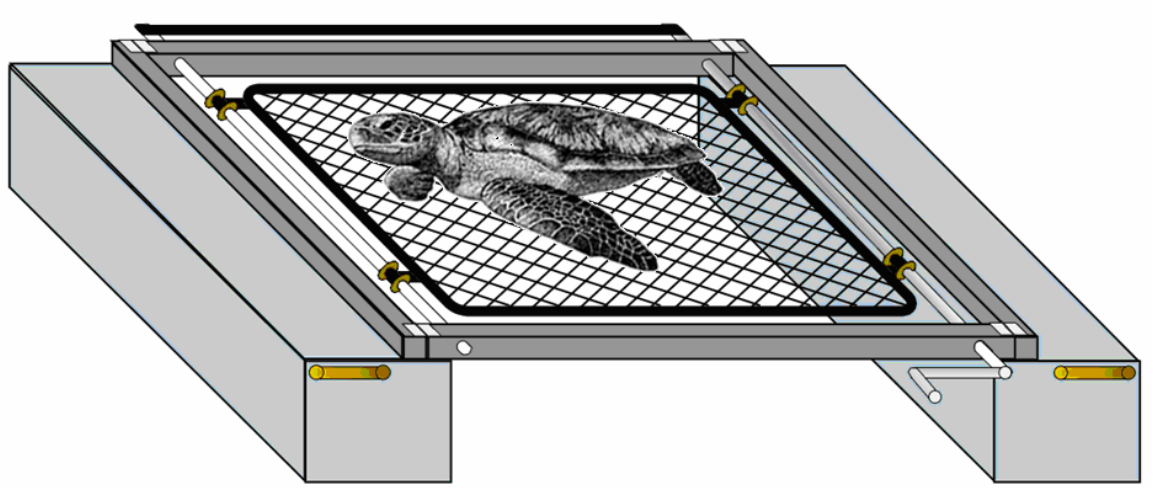
The Ratchet Raft



Prepared for:
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John G. Shedd Aquarium
Chicago, Illinois
March 10, 2007

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****************************Executive Summary***************************

Problem

1. Put a 175 pound sea turtle named Nickel within reach of a user on a platform five inches above the water
2. Keep Nickel stabilized in that spot while the user performs feeding, training, and medical procedures on her.

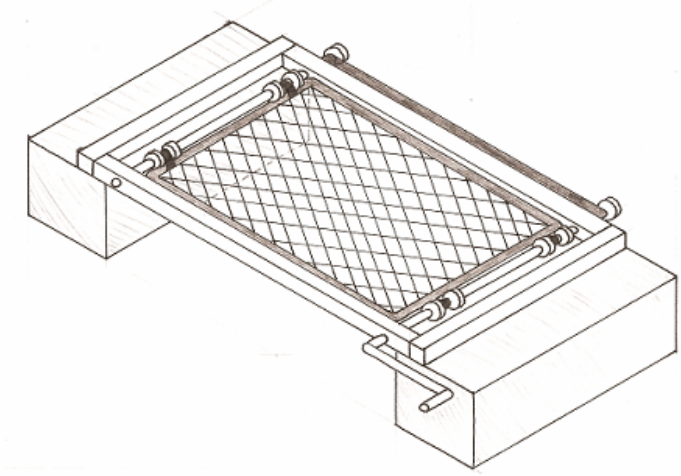
Current Device: Draping net in front of platform supported on two sides by PVC piping.

Flaws

- Falling apart so badly it can no longer be used
- Difficult to set up
- Setup and take down requires five minutes each and is tedious to use twice daily
- Loosely stabilized on platform by drawbridge system
- Crashes into water
- Does not stabilize Nickel to keep her stationary
- Keeps Nickel mostly in water, forcing user into awkward angles
- Requires user's hands to enter water, which contains predatory fish

Solution:

The Ratchet Raft



Features

- **Rotatable billets for easy storage under platform**
- **Locking hinges for added stability**
- **Five to one mechanical advantage with 5" lockable crank**
- **Adjust height of net for easy access to Nickel**
- **Rubber toothed gear belt ensures no slipping when wet**
- **One part free standing device allows full rotation and repositioning**
- **Strong and non-corrosive**

hjkldfkw

The Ratchet Raft enables users at the Shedd Aquarium to perform basic training and medical procedures on their sea turtle, Nickel. The raft is fully operable by a single individual and can be used to lift Nickel up to six inches above water level. A rectangular aluminum frame supported by two Styrofoam pontoons provides the stability by which the turtle can be hoisted out of the water and versatility by which Nickel can be rotated to any desirable position. A second frame made out of PVC pipe and netting is suspended from the aluminum frame. Once Nickel is on the netting, the frame can be raised and lowered to a desirable height using a ratcheting crank. In order to store the raft, the two foam billets flip upwards 90°. The raft can then be slid underneath the existing platform and hooked to the sides of the platform so that it hangs above surface of the water.

Introduction

Nickel's Background

Figure 1 Nickel the Green Sea Turtle

Three years ago, a motor boat hit a green sea turtle off the coast of Florida, injuring her severely. Now in stable condition, this sea turtle, now named Nickel, lives in captivity in a 90,000 gallon exhibit at Shedd Aquarium in Chicago, Illinois. Nickel lives with an array of sea life, ranging from predatory hammerhead sharks and barracudas to bottom feeding catfish. The exhibit experiences constant activity ranging from diving shows to shark feedings. Visitors are constantly looking through glass at the myriad activities underneath the surface, but Nickel is usually the main attraction.

Unfortunately, Nickel still suffers from effects of the accident such as limited use of her back flippers and a severe buoyancy problem at the rear of her shell. Michelle Sattler, a manager at the Shedd Aquarium, gives Nickel special attention, feeding her personally twice a day and performing various training exercises and medical procedures to ensure her health.

Michelle's Desire

In order to perform this feeding/exercise/examination routine, Nickel must remain stationary at the surface of the water and within reach of the trainer. At around 175 pounds, Nickel cannot easily be taken out of the water. While Nickel is in the water with no constraints, she can swim away at any time, so a device needs to be able to support Nickel and keep her stationary at the surface of the water (See Appendix A for project definition). Michelle expressed a desire for an intuitive device that is comfortable for Nickel, and easy for anyone to use, so any staff member can attend to Nickel.

Shedd's Drawbridge

Figure 2 Drawbridge Design

The existing mechanism is an unstable, draping net supported on two sides by PVC piping and hard to store. It is secured loosely on a platform by a dangerous drawbridge design. This device is difficult to set up and falling apart from frequent use. The device keeps Nickel at the surface of the water, but does not substantially support her to keep her stationary. The net remains in the water, forcing the user into awkward angles while interacting with Nickel. Use of the device requires the user's hands to enter the water, which contains predatory sea life. The process of setting up and taking down the device requires about five minutes each and is a tedious task to perform two times a day.

Purpose of the Report

We designed an easily stored, strong and user-friendly turtle holding mechanism that can be operated intuitively and allows the user to perform basic training and medical procedures. This report discusses how the Ratchet Raft addresses the flaws in the existing solution while meeting all the requirements of the problem. We discuss the design in detail, and explain how we came to this final design, its ability to meet the user's needs, and also the next steps needed to further develop the Ratchet Raft in order to put it to use.

Design Requirements

In order to produce an effectively user-friendly device the following requirements were taken into consideration in the development of the Ratchet Raft:

Support

- must support the weight of Nickel (175 pounds and growing) while in use.

Setup/store in less than five minutes

-should take less than five minutes to setup and store and should be done in a few simple steps.

-must not get in way of catwalk

-must not block the end of the platform

Safe for Nickel

- must take Nickel's habits into consideration and keep her safe by having smooth edges and slow movements.

Non-invasive to exhibit

- must not interfere with other exhibit activities while in use or storage.

Aesthetically non-threatening

- must appear friendly towards visitors who enjoy watching the device in use by having dark colors to blend in with the exhibit and have a process that appears enjoyable for Nickel to use.

User Safety

- must avoid shiny materials, which barracudas are attracted to, and keep the user's hands out of the water to avoid any potential for attack.
- must allow the user to maintain a balanced position to minimize the possibility of falling in.

Intuitive

- must be intuitive enough for operation without instruction.

Design Concept

Ratchet Raft Overview

The Ratchet Raft enables users at the Shedd Aquarium to perform basic training and medical procedures on Nickel. The raft is fully operable by a single individual and intuitive enough to use without instruction. A rectangular aluminum frame supported by two Styrofoam pontoons provides the stability by which the turtle can be hoisted out of the water and versatility by which Nickel can be rotated to any desirable position. A second frame made out of PVC pipe and netting is suspended from the aluminum frame. Once Nickel is on the netting, the frame can be raised and lowered to a desirable height using a ratcheting crank. In order to store the raft, the two foam billets flip upwards 90 degrees. The raft can then be slid underneath the existing platform and hooked to the side of the platform so that it hangs above surface of the water.

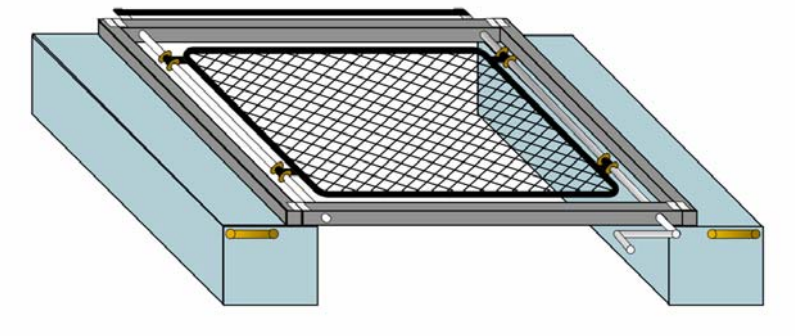


Figure 3 Computer Generated Ratchet Raft

Components

Ratcheting Mechanism

Figure 4. Ratcheting Mechanism Mockup

In order to raise and lower Nickel, a 42”x 32” framed net drops down from the raft. Nylon strapping is attached to each corner of the PVC frame. The other end of the strapping is wound around two parallel stainless steel axels at either end of the raft. The two axels are coupled together using a timing belt and two pulleys. One of the axels is rotated by a long handled winch. Turning the winch causes both axels to rotate, and winds up the nylon strapping to raise the PVC frame. Turning the winch in the opposite direction will lower the frame. The winch can be locked so that the frame can be suspended from any height ranging from one foot below water level to ten inches above the waterline.

Hinging Mechanism

The two Styrofoam billets on either side of the raft are designed to fold upwards so the device can be stored with the frame underneath the platform and the billets hooked onto the sides of the platform. With the billets in the upright position, the device still floats above the water on the billets, so the raft can be pulled back into the storage position. Hinges at each of the four corners of the aluminum frame allow the billets to rotate upwards perpendicular to the raft. The two hinges closest to the front of the raft have locking mechanisms which allow the billets to lock in either position. In order make the billets easier to maneuver; each billet has a handle at the axis of rotation. Once the billets are in storage position, the raft can float underneath the existing platform and be safely stowed.

Figure 5. Hinging Mechanism

Significant Parts

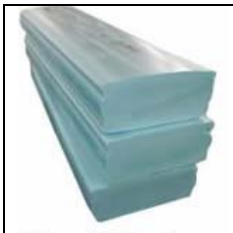
 **Figure 6.** Styrofoam Buoyancy Billet	**Styrofoam Billets** These billets provide the buoyancy and stability for the entire raft while in use and storage. They are non-corrosive and water resistant. They make the raft durable because they do not puncture or break into pieces. The light color of the billets allows them to blend in with the lighter surface of the water.
 **Figure 7.** Use of Handle	**Handle** The handle attaches directly to the Styrofoam Billets and provides a convenient method for rotating the billets.

Figure 8. Hinge Locked Up

Locking Hinge
The non-corrosive locking hinge allows the user to concentrate on rotating one billet at a time. It also provides extra stability in the device by keeping the aluminum frame locked.

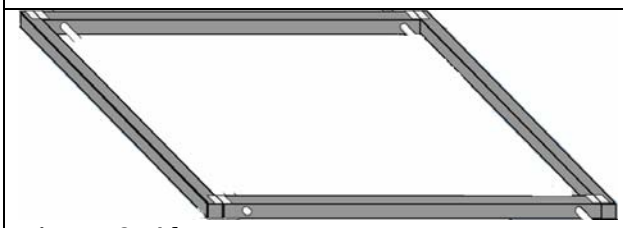


Figure 9. Aluminum Frame

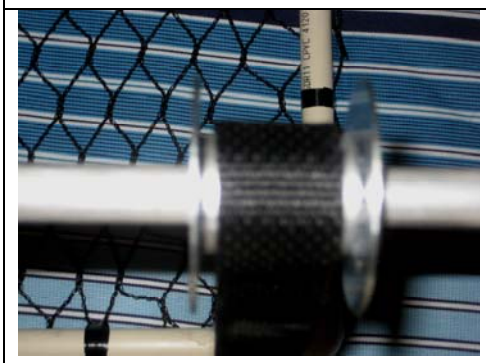
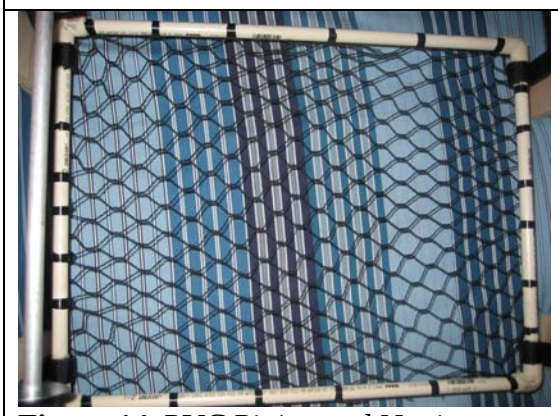
Aluminum Frame
The aluminum frame consists of four bars connected by the hinges. The two side bars connect directly to the Styrofoam billets and form the strong frame used to keep the device sturdy.

Figure 10. Crank in Use

Crank Locking Device
The crank is five inches long, giving it a five to one mechanical advantage over the weight being lifted. It turns the first rod which starts the cycle of raising the net. The locking device is a circle with holes cut in it. The opposite side of the crank has a pin that can be pushed in a hole to lock it into place. It is suggested that the full scale device be built with a two way hand ratchet winch.

Figure 11. Belt around Pulley

Belt and Pulleys
The rubber belt is teethed for extra grip that will be needed when the gear gets wet. The two pulleys are an exact fit to provide a tight grip to rotate the two steel axels.

 **Figure 12.** Steel Axel	**Stainless Steel Axels** The stainless steel axels rotate due to the crank and belt. They each contain two strapping paths to efficiently reel in the strapping that raises the net.
 **Figure 13.** Nylon Strap around Axel	**Nylon Strapping** The nylon strapping makes the net sturdy when it is down because of the elongated side it has. The strapping resists being moved in that direction, which is the direction Nickel will be coming from to make it easy for her.
 **Figure 14.** PVC Piping and Netting	**PVC Piping and Netting** The netting wraps around the PVC piping to give Nickel the texture that she loves to scratch her back on. The PVC frame is weighted with steel rods glued inside the frame to allow it to sink. The net is the same type of netting that the aquarium used with the old device.

Meeting Requirements

-The Ratchet Raft uses buoyancy and a strong aluminum frame to ensure the support of Nickel. The nylon straps also provide extra support on the netting while Nickel attempts to get on.

-Because the raft is stored underneath the platform, there are no problems with it potentially blocking the catwalk. It is only one piece and requires no assembly other than pulling it out from underneath the platform and rotating the billets, which should take less time than the current process of putting the entire device together each time.

-The raft does not contain any sharp edges that enter the water or go near Nickel. The raft is already close to the water in storage, so it does not come crashing down and cannot be dropped. When the netting is raised, Nickel is contained inside a frame to keep her from falling out. The only safety concerns are addressed in the Next Steps section.

-The device sticks out a little when in storage, but not enough to interfere with feeding the sharks or the diving show. When in use, the device takes up a lot of room, but has no cables or materials sticking out from the main frame that could interfere with anything.

-The light color of the billets blends the bottom of the raft in with the surface of the water when looking from underneath (see figure 1). The dark netting and natural color of the PVC pipe do not draw extra attention to the device when it drops into the water. The process of pulling Nickel up will probably cause much interest in the visitors as she will disappear when above the surface of the water.

-To keep the user safe, the metals on the device must have rounded corners and have the shine dulled. Although the aluminum frame will not be going into the water, and the users hands are staying out of the water, we will take the extra safety precaution to make sure there is no chance of an accidental barracuda attack. Because Nickel is coming out of the water, the user will not have to be in such an awkward position and can remain balanced while working with her. Other safety issues are discussed in the next steps section.

-By looking at the Ratchet Raft, it is easy to see how it works. There are only two systems on the device, and the device should still work if the user did not know to move the billets back down to the use position after taking it out of storage. The steps to using the device are simple and clear (see appendix B).

Background Research

Methods

To learn more about Nickel, the green sea turtle, the environment she lives and the most effective way to solve our problem, we gathered preliminary information from:

Nickel's Trainer:
On January 10, 2007 we met with Michelle Sattler from the John G. Shedd Aquarium. (See Appendix C and D for interview specifics.)

User Observations:
On January 15, 2007 we observed Nickel, the environment she lives in, and the current device used for her to "bench" at the Shedd Aquarium. (See Appendix E for observations)

In-Class Presentations:
On January 23, 2007 our class collectively shared research on the following topics: materials, model/competitive products, mechanics, and turtle anatomy. (See appendix F for detailed findings.)

Findings

After reviewing research gathered from the methods above we found important information about the anatomy of Green Sea turtles, competitive and model products, materials, and mechanics.

From the research gathered about turtle anatomy, we learned that Nickel's shell was cracked due to the boat accident and this has caused her to have a buoyancy problem. Her neurological problem causes her to swim at an angle and with mild disorientation. This means Nickel would be entering our device at an angle. We also learned that Nickel has a very tough shell made of mostly keratinous material; and she loves to scratch it on other materials. We could put this into consideration when finding the material for Nickel's "bench".

When researching competitive and model products, some aquariums, like Aquarium La Rochelle, used a net structure with emerging ropes to remove their turtles from the water. Other model products that would be useful in building a turtle "benching" device would be boat lifts, car jacks, and balance air lifts.

Some mechanisms that will aid in building this device are buoyancy compensators, pulleys, and suspension with cables.

Materials that will serve useful in our design all have to be non-corrosive. Through research we found out that aluminum and stainless steel are cheap, non-corrosive metals. Nylon is a chemically-resistant, non-corrosive material that can be used for netting material. Dow Styrofoam buoyancy billets are strong and non-corrosive used in the building of docks and has buoyancy strength of 50 lbs per square foot.

Implications for Alternatives

Some of the major problems occurring with the current device is that it is unstable, has a dangerous drawbridge effect, puts user in danger, and is a nuisance to set-up and store. Potential possibilities to solving this problem may be putting Nickel platform level, so the user is not in a dangerous position. Storing the device under the platform can solve its storage problem. Using stronger and non-corrosive materials may make the device more stable and reliable. Also, using a flotation mechanism gets rid of the dangerous drawbridge effect.

Alternatives Section

Introduction

After brainstorming possible solutions to the problem as a class (see appendix G), we initially generated three possible design alternatives. We then analyzed the strengths and weaknesses of the various alternatives by creating an alternatives matrix (see appendix H). These alternatives were intended to answer several questions for meeting the design requirements (see appendix I).

Alternative Concepts

Alternative 1- "Diver Pit": This alternative makes use of the diver pit rather than using the platform.

Figure 15. Diver's Pit Mockup

Alternative 2- "Turntable": This alternative consists of a basic turntable attached to four supports (possibly cables as in Alternative 3).

Figure 16. Turntable Mockup

Alternative 3- "Suspension with Cables": In this alternative, a strong framed net is suspended over the water using aircraft cable. The cables are bolted to the catwalk.

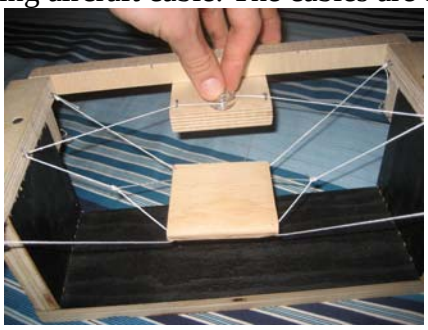


Figure 17. Suspension with Cables Mockup

User Testing

Methods

Testing

We performed simple testing and concept assessment with Michelle Sattler at the Shedd Aquarium on February 13, 2007. These tests were aimed at evaluating our first three separate design alternatives: the diver's pit device, the turntable, and the suspension through cables. During this user testing session we introduced our concepts to Michelle through sketches and mockups, and demonstrated how each concept works (see Appendix J for testing guide).

This testing allowed us to:

- Observe Michelle's reactions for each idea.
- Determine the practicality of each design based on limitations of the exhibit.
- Discover flaws and difficulties in our designs.
- Obtain Michelle's input and suggestions for each design.

Design Review

Conflicting schedules and time constraints did not allow us to do any further testing with Michelle. However, our three alternatives mutated into the Ratchet Raft, a completely different design, after our first user testing, so we performed a design review with our EDC class on February 20, 2007 in attempt to answer questions and receive input. During this review, we introduced the Ratchet Raft with a small scale mockup, sketches and reasoning behind this design, and asked for questions and suggestions regarding it.

Findings

Testing

Michelle offered new insight into our alternative designs and suggestions on how to improve them. (See appendix K for Michelle's reactions and suggestions.)

- Alternative 1: Nickel cannot fit in diver's pit
- Alternative 2: Make the turntable a net instead of a hard device
- Alternative 3: Make the winch and back pulleys detachable

Design Review

Our design review gave us a new perspective on different areas of the Ratchet Raft concept. The comments generated by the class made us aware of potential difficulties in the implementation of this design and helped us solve a few problems that had already surfaced. (See appendix L for the design review summary).

- Will the device fit under the platform?
- What kind of belt to use to rotate the axels
- Can a gear system be made for the crank?

Evaluation

Testing

Based on Michelle's suggestions and our observations of the exhibit with our actual alternatives in mind, we decided that all three of our tested alternatives are not practical and were forced to abandon each of the three original alternatives. (See appendix I for summaries of the faults of the alternative mockups).

Alternative 4- "The Ratchet Raft":

The results of our first testing session caused us to abandon our initial alternative designs, but also encouraged us to combine the basic concept from each alternative into a new alternative with the following concepts:

- A rectangular frame to confine Nickel to a smaller space
- Buoyant materials supporting the frame on the water to allow freedom from attachments and the ability to rotate and move anywhere desired
- A simplified pulley system designed to raise and lower a strong framed net easily within rectangular frame
- Mutation to allow storage underneath the platform

Use: The net is lowered into the water to allow Nickel to swim onto it. It is then raised up by a single crank which is connected to one bar atop one of the pontoons. The crank locks when Nickel is at the desired height, and the entire structure can rotate to get Nickel in the desired position.

Setup and Storage: The device is stored by rotating the pontoons so the frame of the structure floats on the water. It then connects to the platform with one pontoon on each side of the platform and the frame and net underneath the platform.

This alternative requires answers to these questions as well as the ones in Appendix G:
Does the length of the pontoons affect any other activity while in storage?
How easy can Nickel be reached with this device?
Is it beneficial to have Nickel's height level with the platform?

Design Review

After considering all the various suggestions offered by our classmates, we altered our design to include a few of them and also attempted to answer as many questions as possible about our design.

Belt Improvements

-We looked into the various belts suggested, and decided a rubber toothed belt is best for our situation. The rubber allows an extremely tight fit and the rubber and teeth on the pulley gives an extremely strong grip that will not slip when wet. Because of this, we decided encasing the gears is not necessary because being wet is not a factor.

Crank Improvements

- The idea of using a gear system to improve the mechanical advantage appeals to us. Having a crank that can lock and reverse would make the net much easier to raise and lower and lock in place. Two way hand ratcheting winches would allow the user to crank the net both upward and downward and lock it easily at any height. These winches run from $40-60 with a mechanical advantage of 4+, and the potential to modify them for increased mechanical advantage.

Net Improvements

- The fact that the net will float on top of the water because of the PVC piping did not occur to us until the design review. We decided to weight the PVC slightly by gluing steel bars inside the hollow PVC on either side. The very little weight is needed to cause the frame to sink, so it does not significantly increase the total load. Holes could also be drilled in the PVC in order to decrease the buoyancy of the PVC, but this may compromise the strength of the frame.

Billet Improvements

-With suggestions in mind, we did more research on the Dow Styrofoam Billets we plan on using and discovered they are precisely what we need. According to a phone interview with Mary Healen, the Styrofoam Billets are safe to use for our device and there is no need to change anything about that area of our design. (See appendix M for detailed information about the Styrofoam Billets according to Ms. Healen.)

Hinging Improvements

-To lock the hinge in place we initially considered using the bracket device suggested to use by a classmate. However, in our search to discover how to effectively make this part, we discovered a non-corrosive locking hinge that can lock in any position. We decided to keep the hinges in their initial positions and use this locking hinge to keep the billets in place.

Important questions and ideas that we were unable to solve or implement in our design:

- How to effectively store the device under the platform to avoid having it stick out the end.
- Whether the device can be taken out of the water and stored elsewhere.
- How to incorporate the two way winch into our design.
- How to modify the winch to increase mechanical advantage

Next Steps

Due to limited funds, we built two functional prototypes demonstrating the two mechanical aspects of our design rather than building the entire design:

-raising and lowering the net by cranking the gears

-rotating the billets with locking hinges for storage under the platform.

Fortunately, Shedd Aquarium's budget on this project is $400 greater than ours at $500, so they do have enough money to build this device. To aid in the potential building of the Ratchet Raft in the future, we have included a bill of materials (see appendix N), retail and manufacturer contact information to attain the necessary materials (see appendix O), dimensioned drawings (see appendix P), and step by step instructions how to build the design as we have created it (see appendix Q).

To continue developing this design, further testing and information is needed in these areas:

Storage
There is limited space for storage of this device, and further testing needs to be done to find a way to store the Ratchet Raft effectively.

As the design is currently set up, the device can only fit Nickel with her head facing one of the pontoons due to the storage constraints. When storing under the platform, the catwalk interferes with the ability to bring it all the way underneath, making some of the device stick out.

Questions to investigate include:

- Can the device be lifted out of the water and hung on the railing of the catwalk without interfering with other daily tasks?
    - Can the device be easily lifted out of the water by the user?
    - Are there lighter materials we can use that do not compromise the strength of the device?
- Can the device stick out the end of the platform without interfering with other feeding activities?
- Is the device able to dock to the side of the catwalk and remain in the water without interfering with the aquarium life under the water?
- Can the device be created more efficiently in some way that allows better storage?

Mechanical Advantage
Our device currently has a five to one mechanical advantage from the five inch crank. However, the crank is very near the surface of the water and difficult to lock into place. This may require the user to go into an awkward position to raise the net. The design review and working with the mockup led to thought about changing this system to incorporate a more mechanical but simpler system to crank the device.

Questions to investigate include:

- Can a gear system be designed for the crank that allows it to be on top of the frame rather than the side?
    - Will the crank be able to be removed when in storage?
    - Will this be an easier reach for the user than on the side?

- Can a gear system minimize the force needed to turn the crank without requiring noticeably more turns?
- Is there a more effective system to use in moving the net up and down?

Safety

The Ratchet Raft has a few features that are safety concerns for both Nickel and the user. The dimensions of the net and the style of the crank in the design can both potentially cause harm to the user and Nickel (see appendix R). Though the damage may not be significant, these are still concerns that should be addressed. To solve these concerns means solving the two areas above: storage and mechanical advantage. To improve the safety of the device there must be a better storing system that allows a larger frame and net and more mechanical advantage that ensures the user has control over the speed of the crank and net while lowering it.

Conclusion

Our team's mission, to design an easily stored, user-friendly turtle holding mechanism that allows the trainers/divers to intuitively perform basic training and medical procedures was accomplished. Our design not only meets the requirements but goes above and beyond them by having a net with an adjustable height and the ability to rotate 360 degrees. The Ratchet Raft is fully operable by a single individual and can be used to lift a 175lb+ sea turtle up to six inches above water level. A rectangular aluminum frame supported by two Styrofoam pontoons provides the stability by which the turtle can be hoisted out of the water and versatility by which Nickel can be rotated to any desirable position. A second frame made out of PVC pipe and netting is suspended from the aluminum frame. Once Nickel is on the netting, the frame can be raised and lowered to a desirable height using a ratcheting crank. In order to store the raft, the two foam billets flip upwards 90°. The raft can then be slid underneath the existing platform and hooked onto the underside of the platform so that it hangs above surface of the water.

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Appendix A

Project name: The Ratchet Raft

Client: Michelle Sattler, Trainer at John G. Shedd Aquarium

Team members: Eric Bell, Mark Ison, Uchenna Moka

Date: February 12, 2007

Version: Four

Mission Statement: To design an easily stored, user-friendly turtle holding mechanism that allows the trainers/divers to intuitively perform basic training and medical procedures.

Constraints

- Platform only holds 250 lbs
- Canopy cannot be used
- Nothing can be stored on/against the curtain
- $500 Budget

Users and stakeholders

- Nickel
- Nickel's trainer
- Divers/interns
- Other sea life
- Other Aquariums
- Marine Biologists

Requirements	**Specifications**
- Must be able to support Nickel	- Supports at least 200lbs
- Easy to set up	- Less than 5 minutes to set up device
- Storability	- Nothing is blocking the end of the platform - Less than 5 minutes to take down device - When stored, nothing sticks out onto the catwalk

- Must be safe for Nickel	- There are no sharp edges - The device does not splash when it is lowered into the water
- Must not interfere with exhibit	- Device made with dark material - The device does not come in contact with diver's show
- Human safety	- The device does not require the diver's hands to be in the water
-Intuitive to use	- The process of setting up the device, using the device, and storing the device done without any instructions - Entire process takes less than one hour with no instruction

Appendix B

Instructions for Using Design

Assuming the design is in its stored position under the platform.

Setup:

1. Unhook the Styrofoam billets on each side of the platform so the Ratchet Raft now floats on the water
2. Push the floating raft out fully in front of the platform.
3. Reach down and turn the lever on the right front hinge, unlocking it.
4. Grab the right handle and rotate it clockwise as far as the hinge will allow (until the hinge is straight).
5. Turn the lever on the right front hinge to lock it in place.
6. Repeat this process on the left side, unlocking the hinge, rotating the billet counterclockwise, and locking the hinge again.

Use:

1. On the right side of the Ratchet Raft where the crank meets the aluminum frame, pull the safety pin out to release the crank.
2. Lower the net using the crank and allow the net to sink to the desired level.
    a. If necessary, push the pin back in to stop the crank so both hands can be used to help Nickel get on the net.
    b. Grab onto the handle and take the pin out with the other hand to release the crank again.
3. Once Nickel gets on the net, turn the crank clockwise to raise the net.
4. When net is at desired height, push pin back in with hand not holding the crank to lock it in place.
5. Rotate and move the raft as desired to enable all necessary procedures to be done.
6. When finished with procedures, grab onto the crank with one hand and pull the pin out to release the crank.
7. Lower Nickel back into the water by turning the crank counterclockwise.

Storage:

1. Once Nickel clears the net, turn the crank clockwise to raise it all the way up for storage.
2. Push the pin back in to lock the crank in place.
3. Unlock the left hinge by turning the lever.
4. Rotate the billet ninety degrees clockwise.
5. Lock the hinge by turning the lever.
6. Unlock the hinge on the right side by turning the lever.
7. Rotate the billet ninety degrees counterclockwise.
8. Lock the hinge by turning the lever.
9. Place the raft in line with the platform, with a pontoon on each side.
10. Pull the raft back and underneath the platform
11. Hook the billets to the platform

Appendix C

Interview Guide

Client

What's your position at the Shedd Aquarium?

How well do you know this turtle?

What are your expectations for our solution?

Problem

What is the problem we are trying to solve?

What difficulties are you having with the turtle's training exercises?

What solutions have you tried to fix this problem? What went wrong with those?

Users

How often will the device be used?

What training exercises does the turtle do?

Will this device be used on any other turtle, or just this one?

What kind of handling causes the turtle discomfort?

Constraints

How heavy is the turtle?

Does the turtle have any handicaps?

What price range are you expecting for this solution?

Research

Can you suggest anybody else that can give us information about the turtle/device?

Have other aquariums adopted any special techniques to solve this problem?

Follow-up

How often would you like to be updated on our progress?

Appendix D

Interview Details

Michelle Satler- 5 years at Shedd- 15 years aquarium work
Caribbean Reef Exhibit- 90,000 gallons- fish, turtle, eel, sharks, rays…
Each animal has its own time and place to eat- 6 presentations a day

Nickle- been in the exhibit for 3.5 years- rehabilitated turtle- hit by a motor boat- big slit in the back of her shell- found in Florida
Green sea turtle- herbivores but will eat anything endangered animal
Buoyancy issue- back end floats up- needs physical examinations- train an animal to be desensitized to physical examinations
One of the goals is to make examinations easier- desensitization*
She already has a feeding space- trained to come
Went through quarantine- coin stuck in her esophagus- Nickle
Draw blood from the neck, palpitate, flip her flippers over, possible flip her over
She must be in the water but easy to handle
Have to have something removable
Aesthetic element- has to be in the water a few inches- so people will see it from below

Current system
Ugly, falling apart
Hooked on with aircraft cable
Fibergrate board- uprights slip in an out of the fibergrate board
Comes down like a drawbridge- must be weighted because it has to be in the water, but don't want it to come crashing down, lower it slowly?
Have to attach netting to other side- area of improvement*
Platform has to be a little bit in the water- turtle uses the netting, but the netting can rip
Trained to come underneath the platform- but can learn to go the other way.
PBC pipe "schedule 80" is the preferred material- grey seems to blend in better

QUESTIONS
How many people are present?
Platform only holds 250 lbs- only one person can set it up

How many people work with the turtle?
Important to have consistency with training- two shifts of divers, three people, potentially six people using it. But the 6 divers change each day. Large number of users.

Storage space?
Just lies on the catwalk- old design requires attachment. Eat twice a day, store it close

What else do you do to the turtle? Possibly weigh her? Maybe not. Lattice work above the exhibit- could potentially use metal work above the tank. Weight issue?

Movement not limited by injury.

Would she need to be taken out of the water?
She can be out of the water, but difficult- 124 lbs (4 years ago) Probably 175 lbs now, possibly 200. Platform supports 1/3 -1/2 of body weight. Still in the water.

Partly out of the water, or all the way out, but not all the way in

Edges of platform are at the surface, but her weight pulls it down

Nickel attracted to anything in the water- not necessarily attached to particular materials

Slow grower- they get to be 500 lbs, but probably don't have to allow for that.

Netting doesn't have to be detachable

Device used twice a day.

Platform 7-8 inches above the surface of the water.

Any materials we shouldn't use? Nothing that will corrode- stainless steel, PVC is good, definitely no sharp edges because she likes to scratch herself.

Ideal position for blood draw is head at the front, elevate the back end.

Turtle isn't afraid of anything. Nickle is the only turtle that uses the device.

Salinity- 32-35 parts per thousand. Temp 78 degrees

Use a clicker to train the turtle- but not bothered by noises.

Be careful of eyes- nothing that will stick out.

Up to $500

Mondays and Fridays, 1:30- 3:00. Can arrange on a case by case basis. Not after hours.

Fed everyday between 10&11 and 2&3

Store it underneath platform? It's okay for it to be permanently attached.

Ultimate vision- to be able to draw blood.

Whole thing about a half hour process- 5 mins setup, 5 mins take down. No time limit.

Appendix E

Initial User Observations

Observations	Design Opportunities
General	
Tank much smaller than imagined	-Use sides of tank for extra support -Keep device small
Platform seems weak	-Find other ways to support weight
Nickel comes straight to platform after any movement	-Do not need to include anything special to garner her attention
Cannot see anything above surface from window view of aquarium(looking from underwater)	-Do not have to make the part of the design that stays above water blend in with exhibit
Catwalk very narrow	-Device must collapse very small if stored on catwalk -Find another place to store device
Visitors can see anything above waist high on catwalk by looking up from below	-Keep the device below waist high in storage
Catwalk very sturdy	-Attach device higher on catwalk rather than platform -Attach hooks to side of catwalk to hang device in storage
Fiberglass used to create fake coral siding	-Use same idea on underside of device
Yellow railing fairly sturdy, but not safe for handling weight	-Avoid yellow railing when in use and storage
Nickel runs into anything with texture	-Texture device
Divers enter water through pit isolated from rest of aquarium	-Put device in this pit and have Nickel come into it for use.
Rear of Nickel floats to surface when not swimming	-Have Nickel get on device just below surface of water -Do not need to raise back end of Nickel
Using Current Device	
-Awkward angle to reach Nickel	-Bring Nickel to user rather than force user to go to Nickel
-Nickel must be grabbed to rotate	-Make device able to rotate Nickel
-Tough to connect net to pole	-Make device permanently one piece
-Wobbles with Nickel on it	-Use sturdy support system
-Nickel mostly in water, can get out easily	-Make device with stable support system -Secure Nickel to device
-Nickel's back flippers grab net to provide extra support	-Have something for back flippers to grab -Make device stable enough that Nickel does not latch on.

Appendix F

Specifics from Class Presentations

- **Turtle Anatomy**

    - Nervous System
        - fairly spread out through entire skull
        - sees, smells and hears better underwater
        - limited use of back flippers
        - buoyancy problem

    - Circulation
        - organs/circulatory system on belly of shell
        - quite similar to other mammals

    - Skeleton
        - can not fully retract heads into shell
        - “fingers” elongated for swimming
        - rib, body, and hip vertebrae are fused into shell
        - upper shell made up of “scutes” and a keratinous material (tough shell)

Competitive/Model Products

After researching competitive and model products used to lift animals, our findings were as followed:

-Product provided safety both for the animal and for its handlers.
-Some aspects of large animal transport were too extreme to apply to a turtle
-Some of these products are designed for large animals (horses, cows, etc) that require a great deal of control and occasionally need to be lifted over great distances.
-Many aquariums have simpler designs
-Crucial aspect of all sling designs was to aid the rehabilitation of turtles and particularly to reintroduce them into their natural habitats.
-The Carolina Sea Turtle Hospital: wrap structure to keep their turtles stable after injuries and shock.
-Aquarium La Rochelle used a net structure with emerging ropes to remove their turtles from the water.
-Divers, when injured, were removed from the water using a rigid plank with floaties – full design requires many people, but small details of it may have more application.

- Commercial Products
  -Pool lifts - used to lift individuals in and out of pools
  -Stair lift

-Scissor lifts/ lift table -used mainly to lift heavy objects off the ground
-Balance Air lifts
-Vertical Reciprocating Conveyor lifts
-Construction hoists
-Cranes/Cantilever
-Car Products
  - Engine crane
  - Jacks

- Retail Aquatic "Model" Products
  -Retail products, such as boatlifts, perform similar functions to the ones that need to be performed by the device that we created.
  -Boatlifts: buoyancy, in which the watercraft is raised from the water by placing it onto a floating platform, or by hoisting the craft out of the water, with either straps or a moving platform.
  -When the craft is placed on a buoyant platform, there are several distinct styles: modular, solid, lifted platform
  - In the second way mentioned, again, there are numerous ways by which the lifting is achieved. First is a boat elevator, where a platform is slid up and down two parallel inclined tracks (like a gondola). Second is a PWC lift, which is similar to the boat elevator, except that the platform is attached perpendicularly at the end of a bar that is pulled vertically out of the water.
  -Boatlifts used to lift boats completely from the water, using harnesses, and move them around in a shipyard.

Mechanics

The following is a list of mechanical devices that may aid us in building the device:

- Suspension with cables
- Pear-Shaped spring snap carabineers
- Large-diameter textured plastic turntable
- Coupling rods with timing belt
- Pulleys
- Buoyancy compensators
- Submarine tactics
- Adjustable net height mechanism

Materials

The following is a list of non-corrosive materials useful for building the device:

Netting

- Twisted knotted nylon twine
- Non-organic, bateria/mildew resistant
- Chemically stable
- #24- 250lbs breaking strength

Frames

PVC pipe- good strength and corrosion resistance at an economical price.
Aluminum tubes- Ultra Corrosion-Resistant Architectural Aluminum (Alloy 6063) – affordable

Gears

- Timing Belt
  - silicone rubber
  - corrosion resistant
  -single sided w/ trapezoidal teeth (avoids slippage)
- Timing Belt Pulley
  -Stainless Steel (non-corrosive)
- Rods
  -cylindrical (easy to rotate)
  -non-corrosive

Attachments

- Nylon straps
  -strong
  -cheap
  -non-corrosive
- Carabineers
  -stainless steel
  -non-corrosive
- Locking Hinges
  -die cast zinc
  -stainless steel pin
  -non corrosive metals

Buoyancy

- Dow Styrofoam Buoyancy Billets
  -lightweight
  -won't waterlog, rust, or corrode
  -1 cubic foot= 55 lbs of buoyancy

Ropes

- Type 302 and 304 Stainless Steel
  -non-corrosive
  -270 lb breaking strength

Appendix G

Clustered Brainstorming

<u>BRAINSTORM 1</u>: ATTACHMENT METHODS AND MECHANISMS

I. HOOKING MECHANISMS

Use a carabineer to hook the device to the platform/safety-railing/curtain-railing.
Use interlocking pegs that slid to lock the device to the platform/catwalk.
Use an open hook to latch to the back curtain railing.
Use posts that fit into the grid-work of the platform.

II. TYING MECHANISMS

Tie cables/rope to the platform/safety-railing/curtain-railing.
Tether the devise to the platform with cable.
Tie a rope to the latches in the catwalk.

III. LOCKING MECHANISMS

4. Clamp (through grid in platform)
5. Pins through platform and device
23. Spinning lock device (put through slot and turn 90 degrees to lock)
24. Inner and outer tube w/ spring loaded cylinder (like desk leg), tent pole (tensioned poles w/ elastic)
25. backpack click closer
26. Spinning lock device, big (put through yellow bars and turn 90 degrees to lock)
28. device on wheels, rolls out and locks
37. belt buckle loop/strap attaching device to pole

IV. ATTACHED TO CATWALK OR SIDE OF TANK

17 - support bonds on walkway
39 - attached to inside of tank (much lower than platform)
? - Poles bolted to sides of tank
19 - Metal rods attached to sides of catwalk
20 - bolt units on FRP walkway

V. FOLDAWAYS: ATTACHED TO PLATFORM

33 - wing (flips up and sideways to side of platform)
8 - drawbridge
22 - fold over platform
21 - fold under platform

VI. TEMPORARY METHODS

Platform counterbalanced by trainer
Magnets
Removable adhesive
Velcro straps
Suction cups

VII. MISCELLANEOUS ATTACHMENTS

31. Platform attached to bottom of tank with pillars
35. Platform raised/lowered with counterweights

BRAINSTORM 2: TURTLE STABILITY AND SUPPORT

1. Slinging
2. raft/tubes
3. tilt weights
4. attach to existing eye hooks
5. weight the middle down
6. catch her in net
7. Life vest
8. Girdle
9. Carabineer
10. Submarine and Surface
11. Retractable Hammock
12. Boat Lift with Net Bottom
13. Stretcher
14. Drawbridge
15. Triple Barrier and Rope
16. Flatboard
17. Diver Pen and Elevate
18. Surfboard/Boogie board
19. Inclined Grate and tilt up
20. Telescoping sliders through grate-adjustable height
21. Saucer (snow) under platform
22. Custom cradle saucer
23. Raft of rollers
24. Drawbridge/ramp
25. Auto belay
26. Hang netting and reel in
27. Straps around belly
28. Make platform into an elevator
29. Lower entry Platform / Netting
30. Water Bed / Air Mattress support structures
31. Thermo rest pad
32. Nickel in large Tube
33. Inner tube structures
34. Sphere- blow air into
35. Self-inflating thermo rest under water
36. Deflate to orientate then inflate to surface
37. Use her tilt- support front
38. Kickboard
39. Lazy boy recliner mechanism
40. Water jet/ fountain
41. Office chair
42. Locks/dams

Appendix H

Alternatives Matrix

	Support	**Set-up**	**Storability**	**Turtle Safety**	**Interference with Exhibit**	**Human Safety**
ALTERNATIVE 1: *Diver Pit*	Netting attached to walls	Attach netting to side of diver pit	Detach from side of diver pit	Turtle away from other animals	Hidden inside the diver pit	Diver may have to be in the water. Only one animal in the pit
ALTERNATIVE 2: *Turntable*	Cables	Retrieve from under platform	Stored underneath platform	Similar to current system	Stored above the surface of the water, under platform	No hands in the water
ALTERNATIVE 3: *Suspension with Cables*	Cables bolted to catwalk	Retrieve from under platform	Stored underneath platform	Current system. Netting can be gradually raised and lowered with winch	Stored above the surface of the water, under platform	No hands in the water
ALTERNATIVE 4: *Floating Device with Net*	Billets have buoyancy strength of 450 lbs	Unlock hinge, use handles to turn billets	Turn billets upright, lock hinge	Nylon knotted net for turtle comfort, no sharp edges	Stored underneath platform	Turtle brought platform level so Michelle doesn't have to bend over

Appendix I

Detailed Alternative Concepts and Lessons Learned

Questions Considered in Creating Alternatives

Is this alternative easy to set up?
Nickel will use the device several times a day. It must be possible to prepare the device for use in less than five minutes (which is how long it takes for the current system to be set up). In addition, the method of assembly must be intuitively simple.

Will it be possible for a single individual to operate the device?
The platform has the capacity to support only 250 pounds. As such, it must be possible for a single individual to effectively operate the device while at the same time tending to Nickel.

Is the operation of the device intuitive?
This device could potentially be used by any of the six divers on call at the time of use, and there are different teams of divers each day. It must be immediately evident how the device is to be used. No special training should be required to operate the device.

Can the device be stored easily while not interfering with the exhibit?
There is extremely limited space for this device to be stored while not in use. There are many other activities that go on at this exhibit, and the device must not limit these activities in any way while in storage. The device must be easy to disassemble and stored out of the way of other activities.

Initial Alternative Concepts (see appendix S)

Alternative 1- "Diver Pit":

Use: Nickel is lured in front of the door to the pit. The door of the diver pit is opened to let Nickel in. Netting suspended from the sides of the diver pit supports Nickel as she swims on to it. The netting has a roller at one end for adjusting height.

Setup and Storage: Netting is permanently attached to one side of the diver's pit. The other end of the netting attaches to the other side of the diver's pit while in use. In order to store the device, one end of the netting is detached from the wall and attached to the same side as the permanent end.

This alternative attempts to answer these questions as well as the ones in the introduction:
Do you think you would have to be in the water in order to set this up?
Could Nickel be trained to use this device?
Can Nickel be isolated from the other animals for more detailed evaluations?

Is there enough room in the diver's pit for such a device?

Faults: Nickel can barely fit into the diver's pit and the pit is extremely cluttered, so it is obvious that the device cannot be inside there.

Concept kept: confining Nickel into a smaller space

Alternative 2- "Turntable":

Use: Nickel swims up onto the turntable, it is raised so Nickel is only partially submerged in the water, and then the divers can easily position Nickel in whatever orientation they desire.

Setup and Storage: The device is stored underneath the platform when not in use and pulled out from under the platform when needed.

This alternative attempts to answer these questions as well as the ones in the introduction:
How does Nickel respond to a device with a hard surface?
Does this device make it easy for the user to carry out various procedures with Nickel?
Does the turntable safely support Nickel's weight?

Faults: Michelle expressed concern in the hardness of our turntable system, and suggested altercations to make it a net that can turn.

Concept kept: building a device that can turn rather than turning Nickel inside the device

Alternative 3- "Suspension with Cables":

Use: The netting lowers underneath the surface for Nickel to get on. Using a pulley system and a single winch, the netting is gradually raised by cranking the winch. The net is set at whatever height the user desires by locking the winch.

Setup and Storage: The netting is hooked underneath the existing platform for storage by giving the cables slack and pulling the device back.

This alternative attempts to answer these questions as well as the ones in the introduction:
Does the existence of the winch or cables interfere with any of the other day to day tasks?
Is it beneficial for the user to be able to lift Nickel completely out of the water?

Faults: After taking detailed measurements we found multiple problems with our pulley system:

- The angle at which the cables are supporting the force on the net increases the tension dramatically so the pulley system does not reduce the workload.
- The sides of the catwalk are made of fiberglass and cannot support the extreme forces required by our designed pulley system.

- The exhibit is not circular, but made of linear sections at an angle of about 150 degrees.
- The platform is not in the center of its section so the cables will not be symmetric

Concept kept: Simple pulley system with reliable attachments to raise and lower Nickel

Appendix J

User Testing Question Guide

A brief overview:

Our project is to design a device to support Nickel as she is being examined/fed/trained. We will describe a scenario, give you general descriptions of each of the mockups, have you virtually perform a set of tasks using mockups as visual guides, and ask a few questions about each completed task. Please feel free to ask questions and comment any time.

Scenario:

You are in charge of getting Nickel, a 175 pound Green Sea turtle, fed/examined/trained at least twice a day. You have to set up this device in less than five minutes, get Nickel to "beach" herself on the device, feeding her and/or perform all other necessary activities, and store the device out of the way of other everyday activities.

Task 1: Set up the device

1. Task with mockup 1 (Diver's pit)
   -Does this device look easy to setup?
   -Do you think you would have to be in the water to set this up?
   -How long do you think the set-up time would take you?
2. Task with mockup 2 (turntable)
   -Does this device look easy to setup?
   -How long do you think the set-up time would take you?
3. Task with mockup 3 (net-attached buoy)
   -Does this device look easy to setup?
   -How long do you think the set-up time would take you?
4. Task with mockup 4 (net with cables)
   -Does this device look easy to setup?
   -How long do you think the set-up time would take you?

Overall Questions about Mockup:
-What is your initial reaction for each setup process?
-What do you like/dislike about each setup process?
-Any suggestions?
-Which mockup do you favor for this task?

Task 2: Secure Nickel

1. Task with mockup 1
   -Will the lettuce attract any other animals?
   -Will securing Nickel require more than one person?
   -Is this an easy process for you?

-Is this a natural position for Nickel?
-Do you think she will stay on the device?

2. Task with mockup 2
-Will securing Nickel require more than one person?
-Is this an easy process for you?
-Is this a natural position for Nickel?
-Do you think she will stay on the device?

3. Task with mockup 3
-Will securing Nickel require more than one person?
-Is this an easy process for you?
-Is this a natural position for Nickel?
-Do you think she will stay on the device?

4. Task with mockup 4
-Will securing Nickel require more than one person?
-Is this an easy process for you?
-Is this a natural position for Nickel?
-Do you think she will stay on the device?

Overall Questions about Mockup
-Which one do you favor for this task?
-Why?
-What are your likes/dislikes about each mockup to secure Nickel?
-Any suggestions?

Task 3: Perform necessary activities

1.
- How easy is it to reach Nickel?
- Is this a comfortable position for you?
- How safe do you feel?
- Do you feel able to manipulate Nickel's position?
- Do you feel comfortable performing the necessary tasks on Nickel?

2.
- How easy is it to reach Nickel?
- Is this a comfortable position for you?
- How safe do you feel?
- Do you feel able to manipulate Nickel's position?
- Do you feel comfortable performing the necessary tasks on Nickel?

3.
- How easy is it to reach Nickel?
- Is this a comfortable position for you?
- How safe do you feel?
- Do you feel able to manipulate Nickel's position?
- Do you feel comfortable performing the necessary tasks on Nickel?

4.

- How easy is it to reach Nickel?
- Is this a comfortable position for you?
- How safe do you feel?
- Do you feel able to manipulate Nickel's position?
- Do you feel comfortable performing the necessary tasks on Nickel?

Overall Questions about Mockup
-Which mockup do you think Nickel will feel most comfort while this task is performed?
-Likes/Dislikes?
-Any suggestions?

Task 5: Release Nickel and store the device

1.
-Will Nickel be able to get out easily?
-Will this device interfere with any other aquarium activity?
-Can it be stored out of the way?
- How long do you think it will take you to store this device?

2.
-Will Nickel be able to get out easily?
-Will this device interfere with any other aquarium activity?
-Can it be stored out of the way?
- How long do you think it will take you to store this device?

3.
-Will Nickel be able to get out easily?
-Will this device interfere with any other aquarium activity?
-Can it be stored out of the way?
- How long do you think it will take you to store this device?

4.
-Will Nickel be able to get out easily?
-Will this device interfere with any other aquarium activity?
-Can it be stored out of the way?
- How long do you think it will take you to store this device?

Overall Questions about Mockups?
-Which mockup seems easiest to perform this task?
-Likes/Dislikes?
-Any suggestions?

General Overall Questions about Mockups
-What do you like about each mockup?
-What do you dislike about each mockup?
-Which mockup would you prefer to use at least two times a day every day? Why?

Appendix K

Findings from Testing

Model	Comments	Suggestions
Diver's Pit	Interferes with diver equipment	Make both ends of net detachable
	Other fish living in pit	
	Someone may trip over it walking on catwalk	Make device entirely inside pit
	Not enough space for device	Make more compact
	Space already cluttered	
	Tight Squeeze for Nickel	Discard Alternative
Turntable	Need to get Nickel out of the water maybe twice a year	Raise to platform height maximum
	Too many ropes	Use handle for turntable
	Turntable may be uncomfortable	Use neoprene to soften
	Use more often if device can weigh	Add force measurement
Cable Suspension	Ropes can be permanent	
	Wench may be dangerous at end of platform	Add wench cover Detachable crank
	Size of wench may be issue	Minimize size
	No interference with diver's hose	
	Back rope could cause problems while in storage	Make back rope detachable
	Netting should be taunt	Memphis Net & Twine
	Make netting turn	Combine with turntable

Appendix L

Design Review Summary

Suggestions

Gear Mechanics
Ideas for belt
- Put a casing around belt to avoid getting it wet—more durable
- Types of belts:
  - Drive Belts- machines in shop
  - Teeth and smooth
  - Timing Belts-car
  - Tooth belts
  - Bicycle chain with cogs
- Adjust tension in belts to make as tight as possible

Ideas for crank
- Gear crank and put on top—more mechanical advantage
- Lock crank
- Ratchet/locking system to allow one direction to ratchet, other direction locks

Net Improvements
Weigh down net—PVC piping will make it float

Billet Improvements
Material in between billets and handle to avoid handle ripping billets
Cover billets with some durable material to ensure it lasts
Make pontoon material other than Styrofoam
- Plastic box

Contact Dow for custom shorter tubes

Hinging Improvements
Use a bracket to clasp pieces together, lock Styrofoam billets
Have the hinge on the far side of the billet so the rafts weight holds the billet in place

Questions to look into

Storage
Will the device be able to be taken out of the water if needed?
Will it weigh too much to be lifted out of the water easily?
What are pieces that are sliding when stored?
Will it really fit under the platform?

Billets
Will it be easy to replace the billets if they are damaged?

Is it alright to stick cut billet pieces in the water?
Will the pontoons stable while device is in use?

Ease of use
Can the device be docked to the platform while in use?
Is Michelle lefty or righty?
Can hand be pinched in between device and platform?
Enough mechanical advantage in crank?

Is it durable with all the mechanical systems and Styrofoam billets?

Appendix M

Interview with Mary Healen

Dow Styrofoam Billets

- Dow will not custom-make Styrofoam billets for less than three truckloads worth
    - Suppliers may be willing to cut them
    - Only takes a heated wire cutter to cut the billet
- Styrofoam will not break up into pieces
- The Styrofoam is the same throughout the billet, cut billets will be no different than whole billets
- Extremely durable
- Cannot become punctured
- Repels water
- Very buoyant: about 1.35 pounds buoyancy per cubic inch of Styrofoam
- Lightweight

Appendix N

Bill of Materials

Material	Quantity	Price
Dow Styrofoam Billet (7’’x20’’108’’)	1	$97.50
Lever-locking Hinge	2	$17.31/hinge
Stainless Steel Hinges	2	$6.49
Aluminum Frame (15’)	2	$93.00
‘L’ Timing Belt (90’’ inner length)	1	$18.60
‘L’ Timing Belt Pulley (.5’’)	2	$14.24/pulley
Nylon Straps	4	$0.37/ft
Stainless Steel Rods (36’’)	2	$15.18/r
PVC Pipe		
Two way winch	1	$39.50

Appendix O

Retailer/Manufacturer Contact Information

McMaster Carr - www.mcmaster.com
- Nylon Straps
- Lever-locking Hinge
- Aluminum Frame (6’)
- PVC Pipe

ACE Hardware Store - www.acehardware.com
- Stainless Steel Hinges
- PVC Pipe

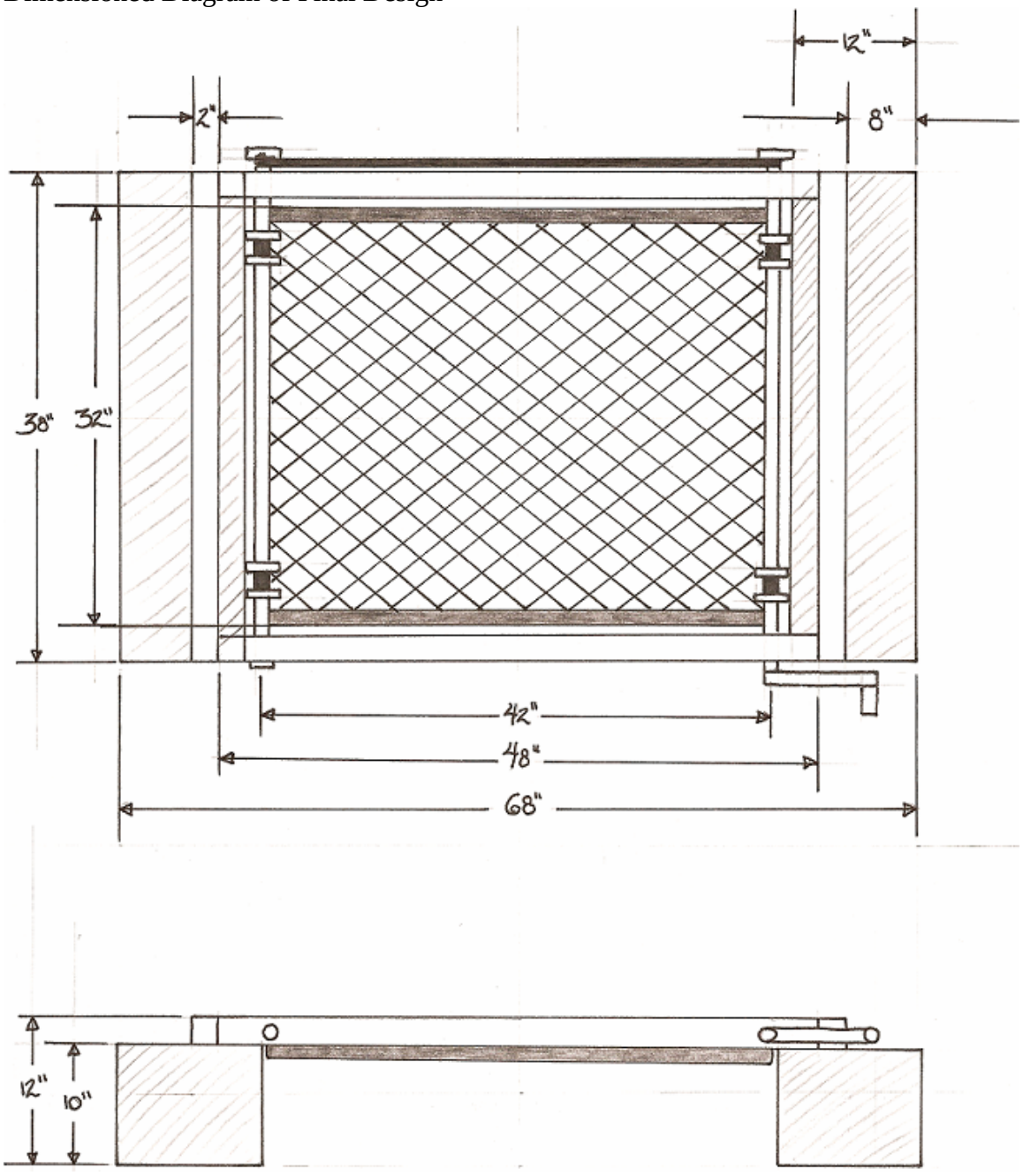
MSC Industrial Supply Corporation - www.mscdirect.com
- ‘L’ Timing Belt (45’’ inner length)
- ‘L’ Timing Belt Pulley (.5’’)

Marine Foam – www.marinefoam.com/styrofoam.html
- Dow Styrofoam Billet (7’’x20’’108’’)

Dutton and Lainson- www.dutton-lainson.com/
- Two Way Hand Ratchet Winch

Appendix P

Dimensioned Diagram of Final Design



Appendix Q

Instructions for Building Design

Construction of PVC Frame
The PVC frame is intended to support Nickel. It should be constructed using schedule 80 PVC and should be built 42” long by 32” wide. The frame should be covered with netting, stretched taut and attached to the frame using the same plastic fasteners used in the existing design. The fasteners should be wrapped with waterproof tape in order to eliminate any potential sharp edges. Nylon strapping should be wrapped around each corner and sewn with nylon thread.

Construction of Gear System
The gear system consists of two parallel stainless steel axels with four stainless steel custom machined spindles. The same timing belt and pulley system should be used as in our half scale model. We suggest that a two way ratcheting winch be used to raise and lower the device. The winch could be modified by custom machining a longer handle for increased mechanical advantage. In addition, the handle may be made detachable for easy storage.

Construction of Billet Hinging Mechanism
Two closed foam billets should be used for flotation. The billets should be secured to the sides of the aluminum frame using through bolts that have been sunk on the underside to eliminate sharp edges. The billets will then be fastened to the rest of the frame using locking hinges in the front, and corresponding standard hinges in the back.

Miscellaneous Details
Carabineer hooks should be attached to the raft and corresponding eye hooks should be bolted to the platform in order to suspend the raft from the underside of the platform. In addition, it may be helpful to have adjustable tethers in order to anchor the raft to the platform while in use.

Appendix R

Details on Safety Analysis

Nickel

Strengths:

- No sharp edges under the water
- Rotating billets does not cause device to crash into the water
- Nickel surrounded by aluminum frame while raised, cannot fall out

Faults:
-Nickel can only fit on the net one way safely. Should she be facing the wrong way, her head and flippers could be pinched between the aluminum frame and the PVC piping when the net is raised. To solve this issue, the specifics on storage above must be solved.

-Nickel must rely on the user to lower her slowly into the water. If the user lets go of the crank before Nickel reaches the water, she will fall fast and splash into the water.

User

Strengths:

- Hands stay out of the water
- No shiny objects in water to provoke any attacking animals
- Nickel brought closer to user, no awkward bending

Faults:
-When lowering the crank with Nickel on the net, the crank is pulled by the weight of Nickel. Due to the free floating device and the placement of the crank on the side of the raft, there is potential that the users hand may get caught between the platform and the crank as Nickel's weight makes it spin. Once the safety pin is pulled, the user is in control of how fast the crank moves. If the user does not have a firm grip when pulling out the pin the crank can easily rotate fast and smash the user's hand.

-Because the device is not attached to anything while in use, there is a possibility that the device could begin to float away, if not careful, the user could lose his or her balance while trying to reach for the raft and fall into the water.

Appendix S

Concept Planning Sheets

Alternative 1

EDC Winter 2007 Concept Sheet

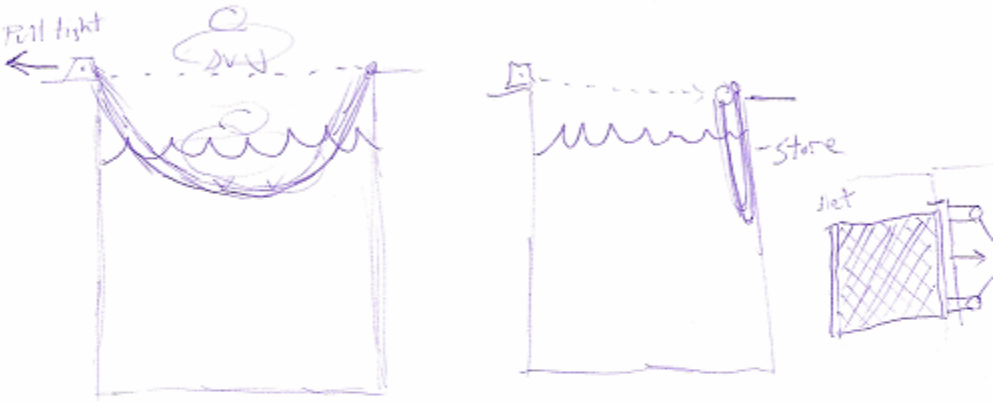
Section: 05
Team: 03
Project: Shedd Aquarium

Concept Name: Diver's Pit

Why is this concept one of your alternatives?

The Diver's Pit provides natural isolation for Nickel from the other life in the aquarium and provides simple processes for use and storage.

Concept Sketch



Strengths	Weaknesses
Nickel isolated from other life Potential to get in water with Nickel Simple storage Simple raising process Crank can give mechanical advantage	No detailed pictures of diver's pit so hard to make design detailed. - Lots of Questions - May be hard to reach Nickel from surface of diver pit. - Nickel may try to come in diver's pit everytime the door opens. - Geometries of net may not fit inside diver's pit depending how low water is.

What questions do you need to answer to evaluate this concept? Consider qualities such as robustness, usability, safety, etc.)

Can Nickel fit in the Diver's pit?
Is the divers pit ~~open~~ a valid option for isolation?
Is it easier to reach Nickel in diver pit than from the platform?
Will it be beneficial to be able to get in the water with Nickel?

Alternative 2

EDC Winter 2007 Concept Sheet

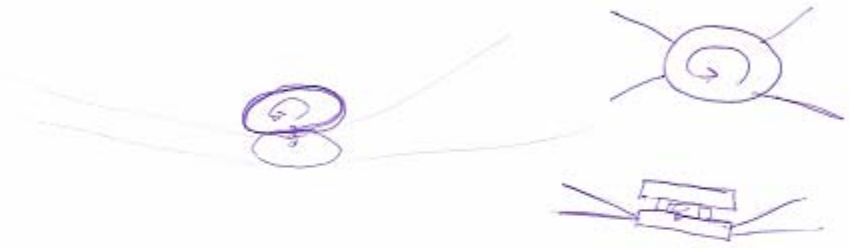
Section: 03
Team: 03
Project: Shedd Aquarium

Concept Name: Turntable

Why is this concept one of your alternatives?

Michelle expressed a desire to rotate Nickel in different positions.

Concept Sketch



Strengths	Weaknesses
Rotatable Non-corrosive turntable (McMaster-carr) Store under platform	Hard Surface Balance

What questions do you need to answer to evaluate this concept? Consider qualities such as robustness, usability, safety, etc.)

How will Nickel stay on device?
How will device be raised and lowered?
Can Nickel be pinched in between parts?
How stable/balanced is the device?

Alternative 3

EDC Winter 2007 Concept Sheet

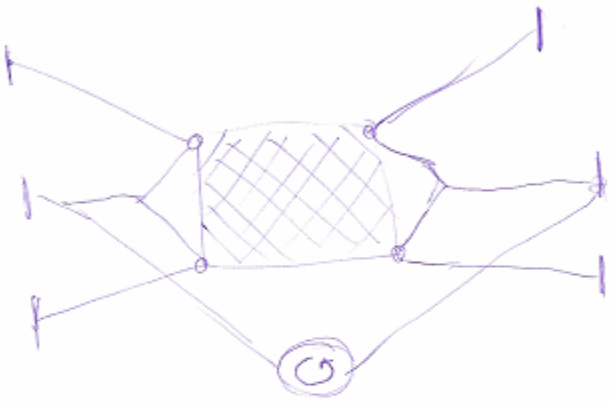
Section: 05
Team: 03
Project: Shedd Aquarium

Concept Name: Suspension with Cables

Why is this concept one of your alternatives?

This device puts no weight on platform, utilizes small aquarium. sturdy for Nickel.

Concept Sketch



Strengths	Weaknesses
No weight on platform	Large tensions in cables
Mechanical Advantage from winch.	No easy fixes with break in cable
Store under platform	Complicated pulley system
	Nickel in fixed position

What questions do you need to answer to evaluate this concept? Consider qualities such as robustness, usability, safety, etc.)

Can the sides of the aquarium support the forces from the tension in the cables?

Will the winch be in the way at the end of the platform?

Alternative 4

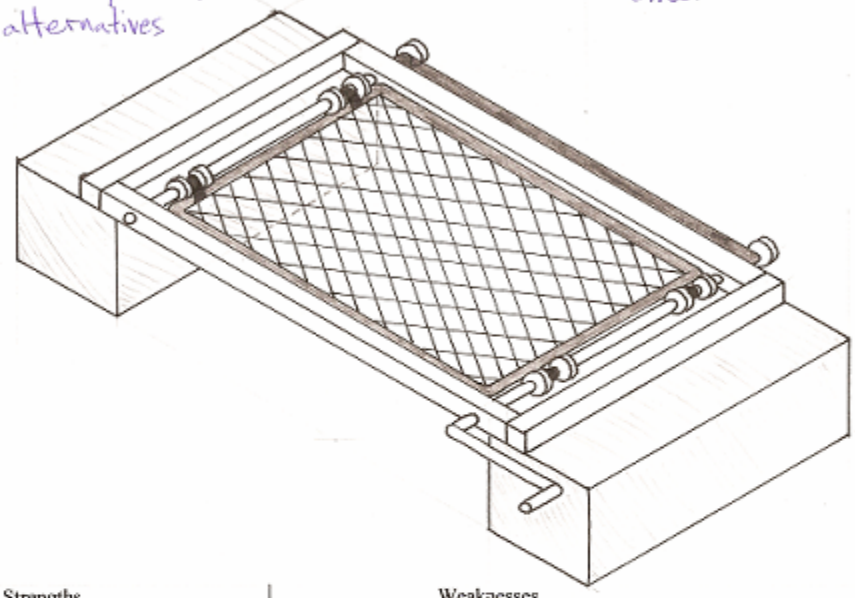
EDC Winter 2007 Concept Sheet

Section: 05
Team: 03
Project: Shedd Aquarium

Concept Name: Ratchet Raft

Why is this concept one of your alternatives?
No attachments. One piece. It is a combination of our other three alternatives

Concept Sketch



Strengths	Weaknesses
No attachments Mechanical Advantage One piece Stores under platform Rotatable No Weight supported by buoyancy.	Cost Very large Complicated gear system Durability?

What questions do you need to answer to evaluate this concept? Consider qualities such as robustness, usability, safety, etc.)

Can the device fit under the platform?
Is the mechanical advantage great enough for easy turning of the crank?