items: $ N/A

TOTAL ENRTF PROJECT BUDGET: $ 175,000

Explanation of Capital Expenditures Greater Than $3,500: Data acquisition systems are $2500 each for a total of $5000. These are needed to record data and control the speakers

VI. PROJECT STRATEGY:

A. Project Partners: Professor Allen Mensinger of the University of Minnesota Duluth will supervise all aspects of the project. He is an expert on fish bioacoustics and will assemble the bioacoustic library and plan the sound experiments. He will train the graduate student to conduct the sound experiments, build the traps and complete the field trials. Undergraduate students will be recruited to assist with the summer experiments.

B. Project Impact and Long-term Strategy:

The overall goal of the project is to develop a bioacoustic trap for the capture of round gobies. If successful, the appropriate state agencies (ie DNR) will be provided with the traps/acoustical library to manage this invasive species. The trap is designed to be lightweight, portable and economical (~$300 per trap) for use by a wide range of interested parties. A reasonable estimate at this time is that strings of 5 to 10 traps could be used to block upstream migration in rivers or streams and/or sample small lakes.

C. Other Funds Proposed to be Spent during the Project Period:

The PI has a 9 month appt at UMD, that is divided approximately 50% research and 50% teaching. He will dedicate 2 months of academic year salary plus fringe per year as in kind support on the project for three years. Total $66,300

D. Spending HIstory: The goby populations in the harbor and preliminary trapping has been conducted over the last several years. Mensinger has used University funds to pay the summer salary of two graduates students for a total of three summers. Approximately $20K has been expended in this preliminary research

VII. DISSEMINATION:

Results will be disseminated through the PI's web site, local and national meetings and in peer reviewed journals

VIII. REPORTING REQUIREMENTS: Periodic work program progress reports will be submitted not later than _____. A final work program report and

associated products will be submitted between June 30 and August 1, 2011 as requested by the LCCMR.

IX. RESEARCH PROJECTS:

The round goby [*Apollonia melanostomus*, formerly *Neogobius melanostomus,* Stepien and Tumeo (2006)], is a benthic fish native to the Ponto-Caspian region of Eastern Europe, which has rapidly spread throughout the Laurentian Great Lakes since its detection in the St. Clair River in 1990 (Charlebois *et al.* 2001). The natural history of the round goby places it in direct competition with native benthic species for food and habitat (Janssen and Jude, 2001), and therefore it has been implicated in the decline of native johnny darters (*Etheostoma nigrum*; Lauer *et al.* 2004), mottled sculpins (*Cottus bairdii*; Dubs and Corkum, 1996; French and Jude, 2001; Janssen *et al.* 2007) and logperch (*Percina caprodes*; Balshine *et al.* 2005). Offshore migration to water depths >50 m (Schaeffer *et al.* 2005; Walsh *et al.* 2007) threaten deeper water sculpin species such as *C. ricei* and *Myoxocephalus thompsonii*.

The round gobies' rapid dispersal from initial invasion loci (Clapp *et al.* 2001; Schaeffer *et al*. 2005) have been attributed to their prolific reproductive strategy (Corkum *et al.* 2004), opportunistic feeding (Carman *et al.* 2006), and aggressive behavior (Dubs and Corkum, 1996; Balshine *et al*. 2005). Substantial dietary overlap for benthic arthropods between sculpins (*Cottus*), darters (*Percidae*), and juvenile round gobies (< 60 mm) places the invasive species in direct competition with native fish (French and Jude, 2001; Carman *et al*. 2006; Lederer *et al.* 2006). Although round gobies (> 60 mm) undergo an ontogenetic change in diet to sedentary bivalves (Ray and Corkum, 1997; French and Jude, 2001; Janssen and Jude, 2001), in the absence of bivalves, larger fish may continue to compete for other benthic invertebrates (Janssen and Jude, 2001; Skora and Rzeznik 2001; Carman *et al*. 2006; Lederer *et al.* 2006).

High fecundity combined with multiple spawning and an extended breeding season provides the round goby with a reproductive advantage over native benthic species. Females round gobies can produce up to 600 eggs per season compared to 10 to 150 eggs generated by the mottled sculpin (Grossman *et al.* 2002). Field observations in the Great Lakes indicate the majority of spawning transpires between May (after water temperature exceeds 9^{o}C) and late July with an average of three clutches of eggs developed per female per season (MacInnis and Corkum, 2000). In contrast, most native benthic fish spawn only once per year. Male round gobies can mate with multiple females resulting in nests containing 1000's of eggs (Charlebois *et al.* 1997).

Invasive species control

The success of many invasive species has been attributed to the absence of natural constraints such as predators in their new environment. Released from environmental pressures, alien species can rapidly proliferate and cause significant ecological damage. As any remnant population has the potential to recolonize an area, complete eradication is often necessary to remove invasive species. However, these endeavors are often handicapped by financial, logistical and/or ethical reasons. Species specific controls are unavailable for many invaders and indiscriminate efforts (i.e. poisoning) can affect many non target species. Importing biological

controls (i.e. pathogens, predators) have had limited success (review: Hajek, 2007), but these alien species do not come without their own risks.

A wide variety of pheromones have been isolated for use in insect management. The two principle strategies are air permeation which disrupts intraspecific communication and mating, or point source lures to control populations by mass trapping and destruction (review: Witzgall *et al.* 2008). Based on success in the terrestrial environment, pheromone manipulation has been proposed to control invasive fish species (Corkum, 2004; Sorensen and Stacey, 2004; Corkum and Belanger, 2007). Recent studies have indicated that sea lampreys possess both a migratory and male releasing pheromone (Li *et al.* 2007) and that both genders of the round goby are capable of releasing pheromones that can be detected by conspecifics (Corkum and Belanger, 2007). However, pheromones represent just one mode of intraspecific communication and Sorensen and Stacey (2004) suggest a multi disciplinary approach of pheromone treatment combined with acoustic and light traps as a more effective control option.

Fish bioacoustics

Acoustic fish deterrent systems have been developed to repel fish away from water intakes. Power plants contribute to losses of various life-history stages of invertebrates and fishes due to impingement on intake screens or entrainment through cooling systems. Up to 94% reduction in the intake of fish species was reported using an acoustic deterrent system (Maes *et al.* 2004). Acoustic stimuli also has been tested as a method to deter the migration of the invasive bighead carp (Taylor *et al.* 2005). However fish may eventually habituate to the sound and it cannot eliminate already established populations.

A wide variety of fish produce sounds for inter- and intraspecfic communication. Therefore, by replacing the pure tone stimulus used by fish deterrent systems with attractive mating calls, target species could be lured to areas or traps for elimination. Bioacoustic control has several advantages: 1) species specific calls are unlikely to affect non-target organisms; 2) gravid female fish will be most responsive to the calls and whose elimination could disproportionately effect the reproductive success of the population 3) acoustical attraction is inherent in the natural history of the species making it unlikely the fish will habituate to the sound.

Sound playback experiments with the gobies *Bathygobius soporator* (Tavolga, 1958) and *Padogobius martensii*, (Lugli, 1997) and damselfish (Kenyon, 1994) demonstrated that fish can localize sound stimuli and be lured to speakers emitting conspecific calls. Male plainfin midshipman and oyster toadfish both use acoustical communication to lure females to nesting sites, and female midshipman have been observed to approach underwater speakers that simulate male sounds (McKibben and Bass, 1998, 2001). Recently, Rollo *et al.* (2007) reported round gobies will approach a speaker emitting conspecific male calls in the field, and female round gobies showed significant attractions to speakers emitting conspecific male calls in the laboratory. Therefore round goby phonotaxis could be used to lure gravid females to traps. However, in many soniferous fish species, females become unresponsive to male calls outside the spawning season. The extended breeding season of the round goby which has been implicated in its success as an invasive species could be used against it for bioacoustic trapping.

As round gobies will spawn multiple times throughout late spring and summer, they should remain receptive to male calls and bioacoustic capture for the entire breeding season.

The vocalization patterns of many species vary with geographic location (Gray and Winn, 1961; Fish, 1972; Fine, 1978; Edds-Walton *et al*. 2002), and are further modified over the season primarily in response to changes in water temperature that influence muscle contraction kinetics or pattern generator activity in the brain (Bass and Baker, 1991; Feher *et al*. 1998). Thus if bioacoustics are going to be useful for round goby control, it is imperative that acoustic playback experiments are correlated with the local "dialect" and seasonal conditions such as water temperature.

Duluth-Superior Harbor and St. Louis River Estuary

The St. Louis River Estuary and Duluth-Superior Harbor provide a unique setting to test the effectiveness of bioacoustic management of the round goby. Round gobies were censused between 1998 and 2004 and exhibited a continual expansion throughout the harbor and upstream into the estuary (Bergstrom et al, 2008). Hard substrate abounds in the form of manmade structures and debris in the harbor resulting in ideal round goby habitat and high population density. In contrast, near the edge of the upstream migration, the industrialized harbor gives way to upper estuarine flats, sheltered bays and clay influenced river mouths which contain, at present, lower numbers of round gobies. Although the present study will concentrate on developing and testing the acoustic traps on the high density population of the harbor, if successful, future studies could use the goby free portions of the river and tributaries to test the feasibility of bioacoustics stopping or impeding round goby migration.

Application

Round gobies have become firmly established throughout the Great Lakes and in the absence of a magic bullet (i.e. pheromone or virus), eradication is outside the realm of current technology. However, if the bioacoustic traps are successful, they could be used to target critical areas such as fish nurseries or strategic bottlenecks such as river mouths. As female gobies are more likely to be lured by the males calls, the reproductive cycle would be interrupted and subsequently reduce pressure on native fish. My laboratory has recently begun to examine the effect of competitive interactions of native fish with round gobies. We have found that at low round goby density, the native fish can compete with gobies for limited food resources (Bergstrom and Mensinger, 2009). Therefore the presence of the goby is not terminal for native fish, but more likely the sheer numbers of round gobies due to its high fecundity overwhelm native populations and contribute significantly to native fish decline.

OBJECTIVE

The objective is to test whether natural bioacoustic stimulation can lure gravid female gobies into traps. An acoustic library of seasonal and temperature specific male round goby calls will be developed as acoustic lures. Specially designed goby traps with underwater speakers will be placed in the Duluth-Superior Harbor and St. Louis River estuary. Acoustic stimuli that mimic the natural calls of the male gobies will be played at different periods throughout the day. The number of fish captured will be compared with non-acoustical traps to determine the efficacy of acoustic lures.

METHODS

1) Develop an acoustic library of seasonal correlated round goby calls

Call number, fundamental frequency, duration and intercall interval are known to change throughout the season in temperate water fish (Maruska and Mensinger 2008). The PI has developed a hydrophone system to record toadfish (*Opsanus tau*) calls *in situ* that will be modified for this study (Figure 1). Sand filled PVC pipe will be formed into an equilateral triangle (2 m per side) with 10 cm posts that project vertically into the water column at each corner of the triangle. A hydrophone will be attached to the top of each post. The entire unit will be placed on the substrate at a water depth of 1 m in the midst of an active goby breeding area in the Duluth-Superior Harbor.

The hydrophone cables will be run to a shored based data acquisition system. The signal from each hydrophone will be amplified by a WPI FC23B DC amplifier and digitally recorded with a PowerLab data acquisition system (sampling rate 10K per channel). Acoustic events are easily recognized as appearing on all three hydrophones (figure 1), and the differential delay in sound reaching each hydrophone can be used to determine the location of calling fish. Water temperature will be recorded at 1 min intervals with HOBO data loggers affixed to hydrophone array.

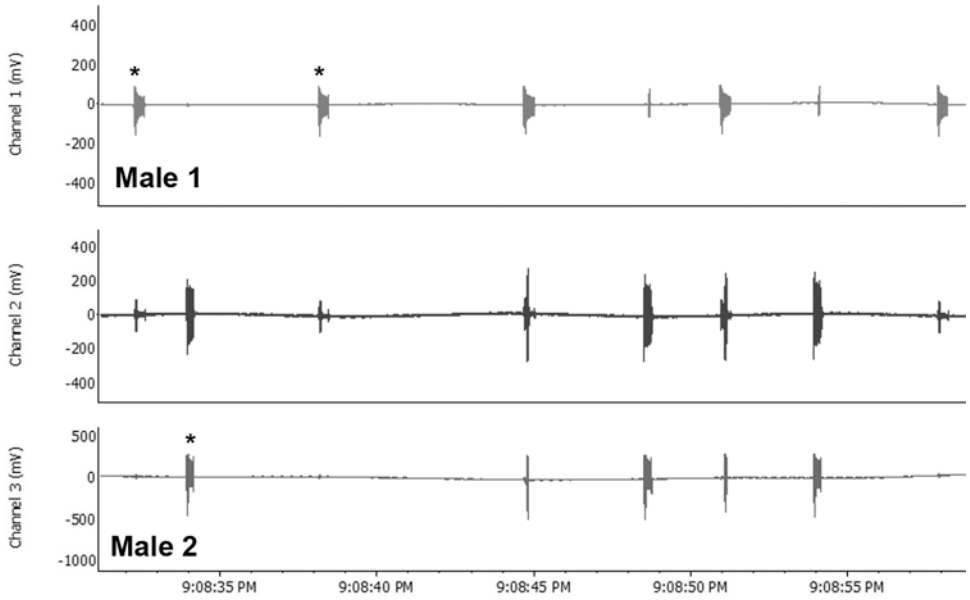

Figure 1. *In situ* recording of male toadfish calls using the hydrophone array. The channel 1 and 3 hydrophones were placed next to calling males and the channel 2 hydrophone placed between the two males. Initial male "boatwhistles" calls in the sequence are indicated by asterisks and are detected by the intermediate hydrophone.

Calls will be monitored for 24 hrs at weekly intervals. Higher frequency sampling will occur if water temperature increases at rates greater than 1^{o}C per week. Calls will be analyzed for amplitude, duration, fundamental frequency, and intercall interval using Avisoft Bioacoustic software. Sound files will be made at each degree of temperature (approximately 9 to 25 ^{o}C) and used for the playback experiments.

2***) Bioacoustic attraction***

Underwater speakers will be placed opposite one another in a 2 meter diameter tank. A single female round goby will be placed in a removable container in the middle of the tank and allowed to acclimate for 30 minutes. The container will be removed remotely (via a pulley system) and sounds recorded in part 1 will be played. An overhead video camera will record round goby movement during the sound playback experiments. The amplitude, duration and frequency of the sound will be altered to determine the optimal sound stimulus. A playback will be counted as positive if the goby approaches to within 10 cm of the speaker. The tank can also be used to test and modify the bioacoustic trap that will be developed in section 3.

3) Bioacoustic trapping of round gobies

The bioacoustic trap will consist of three sections (Figure 2): The anterior section (A), containing a funnel shaped entrance, will be constructed from the front half of a minnow trap which has been successful in capturing round gobies. An Underwater Sound UW-30 speaker will be positioned upright in the middle section (B) of the trap and the speaker will be blocked from the goby's sight by an opaque partition. One way funnel exits will lead from both the front and middle sections to direct the round gobies to the posterior section of the trap, and not impede the egress of additional gobies. The first two sections will be composed of fine wire mesh while the terminal end (C) will be made of opaque plastic perforated with small holes. As this portion will be darker than the rest of the trap, it should further encourage the gobies to move posterior. The terminal section will be lined with netting to allow removal of the captured round gobies. A hydrophone will be mounted to front of the trap to monitor the playbacks and spontaneous calls.

The speaker and hydrophone will be run to a shore based control center. Temperature specific round goby calls will be played by a MP3 player into a Speco PAT-20B portable amplifier that will transmit the sound to the speaker. Hydrophone recording will be similar to the methods outlined in the acoustic library. As the hydrophone will remain a fixed distance from the speaker, the amplitude of the recorded calls can be adjusted to mimic the amplitude of the *in situ* calls for the library. All equipment will be powered by 12 V batteries.

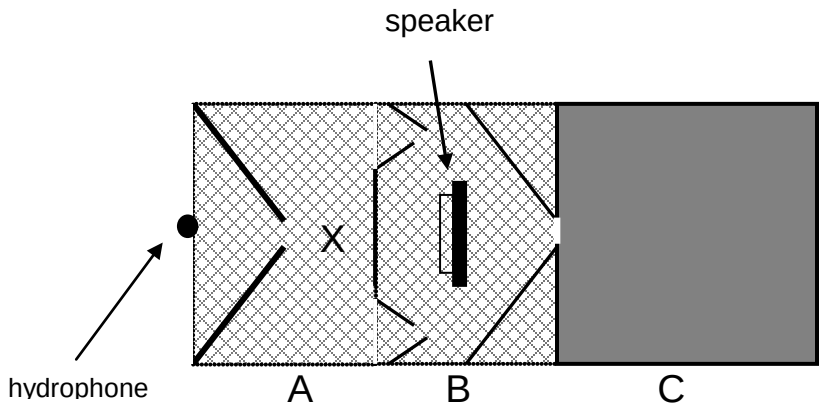

Figure 2. Round goby bioacoustic trap. The schematic displays a dorsal view of the trap. The first two sections (A and B) are composed of fine wire netting from modified minnow traps. The terminal section C is opaque. One way funnel entrances/exits (solid lines) lead into each section of the trap. The speaker will be placed in section B and blocked from the fish's view by an opaque partition. A hydrophone is mounted on the top of the trap to monitor playback.

Field trials

The field trials will take place in the Duluth – Superior Bay, 200 m southeast of the coast guard station on Park Point, MN. This area is littered with rocks and debris (primarily cement), contains high concentrations of gobies of various sex and sizes, and is an active breeding site in late spring and summer (Mensinger, unpublished). The water is relatively clear, shallow (~ 1 m) and interspersed with partially submerged concrete blocks that discourage the approach of motorized boat traffic. Sufficient time (approximately one month) from ice melt will be allowed for the water to warm to breeding temperatures (> 9^{o}C). Four identical traps will be deployed each week. Acoustic traps will broadcast round gobies calls while control traps will remain silent. The placement of the four trap will be determined randomly for each trial to avoid site bias.

Traps will be placed 10 m from shore in water depths of approximately 1 m. The traps will be spaced at sufficient distances to avoid overlap in sound presentation. We will use the acoustic library of male round goby sounds to adjust the playbacks to the appropriate seasonal and temperature conditions. Playbacks will be activated for 1 hr at sunset, midnight, sunrise and noon. Following the noon playback, traps will be recovered and the number, size and sex of round gobies in each trap recorded. All round gobies will be sacrificed by a 1 hr immersion in 0.01% MS-222. The females will be dissected and examined for number, size and maturity of eggs.

The experiments will be repeated weekly throughout the breeding season. Analysis of variance will be performed with Systat software to determine if there were significant differences in goby number and sex between the traps.

EXPECTED RESULTS

It is expected bioacoustic traps will attract large numbers of female round gobies. It is predicted that the goby population in the vicinity of the acoustic traps will experience reduction following bioacoustic sampling. However, there are large numbers of round gobies in the ship channels adjacent to the study area, and it is predicted that they will continually recolonize the area following round goby removal. Thus we expect to see oscillations throughout the study in the numbers of round gobies trapped. The continual incursion of round gobies into the area will allow examination of the efficacy of the trapping procedure throughout the extended breeding season.

It is not expected that the traps will prove a barrier to the round gobies as similar traps in this area have proved very effective in capturing this species. The possibility of "alarm" cues being emitted by captured animals and inhibiting additional captures is also unlikely. Our previous experience in the area suggests that traps containing captured round gobies do not have a negative influence on continued egression into the traps.

In summary, the experimental design should allow determination of the efficacy of round goby attraction by bioacoustic traps. If successful, future grants will target critical areas upstream in the St. Louis River estuary and test the ability of the traps to retard or limit the spread of the invasive round goby.

POTENTIAL USERS

The experimental results will be published and disseminated to a wide audience. The results will also be transmitted to the appropriate state and regional authorities in the Great Lakes area that are faced with similar round goby infestations. If successful, fisheries managers could use the technology to target round gobies in critical nursery areas or at strategic points to prevent the spread into new watersheds.

To this end, our current design is made with portability and future automation in mind. A single MP3 Player and appropriate amplifier could power a large number of traps. All the electronics are powered by DC power sources and can be fully automated. Once deployed, effort would be limited to trap retrieval and destruction of the captured fish at appropriate intervals.

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Attachment A: Budget Detail for 2010 Projects - Summary and a Budget page for each partner (if applicable)

Project Title: Bioacoustic traps for the management of the round goby

Project Manager Name: Allen Mensinger

Trust Fund Appropriation: $ *175000*

1) See list of non-eligible expenses, do not include any of these items in your budget sheet

2) Remove any budget item lines not applicable

2010 Trust Fund Budget	**Result 1 Budget:**	**Amount Spent** *(date)*	**Balance** *(date)*	**Result 2 Budget:**	**Amount Spent** *(date)*	**Balance** *(date)*	**Result 3 Budget:**	**Amount Spent** *(date)*	**Balance** *(date)*	**Result 4 Budget:**	**Amount Spent** *(date)*	**Balance** *(date)*
	Round goby acoustic library	*12/16/2009*	*12/16/2009*	*Round Goby Sound Attraction*	*12/16/2009*	*12/16/2009*	*Round goby bioacoustic traps*	*12/16/2009*	*12/16/2009*	*Dissemination/publication of results*	*12/16/2009*	*12/16/2009*
BUDGET ITEM												
PERSONNEL: wages and benefits PI-Allen F. Mensinger, PhD (nine month appointment at UMD) requesting a total of 3 months summer	9,600	0	9,600	9,700	0	9,700	9,700	0	9,700	6,000	0	4,000
Elise Cordo - Masters student 24 months support	30,000	0	30,000	34,000	0	34,000				8,000	0	8,000
Graduate student - to be determined 12 months support							34,000	0	34,000	3,000	0	3,000
Undergraduate research assistant - to be named - 6 months support (summer only)	3,000	0	3,000	4,500	0	4,500	3,100	0	3,100			
Capital equipment over $3,500 two data acquisition systems are requested @ $2500	5,000	0	5,000									
Supplies *(list specific categories)*												
hydrophones	1,500	0	1,500									
speakers				1,000	0	1,000	2,500	0	2,500			
amplifiers				300	0	300	300	0	300			
fish traps	250	0	250									
lumber, pipes, hardware supplies for modifying fish traps	500	0	500				1,500	0	1,500			
gasoline for boat	500	0	500				500	0	500			
electronic supplies (cables, wire)	500	0	500				500	0	500			
electronic storage device	250	0	250									
Large Aquaria				1,000	0	1,000						
Water chiller				2,000	0	2,000						
Water test kits				500	0	500						
Travel expenses in Minnesota travel to field sites	900	0	900				900	0	900			
Travel outside Minnesota if necessary some of the above field site travel may take place on the wisconsin side on the St. Louis River												
COLUMN TOTAL	**$52,000**	**$0**	**$52,000**	**$53,000**	**$0**	**$53,000**	**$53,000**	**$0**	**$53,000**	**$17,000**	**$0**	**$17,000**