

IPro 358: Product Development & Business Planning for a Fishing Innovation

Summer 2009



FINAL REPORT

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Abstract

IPRO 358 Product Development and Business Planning for a Fishing Innovation is an entrepreneurial project, which was designed to assist the company Sparrowhawk in the product development and business framework for its novel fishing hook that is more likely to:

- 1) Catch and hold fish;
- 2) Avoid snags; and
- 3) Increase safety for both the user and fish.

These objectives are addressed with the Delta Hook Technology (“DHT”), a fishing hook designed by the sponsor of the IPRO. This project, integrating both engineering and business fields, is based off preliminary work completed by the sponsor and his extensive research regarding many facets of the fishing hook (e.g. marketing, product materials, and manufacturing).

The product development sub-team aimed to develop a mock-up of the fishing hook design conceptualized by Taylor Augy Park, the sponsor of IPRO 358 (“Sponsor”). This was attempted by improving upon the original design of the DHT by creating various mock-ups of the product. The sub-team researched different design aspects of the fishing hook (e.g. different types of epoxy, solder, heating methods), materials that exhibit physical characteristics necessary for the proper functioning of the DHT (e.g. resiliency, corrosion resistance, etc), and methods of testing the mock-ups (e.g. snag test, corrosion test, tensile test).

Similarly, the business sub-team focused on developing a business and marketing plan (i.e. current market research, future marketing possibilities, and consumer surveying). Current market trends were researched from the 2006 U.S. Fish and Wildlife Service survey and the 2008 American Sportfishing Association report [24][25]. For possible marketing ideas and trends, the sub-team looked at major competitors and retailers. In addition, a set of features was brainstormed for different iterations of the DHT. Lastly, consumer surveys were administered at local fishing retailers including Bass Pro Shop, Cabela’s, and Henry’s Sports and Bait.

At the beginning and end of every class, both sub-teams met to relay the current status and findings to the other team. During this time, any questions would be addressed and each team would be educated on the progress of the overall team. Many times during the semester, one group’s progress would be influenced by the other team’s research. One example was choosing an approximate size for the DHT to meet the needs of bass anglers. Both the business and development sub-teams were able to work together and communicate cohesively to meet the goals of the project.

Background

The IPRO team worked with the CEO and entrepreneur of Sparrowhawk, LLC, Taylor Augy Park, and with Heartland Angels, Inc. Sparrowhawk has developed an innovative fishing hook, the Delta Hook Technology (“DHT”) that offers its users the potential of greater safety by preventing painful fishing hook injuries and a

greater likelihood of successfully landing fish, while avoiding frustration due to time-wasting snags. Heartland Angels is a private equity network that brings together accredited investors with early stage start-up companies and real estate opportunities looking for equity and debt investments. Heartland Angels' mission is to be a catalyst in the process of innovation by creating forums in which human, intellectual, and financial capitals are joined together for a common purpose. The project offers an opportunity for students to gain experience in developing the components of a business strategy and plan, as well as in development and testing designs and mock-ups that demonstrate the value of the DHT to its potential consumers.

The recreational fishing industry annually contributes one hundred twenty five billion dollars of economic output to the Gross Domestic Product and provides over one million American jobs [25]. One of the key components of the industry is fishing hooks. There are many different fishing hooks available, retaining the same, basic shape and structure as hooks offered many years ago. However, there are many problems that face such hooks. One problem is that fishing hooks are not properly fastened after being embedded in the mouth of a fish. This can be solved by increasing the size of the barb on the fishing hook. However, this would pose a greater difficulty in properly embedding the hook, and it would result in greater damage to the fish. Another problem is that fishing hooks can catch or snag onto nearby rock formations, algae, weeds, and other vegetation. This problem is currently approached by utilizing snag-proof guards. However, this increases the manufacturing cost of the product, and is not shown to be conclusively effective (primarily based on qualitative observations).

Additionally, barbs harm the fish, depending on the size of the barb relative to the fish. Solutions to this problem are to remove the barbs from the fishing hooks or to use a curved or bulb-shaped hook point. However, these solutions risk posing additional problems including:

- Difficulty for the angler to embed or set the hook once the fish has bitten on the hook.
- An increased likelihood of the fish becoming disengaged once hooked.

Perhaps the greatest problem facing conventional fishing hooks is the potential danger facing the anglers, especially the younger, inexperienced ones. The exposed, barbed fish hook can pierce through the skin of an angler and cause injuries. The greatest injury is inflicted upon removal of the hook due to the barb. Among major corporations, there appears to be an absence of fishing hooks equipped with safety measures.

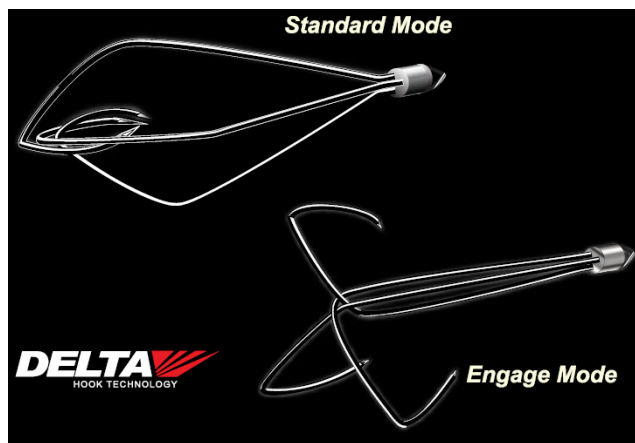


Figure 1 - The DHT in its standard, unengaged mode, and its engaged mode.

Our team attempted to fully develop the DHT to address these problems. A concept design image of the DHT can be seen in *figure 1*. This design, as provided by our sponsor, is comprised of an inverted treble hook (i.e. three barbless J-hooks pointing towards the central axis) with three shanks consisting of a flexible, metallic material. In the standard mode, the three shanks isolate the points of the J-hooks, which harmlessly point inwards. Only an applied force equal to or greater than a fish's bite force is sufficient to drive the shanks toward the central axis, activating the hook. Therefore, safety increases since the force of the hook colliding with another angler during casting is less than the targeted fish's bite force. In the engaged mode, the J-hooks move past the central axis, resembling a regular treble hook with the three points exposed.

Once embedded in a fish's mouth, the inward angle of the hook coupled with the tension on the hook (i.e., the hook wants to return to the standard mode) create an improved hold on the fish's mouth cavity (relative to standard J hooks and treble hooks). Typically, a fish will open its mouth to an effort to discharge a foreign object such as a hook. With the DHT, however, the opening of the mouth further tightens the hold that the DHT has on the fish thus increasing the likelihood that the fish will be effectively retrieved by the angler. This process is shown in *figure 2*. The hook can then be removed without additional injury to the fish since the hook's size is effectively diminished as a result of the removal process as well as the absence of barbs that would otherwise have to be removed through further physical harm. In turn, the DHT will automatically return to its original shape with the hooks aligned along the central axis. Future designs of the fishing hook incorporating the DHT design can be adapted to hold live bait or be incorporated into an artificial lure, such as a jig.

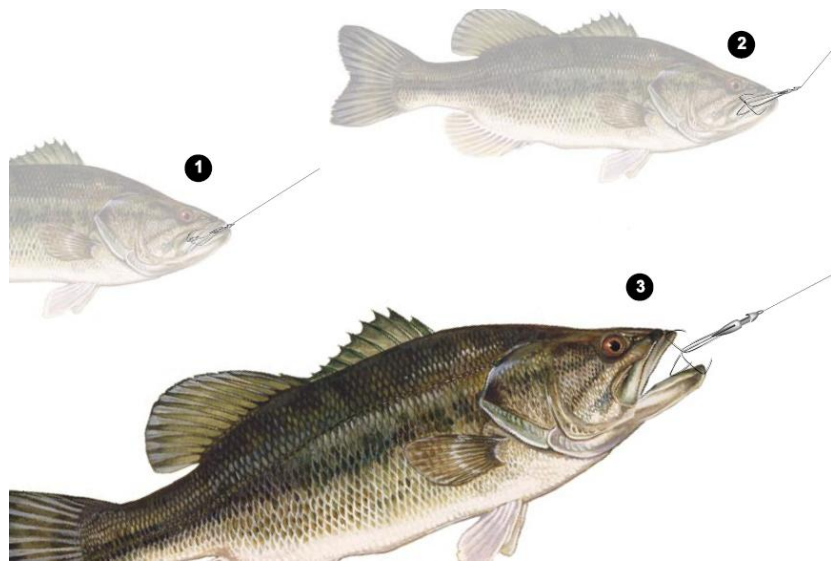


Figure 2 - The hook setting process with the DHT and a largemouth bass.

Furthermore, there are many technological aspects that must be considered during production of the mock-ups. Prior to this IPRO, the sponsor, Taylor Augy Park, created a number of preliminary mock-ups. One of the previous attempts consisted of a shank that was entirely composed of a flexible, metallic wire. However, this enabled the hooks to twist into an ineffective position. The torsional movement of the hooks was prevented by replacing the shanks with a flat, curved, flexible metal. Additionally, each of these mock-ups was larger than the desired size (roughly double the size of a typical treble hook for bass fishing). These are a few of the many technological aspects that were addressed during the design and production of the mock-ups. Furthermore, one of mock-ups made in class contained materials that were not durable enough to withstand engagement and disengagement during testing.

During development, the regulations set forth by fishing tournament organizers and the government must be taken into consideration, as well. For example, the fishing hook must be biodegradable and harmless to the environment so that the materials selection will lessen the ecological impact on the aquatic ecosystem for future anglers. Legislation can also be an advantage for the DHT. Several states have implemented measures to regulate the use of barbed hooks, even to the degree of banning them completely. Therefore, anglers must utilize hooks that have a lower probability of harming fish. We welcome these innovations.

There are many ethical issues that must be addressed involving a project such as this, for example certain aspects of testing our hook may involve using live fish. There are many questions that arise regarding testing on live animals (i.e. fish). These issues will have to be investigated. Each member of the IPRO team also signed a non-disclosure agreement, agreeing not to divulge confidential information regarding the DHT. This agreement specifies that aspects of the intellectual property of the CEO and founder of Sparrowhawk, LLC are confidential. It also specifies how each team member agrees to treat information he/she is privy to. Legal action may be taken against any attempt made at reproducing parts of the design for personal gain. This is to ensure that the intellectual property of the sponsor is protected.

Objectives

During the summer 2009 semester, IPRO 358 plans to develop mock-ups of the Delta Hook Technology (DHT) and to lay the foundation for a business model for Sparrowhawk, LLC, an early stage company. Sparrowhawk has investigated the concept for an innovative fishing hook that is not currently on the market or ready to be launched. The IPRO team will work together to approach the process of designing mock-ups of the Delta Hook Technology (DHT), testing the mock-ups, and determining measures that can be taken to improve the DHT. Subsequent mock-ups will continue to improve based on results of the product testing. Simultaneously, we will do market research in order to identify the target market, determine price points, and develop marketing strategies for DHT.

The IPRO team will be divided into two sub-teams (product development and business) that will work together to achieve their goals. The development sub-team aims to create mock-ups of the DHT, improving the mock-ups with each subsequent redesign. The sub-team also aspires to successfully catch a largemouth bass in a fishing environment with the newly designed DHT. Both of these goals must be achieved through research, design, testing, and redesign. The business sub-team will construct a marketing strategy for the DHT and will develop a report that can be presented to the sponsor for a better understanding of where his product will fit in the marketplace.

While some of these objectives may be completed within the current semester, we hope a solid framework is built for future iterations of the IPRO to expand and complete all the listed objectives.

Development Sub-Team

- Explore different design possibilities to create a mock-up of the DHT that will incorporate safety, ease of use, and practicality, while fishing.
- Select the material for shank and hook of DHT, including the type of material as well as its flexibility, size, quantity and strength.
- Confirm the proper shank and hook geometry necessary for successful landing of fish, while keeping the DHT safe and easy to use.
- Determine the proper size and weight of the DHT to optimize efficiency and performance.
- Confirm cost effective solutions for material selection and manufacturing processes.

Business Sub-Team

- Identify the problem in the marketplace that we are trying to solve, find out anglers' wants and needs for a better fishing experience.

- Determine if the largemouth bass is the fish for which the DHT should be designed. Both primary and secondary data will aid in accomplishing this objective. This involves research online and in magazines, and also engaging the marketplace by talking to anglers.
- Identify target market. In order to understand the future DHT customer, anglers will be divided into subcategories (e.g. recreational and sport anglers). Analysis will be performed as to which subgroup will be targeted.
- In conjunction with the development team, a concept statement will be designed and tested. *To be accomplished in future semesters*
- Determine the DHT price points.
- Identify the optimal marketing mix and strategies of launching DHT. *To be accomplished in future semesters*
- Conduct consumer research such as surveys and focus groups.
- Conduct ethnographic research by observing relevant consumers in the environment in which they purchase and use fishing hooks.
- Research spending behavior and develop price points for the relevant market.
- Understand and document fishing industry product distribution channels.
- Perform a SWOT analysis of Sparrowhawk and the relevant market. *To be accomplished in future semesters*

Methodology

The IPRO team divided into two sub-teams to focus on different aspects of the project: one team focused on product development (e.g. materials selection, manufacturing techniques, and testing procedures to create mock-ups of the DHT), while the other focused on creating a business plan for the project.

The product development team began the design process by determining an appropriate design for the mock-ups. The sub-team then commenced the construction of two major mock-ups of the DHT, improving the design. The sub-team began a third mock-up with consultation from a mechanical engineering professor, Dr. Sheldon Mostovoy (mostovoy@iit.edu); however, the mock-up was unsuccessful due to its high brittleness and low elasticity. The product development team also designed seven testing procedures to evaluate the functionality of the mock-ups. These processes will be explained in detail in the subsequent sub-sections.

The business sub-team of the project focused on marketing. The majority of the work done by the business sub-team includes current market research, marketing possibilities, and consumer surveying. Throughout the semester, secondary research (e.g. 2006 U.S. Fish and Wildlife Service survey and the 2008 American

Sportfishing Association report) was used to help understand areas of interest to pursue when marketing the DHT to consumers. The majority of research was done outside of class, and discussed in the separate sub-team meetings. If necessary, further research was conducted based on the in-class discussions and relayed at the next meeting.

Development Sub-Team

Delta Hook Mock-Ups

Material Selection

- Loctite brand waterproof epoxy putty
- Darice brand French jewelry pins
- Scünci brand barrettes

The epoxy was chosen not as a method to be tested for manufacturing, but as a simple and effective way to join sections of the hook so that the mechanics of the hook could be examined. Standard solder and silver solder were explored, but neither worked. The metals used repelled the solder. The French jewelry pins were chosen because of their ductility and availability. The barrettes were chosen because of their elasticity and availability. After browsing Home Depot, no other materials seen had the properties that these had in terms of elasticity. A conscious choice was made to quickly choose suitable materials based on availability so that a working mock up could be constructed. After examination, the best materials for each section could be determined.

Mock-Up 1 Construction Procedure

The entire DHT is composed of a base, three flexible units protruding from the base (all identical) and three rigid sections that each attach to a flexible section that act as the hooked points. The part of the hook from the flexible section through the straight rigid section are referred to as the shank. The rigid part that is bent upwards is referred to as the tip (*figure 3*).

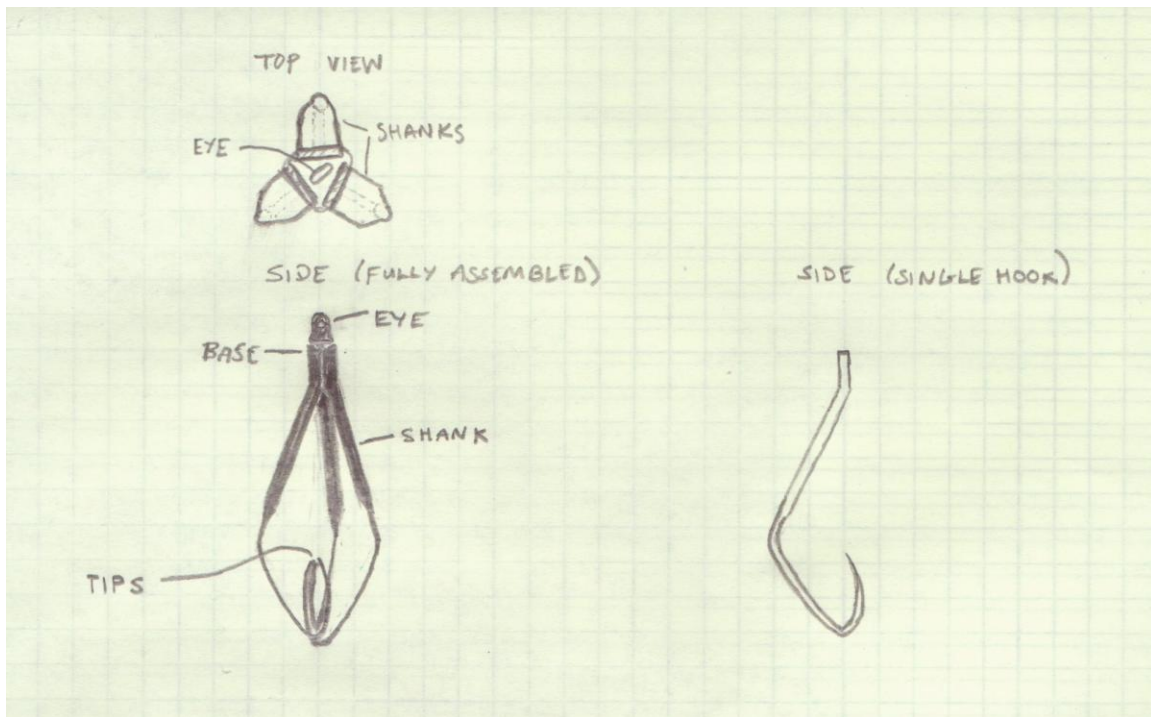


Figure 3 - The visual appearance and the defined sections of the DHT.

The outer bending sections of two barrettes were removed for a total of four flexible shafts, three of which were to be used. Each one needed to be identical to the other. Next the jewelry pins were cut and bent into hook shapes in slightly varying sizes to allow for the DHT design to work. To bend the hooked section, the jewelry pin was held in a vice while force was applied to bend the piece into the shape supplied by Augy Park. All measurements for this mock-up were approximated, since the preferred exact dimensions were unknown. Augy Park's drawing was used as a reference for the mock-up, but no dimensions were given. Then each hooked section was attached to a flexible section using the epoxy mixture. Directions on the package describe how to simply mix the putty by hand. The rigid section was attached overlapping the outside of the flexible part so that a biting force on the hook would not work to separate the two.

After allowing the epoxy to set for one hour, each piece was attached to each other by simply surrounding the ends with epoxy and pushing them together. This formed the base. Minor adjustments were done by approximation to get them to the proper position. A hook eye was cut from a Gamakatsu brand offset shank worm EWG hook and placed in the epoxy base to allow a spot for line to be tied to. After approximately ten hours, including time allotted for experimentation with different soldering techniques and curing time for the epoxy, the construction of the first mock-up was complete.

Major areas for improvement:

- A systematic approach to forming the base.
- Consistent spacing between the acute bend between the shanks and the tips.

One of the hook sections eventually broke off of the base because not enough epoxy surrounded the edges of the flexible section that held it to the rigid section.

Mock-Up 2 Construction Procedure

The second mock-up followed a similar procedure to the first and used the same materials, but relied on more precision for the lengths and of each piece. After examining the motions of mock-up 1, the ideal angles seemed to be 115 degrees for angle 1 and 45 degrees for angle 2 (see figure 4). This allowed the tips to protrude enough to hook a fish while still allowing the tips to line up together at the central axis.

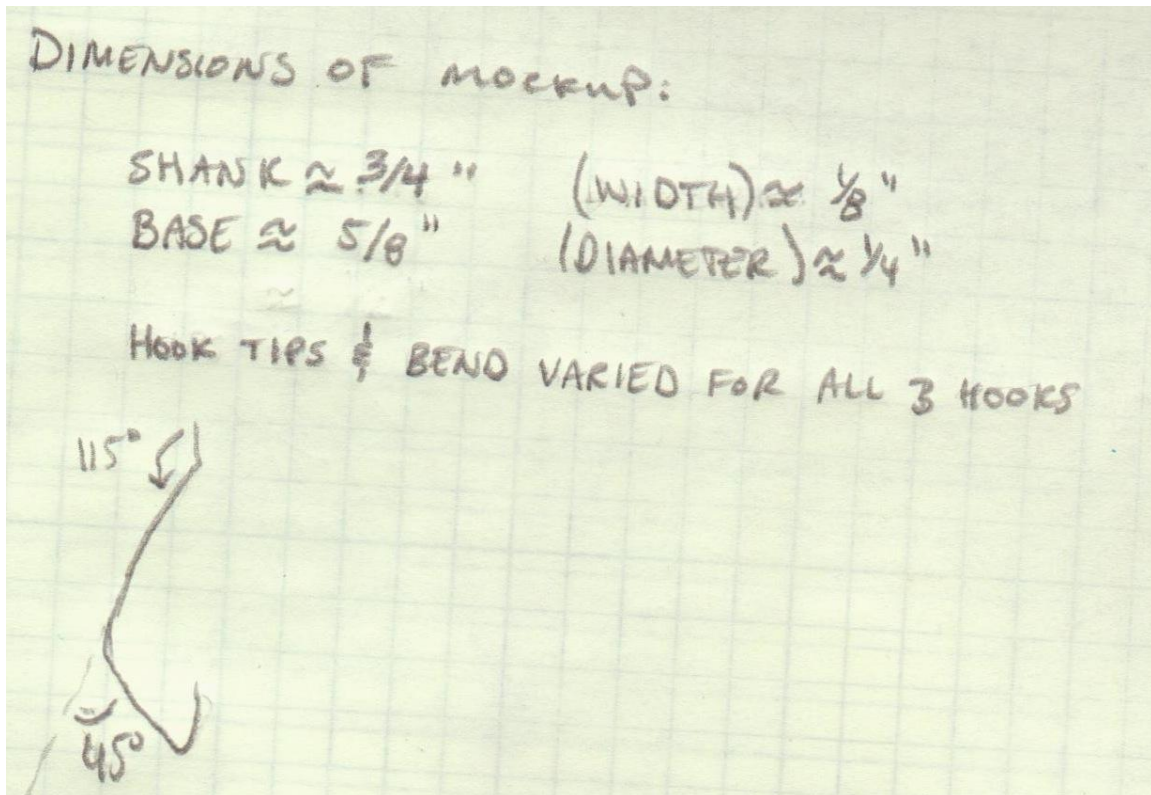


Figure 4 - The angles and dimensions used for the hook sections of the second mock-up.

Each hook section was designed to be identical from the base on down to the 45° bend. The 45° is an approximate angle and was used for the middle hook section. Dimensions after the 45° bend differ to allow each hook section to properly overlap. The lengths of the two sections of the rigid portion differ as well as the acute angles. The joint length between the rigid and the flexible region of the shafts was shrunk to what seemed necessary which allowed the full hook to be shrunk to approximately 75% of the mock-up 1 size, which made it closer in dimension to a regular treble hook.

In order to form the shanks using the desired dimensions, a bending jig was formed from nails hammered into a piece of wood. Each hook could then be bent to a known, consistent angle. Care was taken so that when bending the acute bend, the tips of each hook would meet at a point. This meant that for the shortest hook

section, the tip had to be shorter than the largest by the same distance as the gap from the acute bend of the smaller hook section to the acute bend of the larger hook section. The same method was used for the medium hook section. The base was formed using a pencil eraser cap filled with epoxy. This allowed for a precise form of the base. The shank was measured out to be $\frac{3}{4}$ " long and $\frac{1}{8}$ " wide. The base was measured out to be $\frac{5}{8}$ " long and $\frac{1}{4}$ " in diameter.

Major areas for improvement:

- More precision in the bending of the tips to assure a proper meeting point.
- More precision in base formation due to slightly imperfect line up of the hook sections. The hook worked properly for two of three biting scenarios, but could not properly engage if only a specific two out of the three hook sections were given an applied force.
- A different joining method is needed other than the epoxy. Although it works well for the initial mock-ups, it is too bulky to allow for the fluent operation needed.

A slightly different design is needed overall to include the over-flexing technology for the DHT that our sponsor believes will be beneficial in holding the fish after it has been hooked. The flexible portion of the shank must extend past the meeting point of the engaged hook sections. This will allow for further flexible movement after full engagement of the hook. The goal dimensions of the individual hook section should replicate those shown in *figure 5*.

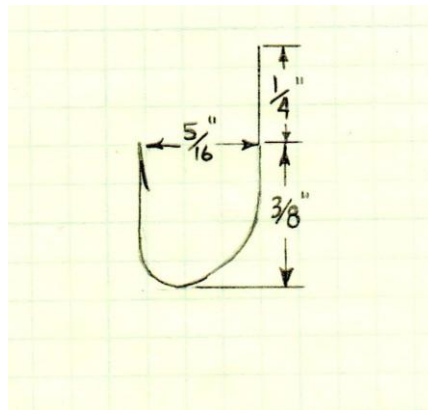


Figure 5 - The exact measurements of each length per individual hook section.

Quenching and Tempering

A Bernzomatic propane torch was used in the quenching and tempering of piano wire given to the group by Professor Mostovoy, a materials science professor here at IIT. While holding the wire with needle nosed pliers, the torch was used to heat different samples of wire to varying degrees followed by quenching them in room temperature water. The temperature of the wire after heating ranged from almost white hot, to red hot, pink hot and same color, but heated. The ideal temperature to heat to is about 850°C. After quenching each sample different portions were tempered for ten seconds, twenty seconds, thirty seconds or one minute.

Before the quenching and tempering, the wire was fairly easy to bend by hand, but difficult to break. After the quenching and tempering the sample was extremely brittle and weak. The samples that were barely tempered were broken as easily as uncooked spaghetti. The samples that were tempered longer, around 30 seconds or so, gained some ductility back, but were still just as weak. No combination of heating, quenching and tempering was found to even recover the amount of strength as the properties of the original state of the wire.

The exact composition of the piano wire is unknown, but believed to be a high carbon steel.

Testing Methods

There are many different testing methods that are applicable for evaluating the functionality of the DHT mock-ups. We detailed the following seven testing methods for use with the DHT mock-ups:

- The bending test measures the ductility of materials by applying a certain force to measure the amount of force required to bend the shank to the central axis. The results can be found in [Appendix J](#).
- The corrosion resistance test measures the amount of corrosion exhibited by a specific material in a specific environment over a length of time, which is compared to other similar materials to obtain a standard. The results can be found in [Appendix K](#).
- The customer satisfaction test compares with other fishing hooks on the market the ability of the DHT to catch fish. The results can be found in [Appendix L](#).
- The fatigue test determines the effect of a cyclic load on a material in real-world conditions to provide a good measure of the use of the DHT while fishing. The results can be found in [Appendix M](#).
- The hook setting test determines the effectiveness of the engagement mechanism of the DHT mock-ups with relation to standard fishing hooks. The results can be found in [Appendix N](#).
- The snag test compares the number of snags from the DHT mock-ups with respect to the number of snags in other fishing hooks. The results can be found in [Appendix O](#).
- The tensile (unbending) test determines how the material specimen reacts to forces applied in tension. The results can be found in [Appendix P](#).

A detailed description of each test is included below and tables for collecting test results can be viewed in the corresponding appendices.

Bending Test

The design of the DHT requires three hooks to collapse towards the central axis. Therefore, the shanks of all three hooks must bend elastically when engaged and spring back to their original position when disengaged. The objective of the bending test is to find the force required to bend the shank to the central axis. These results are then compared to the biting force of a fish; the force required to engage the DHT must be less than the bite force of the fish being caught.

The test requires a C clamp, a rigid central axis marker, a table top, weights, and a shank. The base side of the shank is clamped to the end of table top, along with the central axis marker. Weight is then hung from the free

end of the shank until the shank reaches the central axis. The final weight is then recorded. The bending test can be visualized in [figure 6](#). The test result table can be found in [Appendix J](#).

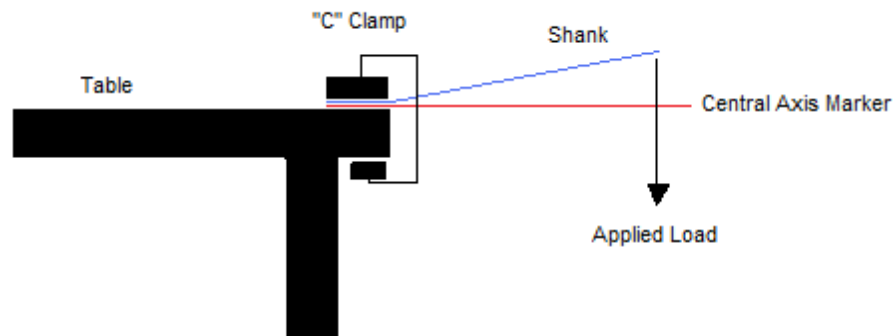


Figure 6 - The procedure of the bending test.

Corrosion Resistance Test

The corrosion resistance testing methods are specific, based off of typical conditions in various environment and applications. A universally accepted method of testing corrosion is simply to use the specific metal in the desired environment and examine its service history. With regards to salinity, fishing hooks are often tested by using the salt spray test for at least 96 hours [7]. Similarly, a salt spray test can be used by creating homemade stimulated saltwater in a "dunk test" [9]. The apparatus for testing consists of a closed testing chamber, where a salted solution, such as sodium chloride, is sprayed by means of a nozzle. This produces a corroding environment in the chamber and parts in it are attacked under the severe corroding atmosphere. A graduate doctoral student from the Mechanical, Materials, and Aerospace Engineering department, Mark Landow (landmar2@iit.edu), may be a useful contact in the future, regarding any facilities available for use in corrosion testing. The results tables for the corrosion testing methods can be found in [Appendix K](#).

Customer Satisfaction Test

The customer satisfaction test compares the DHT with other fishing hooks on the market in terms of its efficiency in catching fish. This test is unique from the other tests due to its ability to assess the angler's ability, not the mechanical properties of the DHT, to catch fish with the delta hook as compared to other fishing hooks. Therefore, it is important to determine the effect that the fishing hook has in catching fish, while accounting for high variations such as the angler's ability.

Anglers with different levels of experience will be approached and asked to complete a form. Each level of experience will be given different types of hooks (e.g. J-hooks, treble hooks, and DHT) and each individual will cast using the hook with a bait or on a lure. The test will be conducted as close to a double blind experiment as possible, by attempting to ensure that neither the angler nor the results recorder is aware of what kind of hook he is using. This would be difficult to implement, however, as a third person would have to ensure that the angler and the recorder do not see the fishing hook until it has already been cast. The results for this test can be seen in [Appendix L](#).

Fatigue Test

Fatigue testing utilizes a machine to apply a cyclic load on a specimen. More advanced fatigue testing machines can cycle through loading and unloading millions of times a second, as well as, vary the force of the load. These tests are done to better understand how vibrating and oscillating forces often weaken a specimen. Fatigue life is measured by the number of cycles of loading and unloading before a specimen undergoes plastic deformation and breaks under a certain load. The damage caused by fatigue is not fixed when the loading and unloading ceases. The machinery used for these tests normally includes actuators attached onto a stiff frame. These actuators are controlled by high frequency hydraulics and servos. The frame is then used to apply loads to the specimen to test its fatigue life [12].

The DHT requires a special rig in order to test for its fatigue life. One reason for this is that the mock-ups would not be able to withstand hundreds of cycles at which modern fatigue testing machines operate. Also, these machines oscillate and vibrate the specimen to test structural fatigue properties. However, the test requires testing of the fatigue caused by the engaging and disengaging of the DHT mechanism as well as its structural integrity. A standard industrial fatigue testing machine would not be able to accommodate these parameters without unique rigs. The machine would need to test the fatigue life of the base of the DHT as well as the flexing unit and the hook itself [12].

To test the fatigue life of the base due to the constant engaging and disengaging of the fishing hook, the fishing hook would have to be manually engaged and disengaged. The design of the fishing hook requires the third hook to be deployed if two of the hooks are engaged. To engage the fishing hook during testing procedures a piece of string must be tied around the DHT. To engage the fishing hook during testing procedures a piece of string must be tied around the DHT. The test form is located in [Appendix M](#).

Hook Setting Test

This test is used to assess the effect of the DHT engagement mechanism compared to other hooks on the market. The engagement mechanism is shown in *figure 2* (replicated from the introduction). It will create an understanding of the number of times in which the individual hooks engage to catch a fish. Some of the hooks can slip out of the mouth or lack enough pressure to penetrate the mouth of the fish. It is also tested as to whether the fishing hooks are able to snag a fish on the outside of its body. When snagging a fish on the outside of the body, a large number of snags would be a negative outcome. This test measures a very important feature of the DHT. If a negative result is found and the DHT engages a fewer number of times than the J-hook or treble hook, adjustments need to be made to the mock-up [14, 15, 16].

This test begins by using the jaw of a largemouth bass; either constructed (outlined in the works referenced) or from an actual fish. Each test has the fish clamped on a table to ensure that the fish does not move around. The fish should also be attached to bars or clamps in order to keep the mouth of the fish closed, as long as the pressure exerted on the jaw is the same as the referenced documents. The jaw of the fish should still be able to open and close. The different hooks (attached to a string or line) should be placed inside the jaw and then the jaw should be closed. Once the mouth is closed, the line should be on the outside of the jaw. The string

should then be pulled with the same amount of force used to set the hook. The test is used to determine whether the DHT moves from its standard mode to its engaged mode [14, 15, and 16].

To conduct the test on the outside of the fish, the fish is placed on its side on a flat table. The fishing hook being tested is taken and the string attached to the fishing hook along the fish's body is pulled. Unlike the other tests instead of pressure on the jaw, record the orientation at which the hook was pulled, such as towards the head. This test form is located in [Appendix N](#).

Snag Test

The snag test compares the snagging tendencies of the J-hook, treble hook, sponsor provided mock up, and IPRO developed mock-up. A snag, for testing purposes, is defined as a situation in which the hook is irretrievable due to engagement with or entanglement in any obstacle. The obstacles will vary with respect to different environments that the fishing hooks are tested in (e.g. different ponds and lakes). This test will determine whether or not the designed DHT will provide a snag-less recovery.

This test can be conducted by finding fishing environments that provide various obstacles (e.g. trees, branches, rocks, roots, lily pads, and weeds). Individual fishing hooks must be cast and retrieved in each environment a significant number of times (≥ 100), using line strength between five and ten pounds. If a hook becomes engaged in an obstacle, the angler will pull on the line until the hook frees itself from the obstacle or the line breaks. For design improvement purposes, a detailed description of the actual obstruction type must be recorded. The test form is found in [Appendix O](#).

Tensile Test

There are different mechanical strengths of materials due to different material compositions and types of heat treatment. Various studies have shown that high mechanical strength is very important in a fishing hook and is characterized by a uniform fine-grain sized microstructure. Also, it should be noted that in a number of studies, it has been shown that the unbending force is positively correlated to wire diameter of the fishing hook [17]. One must determine a fashion in which to measure the mechanical strength of a fishing hook: the tensile (unbending) test. The unbending resistance test (i.e. a specific type of tensile or tension test) provides a direct method in successfully measuring the mechanical strength of a fishing hook [18]. The unbending test is able to provide a quantifiable measure of the force that the bend of a fishing hook can withstand.

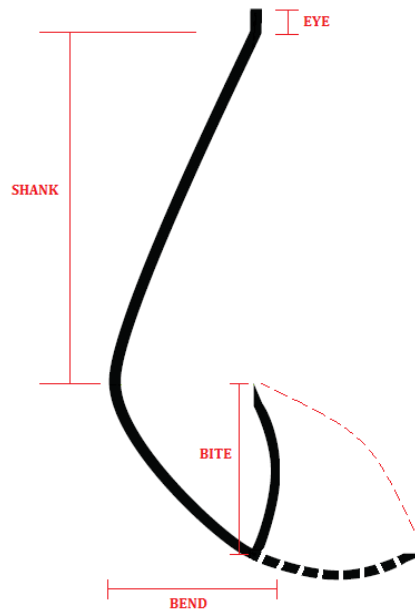


Figure 7 - Shows the extent to which the DHT will bend to the point of deformation.

In most tensile tests, the point of failure is defined as the Ultimate Tensile Strength (UTS). The point of total deformation in the unbending test is regarded as the point of deformation of the fishing hook, equal to the bite length, likely before the UTS. The extent of this bending can be visualized in *figure 7*. This is regarded as such because after this point, the fishing hook becomes useless for fishing. There are many other factors that can be measured with the unbending test [18]. The slope of the stress-strain curve before the UTS will provide a measure of the elasticity (Young's Modulus) of the fishing hook. This is a measure of the stiffness of the fishing hook, which will be further explored in another testing method. Also, the yield strength can be measured as the force is applied during the unbending test. This defines the property of a material to return to its original shape after a force is applied. This value, the resiliency of the object is shown in *equation 1* and is one of the properties that must be considered when determining material properties of the object. The value of the resiliency can be found by evaluating the area under the stress-strain curve shown in *figure 9*.

$$U_o = \frac{\sigma_o^2}{2E}$$

Equation 1 - Provides an evaluation of the resiliency of the object.

Competitors use different types of unbending tests to measure the mechanical strength. For instance, Mustad & Son uses the Mustad Bending Test to measure the amount of kilograms needed to straighten out a fishing hook [19]. The Mustad Bending Test can be seen in *figure 8*.

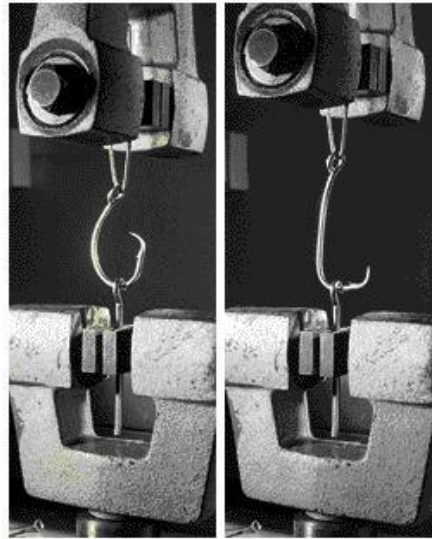


Figure 8 – Demonstration of the unbending test performed by Mustad & Son.

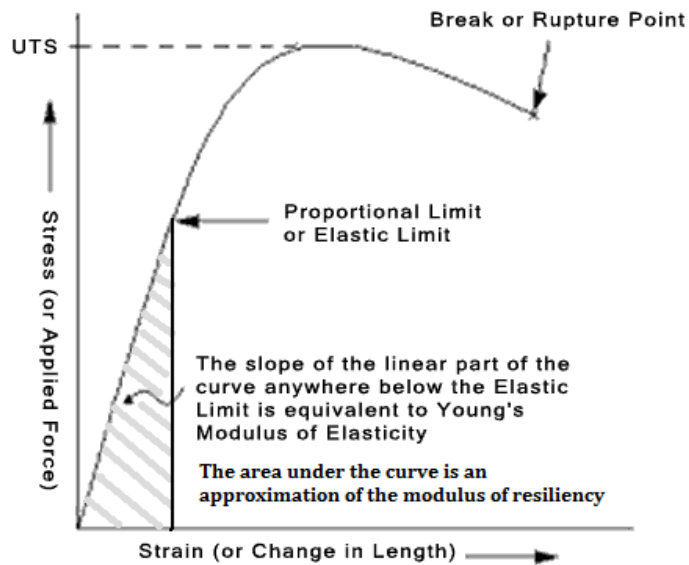


Figure 9 – A graph of the stress versus the strain of a generic metal.

To perform this test, one must axially load a material sample (i.e. fishing hook) in tension, and pull it until it fractures. The applied axial loads and the corresponding deformation of the sample are measured, which allows one to calculate the stress and the strain. It is generally recommended that the UTM is turned on twenty minutes prior to experimentation. When operating the UTM, the fishing hook is loaded onto the machine using the appropriate grips. The desired operating speed is set by adjusting the speed counter, and the units of operation are switched using the speed/units button.

First, the fishing hook diameter is measured by using a vernier caliper for optimal accuracy. Subsequently, the extensometer is connected to the HSC strain conditioner. The extensometer is then interfaced with the strain conditioner, which is interfaced with the UTM. The UTM console and the HSC strain conditioner are started

and the load and extension displays are zeroed. The fishing hook is fixed first in the top gripper. Then, the crosshead is moved towards the bottom very slowly, trying to align the hanging specimen into the bottom gripper. The load and extension display are recalibrated to zero after the fishing hook is fixed.

On a computer, the program for UTM must be initiated. The extensometer is then zeroed by adjusting the zero knob. The extensometer is attached to the test specimen such that it firmly holds on to the sample. The zero knob is then rotated to clear of the lever arm. The desired strain range (e.g. 1:1) is selected. The strain display is zeroed on the HSC strain conditioner. The test is the set up, by inputting all desired values, and started. The measured diameter of the fishing hook must also be inputted. A graph then shows the load and strain relationship by plotting the stress versus the strain of the specimen over time. This graph of the load and strain relationship can be seen in *figure 9*. Before the fishing hook begins to neck (tensile deformation where large amounts of strain localizes disproportionately in a relatively small amount of area), the extensometer is removed and zeroed along with the HSC strain conditioner. The tensile form is in [Appendix P](#).

Business Sub-Team

Most of the business sub-team's research did not require a strict methodology to adhere to, but there were certain areas that benefitted from having a standard. One such example was administering the consumer surveys. When constructing the survey, careful consideration was taken so the surveyed would not be divulging any personal information, while still completing our goal of the survey, which is consumer buying and spending habits. The survey also was designed to cover the experience of the anglers, and also whether or not our "straw person" predictions show an accurate appraisal of the current market.

For administering the surveys, the team also found a method of greeting that worked well. After several failed attempts at handing out surveys, the team brainstormed how to get people's attention and have them willingly complete the survey. We politely approached people and explained that we were IIT students doing research for a fishing project and asked them if we could take approximately two minutes of their time to help us. We found many more willing participants using this method. For clarification on any of the questions, we specifically stated that bass were the target fish for the hook. This helped clear up much of the confusion.

In an overall sense, the team members made sure that all sub-team meetings were captured and that all research was documented and referenced. During all sub-team meetings this information was all relayed to the group and discussed.

Documentation

Throughout the semester, a notebook was used to record the results of the research conducted. The mock-ups and business research produced for the programs (for example: surveys, DHT mock-ups, step-by-step instructions, and photos of finished mock-ups) were also included. The team members contributed, in the notebook, to a compendium of ideas for possible implementation and alterations of the design for future semesters of this IPRO to draw upon. Weekly status reports generated by each team also contributed to the documentation.

The test results were discussed and analyzed by the development sub-team. When applicable, the development team researched and devised several solutions to each problem apparent from testing. These solutions were presented to the business sub-team to evaluate the business implications that would like arise (e.g. budget restrictions). The development sub-team, in turn, considered the recommendations of the business sub-team and proceeded to modify the mock-up.

The IPRO deliverable reports were generated as a collaborative process. While the project plan was mostly written and compiled by a group of three individuals, the entire paper was reviewed by all group members. The final paper, considerably more involved than the project plan, was also written and compiled by a small group of three individuals and reviewed by the entire group. The separate sub-teams, development and business, were responsible for providing specialized information regarding the separate sub-teams. The deliverables for the midterm presentation, poster, brochure, and final presentation each had three members that worked on them. This ensured that each member of the IPRO was able to partake in the documentation of the deliverables and the experimentation process of the DHT process.

Information regarding scheduled tasks and Gantt charts of tasks and progress can be found in Appendices [A](#), [B](#), and [C](#).

Team Structure and Assignments

The initial steps taken in dividing the team involved identifying the major themes requiring the most attention. In that, the classification of task subsets could be established. Because of this understanding the IPRO group was then divided into two sub-teams. These teams are listed below.

Development Sub-Team

The development sub-team focused on assessing different materials for the development of DHT mock-ups, using models created by the sponsor. DHT mock-ups were tested in different locations and were assessed in their design and functions to determine whether the specific hook could be improved. Materials research was also completed to determine what the optimal (i.e. in terms of availability and ease of use) and most inexpensive materials were. It was also determined how the materials could work in a fishing hook application. The goal of the development sub-team was to create a mock-up that met the desired effects and could be manufactured at a relatively low cost in order to increase profits.

The development sub-team met from 1-3pm on Tuesday afternoons.

Team leader

- Patrick Zhu *Biomedical Engineering*

Team members

- Robert Boyer *Biomedical Engineering*

- Austin Champlin *Mechanical Engineering*
- Michael DiVito *Mechanical Engineering*
- Erik Egland *Mechanical Engineering*
- James Lai *Biochemistry*
- Hamza Obaid *Biomedical Engineering*
- Jimmy Ton *Biomedical Engineering*

Business Sub-Team

The business sub-team assessed a business plan and marketing aspects for the DHT. This semester, the sub-team researched several aspects of the current fishing market, brainstormed possible features and price points, and also completed consumer surveying. Also, a business planning aspect, which includes research, was rudimentarily constructed for use in future semesters of this project.

The business sub-team met from 6-8pm on Tuesday evenings.

Team leader

- Bogdan Bistriceanu *Business Administration / Marketing*

Team members

- Rachel Choitz *Biology*
- Herbert Edwards *Psychology*
- Mohit Gaonkar *Finance*
- Sabina Pop *Business Administration*
- Andy Staats *Information Technology & Management*

Project Monitoring Roles

Overall Team Leader: Robert Boyer

- In charge of keeping the entire team going and making decisions, liaison with the professors. The leader ensures that all tasks are accomplished in a timely manner. Resolves conflicts if needed.

Development Sub-Team Leader: Patrick Zhu

- In charge of keeping the development sub-team working and stays focused. This leader ensures that all tasks are accomplished in a timely manner within the team.

Business Sub-Team Leader: Bogdan Bistriceanu

- In charge of keeping the business sub-team working and stays focused. This leader ensures that all tasks are accomplished in a timely manner within the team.

Overall Minute Taker: Michael DiVito

- Writes down all important information discussed in class and posts them on iGroups.

Development Sub-Team Minute Taker: Jimmy Ton

- Writes down all important information discussed in development sub-team meetings and posts them on iGroups. This was a change from the original project plan, as the team deemed it necessary to designate a minute taker to take notes during sub-team meetings as well as during class.

Business Sub-Team Minute Taker: Sabina Pop

- Writes down all important information discussed in business sub-team meetings and posts them on iGroups.

Deliverable Coordinator: Rachel Choitz

- Makes sure that all deliverables are completed online and posts the completed deliverable as a nugget on iGroups.

Weekly Agenda Maker: Robert Boyer

- Writes an agenda of all class meetings and posts them on iGroups before the meeting takes place. Originally, this task was in rotation, but was eventually completely taken over by Robert.

Weekly Attendance Taker: Hamza Obaid

- Records the attendance weekly and ensures that IPRO members are not tardy or absent. The team deemed it necessary to designate an attendance taker to show attendance in the class over time.

Weekly Meeting Report Recorder: All team members in rotation

- Writes a report on what occurred during the class and what the goals are for the next class.

Optimist: All team members in rotation

- Keeps the atmosphere happy and calm in order to maintain team morale. It was later determined that all group members would be mindful of this role, and a specific team member delegated to fulfill this was deemed unnecessary.

Reflector: All team members in rotation

- Reflects and comments on ideas given by team members, makes sure nothing is lost in translation from other team members. It was later determined that all group members would be mindful of this role, and a specific team member delegated to fulfill this was deemed unnecessary.

Skeptic: All team members in rotation

- Acts as a skeptic to comments and ideas in order to encourage opposing ideas. It was later determined that all group members would be mindful of this role, and a specific team member delegated to fulfill this was deemed unnecessary.

Spy(s): All team members in rotation

- Reports on what the other team is working on so no confusion ensues with the product development. Eventually, the team never reached a point in the project to assign this role to specific sub-team members.

Budget / Resources

Our original \$500 budget was used entirely on the construction of DHT mock-ups, the consumer survey, and the class fishing trip. We came in significantly under budget, and considered using these funds buying materials to assist future IPROS. After this consideration, we decided that it would not be possible to buy materials for future research, and the IIT main campus provides so many resources for the product development side, that it was not necessary to purchase any additional materials. For an exploded view of the budget, please see [Appendix Q](#).

Our original resource estimate calendar from the project plan is located in [Appendix C](#).

Budget for IPRO 358, Summer 2009 (Allotted fund \$500)		
Serial	Description	Total cost (Item)
1	Mock-up production materials	\$47.59
2	Sports fishing license for the fishing trip.	\$45.14
3	Incentive for survey participants	\$50.35
4	Material for survey	\$2.94
Total		Balance
		\$146.02 \$353.98

Code of Ethics

Overarching Standard

To assist in developing and marketing a new safer, more efficient fishing hook with the assistance of our sponsor, Sparrowhawk, LLC.

Non-Disclosure Agreements

Pressure

- Being bound by non-disclosure agreements limits our interactions with some people outside of our IPRO.

Risk

- Transmitting information in unlawful manner.
- Disclosing confidential information to parties unauthorized to view it.

Measure

- To ensure that everyone follows and familiarizes themselves with the restrictions of the agreement.

Canon

- To ensure that the intellectual property of Sparrowhawk remains protected.

Market Research

Pressure

- Completing consumer surveys ethically and on time.
- Obtaining usable field documentation legally.

Risk

- Surveying target market consumers without proper ethical considerations.
- Inability to obtain documentation with dues required.

Measure

- Complete IRB testing to administer surveys.
- Receive legal copies of documents from our sponsor.

Canon

- To legally and ethically complete all market research.

Team Dynamics

Pressure

- Unequal participation of individuals throughout the course of the project.

Risk

- Same team members making all decisions, skewing the coursework.
- Lack of input from project members with more experience on certain subjects, for example, mock-up creation.

Measure

- Strict adherence to timesheets with work outside of class, rotating schedules for deliverable items, and an overwhelming push for unity from the team leaders.

Canon

- Being truthful, outgoing, and taking the time necessary to become involved in the overall team.

Moral Values

Pressure

- To meet beyond normal scheduled school hours to complete projects necessary to the success of the product and the IPRO.

Risk

- Conflict with personal plans, including family or work schedule overlaps.
- Weekend days for some might have spiritual value given the diversity of the group.

Measure

- Equal involvement in the project between individuals. A shared calendar indicating free time was distributed.

Canon

- Teamwork both in and outside of class is a key to our success.

Previous Ethical Information

All group members participating in IPRO 358 acknowledge and agree to adhere to the following principles of professional, ethical conduct:

- To complete their assigned tasks in a timely and earnest manner and trust in their fellow team members to do likewise
- To seek help and/or clarification when needed to understand what is required of them
- To remain informed of all topics and important issues addressed by the group
- To treat each of the group members with courtesy and respect as dictated by professional standards
- To communicate clearly and effectively when sharing information with the group
- To be present, on time, attentive, and open-minded during group meetings so as to achieve maximal participation and comprehension
- To resolve any grievances among group members quickly and peacefully, thereby maintaining focus on their primary objective
- To provide/accept constructive criticism to/from other group members politely.

Absences or tardiness will not be tolerated 15 minutes after the meeting has started. An unexcused absence will be documented unless the cause is a result of a family emergency, personal illness, unavoidable academically/professionally-related obligation, or commuting obstacle. If the cause is due to the aforementioned criteria, the absence or tardy will be documented as an excused absence within reason. Any ambiguity must be inquired through iGroups for a vote. The circumstances for voting will be determined by the team leader. There will be only one explained absence and one unexplained absence (no warning given beforehand) for a total of two absences. In the case of repeated tardiness, it will be voted upon whether or not it is counted as an absence.

Problems will be discussed and submitted to the group at the beginning of each meeting. All members are encouraged to speak freely. If a team member is reluctant to discuss a problem with the group, the member can vocalize his concerns with either advisor or team leader. The problem will then be anonymously discussed with the entire group. An example of this process is listed as follows:

- After class the offended individual approaches the team leader and informs him of the concerns.
- If the problem cannot be mediated, and if necessary, the team leader will vocalize the concerns regarding the issue during the next meeting.

- If the problem pertains to the overall team leader, the offended individual may approach an advisor regarding the problem. If necessary during the next meeting, the adviser will vocalize the concerns about the issue.

As it relates to the decision-making process, relevant decisions are to be voted upon, with majority rule. There will be a provision for allowing decisions that were struck down to be reconsidered for discussion after a vote. The motion will be set forth by one individual from the majority party. Up to five minutes will be set aside for discussion before the final vote. This will be the decisive vote. There will be communication established in group meetings, as well as outside of meetings. There are many portals we will utilize for discussion: discussion boards on iGroups, Gmail, Google Documents, etc.

Results

Development Sub-Team

The sub-team was able to accomplish a number of aspects important to the IPRO, which include replicating, testing, and improving upon Sparrowhawk's original DHT design. Through research and implementation, the sub-team attempted to determine the appropriate materials, construction, and shape for the DHT. Initially, this was to include optimal elastic deformation for the engagement of the hook, the size of the hook, and various types of metals and alloys. In the end, it was determined that due to a lack of time, the sub-team was not able to determine specific materials to use for the DHT mock-ups with certainty.

Through experimentation and research, the properties of various materials and alloys under conditions such as pressure were researched. Similarly through research, the shape and structure of the product was to be determined. Inevitably, it was determined that exact dimensions of the fishing hook could not be found given the limited resources and lack of time. However, a relatively small range (within a few millimeters) was found for the relative DHT mock-ups. A balance between flexibility and strength was to be established in order for the hooks to deploy while maintaining enough integrity to reel the fish in.

There were notable products from the development sub-team, including several mock-ups that were qualitatively tested. These mock-ups were constructed using different designs and materials, so that the most efficient design path could be identified. This was done by creating a potential design and improving upon its weaknesses.

Through experimentation, the optimal material and engagement mechanism could be developed for improving upon the original DHT. Also, by optimizing the materials and mechanisms, a cheaper and more effective product could be produced and marketed effectively to compete with the more established products. Although this was an aspiration for the development sub-team, the sub-team was not able to find the optimal materials. However, effective materials were found, if not optimal ones. The engagement mechanism was able to be captured through a test described in the methodology in the section, Engagement Mechanism Test.

All deliverables included design plans for the renovated DHT, as well as, detailed properties of the materials

used to construct the mock-ups. These deliverables were also intended to provide a detailed view of how the improved versions of the DHT would function and a view of their structural properties. The lack of time made it difficult to test the qualities of the mock-ups and the original design, making it difficult to determine how they performed.

Mock-Ups

As explained in the tensile test of the methodology, resilience (a material property that enables that material to resume to its original shape after being bent, stretched, or even compressed) is a necessary dimension to consider in the DHT shank. Research has been completed to find materials that offer high resilience. After examining the following equation, it is clear that having high yield strength and low modulus of elasticity will produce the best results, regarding resilience.

$$U_o = \frac{\sigma_o^2}{2E}$$

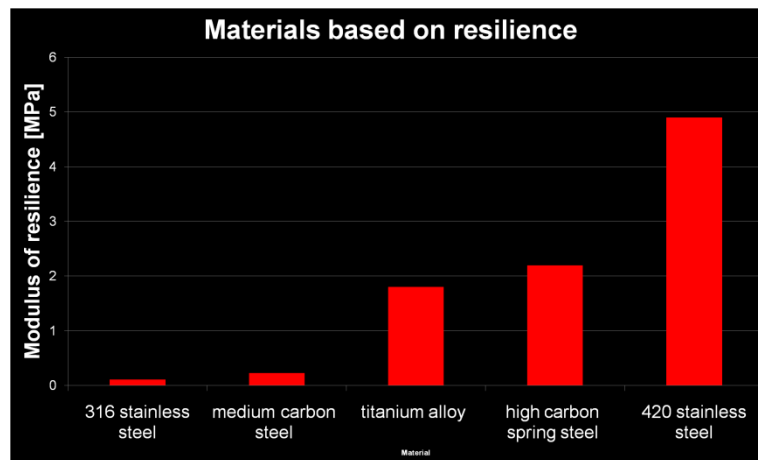


Figure 10 - Different values of the moduli of resistance of different materials.

Preliminary material selection			
material	modulus of elasticity [Gpa]	yield strength [Mpa]	modulus of resilience [Mpa]
316 stainless steel	190	200	0.11
medium carbon steel (0.3 to 0.6% carbon)	206	310	0.23
titanium alloy (Niobium, 30%) (Titanium, 70%)	70	500	1.8
high carbon spring steel (0.7 to 1.0% carbon)	210	580	2.2
420 stainless steel	200	1400	4.9

Figure 11 - Different material properties of materials to be considered for the DHT.

Figures 10 and 11 capture the mechanical properties of materials researched for use in fishing applications. 316 stainless steel and medium carbon steel were found to have relatively low moduli of resilience compared to the high moduli of resistance of 420 stainless steel and high carbon spring steel. It should be noted that the team has experimented with and has tried to develop proper heat treating methods for high carbon spring steel (also referred to as music wire or even piano wire). When the proper heat treating method is discovered, it is believed that this high carbon spring steel will provide excellent results due to its high resilience.

Mock-Ups

The mock-ups created by the development team served several purposes. They represented the progress made by the team as well as a physical manifestation of the design concepts formulated by the team. After each mock-up was created, the team analyzed the benefits of the design and construction as well as its flaws. The team then attempted to correct the flaws in the design and construction while integrating the benefits into the new mock-ups.

The team's first mock-up included a three piece design which included the base, flexing unit, and the body held together with soldering. After analyzing the hook's construction the team realized that the soldering was not strong enough to hold the components together. The solder used was also found to contain traces of lead which is toxic to organisms. When subjected to an engagement testing, the hook deployed seven out of the ten trials. When subjected to snag testing, the hook snagged on objects one out of the ten times. As a reference, a traditional J-hook snagged eight out of the ten trials. One of the connections between the flexing unit and the body severed after the testing was finished.

In order to create a stronger bond between the components the product development team decided to use epoxy instead of solder. Epoxy glue as well epoxy putty was explored. Certain members of the team also explored the possibility of using silver solder which contains no traces of lead and forms stronger bonds. The base of the first mock-up was created by soldering together the three hooks together at the bottom end. The

team decided to redesign the base and use a cap mold created from epoxy putty as the base. To increase the engagement rate, the team redesigned the angles and length of each of the hooks used in the DHT.

The shape and material chosen for the flexing unit worked as expected. The material allowed the hook to deform elastically. The shape of the flexing unit allowed for the hook to flex in only one direction. This attribute was due to the planar shape of the flexing unit which, unlike flexible circular components such as wire, allowed only one dimension of bending.

The second mock-up utilized the same three piece design as the initial mock-up but incorporated the new epoxy base. The body and the flexing unit were joined together using metal specific epoxy glue. The new bonds between the components worked in keeping the DHT together. The base was added an ounce or two to the weight of the DHT. The biggest flaw noticed in this design was the impedance in the engagement of the hook. Due to the bulky attributes of epoxy, the arms were not able to over-flex properly. To fix this problem while still maintaining one dimensional bending, the team decided to come up with a new design.

The team settled on using a single piece design with piano wire as the material of choice. Several members of the development team explored this possibility by heat treating the material in an attempt to give it more rigidity. However, the process of quenching and tempering made the material extremely brittle. The metallurgic process was repeated several times with the same result each time. A constant cooling method is now being explored as opposed to the quenching method.

Business Sub-Team

The business team had several points of interest focused on for this semester, of which all were covered. The three main business focuses were current market research, marketing possibilities, and consumer surveying.

The current market research done by the business team covered several aspects of the sport of fishing. The research was not limited to possible competitor products, but also included sales information, and national consumer buying habits. Since the current fishing market contains many competing companies, eventually the research became focused on similar bass fishing hooks already popular in the market. Some of the key pieces of information discovered about fishing habits in the United States are:

- 40 million Americans recreationally fish which is more than those who golf and play tennis combined.
- There was approximately \$45 billion dollars in retail sales of fishing related items.
- The top five states in terms of revenue are Florida, Texas, Minnesota, California, and Michigan.
- Over \$125 billion in overall economic output, including sales of hooks.
- More than 1 million jobs are supported (e.g. retailers, manufacturers, etc.)
- Approximately 10.3 million anglers fish for black bass, making it the largest species market.

From this information, our focus on black bass, a family that includes largemouth bass, became clear. Knowing this, the product development team was better able to narrow choices of dimensions for the DHT including both size and holding capacity. The information also clearly shows what a large industry the DHT will be entering when it finally hits the market.

Future marketing advances will know the scope of the industry more clearly, and may even want to focus in the top five states listed. Knowing where Illinois ranks may also prove to be of importance with regards to marketing a retail product. This research was accomplished through a national survey done by the U.S. Department and Fish and Wildlife, as well as a document from the American Sportfishing Association. The market research for three major competitors in the market can be found in Appendices [G](#), [H](#), and [I](#).

Next, the business team developed what is commonly known as a "straw person" to get ideas on possible marketing schemas for the DHT. A straw person is essentially a high-level view of brainstorming possible important features to focus on for both development of the product and retail appeal. Initially, during the brainstorming sessions, the thought there could be two separate versions of the DHT available led our straw person to have two separate levels of product.

The team thought that consumers may want a base-level product that offers some of the best features of the DHT, but was fairly standard otherwise. Other consumers may be willing to spend a little more to get a little more, thus a more luxury option was brainstormed. While having two similar but separate products may not come to any sort of fruition, it was decided that the brainstorming for a high point and a low point could have other potential advantages. If only one level of DHT is developed, the end result could share specifications from both sides of the spectrum, making it more of a middle ground product. The straw person spreadsheet can be found in [Appendix D](#).

Finally, the business team crafted a consumer survey and administered the survey to one hundred anglers in the surrounding area. The survey was designed to gauge a person's fishing and spending habits and also gain their insight on a product with features similar to the Delta Hook. Surveys were given at Bass Pro Shop in Bolingbrook, Cabela's in Hoffman Estates, and Henry's Sports, Bait and Marine in Chicago. All three locations were chosen for proximity, but they also are important retailers for the fishing market. Both Bass Pro Shop and Cabela's are large nationwide retailers with a wide customer base and huge inventories. Henry's is a small, local shop located very close to the IIT main campus.

Henry's is of particular interest to our team, since a working relationship with a local retailer could potentially be a great starting point for the DHT to enter the market, and could be used in tournaments or other local events. The survey we used can be found in [Appendix E](#).

From the survey results, we were able to better understand the DHT's future customers. The survey was designed to give insight into personal preference, but also gauge experience. Fishing is a sport that can be something done a few weekends a year, or done constantly. Several of the surveyed informed us that instead of going more than 20 times a year, as the survey indicates, they wanted an option for 20 times a week. We want to target active, experienced anglers since they likely have the most knowledge of the entire fishing field.

Another major piece of information gained from the survey was ranking the importance of certain features. It was our hope that the features most important to anglers would correlate to the most important features of the DHT. This ended up being true, and will be discussed further below. This graph shows how the surveyed

rated the features of most importance to them, with 5 being the most important. We were also able to form ideas of what actual consumers would be willing to pay for a hook that features the DHT's assets. To view more information about our survey results, please see [Appendix F](#). Below, our survey results are summarized with percentages and what we learned from this data.

Current Fishing and Spending Behavior

- The majority of the respondents (78%) are fishing for more than 10 years → We had a significant and experienced pool of respondents.
- About half (47%) of the interviewed go fishing more than 20 times a year and more than 2/3 of them (69%) buy more than 20 fishing hooks per year → They are aware of the fishing process and experience and have specific wants and needs.
- More than half (64%) spend less than 75 cents per hook, 34% spend between 75 cents and 5 \$, and only 3% spend more than \$5 per hook → Their current spending per hook is low, and we concluded that as of now fishing hooks are perceived as commodities.
- About half (55%) of the anglers are shopping at outdoor retailers such as Bass Pro Shop, 30% go to major discount retailers such as Wal-Mart and the rest (15%) are shopping for fishing hooks at local baits shops → The experienced angler is looking for the bigger variety and latest fishing gear, rather than cheap fishing hooks

Current Wants and Needs

- *Figure 12* shows fish hook features ranked in order of importance:
 - o Catch and hold (66 %) → The most important thing for anglers is to be able to hold the fish after it is caught, DHT addresses this by the interlocking design
 - o Barbless (44%) → Barbs usually can damage the fish, especially if they swallow the hook. DHT hook has barbless hooks.
 - o Weedless / snagless (35%) → Anglers lose the fishing hook if they snag to weeds or rocks. DHT hooks have the tips pointed inward which make them virtually snag less.
 - o Safety (35%) → Most anglers have at least one unhappy experience where they pierced themselves or know other people that did. Also, 62% of the anglers fish with both adults and children. DHT addresses this need for safety by the hooks pointed inward which make piercing accidents virtually impossible.

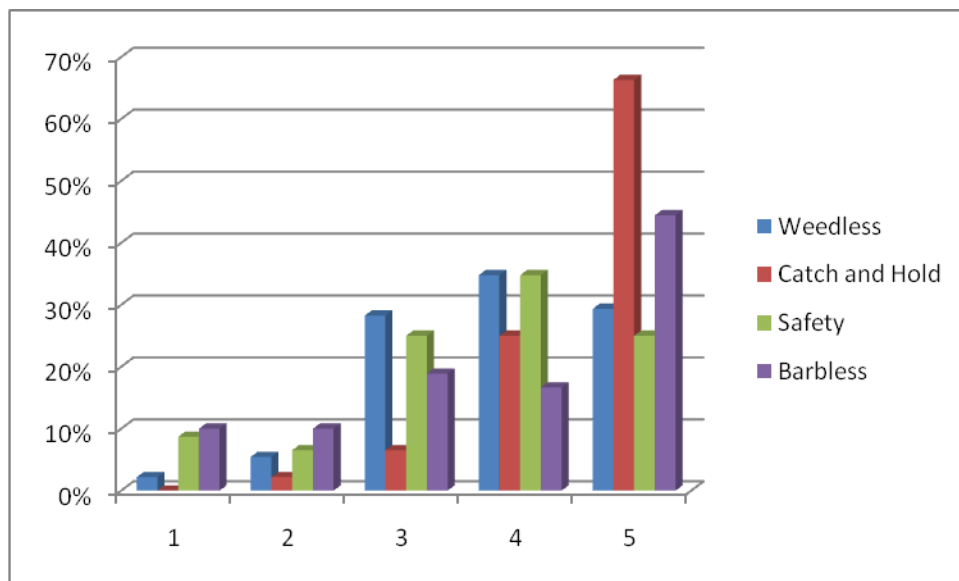


Figure 12 – Shows survey results with ranking of importance (with 5 being most important) of DHT features

Obstacles

With a group of about fourteen students, all from varying fields and backgrounds, the obstacles encountered are not always limited to completing the tasks at hand. This semester, time was the largest obstacle the team was faced with. The condensed time frame of the summer semester strained group member's time outside of class to accomplish the tasks set forth during class. Luckily, most tasks were able to be broken down or divided between smaller subgroups, a method the team used throughout the course of the semester.

Another major obstacle for the entire team was the divide between the product development sub-team and the business sub-team. The development sub-team consists of mechanical engineering, biomedical engineering and molecular biochemistry and biophysics majors. However, the business team consists of members from varying fields, including biology, philosophy, and marketing. Ensuring that all team members were able to understand all aspects of the project was important.

At the start of most classes, the entire team would meet and discuss aspects relating to the overall team progress (e.g. deliverable items). After the team business was covered, the group would split up into sub-teams and meet separately to work on and discuss the sub-team tasks. Near the end of the allotted class time, the entire group would reconvene and give abbreviated presentations of the progress and what was discussed during the sub-team meetings. Whenever questions were raised, they were politely answered, and all team members should have had an equal, overall understanding of the entire project.

As per recommendations from the sponsor, the team had planned to consider different material aspects for the DHT design. However, further research regarding the following recommendations was deemed necessary before they could be pursued. Although there are many types of fish caught for sport, the DHT expects to be specifically geared toward catching the largemouth bass fish due to its ubiquity and great popularity in the

game fishing market. This created a constraint in parameters that must be followed in creating mock-ups of the DHT. Similarly, another condition was that the DHT must be able to flex and collapse to incorporate the activated motion of the hooks. This suggests that if cables were used for the design of the DHT, the materials used to comprise them should have been able to possess a high amount of shape memory (return to their original shape after being plastically deformed, especially when heat is applied). Ultimately, it was deemed impractical to use cables, due to their lack of linear motion and free motion capability.

Furthermore, to incorporate the flexing component of the DHT, the team considered a number of different pieces in the design. To integrate the shank and the bend of the fishing hook, the two separate components were forged together to create the DHT, creating a two-piece design. However, the effectiveness of the two-piece design was unable to be evaluated for durability. In a one-piece design with the shank and the bend of the fishing hook already integrated, one would expect problems with flexibility. However, due to manufacturing complications (i.e. inability to mold metal into a fishing hook shape) the one-piece design was unable to be evaluated.

It was also necessary for the DHT to be strong and durable enough to withstand forces from the fish attempting to escape. However, this may not be as great of a problem in the DHT as it would be in other fishing hooks due to the flexing design of the DHT, allowing for absorption of the shock while capturing fish. Due to time constraints and despite extensive research, the product development team was not able to determine the exact amount of bite force exerted by a fish. Therefore, the amount of force that the fishing hook would need to withstand could not be determined. Similarly, design of the DHT should also have been able to incorporate the weight of the lure. Heavy designs would cause the lure and hook to sink, while very light designs would cause the lure and hook to float. The team anticipated a heavy design at the onset of the semester due to expected material compositions of the DHT, as expected from standard competitor fishing hooks. Unfortunately, due to the lack of a complete prototype (i.e. lack of clearly defined materials and lack of dimensions for the mock-up), the development team was not able to evaluate the weight of the DHT and its effect on functionality in catching fish.

Similarly, there were a few, notable difficulties in the creation of the DHT mock-ups. All team members that developed mock-ups found difficulties in connecting the separate components to create the mock-ups. In these preliminary product mock-up synthesis sessions, it was difficult to solder the different components of the mock-ups together. Therefore, epoxy was used, which was found to be very effective. In future trials, one would expect to use different types of epoxy that would allow for more flexibility. It should also be determined if the soldering techniques applied could be improved to create a better mock-up. Similarly, exact dimensions of the DHT must be determined to be able to create a more accurate design. Moreover, there have been notable difficulties in finding the correct materials for such an application with the correct size parameters at local hardware stores. Regarding the testing of the mock-ups, it was found that, although the preliminary test structure suggested that the DHT mock-ups were better at preventing snags than regular j-hooks, the mock-ups must also be tested in actual lakes to provide a more accurate picture of the expected behavior of the DHT in real-life situations.

Another major obstacle that we faced was a difficulty in applying materials testing methods to fishing hooks. This was overcome by considering specific characteristics of DHT to be tested for. This similarly led to a difficulty in developing a procedure for entirely new testing methods for the DHT. This was overcome by determining exactly the parameters needed in the DHT design and how they would be tested for with the new testing methods. Moreover, there was additional difficulty in determining the exact number of trials in experimental testing (i.e. for the hook setting test and the snag test). This was solved by qualitatively assessing the dynamics of these testing methods and finding a number of times they need to be measured. It is important to note that a more accurate number of trials in which to conduct the experiment will only be found through experimentation and testing.

The business sub-team faced several other obstacles throughout the semester, including the development of a business plan, budgeting constraints, and the consumer survey. Developing a business plan requires lots of careful planning and, typically, a near-finished product. We were only working with an idea and a few mock-ups, so a lot of our brainstorming was completed through educated guesswork. Our “straw person” was derived before any material research was done; so much of it was based on our best estimations.

Another obstacle we faced was the budget limitations as an IPRO. This also ties into the product development team, since the materials and resources needed to manufacture the DHT could be quite expensive. The product development team tried several working materials, but certain materials (e.g. titanium) could be used and end up being too expensive. Also, with a larger budget, the business sub-team could have greatly expanded the consumer survey. An online version of the survey could potentially reach thousands of anglers, but would cost too much money.

Lastly, the survey provided several of its own obstacles. The survey itself was designed with great care, and there were several meetings with deliberations on the questions and their potency. We wanted the questions to be direct, but not so direct that they did not provide general information. Administering the surveys was a challenge in its own right, since many people out shopping do not want to be bothered. We were completely ignored several times, and some of the surveyed did not completely fill out the survey form. To overcome these obstacles, we decided to spend more time talking with the surveyed to help them along while they took the survey.

Recommendations

Future iterations of IPRO 358 should be able to continue the work completed this semester with little trouble. Both the product development team and business team have built a strong foundation for semesters to come, and the information available is plentiful. Some recommendations to future IPRO semesters include:

Business Sub-Team

- Continued surveys at varying locations, broaden the survey scope by surveying consumers at other retail locations (Wal-Mart, Dick's, etc.)

- Develop and disseminate a separate employee-specific survey
- Focus the survey towards bass fishing
- When administering surveys use the technique of introducing yourself as an IIT student and briefly explain the purpose of the IPRO and that the survey should be quick and easy to complete.
- Consider focus groups, Survey Monkey, etc.
- Continue defining the 4 P's (price, product, place, promotion)
 - Focus on *place*
- Research hooks vs. lures
 - Selling with lures vs. manufacturing lures
 - Is it a bigger market?
- Look into licensing the Delta Hook Technology
- Try forming working relationships with local retailers (Henry's Sports and Bait)
- Continue developing a business plan, SWOT analysis, etc.
- Utilize all of Augy Park's resources
- Update "straw person" based on research done
- Try to go on a fishing trip for hands-on experience

Product Development Sub-Team

- Refine the exact parameters of the DHT mock-up
- Contact Materials Science professors early in the semester to establish a strong bridge of communication
- Schedule a fishing trip early in the semester to build team camaraderie and learn the importance of the DHT design and features
- Build upon the testing method procedures
- Investigate different materials to be used in creating the DHT
 - What is the exact material used in the hook and flexible unit?

- What is the availability of this material? Would it need to be shipped in?
- What is the cost of the material? Are some materials worth the extra cost?
- Perform further research on the anatomy of largemouth bass
- Set up a material selection matrix that relates to testing procedures
- Consider manufacturing methods of delta hook
 - How easily can the mock-up be created for manufacturing?
- Establish on-campus workspace for performing tests and constructing mock-ups
- Create mock-ups using a different method of connecting the flexible shank to the hook.
 - Investigate which method is best for manufacturing purposes
- Find the benefits or detriment to using coating on hooks for corrosion resistance
- Contact the sponsor if questions arise about the nature of the hook or its exact functions
- Create a quick method to construct mockups so that designs can be tested and optimized in a timely fashion

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Glossary

A

Actuator

- A servomechanism that supplies and transmits a measured amount of energy for the operation of another mechanism or system.

Angle of the hook

- The space between the shank and the tip.

B

Barb

- A small sharp piece of metal that sticks out near the hook in order to get a better hold in the fish's mouth.

Base

- The part of the hook where all three shanks are connected to the hook eye.

Bending test

- Test that quantifies how much force is required to bend the shank into engagement mode.

Bernzomatic propane torch

- Heat source used to quench and temper piano wire.

Body

- The shank and flexing unit combined together.

Business goal

- An objective or target to be achieved, generally by a specific date.

Business plan

- A business plan is a formal statement of a set of business goals, the reason why they are believed attainable and the plan for reaching those goals.

Business strategy

- A long term approach to implementing a firm's business plans to achieve its business objectives.

C

Cabela's

- A direct marketer and specialty retailer of hunting, fishing, and camping and related outdoor recreation merchandise.

Commodity

- A physical substance, such as food, grains, and metals, which is interchangeable with another product of the same type, and which investors buy or sell.

Competitor

- A company in the same industry or a similar industry which offers a similar product or service.

Competitive analysis

- The practice of analyzing the competitive environment in which a business operates or wishes to operate, strengths and weaknesses of the business, desires of marketplace, customer, strategies that can improve market position, impediments in entering new markets and barriers that can be erected to prevent competitors from eroding a business' market position.

Corrosion resistance

- The ability for a material to have reduced amount of rust or deterioration.

Customer satisfaction

- The angler's level of contentment with the delta hook, and the extent which their needs and desires are fulfilled by the DHT.

Customer satisfaction test

- A test that analyzes an angler's ability to catch fish with the delta hook and their experiences using the Delta Hook.

Cyclic load

- A cyclic load involves the constant loading and unloading of a force upon a specimen.

Cyclic polarization

- Measurements for determining susceptibility to localized corrosion.

D

Debt investment

- Investment in the financing of property or of some endeavor, in which the investor loaning funds does not own the property or endeavor, nor share in its profits.

DHT

- Delta Hook Technology. A break-through fishing hook idea the driving idea behind this IPRO as originally designed by our sponsor.

Double blind experiment

- Experiment where neither the tester nor researcher are aware of who is in the control group and who is in the experimental group.

Ductility

- The ability of a material to deform plastically without breaking.

Dunk test

- A specific type of corrosion test where a material is sprayed with a salted solution to determine the rate of its corrosion over time.

E

Economic output

- Total value of all of the goods and services produced in an entity's (business entity's) economy.

Elastic deformation

- The temporary change in length, volume, or shape of a material produced by a stress that is less than the elastic limit of the material (i.e. change in shape, while allowing it to return to the original shape after the stress is removed).

Engaged mode

- The engaged mode refers to the state in which the hooks of the DHT are pointed outwards.

Entrepreneur

- A person who starts his own business venture and assumes all the risks that come with starting that business.

EWG hook

- Extra Wide Gap hook - Sometimes the plastic and worm bait used are too thick and heavy to rig on a standard worm hook, Extra Wide Gap hooks allow that.

Equity investment

- Money that is invested in a firm by its owner(s) or holder(s) of common stock (ordinary shares) but which is not returned in the normal course of the business.

F

Fatigue test

- A fatigue test is done to determine the maximum cyclic loading a specimen can endure before failing.

Flexing unit

- A part on the shank of the DHT that bends to expose the hooks.

Focus group

- A small group selected from a wider population and sampled, as by open discussion, for opinions about or emotional response to a particular subject or area, used especially in market research or political analysis.

G

Gamakatsu

- A leading world-wide hook manufacturer.

Gantt chart

- A type of bar chart that illustrates progress in relation to time of projects, tasks, schedules, etc.

H

Heartland Angels Inc.

- A private equity network that brings together accredited investors with early stage start-up companies and real estate opportunities looking for equity and debt investment.

Hook eye

- A ring placed at the end of a hook in order to attach a fishing line.

Hook setting test

- A test to explain how hooks engage in the mouth of the fish in order to analyze how well the hook will catch the fish.

HSC strain conditioner

- Component in the Ultimate Testing Machine used in tensile tests.

I

Inverted treble hook

- A treble hook with the hooks pointed towards the central axis

Institutional Review Board (IRB)

- Reviews research proposals that involve human participants. Even projects that require minimal involvement of human participants, such as surveys or questionnaires, require some procedural IRB review.

IRB certificate

- Shows completion of training module for all researchers who plan to work with human subjects.

Inventory

- A company's merchandise, raw materials, and finished and unfinished products which have not yet been sold. These are considered liquid assets, since they can be converted into cash quite easily.

J

Jig

- A metal fishing lure with one or more hooks, usually containing a large metal head to act as a weight. A jig is deployed on or near the bottom of a lake with a bouncing motion to entice fish.

L

LLC

- Limited Liability Company. A type of company, authorized only in certain states, whose owners and managers receive the limited liability and (usually) tax benefits of an S

Corporation without having to conform to the S corporation restrictions. Essentially the liability of the investor is limited to what they invested.

Loctite brand adhesive

- Epoxy product used on the mockup to join to pieces of metal.

M

Marketing mix

- Essentially the four 4p's (price, product, place, promotion), and how you control each of them.

Marketing strategies

- The approach that a company takes when bringing its product to market i.e. price leadership strategy where a company slashes prices and ensures it has the lowest prices on the market.

Mustad & Son

- A Norwegian company that manufactures and sells fishing tackle and accessories since 1877.

Modulus of elasticity

- Any of several coefficients of elasticity of a body, expressing the ratio between a stress or force per unit area that acts to deform the body and the corresponding fractional deformation caused by the stress.

P

Price points

- Price points for an economic good or service are the points at which the amount of that good or service that a consumer or a group of consumers will want to purchase is relatively high.

Private equity

- Equity securities of companies that are not listed on a public exchange.

Q

Quenching and tempering

- A strengthening process of steels which involves steel being heated to about 850 degrees Celsius followed by rapid cooling. The rapid cooling can be accomplished by submerging the heated steel in oil or water, which is called quenching. At this point, the steel has gained strength, but has also become

brittle. The steel can then be tempered, which is heat treatment at a lower temperature, to increase the ductility.

R

Resiliency

- A material property that enables that material to resume to its original shape after being bent, stretched, or even compressed.

Retailer

- A business which sells goods to the consumer.

Rigidity

- Describes a body in which the distance between any pair of points remains fixed under all forces (has infinite values for its shear modulus, bulk modulus, and Young's modulus).

S

Shank

- The straight part of the hook before the bend.

Snag

- Is defined as a situation in which the hook is irretrievable due to engagement or entanglement in any obstacle.

Snag proof

- The ability for an object to not get caught on a tree or part of a tree held fast in the bottom of a river, lake, etc., and forming an impediment or danger to navigation.

Snag test

- Test that measures how many times a hook gets caught or stuck in any environmental obstacles relative to the number casts made with that hook.

Soldering

- Soldering involves joining two metals together by melting a filler metal between the two specimens. Once the filler metal cools, the two specimens will be bound at the connection point.

Sparrowhawk

- The company name of our sponsor, Augy Park.

SPRO (Sports Professionals)

- A website (www.spro.com) that distributes and sells fishing accessories.

Standard mode

- The standard mode refers to the state in which the hooks of the DHT are pointed inwards.

Start-up

- A company which has just begun operations.

Strength

- Stress that causes a deformation or fracture failure of a material.

SWOT Analysis

- Strengths, Weaknesses, Opportunities, and Threats. A tool that identifies the strengths, weaknesses, opportunities, and threats of an organization.

T

Tensile test

- A test that determines how a material specimen reacts to forces applied in tension. This is also known as the unbending test, and it provides a method in successfully measuring the mechanical strength of a fishing hook.

U

Ultimate tensile strength

- The maximum stress on the stress-strain curve of a tensile test, i.e. the maximum load applied during a tensile test divided by the initial cross-sectional area of the test specimen.

V

Vernier caliper

- A caliper is an instrument that determines the width of a specimen by measuring two symmetrically opposing sides. A vernier caliper uses the vernier scale to obtain more precise measurements.

Y

Yield strength

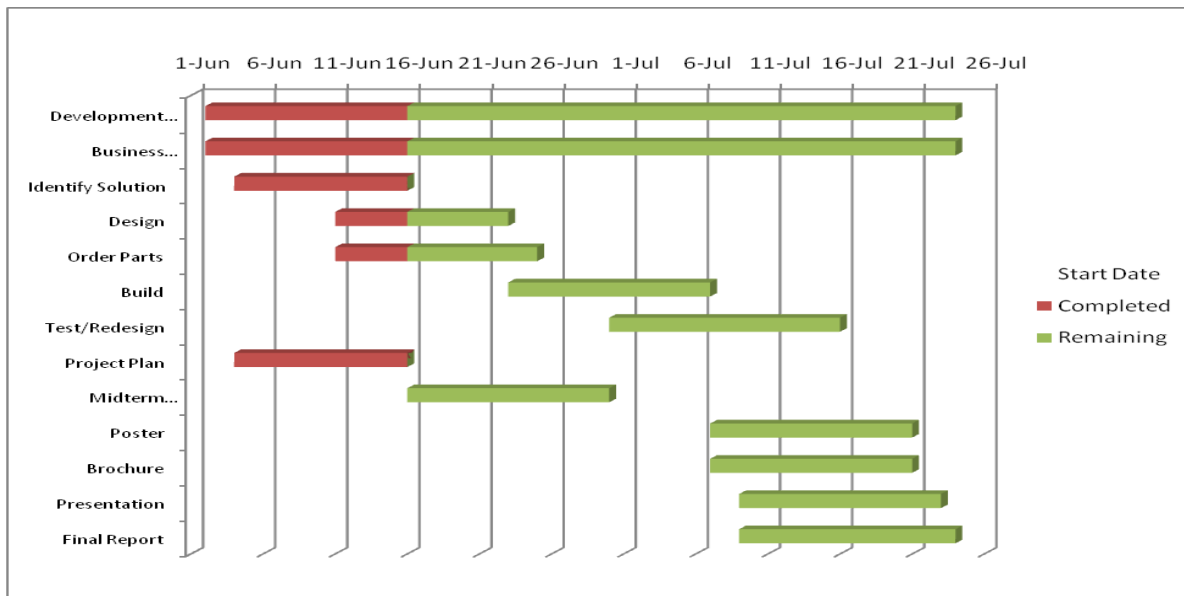
- The stress at which a material begins to plastically deform (i.e. produce a given inelastic strain).

Appendices

A – Original Gantt Chart

This is the original set of scheduled tasks and accompanying Gantt chart.

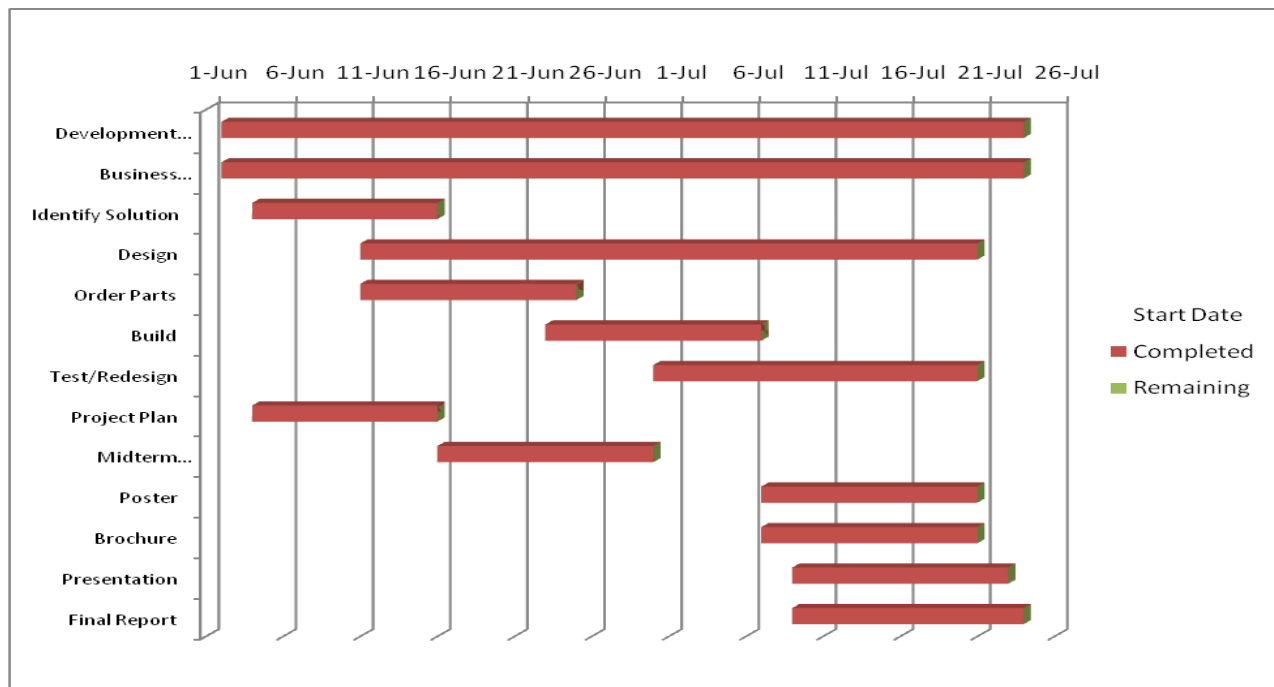
	Start Date	Completed	Remaining	End Date
Development Research	2-Jun	14	38	24-Jul
Business Research	2-Jun	14	38	24-Jul
Identify Solution	4-Jun	12	0	16-Jun
Design	11-Jun	5	7	23-Jun
Order Parts	11-Jun	5	9	25-Jun
Build	23-Jun	0	14	7-Jul
Test/Redesign	30-Jun	0	16	16-Jul
Project Plan	4-Jun	12	0	16-Jun
Midterm Presentation	16-Jun	0	14	30-Jun
Poster	7-Jul	0	14	21-Jul
Brochure	7-Jul	0	14	21-Jul
Presentation	9-Jul	0	14	23-Jul
Final Report	9-Jul	0	15	24-Jul



B – Updated Gantt Chart

This is the finalized task schedule and Gantt chart.

	Start Date	Completed	Remaining	End Date
Development Research	2-Jun	52	0	24-Jul
Business Research	2-Jun	52	0	24-Jul
Identify Solution	4-Jun	12	0	16-Jun
Design	11-Jun	40	0	21-Jul
Order Parts	11-Jun	14	0	25-Jun
Build	23-Jun	14	0	7-Jul
Test/Redesign	30-Jun	21	0	21-Jul
Project Plan	4-Jun	12	0	16-Jun
Midterm Presentation	16-Jun	14	0	30-Jun
Poster	7-Jul	14	0	21-Jul
Brochure	7-Jul	14	0	21-Jul
Presentation	9-Jul	14	0	23-Jul
Final Report	9-Jul	15	0	24-Jul



C – Scheduled Tasks

A full list of scheduled tasks with skills required and hours allotted per task.

	<i>Description</i>	<i>Skills Required</i>	<i>Estimate of Hours Needed to Complete</i>
<i>Development Research</i>	Physical specifications of the DHT must be ascertained.	Extensive background in materials science engineering, particularly regarding metals.	150 All development sub-team members must conduct research to partake in class discussions.
<i>Business Research</i>	Thorough research is required within the market regarding species of fish, sport versus recreational fishing, as well as competitors. Research with consumers and distribution channels will also be done.	Extensive background in marketing and business.	150 All business sub-team members must conduct research to partake in class discussions.
<i>Identify Solution</i>	Different solutions to the problems outlined in previous sections must be explored. Effective solutions must be pursued.	Extensive background in materials science engineering, particularly regarding metals. Extensive background in marketing and business.	40 All team members must collaborate to determine effective solutions.
<i>Design</i>	The DHT must be designed, finding specifications for the different parameters outlined previously. A business plan must be created.	Design background is required. Business experience is required.	50 All team members of the prototyping sub-team must participate.
<i>Order Parts</i>	Different parts for the DHT must be ordered through the IPRO Office.	Knowledge of the IPRO Office.	3 One or two members of the development sub-team.
<i>Build</i>	A number of mock-ups of the DHT must be created, based on time available and effectiveness of previous mock-ups.	Design background.	50 All team members of the development sub-team
<i>Test/Redesign</i>	The different mock-ups of the DHT must be tested and redesigned to determine the most effective one.	Design background.	50 All team members of the development sub-team.
<i>Project Plan</i>	The project plan must be created. The entire group will review it.	Knowledge of the IPRO and communication and literary composition skills required.	20 Three members of the team will compile and edit the plan.
<i>Midterm</i>	The midterm presentation must be created. There must be time included for practice of the	Knowledge of the IPRO and	30

	presentation.	communication skills required.	Two members of the team will create and present.
<i>Poster</i>	The poster must be created. The entire group will review it.	Knowledge of the IPRO and communication and literary composition skills required.	15 Two members of the team will create the poster.
<i>Brochure</i>	The brochure must be created. The entire group will review it.	Knowledge of the IPRO and communication and literary composition skills required.	10 One member of the team will create the brochure.
<i>Presentation</i>	The final presentation must be created. There must be time included for practice of the presentation.	Knowledge of the IPRO and communication skills required.	15 Two members of the team will create and present.
<i>Final Report</i>	The final report must be compiled, a collaborative effort.	Knowledge of the IPRO and communication and literary composition skills required.	40 All members of the team will contribute. One or two members will edit and revise.
<i>Miscellaneous</i>	"Slack Time"		10
<i>Total Hours</i>			633

D – “Straw Person”

This “straw person” is the product of a high level brainstorming session within the business sub-team to derive possible attributes to have two versions of the DHT in production. The “Cheap Hook” was brainstormed to be a very basic model with no frills, but all the great features of the DHT. The “Expensive Hook” was to be aimed at professional anglers, or people that may want more features. The overall performance of both hooks was supposed to be nearly identical. These ideas helped the product development sub-team narrow their field of research for some items, and will give future IPRO semesters some further points of research.

Attribute	Cheap Hook	Expensive Hook
Sale price	\$1.53	\$10.77
Target market	Kids & parents (novice)	Professional angler (expert)
Pitchmen	Billy Mays	Top fisherman
Endorsements	Boy/Girl Scouts	Top fisherman
Name	"Princess" hook	Sparrowhawk "King" hook
Warranty	None	1yr corrosion resistance
Packaging	Plain	Plastic carry case/fancy
Product augmentation	None	DVD/coupons
Aesthetics	Plain	"Golden hook"
Where sold	Target/Wal-Mart Boy/Girl scout shops	Pro shop/website
Promotion	Safety and snag-less	Holding and snag-less
Sizes	Small to medium	Medium to large
Range	Narrow	Wide
Material	60 C steel	Stainless steel
Hook corrosion	Low corrosion resistance	High corrosion resistance
Base design	Crimp	Machine molded
Sharpness	Less sharp	More sharp
Hook weight	Light?	Heavy?
Fish weight	Light/small fish	Heavy/big fish

E – Consumer Survey

The consumer survey handed out by the business sub-team in its entirety.

Angler Consumer Survey

Please circle one of the following or fill in the blanks if none of the given applies.

1. How often do you go fishing each year?

0 1-4 5-9 10-19 20 or more

2. How many years have you been an angler?

0-1 2-5 6-10 10 or more

3. How many fishing hooks do you purchase yearly?

0 1-4 5-9 10-19 20 or more

4. What do you usually pay per hook?

\$0.01-0.49 \$0.50-.74 \$0.75-0.99 \$1.00-5.00 other_____

5. Where do you purchase the majority of your fishing hooks?

Outdoor Retailer Discount Retailer Local Bait Shop other_____
(e.g. Bass Pro Shop) (e.g. Wal-Mart)

6. Please rate the following hook features by order of importance (5 is most important):

Weed less/snag less	1	2	3	4	5	
Catch and Hold		1	2	3	4	5
Safety		1	2	3	4	5
Barbless	1	2	3	4	5	
Other_____		1	2	3	4	5

(Also, please circle the most important feature)

7. If there was a hook that offered all of the following features (weed less, better catch and hold, and safety), what would you be willing to pay per hook?

\$.50-0.99 \$1.00-1.99 \$2.00-4.99 \$5.00-10.00 other_____

8. With whom do you fish?

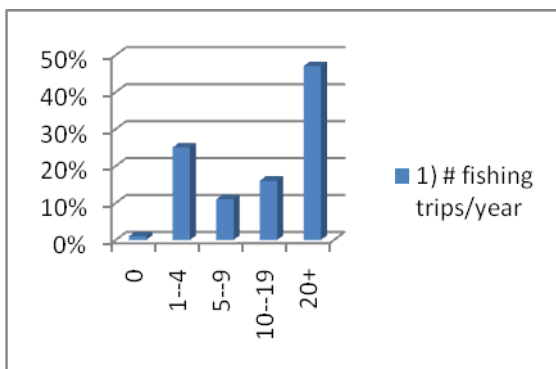
Adults Children Both Neither

10. What's your favorite fishing hook? Why?

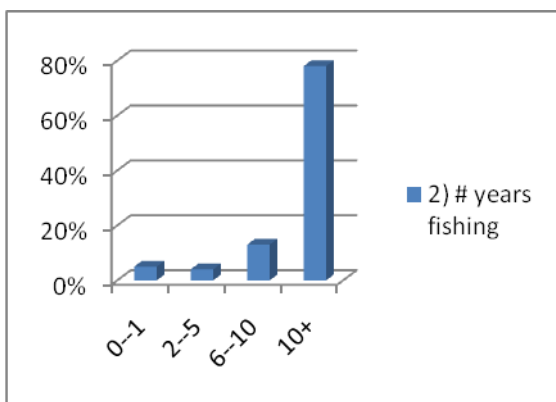
F – Survey Results

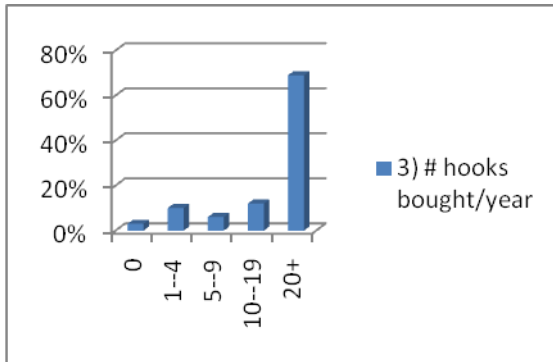
Below are the overall consumer survey results broken down by question and percentage of the total responses. The red boxes are the most popular responses.

	0	1--4	5--9	10--19	20+
1) # fishing trips/year	1%	25%	11%	16%	47%
	0--1	2--5	6--10	10+	
2) # years fishing	5%	4%	13%	78%	
	0	1--4	5--9	10--19	20+
3) # hooks bought/year	3%	10%	6%	12%	69%
	\$0.01-0.49	\$0.50-0.74	\$0.75-0.99	\$1.00-5.00	Other
4) Average price/hook	32%	32%	20%	14%	3%
	Outdoor Retailer	Discount Retailer	Local Shop	Other	
5) Where hooks purchased	55%	30%	14%	1%	
	\$0.50-0.99	\$1.00-1.99	\$2.00-4.99	\$5.00-10.00	Other
7) Willing price for DHT	17%	39%	37%	6%	1%
	Adults	Children	Both	Neither	
8) Whom do you fish with	25%	1%	62%	12%	

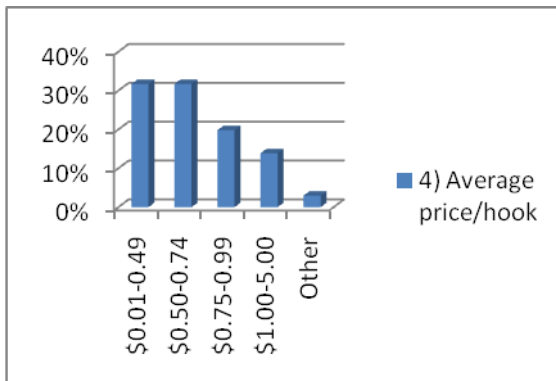


These two graphs shows the experience of the anglers surveyed

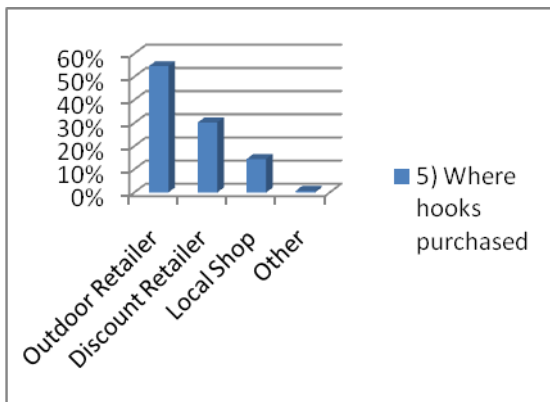




The vast majority of surveyed purchase many hooks a year, which could show the disposable nature of regular fishing hooks



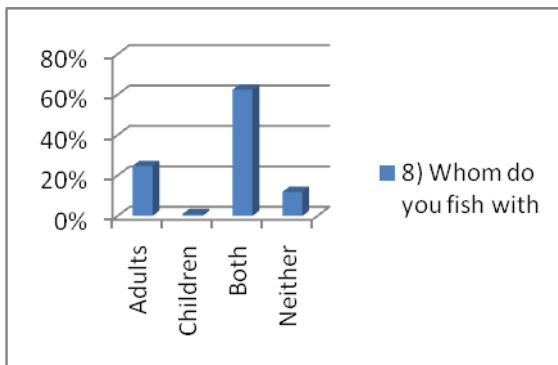
Most fish hooks purchased cost less than \$0.75



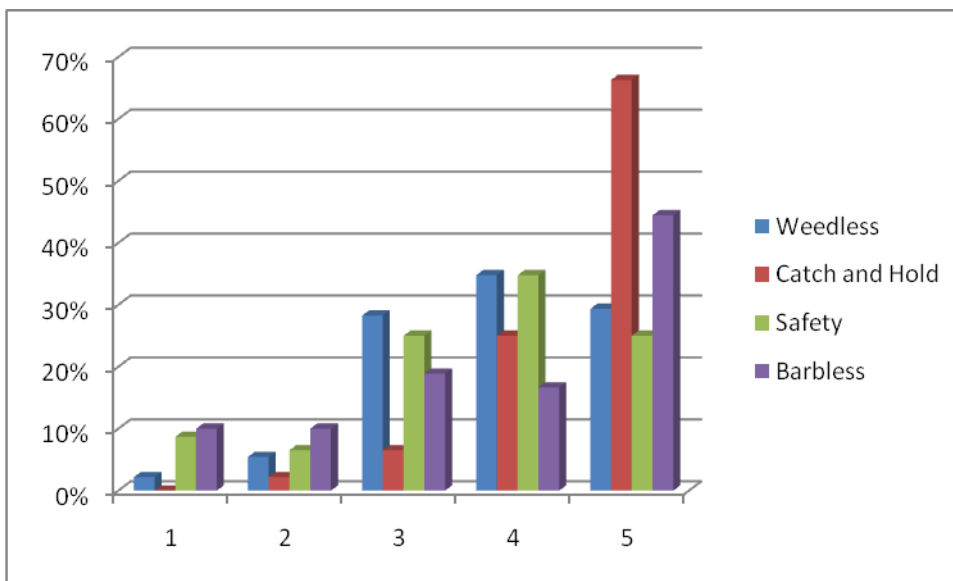
Outdoor Retailers like Bass Pro Shop seem to be preferred



In contrast to what consumers currently pay for hooks, the DHT could be priced between \$1.00 and \$5.00



Many surveyed fish with others, but many fish with children, so safety



Catch and hold is the most important desired feature

G – Mustad and Sons Competitor Research

Mustad and Sons:

Based in Norway

Slogan - *So sharp even fish talk about us*

Business Processes:

- Sales representative travel the world investigating the sort of hooks favored by anglers from Alaska to Asia and then report back to the outfit's factories. **(Close and continuous contacts with the market forces) / (Business Process Re-engineering)**
- Global supply chain control.
This framework is built on eight key business processes that are both cross-functional and cross-firm in nature. A cross-functional team, including representatives from logistics, production, purchasing, finance, marketing and research and development, manages each process.

Business Strategy:

- Constantly introduces new products. **(Innovation)**
- Mustad own s a wire mill which gives it greater control over the end product as having high quality wire is a key part of producing superior hooks. **(In house material production)**
- Establishing subsidiaries in primary market **(Capturing demand in new markets)**

Manufacturing Process:

- Mustad hooks are strong because of their unique three stage tempering process (computer controlled) which transforms the steel into a fine grained ultra strong microstructure. This increases structural strength up to 30% compared to conventional tempering methods.
- Quality control at all stages of production is of major concern to Mustad. At the initial stage of the process, every batch of steel wire is physically and chemically tested in laboratories. In addition, hooks are tested before and after tempering, after surface treatment and when being packed. Despite the high technological level of manufacturing process, the most important contributors to quality assurance are still the people involved, both those involved in the manufacturing process and the customers
- Hooks made by machines ensure that each hook is the same size; this consistency is a key factor in retaining customers.

Distribution and sales:

- Mustad makes an effort of becoming a total supplier of fishing gear in Norway and extends the product range quite drastically. The new structure entails that Mustad will not only supply products to

distributors, but also supply products directly to retailers. This means access to a broader assortment, higher level of service and shorter delivery time.

- Website. Mustad offers comprehensive catalog of its products enabling anglers from all over the world to view the entire range of its product offerings.

Things we need to look at:

- Exhibiting at ICAST 2009.
- Getting our product on the shelves of discount retailers like Wal-Mart, Target.

H – Gamakatsu Competitor Research

Gamakatsu:

Slogan - *Fishin' Ain't Luck!*

Business Strategy:

- Constantly testing new materials, trying to improve existing products. **(Research ,development and innovation)**
- Centralized manufacturing (Japan) to maintain quality and distribution through subsidiaries based in China, Thailand to reduce overheads in getting to the finished product.
- Adherence to environmental standards in manufacturing processes.
- Market research and product development specific for researched market.

Manufacturing Process:

- High carbon steel as the manufacturing material.
- The most premium grade of high carbon steel is used insuring protection against any blemishes in the metal that can weaken the hook.
- Gamakatsu developed a unique electronic tempering process that enables hooks to be tempered in a stable condition
- Every hook is heated to the exact temperature that is perfect for that particular style and size then cooled in oil. This process produces hooks which are super strong, but not brittle.
- Modern sharpening process resulting in a perfectly conical point with high sharpness.

Distribution and sales:

- Gamakatsu USA inc. was established to provide Gamakatsu branded hooks to the U.S. market.
- SPRO was established in the Netherlands to service the European market.
- Comprehensive catalog online and facility to order fishing gear online.
- Availability at all major outdoor retail locations.

I – Eagle Claw Competitor Research

Wright and McGill Company (Eagle Claw):

Slogan - *Where great fishing begins*

Business Strategy:

- Multiple brands spread across product lines as following
 - Eagle Claw: Rods, Reels and terminal tackle products
 - Lazer: Premium tackle items (hooks, rigs etc)
 - Nitro: Bait
 - Wright and McGill (M&G): Accessories for Fly fishing
- The only US hook manufacturer and the exporter of hooks emphasizing on “we ship our hooks overseas-not jobs”. **(Home-made brand as a selling strategy)**
- Point of differentiation being immediate availability of quality components for lure manufacturers. **(Manufacturer of Hooks for lures)**

Distribution and sales:

- Distribution Hub in Taiwan
- Customers access a website that allows vendors to see inventory levels in real time minimizing any delay in their production cycle.

J – Bending Test Result Form

This test is created uniquely for the DHT, and therefore, there is no American Society for Testing and Materials, ASTM, standards. ASTM generates standards for use in testing for a wide variety of procedures and materials. The standards can be found on many material information website such as *MatWeb*. The test involved the research of various materials and their structural properties in order to find the optimal material for the shank and flexing unit.

Bending Test				
Date:		Tester:		
Material:				
Bend Angle	Length	Width	Thickness	Weight
Comments:				
Material:				
Bend Angle	Length	Width	Thickness	Weight
Comments:				
Material:				
Bend Angle	Length	Width	Thickness	Weight
Comments:				
Material:				
Bend Angle	Length	Width	Thickness	Weight
Comments:				
Material:				
Bend Angle	Length	Width	Thickness	Weight
Comments:				
Material:				
Bend Angle	Length	Width	Thickness	Weight
Comments:				
Material:				
Bend Angle	Length	Width	Thickness	Weight
Comments:				
Material:				
Bend Angle	Length	Width	Thickness	Weight
Comments:				

K – Corrosion Rates

The corrosion rate can be determined by subjecting the specimen to corrosive environments over long periods of time and measuring the mass lost after the specimen has been cleaned. This mass lost is translated to surface area lost which is the unit of corrosion rate, inches per month. The corrosion rates are different for different kind of materials. The chart below gives examples of several types of components and their corrosion rates. Similar charts are available on various websites detailing a vast number of materials and components along with their corrosion rate.

TABLE 1		
ASTM G28 A Corrosion Rates		
Sample		Corrosion Rate
#	Description	(inches per month)
1	Open butt weld	0.0051
2	Butt weld with backing	0.0061
3	Corner fillet weld	0.0036

L – Customer Satisfaction Forms

From the table below, several sets of customer satisfaction data will be acquired. For a set period of time, the ratio of fish landed to the number of casts that had activity (e.g. nibbling, bites, etc...). Activity can be felt as vibrations from the lure transmitting through the line and rod. According to our sponsor, there is a say in fishing, “when in doubt, set the hook”. The form will exclude casts that appear to not experience any activity. Since more experienced anglers are familiar at distinguishing different types of activities, the results will be standardized. The form will also take into account the area of the large-mouth bass’s mouth the hooks were engaged and which hooks. In addition, the amount of snags will be recorded.

Type of Hook:			
Location:			
Years of Experience:			
Number of Casts with Activity	Number of fish landed	Bait (B) or Lure (L)	Snags

*Use tally marks

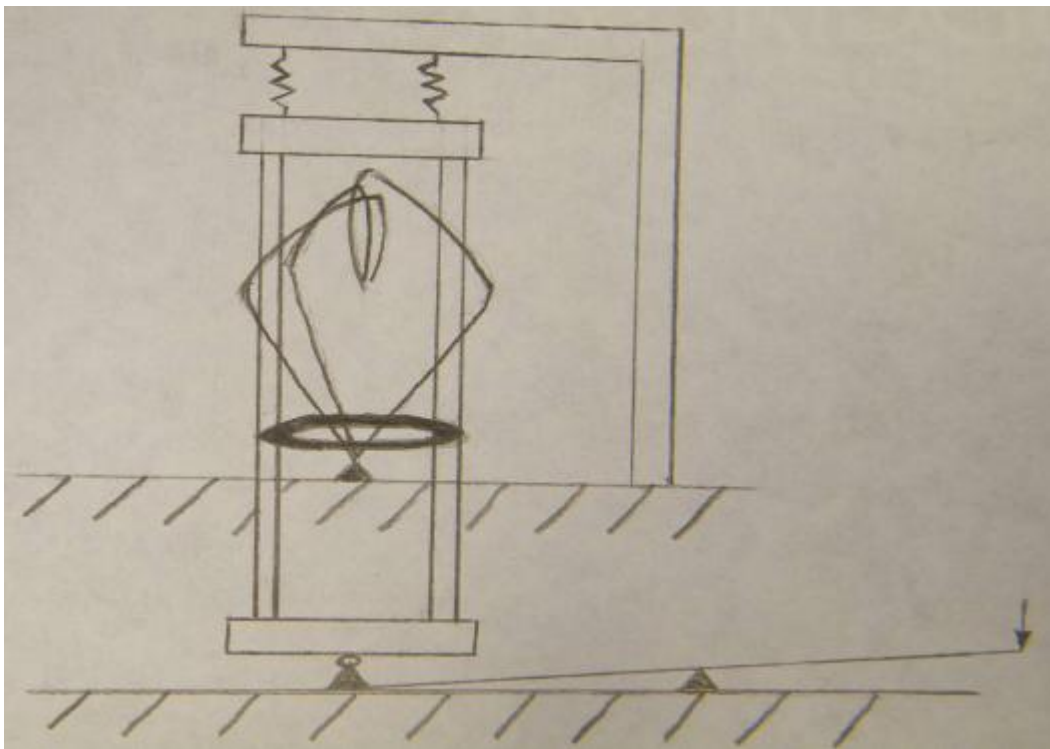


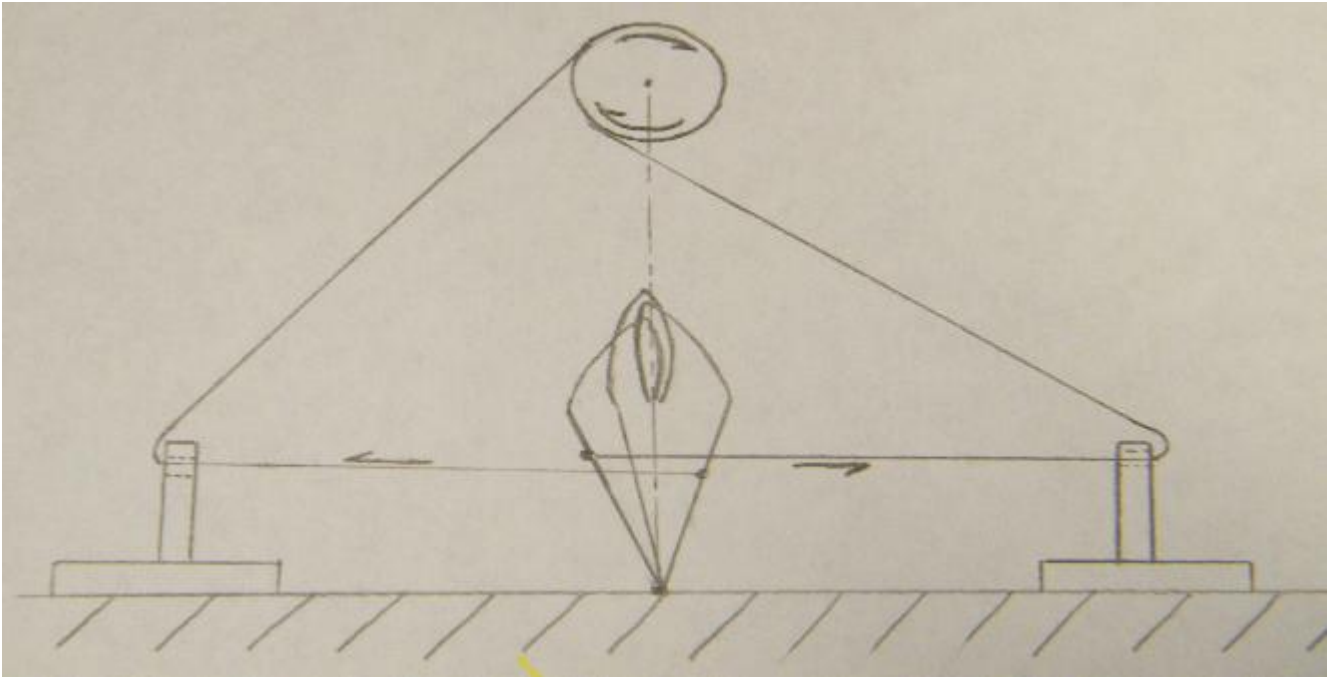
*Mark where hooks engaged

Hook 1	Hook 2	Hook 3

M – Fatigue Test Result Form

Fatigue testing utilizes a machine to apply a cyclic load on a specimen. More advanced fatigue testing machines can cycle through loading and unloading millions of times a second as well as varying the force of the load. These tests are done to better understand how vibrating and oscillating forces can weaken a specimen. Fatigue life is measured by the number of cycles of loading and unloading before a specimen fails under a certain load. The damaged caused by fatigue is not fixed when the loading and unloading ceases. To test the fatigue life of the base due to the constant engaging and disengaging of the hook we would have to manually engage and disengage the hook itself. The design of the hook requires the third hook to be deployed if 2 of the hooks are engaged. To engage the hook during testing procedures we would tie a piece of string around the body which would be pulled up and down to engage and disengage the hook.





Trial	Number of cycles until failure (String)	Number of cycles until failure (Ring)

N – Hook Setting Result Form

This test is used to see the effect of the Delta hook engagement mechanism compared to other hooks on the market. Utilizing this test will allow researchers to better understand where on the fish the hooks become engaged the most. Some of the hooks can slip out of the mouth or not have enough pressure in order for them to cling to the fish's mouth. There is also an additional criterion to test which is whether the hooks would catch a fish on the outside of its body. The test requires the researcher to anchor a fish to the table and attach movable platforms to the fish's mouth. The DHT would then be placed into the fish's mouth and the platforms adjusted to apply a force similar to that of a largemouth bass. The DHT would then be set to observe where the hooks engage on the fish. This data is recorded for later analysis.

Specific Test			
<u>Position With Respect to Jaw</u>			
Trial number	Pressure on Jaw (and whether open or closed)	Number of Catches	Number of Hooks Engaged
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

O – Snag Test Result Form

The snag test is performed to observe the snagging tendencies of the J-hook, treble hook, sponsor provided mock up, and the IPRO developed mockup. A snag is defined as a situation in which the hook is difficult to retrieve if at all possible due to engagement or entanglement in any obstacle. This test will determine whether or not the IPRO designed DHT will actually have less occurrences of snag. The test involved dropping the test subject into either a simulated or natural environment or observing the occurrences of snag. The hook would then be attempted to be retrieved.

Testing Environment:				
Line Strength (lb test):				
Hook Style: J Hook / Treble / Mock__ / Sponsor Mockup				
Cast	Snag but Retrievable? [Y or N]	Snag and Irretrievable? [Y or N]	Obstruction Type	Comments
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

P – Tensile/Unbending Result Form

In most tensile tests, the point of failure is defined as the Ultimate Tensile Strength (UTS). The point of total deformation in the unbending test is regarded as the point of deformation of the fishing hook, equal to the bite length, likely before the UTS. This is regarded as such because after this point, the fishing hook becomes useless for fishing. There are many other factors that can be measured with the unbending test. The slope of the stress-strain curve before the UTS will provide a measure of the elasticity (Young's Modulus) of the fishing hook. This is a measure of the stiffness of the fishing hook, which will be further explored in another testing method. Also, the yield strength can be measured as the force is applied during the unbending test. This defines the property of a material to return to its original shape after a force is applied. This value, the resiliency of the object is shown in Equation 1 and is one of the properties that must be considered when determining material properties of the object.

To perform this test, one must axially the specimen in tension and increases its force until it fractures. The applied axial loads and the corresponding deformation of the sample are measured, which allows one to calculate the stress and the strain. It is generally recommended that the universal testing machine, UTM, is turned on twenty minutes prior to experimentation. When operating the UTM, the fishing hook is loaded onto the machine using the appropriate grips. The dimensions of the specimen would also have to be found before the test can begin so the information can be use later as the test will deform the subject.

Trial	Yield strength (MPa)	Tensile strength (MPa)	Elastic modulus (MPa)	Stress (MPa)	Strain	Ultimate Tensile Strength (MPa)	Young's Modulus (MPa)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Q - Budget

An expanded view of the overall budget for this semester shows the specific line items and is divided by receipt.

Budget for IPRO 358,Summer 2009(Allotted fund \$500)						
Serial	Transaction Date	Item Detail (as on receipt)	Price(unit)	No. of Units	Total cost (Item)	Description
1	6/17/2009	1/8x3RNRDPLN	\$1.98	1	\$1.98	Mock-up production materials
		EXT. SPRING	\$3.39	1	\$3.39	
		STRAIT SNIP	\$12.97	1	\$12.97	
		L/CNCEPXSyr	\$4.99	1	\$4.99	
		FASTSTEEL	\$3.97	1	\$3.97	
		4D NAIL	\$2.24	1	\$2.24	
		ROPE REEL	\$0.25	4	\$1.00	
		TAX				
	Total				\$33.67	
2	6/22/2009	FASHION 004145746023	\$2.50	1	\$2.50	Mock-up production materials
		FISH HOOK 008972603500	\$3.16	1	\$3.16	
		FISHHOOK 004770860248	\$0.96	1	\$0.96	
		EPOXY PUTTY	\$3.94	1	\$3.94	
		TAX				
	Total				\$11.51	
3	6/27/2009	License(Sports Fishing 24-Hour)	\$5.50	1	\$5.50	Sports fishing license for the fishing trip.
		Convenience Fee			\$1.16	
	Total				\$6.66	
4	6/28/2009	License 068113147314	\$5.50	1	\$5.50	Sports fishing license for the fishing trip.
		Total				
5	6/28/2009	License(Sports Fishing 24-Hour)	\$5.50	1	\$5.50	Sports fishing license for the fishing trip.
		Convenience Fee			\$1.16	
	Total				\$6.66	
6	6/28/2009	License(Sports Fishing 24-Hour)	\$5.50	1	\$5.50	Sports fishing license for the fishing trip.
		Convenience Fee			\$1.16	
7	Total				\$6.66	
	6/28/2009	License(Sports Fishing 24-Hour)	\$5.50	1	\$5.50	Sports fishing license for the fishing trip.
		Convenience Fee			\$1.16	
8	Total				\$6.66	
	6/28/2009	License 068113147314	\$13.00	1	\$13.00	Sports fishing license for the fishing trip.

	Total					\$13.00	
9	6/29/2009	SCUNCI CLIP 12CT	\$2.24	1	\$2.24	Mock-up production materials.	
		TAX			\$0.17		
	Total						\$2.41
10	7/11/2009	Beetle Spin(0022021553501)	\$1.19	39	\$46.41	Incentive for survey participants	
		Sales tax			\$3.94		
	Total						\$50.35
11	7/11/2009	77462998877 BINDER	\$0.48	4	\$1.92	Material for survey	
		76023645611 PENS	\$0.79	1	\$0.79		
		Tax			\$0.23		
	Total					\$2.94	Balance
	Grand Total					\$146.02	\$353.98