State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Aquatic Resources
Honolulu, HI 96813

April 26, 2013

Board of Land and Natural Resources
Honolulu, Hawaii

REQUEST FOR APPROVAL TO AUTHORIZE CHAIRPERSON, BOARD OF LAND AND NATURAL RESOURCES, TO EXPEND *PORT ROYAL* TRUST FUNDS FOR 2013-2014 PROJECT: "CORAL REEF RESTORATION: REMOVING INVASIVE ALGAE, OUT-PLANTING URCHINS, AND MITIGATING THE EFFECTS OF SHIP GROUNDINGS" THROUGH A CONTRACT WITH THE UNIVERSITY OF HAWAII FOR A COST NOT TO EXCEED $600,000

This Coral Reef Restoration: Removing Invasive Algae, Out-Planting Urchins, and Mitigating the Effects of Ship Groundings (Project) is a continuation of coral reef restoration work in Kaneohe Bay, at Anuenue Fisheries Research Center, and onsite restoration to mitigate damage on coral reefs due to ship grounding. *See* Exhibit A (Project Narrative).

This is a request to authorize the Chairperson, Board of Land and Natural Resources, to use *Port Royal* trust funds as bridge financing for the 2013-2014 Project, intended to be contracted to the University of Hawaii.

For the past 10 years, the work has been conducted with a combination of funds from the Hawaii Invasive Species Council ("HISC"), the Dingle Johnson Sport Fish Restoration Fund (federal recreational sport fish fund allocation to the State), private foundations, University of Hawaii, U.S. Fish and Wildlife, and National Oceanic and Atmospheric Administration. *See* Exhibit B (2011-2012 Project). A number of these funds and contracts are being reduced, redirected, or terminated in the normal life cycles of project grants.

DLNR is seeking dedicated funding for the work covered by the Project, but currently none is fully secured. A lapse in work would result in an ecological decline in the target patch reefs unless this bridge funding is secured.

The 14-month Project requests a total not to exceed $600,000 that will be contracted to remove invasive algae, culture and out-plant native urchins, monitor the effectiveness of the project, and undertake mitigation (onsite and offsite) for coral loss due to ship groundings. *See* Exhibit C (Estimated Budget).

ITEM F-1

The key objectives of the Project are to:

1. Directly restore habitat in Kaneohe Bay by removing alien algae and out-planting native herbivorous urchins to save existing corals, increase coral cover, and enhance native ecosystem function.
2. Pilot reef recovery methods to mitigate coral and ecosystem loss due to severe ship groundings at the site of the *Port Royal* grounding.

The methods designed to do the restoration work in Kaneohe Bay have been developed by the Department and partners over nearly a decade. Rehabilitating patch reefs requires three activities that will be supported by the Project:

1. Mechanically removing the algae using the SuperSucker,
2. Rearing native herbivorous urchins,
3. Out-planting cultured urchins to cleared patch reefs in Kaneohe Bay.

Monitoring is critical for any management or research project. It will be conducted as part of the Project so the Department can continue to refine Project methods including density of urchins and required frequency of re-treatment (i.e. out-planting more urchins).

Historically, there has been little work done in Hawaii to restore coral reefs damaged by large ship groundings. However, the Department has identified potential tools that could allow the reef area damaged by the 2009 grounding of the *Port Royal* to naturally rehabilitate. The Project will support further study of the scar area to develop and apply pilot restoration activities at the site.

Pilot restoration techniques will also be monitored to evaluate effectiveness of on-site mitigation tools. This information will be crucial for the Department in addressing physical damage to fragile aquatic ecosystems in the future.

RECOMMENDATION:

That the Board:

1. Authorize the Chairperson to expend *Port Royal* trust funds (up to $600,00) for a DLNR Project with the University of Hawaii to continue the Coral Reef Restoration work for the period May 1, 2013 through June 30, 2014 or until such earlier time as other funding mechanisms can be secured to support the Project.

2. Require Quarterly Status Reports to the Board of the progress made in the Project and the expenditures to date.

3. Require a Final Report and Briefing for the Board within three months of the end of this Project cycle (June 30, 2014).

Respectfully submitted,

WILLIAM M. TAM
Acting Administrator
Division of Aquatic Resources

APPROVED FOR SUBMITTAL:

WILLIAM J. AILA, JR.
Chairperson
BLNR

Attachments: Exhibit A (Project Narrative)
Exhibit B (2011-2012 Project)
Exhibit C (Estimated Budget)

PROJECT NARRATIVE

Overall Project Goals:

- Preserve and restore coral reef habitat in Kaneohe Bay, Oahu, Hawaii, by removing/reducing populations of non-native invasive algae species.
- Prevent further spread of introduced Kappaphycus/Eucheuma spp. complex ("K/E") within and outside of Kaneohe Bay.
- Eradicate and/or manage below a target threshold level the percent cover of K/E on treated patch reefs.
- Prevent/mitigate negative effects of K/E to benthic (coral, algae and invertebrate) and fish communities on treated patch reefs.

Monitoring Project Goals:

- Identify key indicators for determining coral reef ecosystem health.
- Develop performance measures to determine the success of the project (target algae levels, coral recruitment, abundance of key species, urchin survivability).
- Develop an efficient and effective adaptive plan for management of non-native invasive algae species.
- Collect scientifically sound data to test/compare efficiency and effectiveness of methods and tools for coral reef restoration.

Outstanding Research Questions to Answer:

- What are the negative effects, if any, of substantially increasing the *Tripneustes gratilla* populations on Kaneohe Bay patch reefs?
- What is the optimal density of urchins for effective management of K/E?
- Does size of urchins at out-plant play a role in effectiveness? Survivability?
- How long after removal do you have to out-plant urchins at target density to remain effective? How frequently do we have to out-plant urchins on treated reefs to manage K/E at acceptable levels?
- What activities are most effective to reduce coral loss and promote future coral growth in a large ship grounding location?
- What are the subsequent outcomes to other marine life (fish, algae, echinoderms, etc) with the restoration activities in place at a large ship grounding site?

EXHIBIT A

Adaptive Management

This project has an advisory group to provide scientific advice, assist with developing field methods, survey protocols, and performance measures. This restoration project will rely heavily on adaptive management to continually refine the methods and interpret the outcomes. While pilot projects on reefs 15 and 16 have provided a strong base for expanding to landscape scale, success in this project will require even greater flexibility. Therefore, decisions about out-planting size or density, survey methods, and overall experimental design will be reviewed and evaluated quarterly.

Methods

This restoration project has three distinct and critical components: physical removal of invasive algae, culture and out-plant of native sea urchins as a natural biocontrol, and benthic monitoring to survey the reefs before and after treatment.

1. Algae Removal

Mechanical removal utilizes a device known as the "Super Sucker" (Figure 1). The Super Sucker consists of a 13' x 25' (~ 4m x 7.6m) covered barge equipped with a mini barge that houses two trash pumps that draws water and algae from the reef through a hose controlled by a pair of SCUBA divers positioned on the reef. Both loose and attached alien algae are lifted off the reef substratum by SCUBA divers and placed into the intake of the suction hose of the Super Sucker. Water and algae are pumped onto the barge and are deposited on a table with a mesh bottom that allows the water to drain, while retaining algae on the table. The alien algae is then placed into mesh bags and later given to farmers to be used as compost. Experience with this system has shown very little to no by-catch; however, the sorting process allows for control and oversight to monitor the material being removed from the bay.

Figure 1 shows the Super Sucker working in Kaneohe Bay.

2. Culture and Release of Native Urchins

Studies have been conducted both on small scale and large scale to test the effectiveness of native collector urchins, *Tripnuestes gratilla*, as a bio-control agent for invasive algae (DLNR, unpublished; Hunter 2002; Stimpson et al 2007). The large scale pilot project saw the successful control of algae on a small patch reef using adult urchins that were collected and transferred from another site on Oahu. Long-term effectiveness of this restoration strategy requires that urchins be reared in captivity to produce sufficient numbers for out-planting to reefs. In order to achieve this goal, DLNR built an urchin hatchery at Anuenue Fisheries Research Center. The hatchery includes larval culture systems, juvenile grow-out systems, brood-stock systems, and native microalgae and macroalgae culture systems. In Hawaii, *T. gratilla* has been successfully reared from externally spawned gametes to larvae, through metamorphosis and settlement. In the past, ensuring the survival of later larval and pre-settlement stage urchins has been a hurdle to successfully settle large numbers of urchins. However, recently there has been success in settling large numbers of urchins that will be suitable for reef restoration. Hatchery output has been steadily increasing and is expected to continue to do so.

The facility is currently producing an average of ~5,000 urchins per month that are outplanted to various patch reefs in Kaneohe Bay. Field trials and monitoring will continue to determine the optimal density and restocking schedule necessary to prevent *Kappaphycus/Eucheuma* spp from overgrowing patch reefs following algae removal. Densities between one and three urchins per m^2 will be compared on a number of reefs following removal of alien algae. These reefs will be monitored for changes in urchin and other invertebrate density, coral cover, coral recruitment, and algal density and diversity.

3. Monitoring

A five year monitoring commitment was made using Sport Fish Restoration funds from USFWS as a requirement of the NOAA ERA grant received in 2011. Monitoring will continue to follow the same method as have been for two years, measuring both structural and functional parameters. Current monitoring methods include the following surveys and frequencies:

- **Fixed Transect Monitoring Sites** (fish biomass and density, benthic species % cover, echinoderm species density) – *Quarterly (Winter, Spring, Summer, Fall)*
- **Random Benthic Quads** (benthic species % cover) – *Bi-Annually (Winter, Summer)*
- **Random Urchin Quads** (urchin species density) – *Bi-Monthly (Prefer Monthly if Possible)*

Accomplishments

Summary of patch reefs cleared 2011-2013. Funds came from HISC special funds and NOAA Estuary Restoration Act grant. Urchins will continue to be outplanted on these three reefs through this year.

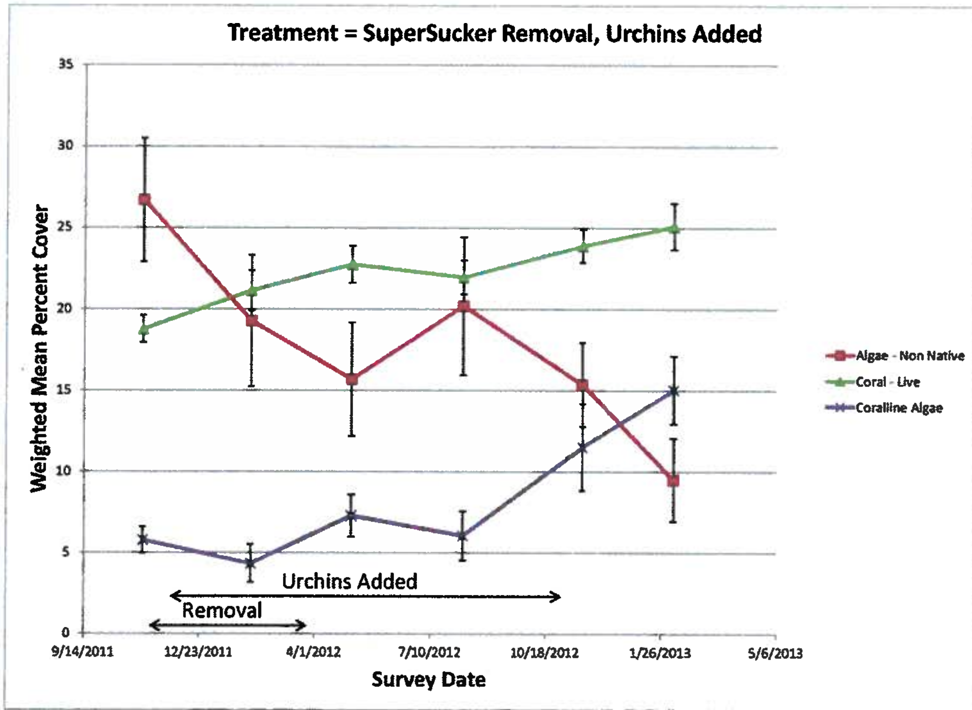
Reef #	Area Cleared	Pounds Removed	Days of Removal	Urchins Out planted
15				5119
26	12,000 sq. meters	11,053	23	34,777
27	12,000 sq. meters	15,630	25	48,785
29	29,000 sq. meters	111,438	39	80,032
12	20,800 sq. meters	26,220	21	0

Current removal of algae on Marker 12 fringe reefs located in the Northern section of the bay and is considered the Northern most extent of the smothering seaweed. Pushing this back will further help to prevent the spread of this alga outside Kaneohe Bay.

Preliminary Results

Reef 15 was the first full patch reef to be stocked with urchins cultured at the hatchery. Reef 26 was the next patch reef and the first large scale reef to be attempted. Since this is the longest dataset we have so far for this project, the figures that follow are from Reef 26 only. Similar results are being seen on Reef 27 which is also now fully stocked.

Figure 1. Reef 26 Mean Percent Cover by Benthic Group

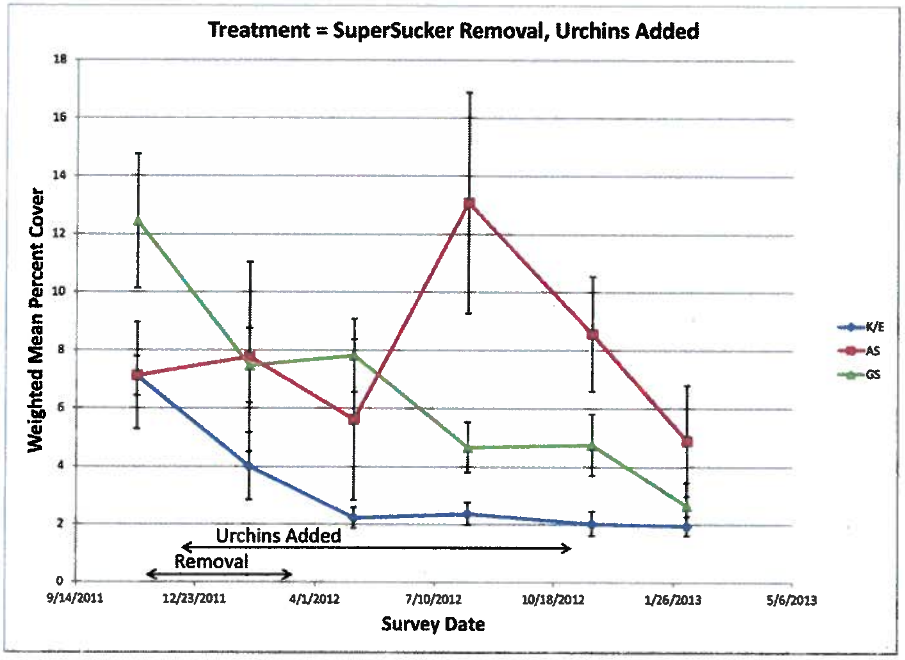


Mean cover of non-native invasive algae on the reef has decreased by 67% from baseline levels.

Mean cover of live coral has increased by 34%. Since this data was collected on fixed transects over a short time period, new coral recruitment is unlikely at this time. We are now seeing more coral because it was previously covered by invasive algae. This coral was saved by removing the non-native algae.

Mean cover of coralline algae has increased by 160%. Coral larvae settle on crustose coralline algae. By reducing the amount of invasive algae we have exposed a much larger area of suitable settlement habitat for new coral recruits.

Figure 2. Reef 26 Mean Percent Cover by Invasive Algae Species



All non-native invasive algae species found on Reef 26 were reduced substantially by management efforts.

K/E (*Kappaphycus/Eucheuma* spp. complex) was reduced by 73%; GS (*Gracilaria salicornia*) was reduced by 79% and *Acanthophora spicificera* ("AS") was reduced by 31% from baseline levels.

The spike in AS in summer is consistent with data collected on other reefs (accounts for the spike in Fig.1) in Kaneohe Bay. It appears that this species bloomed in this area of the bay during the summer of 2012. The area where AS grows on Reef 26 was also the last area to be stocked with urchins. Urchins will eat AS and we expect to see further reduction in the percent cover of this species over time.

K/E and GS are now below our target threshold of 3%.

Work Plan

			Month (May 2013-April 2014)											
	Activity	**Output**	1	2	3	4	5	6	7	8	9	10	11	12
AIS Crew	Clear ~15,000 sq. meters on Marker 12	~20,000 lbs of algae.												
	Re-Clear patch reef 29 (~29,000 m2)	~100,000 lbs of algae												
	Begin removal on Reef 44 (~45,000 m2)	Many thousands of pounds.												
Urchin Culture and Outplanting	Rear Urchins	1 spawn/mo; ~7000 urchins/mo starting 09/13												
	Outplant to patch reef 26-29	~30,000 m2 treated												
	Outplant to patch reef 44	TBD based on hatchery output												
Mitigation of Grounding Site	Survey site and Identify Pilot Methods	White paper summarizing current condition and options for mitigation												
	Apply Methods	Report of methods applied and total area treated												
Monitoring	Monthly Surveys of Kaneohe patch reefs	Quarterly survey reports												
	Surveys of Port Royal Site	Quarterly report												

Super Sucker Crew

The Super Sucker crew will continue to remove invasive algae from a large fringing reef (Marker 12) in the Northern section of Kaneohe Bay. This reef is considered the Northern most extent of the algae and therefore is important to remove in order to prevent further spread outside

Kaneohe Bay. However, this reef will not receive urchins at this time because it is too large to efficiently stock with urchins at the necessary density for success. But the removal of algae will prevent further spread and loss of coral in the near future.

Because the hatchery was not able to produce enough urchins at the time of previous removal on Reef 29, this reef will need to be re-cleared beginning in August/September once the hatchery starts the outplant of urchins once again.

Removal will then begin on patch reef 44, which is over 45,000m^2. Hatchery output and urchin availability will determine when this reef receives urchins.

Urchin Hatchery

The urchin hatchery will conduct one spawn per month and will begin to outplant urchin of appropriate size beginning in September, 2013. Recent expansions will create additional space for the urchins to reduce hatchery density and prevent any mortality. Current estimates predict the output of the hatchery to be 7,000 urchins per month.

Mitigation of Grounding Site

Reviewers will evaluate and recommend an initial survey protocol for the *Port Royal* grounding site. Due to summer swells, surveys will not be doable until September and completion of these surveys will be highly based upon weather conditions. Once surveys are completed, a restoration plan will be vetted, reviewed, and approved. Depending on the methods chosen, it is expected to take 2-5 months to complete the restoration activity. This again will be based on necessary activities, diver availability, and weather conditions.

Monitoring

Surveys will be conducted at one to two of five patch reefs (treated and control) in Kaneohe Bay on a monthly basis where each of the five reefs will be surveyed on a quarterly basis. A quarterly progress report will be produced with analysis of data collected.

Initial surveys will be conducted at the *Port Royal* grounding site to determine the current baseline of coral and algae cover, fish species/abundance, echinoderm density, substrate characteristics (loose rubble, pavement, new coral recruits, etc). Following restoration activity, monitoring surveys will be conducted on a quarterly basis.

Project Management

This project will be coordinated within the Division of Aquatic Resources and Department, and will also continue to foster a working relationship with several federal, state, and NGO partner agencies.

Field Team

A team of four to five staff is required for safe and effective operation of the Super Sucker system. Two divers control the collection hose in the water, one to two sorters separate out the alien algae and serve as stand-by divers, and one operation supervisor oversees the safety of the activity. In addition, a support boat is required to support the operation by offloading algae and transporting personnel, as well as providing additional safety to the operation.

Hatchery Team

A team of four to five is required to conduct all necessary urchin husbandry duties including water exchanges, tank cleaning, feeding, maintenance, repairs, and proper management of urchins to prevent mortality.

Monitoring Team

A team of at least two is required for safe operations in the water while collecting data, conducting necessary repairs to permanent transects, planning/logistics, repair/maintenance of vessels and for data input and analysis.

Budget:

The budget for this project includes the following components:

- **Salaries**
  Salaries for up to 12 staff
- **Fringe**
  All salaries have a 25-35% fringe benefit rate, which goes toward FICA, medical dental insurance, retirement and disability.
- **Supplies**
  Supply costs for the AIS team include replacement scuba supplies (mask, fins, wetsuits, regulators, etc.), fuel costs, engine repair parts, equipment maintenance parts, and field gear for mechanical removal of algae. These costs are $2,000 per month.

Supply costs for the sea urchin hatchery include PVC, screens, microalgae supplies (bicarbonate, bleach, etc.), and miscellaneous hatchery supplies. These costs are $2,500 per month.

Supply costs for the monitoring activities include replacement survey supplies (measuring tapes, reels, rebar, safety supplies, etc.). These costs are $1,000 per month.

Supply costs for the mitigation restoration project are to be determined based on the approved restoration methods.

- **Other Costs**
  Other charges include charges for communication (cell phones in field), safety training requirements, scuba diving medical exams, and utility costs. These costs are $1,000 per month.

Deliverables

Quarterly:
- Briefing for the BLNR
- Written report to include budget/expense summary, survey and monitoring report, summary of reefs/area cleared, pounds of algae removed, number of urchins out-planted, and ecological trends.

Yearly:
- Division presentation and technical report to include:
  - Budget report
  - Monitoring report
  - Ecological indicators
  - Status and trends of treated and control reefs
  - Performance measures
  - Recommendations for adaptive management

- Division/partner agency review and evaluation of methods and performance measures

Part I: Summary Information

Project Title: Habitat Restoration in Kaneohe Bay, Hawaii

Project Location: Kaneohe, City and County of Honolulu, Hawaii

Non-Federal Sponsor's Organization Name: Hawaii Department of Land and Natural Resources/ Division of Aquatic Resources

Non-Federal Sponsor's Point of Contact:
Authorized Representative:
Robert T. Nishimoto
Program Manager
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Honolulu, HI 96813

Project Contact:
Jonathan Blodgett
AIS Program Leader
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Non-Federal Sponsor Type: State Agency
Project Start Date: August 2, 2011
Project Timeline: 12 months

Project Abstract:
Kaneohe Bay is located on the island of Oahu and is considered a complex mix of both estuarine and coral reef ecosystems. The bay is approximately 11,000 acres with 12 streams and 7 watersheds (Kaneohe Bay Master Plan, 1992). The bay has significant freshwater input from its 12 streams thereby affecting the salinity of the bay. Kaneohe Bay has been subjected to a number of ecological stresses over the last century including overfishing and land-based pollution. However, the increased introduction of non-native species has been one of the largest impacts of the last decade. Specifically, the introduction of non-native algae has allowed a phase shift to change the bay from a coral dominated system to a non-native algal dominated system. A partnership of State government, University researchers and a non-profit have worked for over 5 years to develop a multi-tiered approach to address the expanding distribution of non-native algae in Kaneohe Bay. This multi-tiered approach includes the efficient mechanical removal of algae coupled with an increase in native herbivory via outplanting of the sea urchin, *Tripnuestes gratilla*. These proven techniques will aid managers in the restoration of 13 acres of habitat, which will help to save existing corals as well as create increased habitat for coral recruitment and fish habitat.

EXHIBIT B

Habitat Acreage:
13 acres of Coral Reef
Permits and Approvals: N/A

Funding and Partners:
Estimated Total Project Funds Available: $894,051

ERA Funding Request: $286,358

Total of Federal Funds from other sources: $170,000
NOAA Coral Reef Conservation Program – State Management Grant -- $60,000
Department of Interior–U.S. Fish and Wildlife Sport Fish Restoration -- $110,000

Non-Federal Share: $437,693
Hawaii Invasive Species Council -- $387,693
The Nature Conservancy -- $50,000

Budget:

	ERA	HISC	TNC	NOAA-CRCP	USFWS
Planning	Completed	Completed	Completed	Completed	Completed
Design	Completed	Completed	Completed	Completed	Completed
Implementation	$286,358	$387,693	$50,000	$60,000	$0
Post Monitoring	$0	$0	$0	$0	$110,000
Admin and oversight	In-kind	In-kind	In-kind	In-kind	In-kind
Value of Lands	N/A	N/A	N/A	N/A	N/A
Annual Costs	$0	$0	$0	$0	$0

*** The amount of restored habitat in Kaneohe Bay can be proportionally scaled up or down in relation to funds available.**

Grant Budget Table:

	ERA	Total Non-Fed	TOTAL
Salary	$173,940	$93,660	$267,600
Fringe	$60,879	$32,781	$93,660
Travel	$0	$0	$0
Equipment	$0	$0	$0
Supplies	$15,600	$8,400	$24,000
Contractual	$17,297	$9,314	$26,611
Construction	$0	$0	$0
Other	$18,642	$10,038	$28,680
Total Direct	$286,358	$154,193	$440,550
Indirect	$0	$0	$0
TOTAL	**$286,358**	**$154,193**	**$440,551**

Grant Budget Narrative:

Budget was calculated on a project need and all costs are split 65/35 for federal/non-federal cost sharing ratio. Stated matching funds will be cash match; however, addition in-kind match may be available. **THIS PROJECT CAN BE EASILY SCALED EITHER UP OR DOWN DEPENDING ON FUNDS AVAILABLE. Currently estimated, this project covers 12 months of habitat restoration work.**

Personnel -- $267,600 (includes ERA + match)

All staff will be paid prevailing wages.

Program Leader will be 100% FTE for six months for project supervision, reporting and management of mechanical removal, bio-control, and monitoring. Total: $29,400

Field Supervisor will be 100% FTE for twelve months for mechanical removal, mechanical repairs and maintenance, and overall supervision of operations in the field. Total: 43,200

Senior Field Technician will be 100% FTE for twelve months for mechanical removal supervision in the field as well as data analysis. Total: $36,000

Research Associate will be 100% FTE for six months for mechanical removal, monitoring activities and data analysis. Total: $18,000

Field Technician will be 100% FTE for twelve months for mechanical removal operations. Total: $30,000

Bio-control Specialist, will be 100% FTE for twelve months for supervising the culture of sea urchins. Total: $51,000

Hatchery Technician, will be 100% FTE for twelve months for assisting with duties related to the culture of sea urchins. Total: $30,000

Hatchery Technician, will be 100% FTE for twelve months for assisting with duties related to the culture of the sea urchins. 30,000

Federal Share (ERA) -- $173,940
Non-Federal Share -- $93,660

Fringe Benefits -- $93,660 (includes ERA + match)

All salaries have a 35% fringe benefit rate. Fringe benefits go toward FICA, medical dental insurance, retirement and disability.

Program Leader --$10,290
Field Supervisor --$15,120
Sr. Field Tech -- $12,600
Research Assoc -- $6,300
Field Tech -- $10,500
Bio-control Specialist -- $17,850
Hatchery Tech -- $10,500
Hatchery Tech -- $10,500

Federal Share (ERA) -- $60,879
Non-Federal Share -- $32,781

Travel -- $0
Equipment -- $0

Supplies -- $24,000 (includes ERA + match)

Supply costs include replacement scuba supplies (mask, fins, wetsuits, regulators, etc…), fuel costs, engine repair parts, equipment maintenance parts, and field gear for mechanical removal of algae. These costs are calculated to be $2,000 per month for 12 months.

Supply costs also include repair parts and supplies for sea urchin hatchery work. These items include PVC, screens, microalgae supplies (bicarbonate, bleach, etc…), and misc hatchery supplies.

Federal Share (ERA) -- $15,600
Non-Federal Share -- $8,400

Contractual Charges -- $26,610.15 (includes ERA + match)

This project has two different indirect rates charged due to different administrative avenues for project administration. All mechanical removal activities are administered under a DLNR-Research Corporation of the University of Hawaii (RCUH) and has an

indirect rate of 2.7%. All urchin culture activities are administered through the Pacific Cooperative Studies Unit (PCSU) has an indirect rate of 11%.
PCSU indirect rate of 11% - $19,380.90
RCUH indirect rate of 2.7% - $7,229.25

Federal Share (ERA) -- $17,296.60
Non-Federal Share -- $9,313.55

Other -- $28,680 (includes ERA + match)

Other charges include charges for communication (cell phones in field), safety training requirements, scuba diving medical exams, dock maintenance (HIMB rental), and utility costs.

Utilities -- $1,000 per month for 12 months for a total of $12,000
Communication -- $200 per month for 12 months for a total of $2,400
Training -- $160 per person per year for a total of $1,280
Scuba medical exams -- $200 per person per year for a total of $1,000
Super Sucker dock space maintenance (HIMB rental) -- $1,000 per month for 12 months for a total of $12,000

Federal Share (ERA) -- $18,642
Non-Federal Share -- $10,038

Indirect Charges – $0.00 – Opting to waive State indirect charges.

Total Charges: **Federal (ERA): $286,358**
Non-Federal: $154,193

Project Budget Table:

	ERA	Monitoring - USFWS	NOAA-CRCP	Total Federal	TNC	HISC	Total Non-Fed
Salary	$173,940	$72,000	$40,000	**$285,940**	$36,000	$250,000	**$286,000**
Fringe	$60,879	$20,200	$14,000	**$95,039**	$12,600	$87,500	**$100,100**
Travel	$0	$0	$0	**$0**	$0	$0	**$0**
Equipment	$0	$0	$0	**$0**	$0	$0	**$0**
Supplies	$15,600	$5,000	$0	**$20,600**	$0	$20,000	**$20,000**
Contractual	$17,297	$10,800	$6,000	**$33,435**	$1,400	$10,193	**$11,593**
Construction	$0	$0	$0	**$0**	$0	$0	**$0**
Other	$18,642	$2,000	$0	**$20,642**	$0	$20,000	**$20,000**
Total Direct	$286,358	$110,000	$60,000	**$455,656**	$50,000	$387,693	**$437,693**
Indirect	$0	$0	$0	**$0**	$0	$0	**$0**
TOTAL	**$286,358**	**$110,000**	**$60,000**	**$456,358**	**$50,000**	**$387,693**	**$437,693**

Project Budget Narrative Including Partnership Funds Available:

Sport Fish Restoration -- Approximately $110,000 per year (5 years totaling $550,000) has been granted from Dingle-Johnson Sport Fish Restoration Federal Aid (under Department of Interior, U.S. Fish and Wildlife). These funds will support all monitoring aspects of this project.

The Nature Conservancy -- The Nature Conservancy currently has approximately $50,000 for mechanical removal of alien algae from private donors and is willing to support staff costs associated with alien algae removal in Kaneohe Bay.

The Hawaii Invasive Species Council -- The Hawaii Invasive Species Council has been a strong support of aquatic invasive species issues in Hawaii. They have provided state funds to DLNR/ DAR every year to maintain a capacity to control invasive species in Hawaiian marine waters. With recent budget restrictions, DLNR/DAR has concentrated its efforts in Kaneohe Bay (both mechanical and biocontrol) to focus resources. Currently, DLNR/DAR has a $135,000 encumbered in contract (estimated in July 2010 through June 2011) for mechanical removal and $60,000 for biocontrol. It is also expected to receive approximately $200,000 in FY2011. This equals approximately $395,000 in state funds available for match.

NOAA's Coral Reef Conservation Program -- Under NOAA's Coral Reef Conservation Program, states with coral reef resources are allotted funds for coral reef management. DLNR/DAR is expected to receive $60,000/yr in order to culture and outplant urchins for algae control for the next three years.

Part II Proposal Elements

Project Description

Kaneohe Bay is located on the island of Oahu and is considered a complex mix of both estuarine and coral reef ecosystems. The bay is approximately 11,000 acres with 12 streams and 7 watersheds (Kaneohe Bay Master Plan, 1992). The bay has significant freshwater input from its 12 streams thereby affecting the salinity of the bay. These effects have been described by Ostrander et al (2008); however, despite these effects the bay supports three types of coral reef habitats: fringe reef, patch reef, and barrier reef. Kaneohe Bay has been subjected to a number of ecological stresses over the last century including overfishing and land-based pollution. However, the increased introduction of non-native species has been one of the largest impacts of the last decade. Specifically, the introduction of non-native algae has allowed a phase shift to change the bay from a coral dominated system to a non-native algal dominated system.

Healthy coral reef systems are dominated by reef-building corals, with much of the production of algae removed by grazers. In areas of anthropogenic influence, however, benthic communities can undergo "phase shifts" from coral to algal domination (Done 1992; Hughes 1994; Schaffelke and Klumpp 1997). Increased algal growth can physically smother coral and also harm reefs by decreasing the diversity and abundance of coral-associated fish and invertebrates (McClanahan et al. 1999), and potentially increasing the erosion of physical reef structures (Done 1992). Phase shifts have been observed on reefs in the Caribbean, Western Atlantic, Western and Central Pacific, and Indian Ocean (Done 1992; Littler et al. 1992; Naim 1993; Hughes 1994; Hunter and Evans 1995; Lapointe 1997; McClanahan et al. 1999). These phase shifts have been attributed to increased anthropogenic nutrient input (Cuet et al. 1988; Littler et al. 1992; Lapointe 1997, 1999), reductions in the abundance of herbivores (Hay 1984; Carpenter 1990; Hughes 1994; Hughes et al. 1999), or coral mortality creating space for algal growth that overwhelms natural herbivory (Williams and Polunin 2001; Williams et al. 2001). Reef comparisons of infested reefs with non-infested reefs in shown in Figure 1.

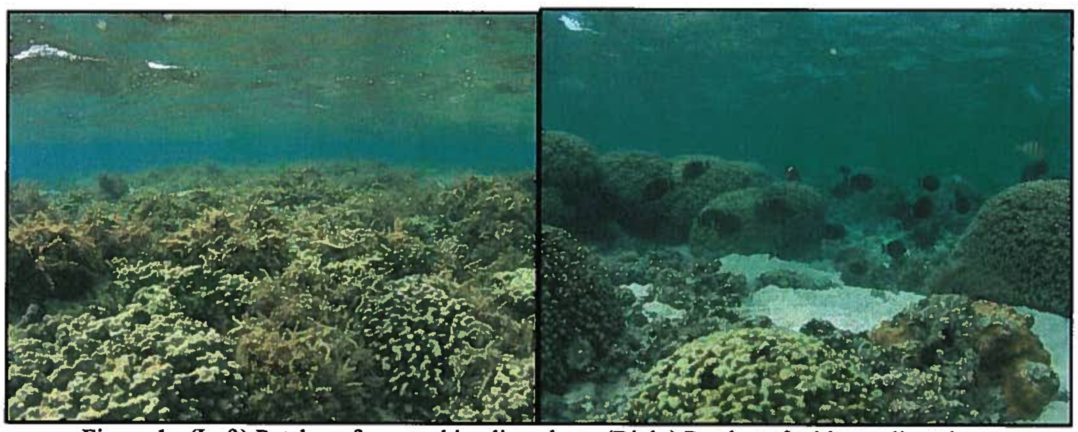

Figure 1: (Left) Patch reef covered in alien algae. (Right) Patch reef without alien algae.

In Hawaii, an additional contributing factor to phase shifts is the introduction of over 20 species of non-indigenous (alien) algae into the state since the 1950's (Russell 1992). Five of those alien algal species have become the dominant component of marine benthic communities in at least some of the habitats in which they occur (Doty 1961; Brostoff 1989; Rodgers and Cox 1999; Russell 1987, 1992; Woo 2000; Smith et al. 2002). One group of alien algae in particular, *Kappaphycus/Eucheuma* spp., is a threat to coral reefs in Hawaii. This species group forms extensive, destructive blooms on the benthos, invading coral habitat and forming large mats that overgrow and kill reef-building corals (Rodgers and Cox 1999; Smith et al. 2002; Conklin and Smith 2005), producing a phase shift to algal dominance. These are also threatening candidate species of corals, particularly *Montipora dilatata* on patch reef #44 (proposed restoration site) (Hunter, 2009).

Hawaii's marine ecosystems support fishing and recreational activities, a tourism-based economy, and are an important part of Hawaii's unique cultural heritage. Currently, alien algae present one of the most insidious threats to the health of Hawaii's coral reef ecosystems and is an increasing threat to Kaneohe Bay. The most successful alien algae (i.e. the most invasive) are often unpalatable to native fish grazers, which likely contribute to their ability to out-compete and overgrow corals (Stimson et al 2001). Without the development of an effective removal and control program these algae will probably continue to spread, threatening the health and survival of Kaneohe Bay. Figure 2 shows the spread of *Kappaphycus/Eucheuma* spp. over a 3-year timeframe.

Despite the global prevalence of phase shifts caused by algal overgrowth, relatively few management techniques have been developed to restore impacted coral reefs or protect threatened reefs. Nutrient inputs that fertilize algal growth are often difficult to control, and fishing regulations to protect algae-eating fishes are politically unfeasible and difficult to enforce in many situations (Bohnsack, 1993). Recent observational (Williams and Polunin 2001), experimental (Williams et al. 2001), and theoretical (Mumby 2006) research has suggested that even robust herbivore communities have a threshold abundance of algae above which they will be unable to control algal growth. The large quantities of alien algae that can be found on the reef flats and slopes of Kaneohe Bay, Hawaii may exceed such threshold levels and intervention is required to reduce the abundance of the algae below a level at which they can be controlled by herbivores. Without any intervention, many more reefs in Kaneohe Bay will undergo a phase shift.

In Hawaii, a group of State, Federal, and non-governmental organizations has collaborated to develop control strategies for alien algae that attempts to stop the further spread of these alien species to new environments, remove mass quantities of algae from the most impacted habitats, and decrease the ability of the algae to re-grow following removal.

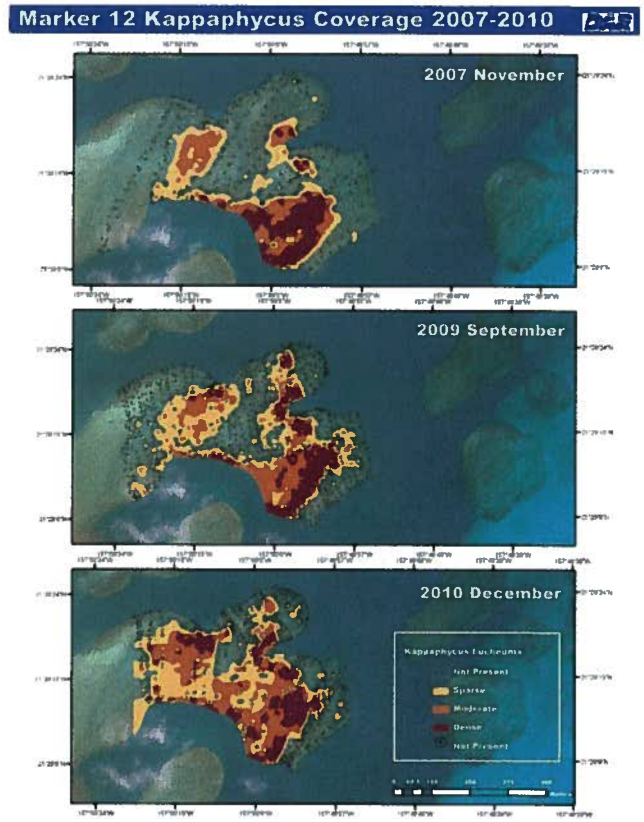

Figure 2. Distribution of *Kappaphycus/Eucheuma* spp. in yellow, orange, and red from 2007 – 2010.

The first process employed by this partnership was the shore-based removal of alien algae populations with community volunteer events. Events drew over 1200 community volunteers to remove algae from the reef by hand, and were capable of removing several thousand pounds of algae within a single day. These efforts were limited, however, in that they could not be held frequently enough to address the problem of alien algae at the scale at which it grows, and were restricted to near shore areas, whereas the alien algae are often abundant on reefs far from shore. To overcome these limitations, a new tool was developed that would be capable of operating full time, in areas that community members could not easily reach.

The partnership developed a mechanical removal device nicknamed the "Super Sucker," that was capable of removing mass quantities of algae with a small crew. The Super Sucker has been used to remove the accumulation of several thousand kilograms of the invasive alien alga *Gracilaria salicornia* from two sites on the leeward reef slope of Coconut Island, a marine reserve where fishing is prohibited and herbivores are abundant. Benthic surveys were conducted to quantify the subsequent response of the reef slope community over time. The removal of this biomass may have reduced the algae below a threshold abundance allowing herbivores to maintain low algal cover in the face of continuing influx of *G. salicornia* from the neighboring reef flat. These encouraging results suggest that removing mass quantities of alien algae from overgrown reefs, coupled with enhanced herbivory, could be a viable restoration technique that has the ability to produce long-lasting recovery of coral reef communities (Conklin 2007).

A key element of reef restoration, therefore, is the enhancement of native herbivory following algal removal. Ideally, the herbivory would consist of both vertebrate and invertebrate grazers; however, it is considered infeasible to increase vertebrate grazers either through propagation or protected areas in the short timeframe of the proposed project. The artificial propagation and out-planting of the native sea urchin, *Tripneustes gratilla*, is a viable solution until longer-term solutions can be implemented. This sea urchin species has been shown to be an effective component in control of alien algae in experimental plots in Kaneohe Bay (Conklin and Smith 2005), particularly when used as a follow-up to removal of alien seaweeds (Stimson unpublished; Conklin and Smith unpublished; Hauk et al unpublished; Figure 4).

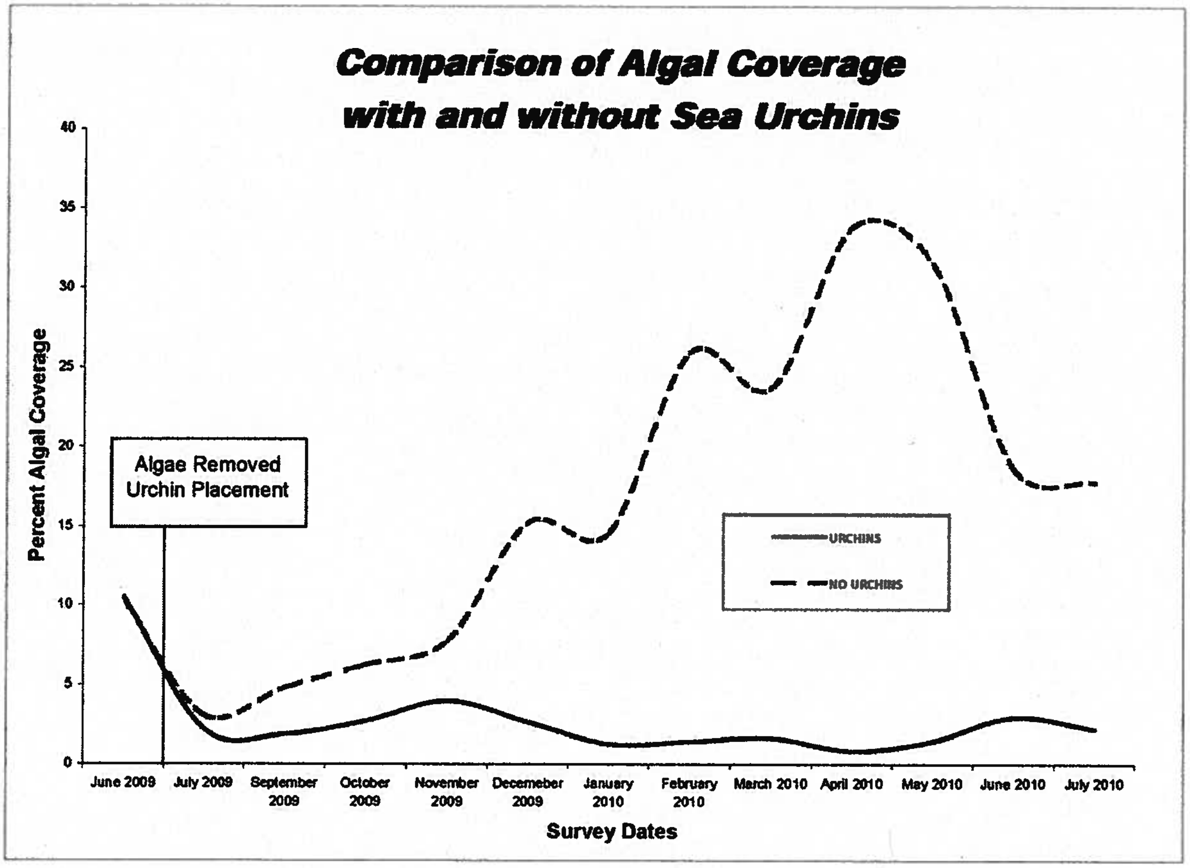

Figure 4. Pilot study results of alien algae, *Kappaphycus/Eucheuma* spp., regrowth over a twelve-month period on Reef 16 without urchin enclosures, with and without the addition of the native urchin, *T. gratilla* in Kaneohe Bay (Montgomery, unpublished).

Anecdotal reports suggest that populations of these sea urchins in many locations have been greatly reduced from historical levels. Two likely hypotheses that may explain the reduction in urchin densities within Kaneohe Bay are the reduced water quality has decreased fertilization success and larval survival in this very susceptible species, and that over-harvesting for this prized food resource has diminished populations. Reductions in sea urchin populations can have a profound effect on coral reef ecosystems, as urchins play a critical role in regulating subtidal community structure, primarily as herbivores controlling algal abundance and secondarily as a food source for large fish (Lawrence 1975; Lawrence and Sammarco 1982; Harrold and Pearse 1987). Widespread loss of sea urchins due to a disease outbreak in the Caribbean resulted in a shift from coral-dominated communities to algal-dominated communities (Hughes 1994). Conversely, increased urchin grazing following recovery of stocks from the disease outbreak resulted in an increased abundance of juvenile corals (Edmunds and Carpenter 2001, Ogden and Lobel 1979).

The abundance of *Tripneustes gratilla* in Kaneohe Bay has been low in recent decades, and their historical abundance is unclear. Anecdotal reports suggest historical abundances were once much higher. Collection pressure and water quality degradation may be two contributing factors to the low abundance of sea urchins observed in Kaneohe Bay. Researchers at HIMB have observed approximately 100 sea urchins tests broken cleanly in half shortly after they were transplanted to an experimental plot in Kaneohe Bay (J. Stimson, pers. comm. 2006). Once reported to number in the tens of thousands near Kaneohe Bay (R. Brock, pers. comm. 2006), the abundance of *T. gratilla* is now at least an order of magnitude lower.

In Hawaii, *T. gratilla* placed into cages surrounding small (0.25 m^2) algal removal plots have shown that these urchins can be successful at slowing the rate of algal regrowth, suggesting that these native sea urchins may be used as effective biocontrol agents to control alien algae (Conklin and Smith, 2005, Stimpson, 2007). In addition, a large-scale pilot study using urchins (< 1 /m^2) without enclosures on half of reef 16 (1500 m^2) in Kaneohe Bay has shown promising results for the control on alien algae (Hauk et al unpublished; Figure 4).

This project proposes to directly restore habitat in Kaneohe Bay by removing alien algae and enhancing native herbivory with the ultimate goal of saving existing corals as well as creating increased habitat for coral recruitment. The activities proposed are shovel ready and can begin almost immediately upon project initiation. This restoration project has completed project conception and design with some monitoring and data collection ongoing. This project will be able to be at full capacity within 90 days, but can begin moderate operations on day one. The amount of restored habitat in Kaneohe Bay can be proportionally scaled up or down in relation to funds available. Enhanced native herbivory will provide persistence of restoration outputs over a long-term timeframe with minimal future work and resources.

Algae Removal

Mechanical removal utilizes a device known as the "Super Sucker" (Figure 5). The Super Sucker consists of a 13' x 25' (~ 4m x 7.6m) covered barge equipped with a 40 hp Venturi pump that draws water and algae from the reef through a hose controlled by a pair of SCUBA divers positioned on the reef. A second diver uses a secondary pump or aides in feeding algae to the Venturi pump. Both loose and attached alien algae are lifted off the reef substratum by SCUBA divers and placed into the intake of the suction hose of the Super Sucker. The suction in the device is gentle, and as a result rarely pulls in other items. The suction does, however, easily entrain algal fragments. Water and algae are pumped onto the barge via Venturi-driven suction and are deposited intact on a table with a mesh bottom that allows the water to drain off, while retaining algae and other marine life on the table. Alien algae are sorted from incidental by-catch and placed in mesh bags. Experience with this system has shown there to be very little to no by-catch; however, the sorting process allows for control and oversight to monitor the material being removed from the bay. Additional pumps that are not venture-driven have also been tested. Although the power of the pump is greater and has to be operated carefully, the cost of the pump is less and its efficiency is equal or greater. Figure 5 shows the Super Sucker working in Kaneohe Bay.

Figure 5. The Super Sucker is a Venturi type pump mounted on a barge with sorting table, dive compressor, and other equipment. Divers efficiently feed algae into a suction hose (top right). The algal material is deposited on the sorting table (bottom right) to remove native species. The algae are then bagged for transport to local farmers.

A team of four-five staff is required for safe and effective operation of the Super Sucker system. Two divers control the collection hose in the water, one-two sorters separate out the alien algae from the native by-catch as well as serve as stand-by divers, and one operation supervisor oversees the safety of the operation. In addition, a support boat is required to support the operation by offloading algae and transporting personnel as needed as well as providing additional safety to the operation.

All algal material will be utilized for composting in nearby watersheds. Several farmers in the area currently use the alien algae as fertilizer in crops. One farmer has routinely used algae from Kaneohe Bay as compost in taro and corn crops with excellent success. Previous operations have not exceeded the capacity of the farm to compost, so it is expected that several farms in the immediate area will be able to accommodate the large quantities of biomass during the course of the restoration activities. We have selected farms for disposal carefully in order to minimize the potential for spreading algae to areas not currently infested. Only allowing farms from watersheds within Kaneohe Bay will minimize exposure of other areas to *Kappaphycus/ Eucheuma* spp.

Biocontrol

Studies have been conducted both on small-scale and large scale to test the effectiveness of native collector urchins, *Tripnuestes gratilla*, as a bio-control agent for invasive algae (DLNR, unpublished; Hunter 2002; Stimpson et al 2007). Long-term effectiveness of this strategy requires that urchins be reared in captivity to produce sufficient numbers for outplanting to reefs. In order to achieve this goal, DLNR built an urchin hatchery at Anuenue Fisheries Research Center. The hatchery includes larval culture systems, juvenile grow-out systems, broodstock systems, and native microalgae and macroalgae culture systems. The urchin, *Tripneustes gratilla,* is actively cultured in large quantities in other parts of the world, most notably in Australia, Okinawa and the Philippines (Junio-Menez et. al. 2008). The general state of knowledge on culturing sea urchins is rather high (Kelly 2005). In Hawaii, *T. gratilla* has been successfully reared from externally spawned gametes to larvae, through metamorphosis and settlement. In the past, the survivorship of later larval and pre-settlement stage urchins has been a hurdle to successfully settle large numbers of urchins. However, recent achievements have been made to successfully settle large numbers of urchins that will be suitable for reef restoration. A brief description of the methodology is as follows: adult urchins spawn gametes when gonads are injected with 0.5M KCl; the gametes are mixed to fertilize the eggs, and developing larvae are reared on the diatom *Chaetocerous* in large tanks with gentle agitation and air until competency, competent larvae are then transferred to settlement tanks containing clear rippled polycarbonate settlement plates coated with a benthic diatom film, where they settle, metamorphose, and fed algae until juveniles are ~2 cm test diameter.

To date, DLNR has been successful in rearing sea urchins to juvenile stages and it is estimated to take one year to achieve full-scale production of urchins. Despite this success, there remain several steps of the process that need refined and improved. After juveniles have grown and started to feed on macroalgae and are approximately 2.5 cm in size, they are ready to be outplanted into Kaneohe Bay. Based on observed growth and results from a *T. gratilla* hatchery in Okinawa, Japan, it is anticipated to require five to six months to produce urchins to outplantable size. Once sufficient numbers of urchins are produced; field trials and monitoring will be necessary to determine the optimal density and restocking protocols necessary to prevent *Kappaphycus/Eucheuma* spp from overgrowing patch reefs following algae removal. The reef will be monitored for changes in urchin and other invertebrate density, coral cover, coral recruitment, and algal density and diversity. The density of urchins will be controlled in order to maintain low algal abundance without any impacts to the reef (i.e. native coralline algae). This approach will be repeated for each reef that previously had significant algal densities. Reefs with lower algal abundance will be monitored closely and urchin density will be tailored to the needs of the individual reefs. In the long-term an overall outplanting strategy will be developed.

The goal of the urchin hatchery is to produce approximately 20,000 juvenile urchins per month 10 times per year with an annual production of approximately 200,000 urchins. With an estimated maximum stocking density of 3 urchins per m^2 in all primary restored areas, a total of 165,000 urchins would be needed. However, in anticipation of natural and fishing mortality, continual rearing will be conducted to offset any reduced survivorship in order to determine the long-term viability of urchin outplanting.

Scale of Restoration

The Department of Land and Natural Resources (DLNR) has mapped the current distribution of *Kappaphycus/Eucheuma* spp. within Kaneohe Bay (Figure 6). These surveys have identified the largest population center of the algae, which will be targeted as the primary reef restoration sites. Given the unique habitat characteristics, this restoration initiative will focus on patch reefs in the central section of the bay as a primary focus. Patch reefs in the Northern section and fringe reef communities also represent an area of interest and will be addressed to the extent possible as secondary sites. The algal distribution maps constructed by the DLNR form the basis of site prioritization and project implementation.

Studies to determine the removal rate on an area basis have been conducted. From July 2006 to November 2007, nine studies were conducted to measure how many square meters the Super Sucker operation can remove per minute of dive time. These studies used divers with various levels of experience and work speed on both *Gracilaria salicornia* and *Kappaphycus/Eucheuma* spp. This average has also been tested on larger plots and seems to be a reasonable estimate of effort to remove algae. The average is 0.73 m^2/ minute plus/minus 0.19 m^2. The process can collect a wide range of biomass on a given day of work. Removal rates have ranged from 250 to 8,000 lbs (115 to 3600 kgs) of algae in a full workday. The wide range can be accounted for by the variation on different reefs, different algal morphologies, and different stages of removal (early in the process compared to cleaning up small patches at the end).

Removal operations typically have a 4 hour underwater workday. Although this can vary, an average of 4 hours of dive time is a reasonable estimate for long-term operations. In addition, the operation can operate reliably 3-4 days per work week due to required maintenance, holidays, and staff shortages. It is estimated to be able to work 3 days per week for approximately 50 weeks of the year allowing a total of 150 work days per year. These are estimations and may vary depending on staff availability, work area, mechanical problems, and environmental and weather limitations. The measured area of individual algal populations and estimated rates of algal removal allow the calculations in Table 1.

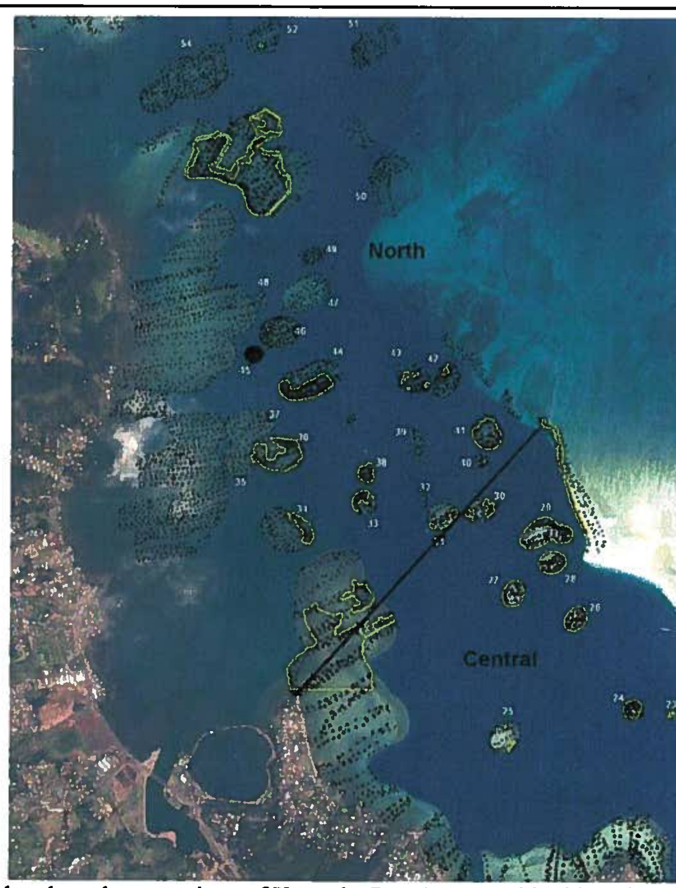

Figure 6. Map of the central and northern portions of Kaneohe Bay (separated by black line) showing algal infestation in yellow circles. The numbers represent patch reef designations used to monitor and plan for removal efforts. Small black dots represent survey areas that determined the extent of algal infestations.

Table 1. Table showing the area of algal cover, area of reef size, removal rate and time to clear calculations.

Reef #	Algae Cover Meters	Algae Cover Acres	Reef Area Meters	Reef Area Acres	Section of bay	Rate of removal	# of hours	# of days	# of Weeks
26	11,235	2.8	12,259	3	Central	0.73	137	34	11
27	11,094	2.7	12,440	3.1	Central	0.73	135	34	11
29	28,959	7.2	29,965	7.2	Central	0.73	352	88	29
Total	**51,288**	**13**	**54,664**	**13**		**2**	**624**	**156**	**51**

The priority reef restoration sites represent an algal coverage of approximately 51,288 m^2 (13 acres) over approximately 54,664 m^2 (13 acres) of reef area. Individual patch reefs will be prioritized based on total area covered for mechanical removal. Restoration activities will address the spectrum of reef impact and balance both high and low algal infested areas.

These three reefs were selected first because they are the most heavily infested reefs where the ultimate goal of producing enough urchins to cover the entire restoration area will be achievable. All three reefs are estimated to have 55,000 m^2 of reef area that will require the production of 55,000 to 165,000 urchins. Because of comparable size and algal coverage, optimal urchin stocking density will be tested on reefs 26 and 27. Production runs can be conducted concurrently providing enough tank space is available for post settlement grow-out. These estimations allow for flexibility in urchin production.

Administrative Management

Respective Roles of Partners:

The Nature Conservancy is part owner of the "Supersucker" barge and will provide expert advice on project implementation. They will assist with outreach and public relation efforts as needed.

University of Hawaii-Marine Biology can provide expert advice and guidance on coral reef biology and more specifically advice regarding the distribution and concerns with the candidate species, *Montipora dilatata*. In addition, the UH Marine Option Program can provide students trained as UH Scientific Divers to assist with monitoring.

University of Hawaii-Botany can provide expert advice and guidance on algal biology and ecology. The Botany Department is well versed in the impacts of invasive algae in Kaneohe Bay and can provide valuable insight in finalizing project implementation.

Hawaii Institute of Marine Biology can provide a staging ground for algae removal activities by use of dock space and small equipment storage. In addition, HIMB may be able to support some limited urchin propagation to supplement DLNR's urchin propagation.

Pacific Cooperative Studies Unit can provide administrative support for urchin rearing and monitoring activities.

Local farmers, specifically the Reppun Farm can provide a safe, environmentally responsible disposal location for removed algal material.

The Department of Land and Natural Resources can provide expert staff on the algal removal methodologies as well as the Anuenue Fisheries Research Center for urchin propagation activities. In addition, DLNR will provide administrative and supervisory support for all activities and be the primary point of contact for the project.

Adaptive Management

This restoration project will utilize an adaptive management approach to manage the overall project. The adaptive management will be guided by an advisory committee developed specifically for the purpose of providing scientific advice on restoration activities. The advisory committee will be comprised of representatives from all partners as well as other University experts and Federal management agencies (specifically NOAA and USFWS). The committee will meet quarterly or as needed to review the project status. The committee will review the progress of the project in comparison to the projected timetable as well as the success and obstacles in the work. This will allow the committee to make suggestions and advise on the direction and decisions of the project. Ideally, the committee will serve a vital function and help to keep pressure on the project to meet tight deadlines and help change course as needed. This will allow the project manager to receive instant feedback and advice on the continued progress of the restoration. The intensive monitoring regime will measure the performance of the restoration activities and be structured to measure the empirical outcomes of the project. The results of the monitoring activities will be presented to the advisory committee for review; therefore allowing the committee to gauge the status of the activities compared to the projected timetable and goals.

Project Safety

Safety for all aspects of the proposed activities is of primary importance. To this end, we have developed specific protocols while conducting these and similar operations. The two most significant activities that require considerable safety protocols include both SCUBA diving and small vessel operations. All individuals operating vessels will undergo extensive training in the safe operation of small vessels. All small vessel operations will comply with Coast Guard regulations. SCUBA diving operations will be under the auspices of the DLNR Diving Safety Program, which is accredited under the American Academy for Underwater Sciences (AAUS). However, given the type of activities being conducting while using SCUBA, all diving operations will comply both with AAUS standards as well as CFR 1910 Commercial Diving Regulations.

Project Life Expectancy

The restoration of Kaneohe Bay is believed to take many years given the distribution and impact alien algae have had on the bay. However, the bay itself is highly compartmentalized and lends itself very well to a step-wise approach to restoration. Since patch reefs in the bay are individual units that can be addressed individually with minimal effect from other reefs, we believe that restoration efforts will be highly effective on a localized scale. As more resources become available, more reefs can be restored until the bay has achieved complete restoration. The bay contains 54 individual patch reefs as well as many kilometers of fringe and barrier reef. This project is targeting the patch reef habitat in the central section of the bay as a starting point due to its large quantities of algal biomass and acreage size that will allow for proper urchin stocking density. It is estimated to achieve the restoration of three patch reefs in **twelve months** with several years of post-monitoring.

With the outplanting of urchins, the long-term outcome and management of the restored reefs is expected to be positive. Ideally, urchin populations will become self-sustaining, but small-scale urchin propagation may be able to sustain the urchin population as well. The long-term effort to maintain these reefs is expected to be low.

Implementation Schedule (Quarterly)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Algal removal	• Add funds for contract staff • Begin and complete full scale algal removal on reef 26	• Begin and complete full scale algal removal on reef 27 • Begin clearing of reef 29	• Continue clearing of reef 29	• Complete clearing reef 29 • Comprise data, compile reports
Urchin Culture	• Complete first full-scale urchin production	• Complete second full-scale urchin production • Begin second round of spawning	• Complete third full-scale urchin production •Begin third round of spawning	• Complete fourth full-scale urchin production
Monitoring	• Complete a full round of surveys for target and control reef areas	• Complete a full round of surveys for target and control reef areas	• Complete a full round of surveys for target and control reef areas	• Complete a full round of surveys for target and control reef areas

* Monitoring will continue each quarter for five years to monitor for long-term results of restoration activities.

Monitoring Plan

The monitoring activities under this restoration project will be created and conducted by the Kaneohe Bay Monitoring Coordinator and reviewed and guided by the advisory committee. All stated monitoring activities are structured to measure success criteria for project goals. The project goals and success criteria are:

- Reduce algal distribution (< 5 acres over the targeted five patch reefs)
- Reduce algal cover (< 2% total cover on each patch reef)

- Increase coral cover (10% increase in the first year and 3% each year after)
- Increase fish biomass (increase biomass by 25% of baseline)
- Maintain *T. gratilla* density (>1 urchin per m^2)

Our basic null hypothesis for this restoration project is:

Mechanical removal and urchin biocontrol can reduce algal cover, increase coral cover, and allow an increase in fish biomass over a one to five year period.

Monitoring Parameters

Monitoring parameters will include the following *structural* parameters: large-scale algal distribution and rugosity; and *functional* parameters: algal cover (fine-scale) and biodiversity, coral cover and biodiversity, coral size structure, fish biomass and biodiversity, fish size structure, and urchin density and biodiversity.

The two *structural* parameters used to measure restoration activities require different methodologies. Large-scale algal distribution will be measured by a mapping invasive algae presence/absence and relative abundance over northern and central Kaneohe Bay. This data will provide essential maps to high density algal cover areas as well as indicate trends in algal cover (see Figure 2 for example data product). This data can allow models to be created in ArcGIS to better understand large-scale algal distributions. Rugosity will be measured at various sections of each patch reef (target and reference) to determine the impact of high algal biomass on reef structure. Standard rugosity protocols will be implemented.

The *functional* parameters will be measured with standard transect methodology (Jokiel et al 2005). Size and length of transects will be determined based on appropriateness for patch reef habitat.

Results Evaluation

All transect data will be analyzed using basic statistics. The datasets will be compared using Analysis of Variance (ANOVA) in order to accept or reject all or part of our null hypothesis.

Establishing Baseline

Baseline conditions will be established through two mechanisms. One, existing datasets that are available (Jokiel et al 2004; Jokiel et al 2005; Maragos 1972; Hunter and Evans 1995) will be mined for appropriate data on targeted monitoring parameters. Two, at least one complete round of transects and algal mapping will be completed before restoration activities begin (including target reefs and reference reefs).

Reference Sites

This project is targeting restoration on patch reefs #26, 27, and 29 based on the algal distribution shown in Figure 6. Although each individual patch reef can have unique characteristics, nearby patch reefs (such as 28) can be used as an ideal reference site.

Frequency and Length of Monitoring

The frequency for monitoring will vary (monthly, quarterly, or annually) depending on the parameter. Algal distribution maps will be produced approximately on an annual basis considering seasonal influences of algal biomass. Coral size structure will also be conducted on an annual basis due to slower, less change expected. Fish biomass and rugosity will be measured on a quarterly basis while algal and coral cover will be monitored monthly.

Monitoring of the restored and reference reefs will continue as long as is needed, but is expected to be conducted for a minimum of 5 years. Long-term monitoring efforts will require dedicated staff and resources and will be supported by a Sport Fish Restoration grant (under Department of Interior, U.S. Fish and Wildlife). Sport Fish Restoration projects are typically 5 years in duration.

Project Readiness

The components of this project have been developed over the past several years, and all components are at a critical juncture and fully ready to be conducted at the scale proposed. Particularly, the Super Sucker is currently ready for full time operation as the techniques, equipment, and protocols have been successfully demonstrated and tested. The only component not in place over the past 2 years is the appropriate funding and staffing to operate the system at a full time level. These restoration activities are considered shovel ready by all agencies and partners involved in the project.

The most immediate steps required to complete once funds have been received are to encumber the funds in established contracts. Any position vacancies can be filled during this timeframe, and this is estimated to be completed within 90 days, maybe sooner if contract amendments are initiated before official start date.

All permits and clearances have been obtained for the proposed activities. The Hawaii Department of Health has cleared the operation and found no significant impact on water quality. Previous NOAA funded projects have passed a NEPA review. The DLNR has legal authority to control pest species and associated activities conducted by DLNR are considered exempt under Hawaii Environmental Policy Act.

The State of Hawaii/ DLNR is the landowner and steward for all submerged lands in the Hawaiian Islands. No land acquisition is required for the project to move forward.

Restoration Plans

Hawaii has produced a number of plans that address restoring habitats in Hawaiian waters. Most of the plans are general in nature and others are fairly dated to the issues of today. However, a number of the plans are applicable to the guidelines of this solicitation. They include the Kaneohe Bay Master Plan, the State of Hawaii Aquatic Invasive Species Management Plan, The Nature Conservancy's EcoRegional Plan, and the Hawaii Ocean Resources Management Plan.

Kaneohe Bay Master Plan by State of Hawaii, Office of Planning accepted May 1992.

The Kaneohe Bay Master Plan is a State Plan for Kaneohe Bay that was developed with input from nearly 100 individuals from the community to address concerns with the bay. The plan was vetted through public meetings and eventually accepted by the State Office of Planning in March 1992. The plan indicates that a priority action (page iii) is "evaluate opportunities for fish re-stocking and habitat enhancement of Bay waters and fishponds."

Our restoration project broadly addresses this; however, it is important to note that alien algae, although present in the bay, was not perceived to be a problem in the early 1990s. Since the mid 1990s, alien algae have bloomed and have consistently expanded throughout the bay. We will address the implementation recommendation to "enhance Bay waters."

Hawaii's Coral Reef Strategy by the Department of Land and Natural Resources is still in development.

Hawaii Coral Reef Strategy is a State and Federal Strategy for the Main Hawaiian Islands that was developed with input from many stakeholders in the Hawaii region through various committees and public planning meetings. The strategy defines medium term goals and objectives for Hawaii's coral reef. A priority strategy is to "Prevent new AIS introductions and minimize the spread of established AIS populations by 2020."

This restoration project direct addresses the prevention of spreading invasive species.

State of Hawaii Aquatic Invasive Species Management Plan by State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources accepted September 2003.

The State of Hawaii Aquatic Invasive Species Management Plan is a State Plan for the Hawaiian Archipelago that was developed with input from hundreds of experts, community members, and resource managers though an intensive collaborative approach including public input. The plan was accept in September 2003 by the State of Hawaii Governor, Aquatic Nuisance Species Task Force, and the Coral Reef Task Force. The plan indicated priority strategies as: 1) Develop and deploy a mechanical suction system capable of removing large volumes of algal biomass from coral reefs while minimizing damage to other reef organisms and 2) Further investigate the use of native grazers, such as urchins, to assist in the control or elimination of invasive algae.

Our restoration project is a direct result of the research and planning that was developed from this plan. This plan is considered one of the most important documents for the removal and management of aquatic invasive species in Hawaii.

Hawaiian High Islands EcoRegional Plan by The Nature Conservancy of Hawaii accepted 1998.

The Hawaiian High Islands EcoRegional Plan is a Regional Plan for the Main Hawaiian Islands that was developed with input from several federal, state, and university agencies through an established standard process for developing a conservation area portfolio. The plan was accepted in 1998 and Kaneohe Bay is an action site (Conklin, pers.

comm.). The plan indicates a priority strategy for the "Prevention of Alien Species." In addition, priority weed control is an urgent action in conservation areas.

This restoration project directly addresses the spread of alien species and the target alga is a priority weed.

Hawaii Ocean Resources Management Plan by State of Hawaii, Office of Planning, Coastal Zone Management Program accepted December 2006.

The Hawaii Ocean Resources Management Plan is a State Plan for the Hawaiian Archipelago that was developed with input from many individuals, agencies, and organizations with public consultation. The State Office of Planning accepted the plan in December 2006. The plan indicates priority management goals to be "Improve the health of coastal and ocean resources for sustainable traditional, subsistence, recreational, and commercial uses" and "Improve coastal water quality by reducing marine sources of pollution." Within these priorities, there are the following strategic actions: 1) Minimize the introduction and spread of marine alien and invasive species into and throughout arch pelagic waters, 2) Establish and institutionalize approaches for restoring, operating, and preserving ancient Hawaiian coastal fishponds and salt ponds for the benefit of coastal communities around the State, 3) Enhance the recovery and conservation of Hawaii's marine protected species, unique habitats and biological diversity, and 4) Identify, protect, and restore essential fish habitat for nearshore fish stocks, including marine and estuarine habitats.

This restoration project directly addresses these management goals and strategic actions.

Other Information

Recently, research into non-point sources of pollution has increased in Kaneohe Bay. In the last few months, DLNR via the NOAA State Coral program funded a project to measure nutrients in the bay. More recently, the Hawaii Coral Reef Initiative included research projects that address nutrients in Kaneohe Bay as a major priority

Status of Total Project Funding

Sport Fish Restoration -- Approximately $110,000 per year (5 years totaling $550,000) is being requested from Dingle-Johnson Sport Fish Restoration Federal Aid (under Department of Interior, U.S. Fish and Wildlife). These funds will support all monitoring aspects of this project. Discussions with the local program officer have indicated that they are willing to support the monitoring efforts.

The Nature Conservancy -- The Nature Conservancy currently has approximately $50,000 for mechanical removal of alien algae from private donors and is willing to support staff costs associated with alien algae removal in Kaneohe Bay.

The Hawaii Invasive Species Council -- The Hawaii Invasive Species Council has been a strong support of aquatic invasive species issues in Hawaii. They have provided state funds to DLNR/ DAR every year to maintain a capacity to control invasive species in Hawaiian marine waters. With recent budget restrictions, DLNR/DAR has concentrated its efforts in Kaneohe Bay (both mechanical and biocontrol) to focus resources. Currently, DLNR/DAR has a $175,000 encumbered in contract (estimated in July 2010 through June 2011) for mechanical removal and $60,000 for biocontrol. It is also expected to receive approximately $200,000 in FY2011. This equals approximately $435,000 in state funds available for match.

NOAA's Coral Reef Conservation Program -- Under NOAA's Coral Reef Conservation Program, states with coral reef resources are allotted funds for coral reef management. DLNR/DAR will receive $60,000/yr in order to culture and outplant urchins for algae control for the next three years.

Relationship to Larger Project

Similar activities have been proposed for Kaneohe Bay restoration. The proposals have been suggested through compensatory mitigation for natural resource damage assessment cases. However, there is currently, no proposed overlap in the areas of targeted restoration. There will be no overlap in restorations even if these cases are settled.

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Coral Reef Restoration: Removing Invasive Algae, Out-Planting Urchins, and Mitigating the Effects of Ship Groundings
ESTIMATED BUDGET

Current staff budget	Salary- yr rate	Fringe	Subtotal	# months	=	Total $
AIS Field Team						
Project leader	59000	17700	$76,700	6		$38,350
Sr. field tech	38000	11400	$49,400	6		$24,700
Sr. field tech	38000	11400	$49,400	6		$24,700
Research associate	38000	11400	$49,400	6		$24,700
Field tech	32000	9600	$41,600	6		$20,800
Field tech	32000	9600	$41,600	6		$20,800
Monitoring Team						
Monitoring coordinator	49248	13510	$62,758	14		$73,426
Monitoring tech	30000	5958	$35,958	14		$42,071
Hatchery Team						
Hatchery project leader	52536	11499	$64,035	12.5		$66,596
Hatchery tech	27000	8520	$35,520	12.5		$36,941
Hatchery tech	30000	9327	$39,327	12.5		$40,900
Hatchery tech	30000	9327	$39,327	12.5		$40,900
						$454,884

Other costs	Annual
Field team	25,000
Hatchery supplies/equipment	30,000
Monitoring supplies/equipment	15,000
Misc (phones, medical exams	15,000
	$85,000

Total Annual Project Cost	**$539,884**
11% overhead	$59,387
	$599,271

EXHIBIT C