ILLINOIS INSTITUTE OF TECHNOLOGY

Product Development and Marketing for Delta Hook Fishing Innovation

EnPRO 358- Spring 2010

Advisors: Dr. David Gatchell and Professor John Stoner

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1.0 Description of IPRO

The Interprofessional Projects (IPRO®) Program at Illinois Institute of Technology

An emphasis on multidisciplinary education and cross-functional teams has become pervasive in education and the workplace. IIT offers an innovative and comprehensive approach to providing students with a real-world project-based experience—the integration of interprofessional perspectives in a student team environment. Developed at IIT in 1995, the IPRO Program consists of student teams from the sophomore through graduate levels, representing the breadth of the university's disciplines and professional programs. Projects crystallize over a one- or multi-semester period through collaborations with sponsoring corporations, nonprofit groups, government agencies, and entrepreneurs. IPRO team projects reflect a panorama of workplace challenges, encompassing research, design and process improvement, service learning, the international realm, and entrepreneurship. (Refer to http://ipro.iit.edu for information.) The *Product Development and Marketing for Delta Hook Fishing Innovation* team project represents one of more than 40 IPRO team projects for the *Spring 2010* semester.

2.0 Abstract

Recreational fishing is an enormous market, generating $125 billion of economic output and providing over one million American jobs. Many different fishing hooks are available, retaining the same, basic shape and structure. However, there are many dilemmas that face contemporary fishing hooks. One problem is that fishing hooks are not able to properly fasten onto the fish after embedding. 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 incurred to the fish. Furthermore, barbs can cause damage to the fish during the removal process. Another problem is that fishing hooks can catch (snag) onto nearby rock formations, algae, weeds, or any other obstacle both above and below the water. This problem is approached by utilizing snag-proof guards. However, this increases the manufacturing cost of the product, and is not shown to be conclusively effective. Yet another problem with conventional fish hooks is the danger facing anglers, especially young or inexperienced anglers. The exposed barbed fish hook can pierce through the skin and lodge the hook into the angler. Due to the nature of the barb, the angler can 1) push the hook the remaining distance until the barb penetrates the skin again, then cutting the barb off and removing the hook, or 2) have the hook surgically removed. Among the major corporations, there appears to be an absence of fishing hooks equipped with all the above mentioned features: barbless, safe, snag-proof, weedless, and most importantly consistent effectiveness in catching and holding a fish. Sparrowhawk promises to develop an innovative fishhook, The Delta Hook Technology (DHT) that offers its users these features.

The EnPRO 358 team will work with the CEO and founder of Sparrowhawk, LLC, Taylor “Augy” Park and several other professional organizations to develop a prototype of Delta Hook Technology (DHT) which will be showcased at iCAST 2010. iCAST 2010 is the premier fishing expose for sport fishing anglers and provides Delta Hook Technologies the appropriate environment to gain entrance in the sports fishing market and establish the company’s reputation.

EnPRO 358 offers an opportunity for students to gain experience in developing the components of a business strategy plan, as well as, developing and testing designs and mock-ups that demonstrate the value of innovation and its place in the market.

Short biographies of each team member can be found in Appendix #1.

3.0 Purpose and Objectives

3.1 Mission Statement

Create a prototype for the Delta Hook Technology that is safe, snag free, durable, and efficient to build consumer interest at iCAST 2010. In addition, conduct market research and develop a viable business plan that will bring DHT to the market.

3.2 Objectives

3.2.1 General

- Attend iCAST 2010 in order to introduce Delta Hook Technology to the fishing industry
- Implement safety and ethics in business planning and prototype development

3.2.2 Business Development

- Identify and gain a sound analysis of the market that Sparrowhawk will launch its DHT into
- Develop an in-depth business plan for Sparrowhawk to use to gain funding from investors
- Establish strategies for necessary business processes such as funding, manufacturing, packaging, distribution, sales, promotion, partnerships, and financials

3.2.3 Product Development

- Produce a functional prototype that manifests the physical and mechanical properties which are ideal for catching Micropterus salmoides, commonly known as the largemouth bass
- Gain knowledge of the anatomical features of a bass, especially the way they feed

4.0 Background and Approach

4.1 Background

4.1.1 Sparrowhawk

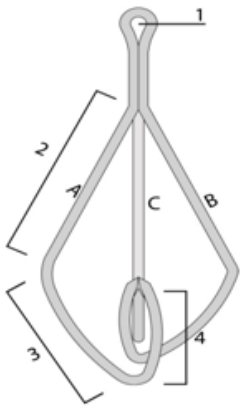
Sparrowhawk was founded in 2008 by Taylor "Augy" Park. Augy recognized that there is great potential for a company that can produce a more effective fish hook. The company was originally founded with the sole intent of producing and marketing the Delta Hook Technology. In 2009, Augy partnered with the Illinois Institute of Technology's Inter-professional project to develop Delta Hook Technology and a business plan.

4.1.2 Business Development

EnPRO 358 Summer 2009 and Fall 2009 made big strides with Sparrowhawk. First off, they conducted market research. This research included market, industry and competitor analysis. Also, angler surveys were conducted in order to determine the preferences of Chicago land anglers and to narrow the target market. Next, supply chains were investigated and manufacturers were talked to, both domestic and international. Finally, the business development teams created financial projections and cost evaluations. The Spring 2010 Business Development team will build upon this market research to get a more in-depth knowledge of our market. Also, they will use the financial and cost evaluations to develop a business plan.

4.1.3 Product Development

The Spring 2010 Product Development team had lots work to build on thanks to Summer 2009 and Fall 2009. First off, the critical parts of the hook were identified. In order to best understand the Delta Hook, Figure 1 is provided as a reference.



1.	Eye
2.	Shank
3.	Arm
4.	Engagement mechanism

Figure 1. An illustration of the Delta Hook. Components A, B, and C are the shanks.

Each semester created several mock-ups using different materials. None of the mock-ups utilized the right combination of strength and flexibility. Heat treatment was introduced and tempering was explored. The Spring 2010 Product Development team will continue to investigate techniques to gain the strength and flexibility needed. Also, a method to join the three hooks will be found. Figure 2 is provided to show the different mock-ups that the sponsor and previous semesters EnPRO provided.

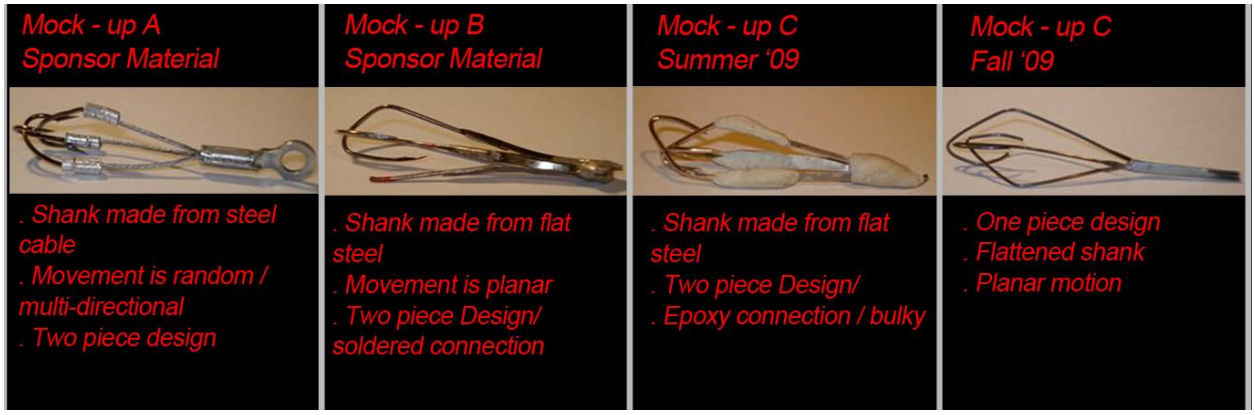


Figure 2. A brief pictorial history of Delta Hook Mock-Ups.

5.0 Analysis and Findings

5.1 Business Development

Market Research

5.1.1 Consumer Surveys

Consumer surveys are necessary to understand the customer base Sparrowhawk is targeting; additionally, information collected from the survey will add to published data about sport fishing in the United States. At the beginning of the semester, conduction of the survey was planned to occur in three venues:

- Outdoor Retailers (e.g. Bass Pro Shops)
- Internet (e.g. Zoomerang, Facebook)
- Local Retailers (e.g. Henry's Bait shop [Chicago, IL])

The diversity of the venues was to obtain a holistic view of the fishing market (i.e. exclude as few as possible age categories and nexus's as possible). Additionally, the results were compared and combined with EnPRO 358 summer 2009 class results.

The Outdoor retailers were reluctant to allow EnPRO 358 to conduct surveys at their locations. Cabela's (Hoffman Estates, IL) responded no, citing that allowing EnPRO 358 to administer survey's causes controversy with animal rights activists and therefore Cabela's does not allow any surveys to be administered. Bass Pro Shops (Portage, IN) contingently agreed to allow surveys to be conducted, however, the contact there, Duane Ebach, did not respond to multiple emails (3) and phone calls(2). Due to these responses, no surveys were conducted at outdoor retailers.

To overcome this obstacle, an internet survey was conducted through Zoomerang (www.zoomerang.com). The survey was posted 4 weeks and a total of sixty-two (62) surveys were completed. The copy of the survey can be seen in Appendix #2. Results of the survey can be found in Appendix #3. Additionally, the results that combine the data from EnPRO 358 summer 2009 with EnPRO 358 spring 2010 results are listed. Also, a link to the survey was posted on nine Facebook groups dedicated to fishing and Windycityfishing.com, a forum dedicated to fishing in the Chicago land area. Finally, surveys were emailed out to family and friends of the founder of Sparrowhawk, Augy Park.

Local Bait shops were contacted in regards to conducting the survey, however, due to the weather conditions and time of year (January—March), fishing in the Chicago area was at a minimum and thus, on the advice of the store owner at

Henrys and Freddie Bear's Tackle (Tinley Park, IL), EnPRO 358 decided not to conduct market research at these locations.

Additionally, the results from EnPRO 358 summer 2009 and spring 2010 were compared.

The valuation results are currently regarded as the most important as EnPRO 358 looks to develop marketing campaigns, sales pitches, and packaging for the Delta Hook Technology. Other results obtained will be used to identify retail locations for the Delta Hook Technology along with identify pricing of the Delta Hook. All survey results can be found in Appendix #3.

5.1.2 Market Analysis

From latest available data from the United States Fish and Wildlife Service, freshwater fishing is a $26.3 billion industry with 25.4 million individuals taking part each year. Terminal tackle (hooks, sinkers, and swivels), fishing lures and artificial baits accounted for $1.3 billion of that number. Sparrowhawk, through the Delta Hook Technology (DHT), hopes to capitalize on this vibrant market.

In 2001 34.1 million individuals fished, while in 2006 that number dropped to 30 million - this marks a 12% drop. Although participation declined, it was not the same case with expenditure - in 2001 there was a total expenditure of $35.6 billion, while in 2006 this number rose to $42.0 billion - this marked a 17.9% increase. More specifically in concern to the freshwater fishing market, in 2001 28.4 million individuals fished, while in 2006 this number dropped to 25.4 million and expenditure increased from $21.3 billion ('01) to $ 26.3 billion, marking an increase of 23.4%.

USFWS surveys from 1991 and 1996 were also analyzed to give an idea on market trends and growth. The surveys suggest that as the economy declines, expenditures increase and vice versa.

5.1.3 Competitor Analysis

According to the surveys we have conducted thus far our main competitors seem to be **Gamakatsu**, **OwnerHooks** and **Mustad & Son**, with a majority preference towards Gamakatsu.

Gamakatsu:
Gamakatsu is the leading manufacturer of fish hooks in the world. Based out of Japan, they have branches that service both the US and Europe, with different

advertisement campaigns for both websites. Also, according to our surveys it is the most preferred brand among anglers.

Owner Hooks:
Owner Hooks is an American Corporation. While they claim to be producers of both fresh and salt water products, it seems that most consumers prefer them for salt water products (according to our surveys). As Sparrowhawk is focusing on the fresh water market with the DHT, this means that we may not meet as much opposition from Owner Hooks.

Mustad & Son:
Mustad & Son is one of the oldest hook manufacturers in the world, from their website, "For more than 100 years, Mustad has been known as the World's largest manufacturer of fish hooks". The company is based out of Norway and had its beginnings about 178 years ago. The first automated fish hook machine was developed at Mustad. Today they seem to approach fish hook design with a scientific approach.

The main advantage that Sparrowhawk has over these companies is the revolutionary design of the DHT. None of the aforementioned companies have a hook design quite like the DHT, that combines features such as improved catch and hold, snag less properties and safety into one hook.

5.1.4 Target Market

The Business Development team has identified three different market segments for Sparrowhawk to target. The first is the sports fishing enthusiast. This segment includes professional anglers as well as anglers that fish on a regular basis. This market will be targeted with the Sparrowhawk Pro product line. The marketing strategy to optimize sales in this segment is to push the increased catch and hold properties that one gains with the use of Delta Hook Technology. The next segment is the angler who takes children fishing. This market will be targeted with Sparrowhawk Family by pushing the safety features of Delta Hook Technology. Finally, the last segment is the Sparrowhawk Memento segment. Sparrowhawk looks to capture the segment of the market that is looking for a gift that can be passed on from father to son. It is more of an heirloom that captures the memories shared while fishing. Promotional strategies for each segment will be detailed later in the “Promotional Strategy” section.

5.2 Business Plan

To obtain funding from either banks or investors, Sparrowhawk needs a business plan. EnPRO 358 has created an in-depth business plan using Business Plan Pro Premier software. The business plan covers everything from market analysis, to

products, to management, to finances. It covers everything a bank or investor would want before investing in the company.

5.3 Strategies

5.3.1 Funding

Sparrowhawk will attempt to obtain funding in two different phases. The first phase is for $200,000 of Angel funding, while the second is $500,000 of LOC/Angel funding. The use of funds for each phase can be found in Appendix #4.

5.3.2 Manufacturing

There are several factors to take into account when considering the possibilities for the manufacturer of our product, including the scale of the order, the type of processing the hooks need to go through and whether those processes can be completed at one manufacturer.

Currently the product team is considering several types of prototypes to get the desired flexibility. Amongst these processes is the use of a rubber ball, coiling of the shank, and flattening of the shank. None of these processes are conventionally found in fish hook manufacturing factories. Other processes that the hooks need to go through are heat treating, sharpening, coating (for elemental resistance) and base joining (joining the hooks together). These latter processes are more conventional and could most likely be taken care of at a conventional fish hook manufacturing company. Considering the unconventional processes the hooks have to go through, it is likely that they will be processed in a few different locations – unless a manufacturer is willing to buy new machines.

The size of the order may also play a factor; larger manufacturers may prove to be uneconomical if the order size is too small. In which case, specialty manufacturers (small scale) may be sought out. The business team investigated these smaller manufacturers, and based upon our primary order quantity and the variety of processes that the hooks have to go through, it was decided that smaller specialty manufacturers would be best. Currently, the EnPRO has been working to negotiate a relationship with 'Master Spring & Wire Form Company", which is a wire bending company based out of Illinois.

In the previous semester the possibility of working with a Chinese manufacturing company was also explored, however as at the time there was no working prototype we could not push on any further.

5.3.3 Packaging

To prepare the Delta Hook Technology for retail sales, a packaging quote was obtained from Sigma Services, Inc. (Mundelein, IL)(www.sigmasvs.com). Initial

machine retooling was quoted at $1250.00 USD ; material and labor costs were $0.15-0.30USD and $0.14 (based on an order of 10,000 packages), respectively. This quote applies to blister packaging and the material cost comes from the card stock

An example of the image that will be seen on Sparrowhawk's packaging can be found in Appendix #5.

More inquires should be made with different companies before a packaging decision is made, however at this stage in the development of the Delta Hook Technology, cost estimates can be calculated for investor use and financial analysis.

5.3.4 Distribution/Sales Channels

After analyzing the current market and the strategies that Sparrowhawk's competitors take, a decision on distribution and sales channel was made. For the Sparrowhawk Pro line, outdoor retailers such as Bass Pro Shops and Cabella's were targeted. This is consistent with our consumer surveys, where 58% of respondents named these types of retailers as their main source for fishing hooks. Also, we plan to use Sparrowhawk's Chief Operating Officer, Rick Ice, who has many years of experience in the fishing hook market, as a connection to supply chains. For the Sparrowhawk Family market, we plan to sell through more family oriented stores, such as Wal-Mart and Toys R Us. Customers at these stores will highly value the safety aspect of our hook. Finally, we plan to sell Sparrowhawk Memento through avenues such as QVC and the Home Shopping Network.

In terms of units per package, the Business Development team decided on 5 hooks per package for the Pro and Family lines. This number was strategically chosen after analysis of market trends and consumer preferences. Also, this allows for anglers to change hooks on two lures.

A price was decided upon after analyzing competitor prices, demand, value created by DHT, and costs. A price of $7.50 was decided for both the Pro and Family lines. A price for the Memento line was not decided upon. A detailed table of costs can be found in Appendix #6. Also, a sales forecast for Sparrowhawk Pro and Family can be found in Appendix #7.

5.3.5 Promotion

Gaining exposure for your product is one of the most essential steps in building and sustaining a startup company. No matter how well your product works or how cool it is, if no one knows about it then your company will fail. There are many ways that Sparrowhawk can promote each of its Delta Hook product lines. First, the optimal strategy for Sparrowhawk Pro would be to heavily attack

fishing/hunting/outdoor magazines, television channels, websites, and blogs with advertisements. Magazines are a key because 39% of survey respondents reported learning about new products through magazines. Fishing/hunting/outdoor venues would be strategically chosen because the people coming into contact with these visuals would be very likely to be in the market for fishing hooks, especially fishing hooks that will increase their performance. DHT's increased catch and hold capabilities will be especially valuable to these customers. The optimal strategy for Sparrowhawk Family would be to promote the safety features of the hook. Finally, the optimal strategy for Sparrowhawk Memento would be to promote the product as an item that will stay in the family for many years to come. It is a portal to the memories that family members and friends shared when fishing. By increasing the size of the hook and offering laser engraving, consumers will purchase the hook in order to pass on to others.

Also, Sparrowhawk will create videos demonstrating how the hook works and show it catching bass. These videos will be posted on Youtube, blip.tv, metacafe and other video sharing sites.

Next, Sparrowhawk representatives will hand out samples at bait stores, outdoor retailers, lakes, and other high traffic areas for anglers. The object is for the anglers to try out the hooks and be so impressed that they will come back to purchase more. Also, Sparrowhawk will have a fish pond at their place of business for anglers to test out the hooks.

Along with free samples of hooks, Sparrowhawk representatives will give away promotional items such as hats, tackle boxes, beer cozies, coolers, pocket knives, and any other item that anglers use on a regular basis. The object here is to just get the Sparrowhawk and DHT name into the minds of anglers.

Next, Sparrowhawk will host a fishing tournament with a cash prize. The only catch is that all anglers must use Delta Hooks when fishing. This will attract many anglers and at the same time will show the effectiveness of Delta Hook Technology.

Finally, Sparrowhawk will attend iCAST 2010, which is the world's largest sports fishing trade show. iCAST will grant Sparrowhawk both exposure to buyers, media, and potential partners. In 2009, there were 7400 attendees, including 500 media representatives.

EnPRO 358 has created 3 different promotional advertisements, one for each product line, which will be used in different situations. These advertisements can be found in Appendix #8.

5.3.6 Strategic Partners

Lure Manufacturer

Sparrowhawk's success can be greatly increased by a strategic alliance with an established lure manufacture. There are many lure manufactures that benefit from brand recognition and respect. Pairing with one of these manufacturers will boost the sales of Delta Hook Technology and will speed up the process of creating a brand name. The optimal partner in this scenario is Rapala. This is due to the fact that Rapala is a top lure manufacturer that is currently used across the Chicago land area, the Midwest, and all of the United States. Anglers will see DHT on Rapala lures and instantly respect the product. There will be no doubt of whether or not DHT is legitimate.

Outdoor Retailer

Likewise, an alliance with an outdoor retailer, such as Cabella's or Bass Pro Shops will increase Sparrowhawk's success. Such a partnership will allow for national exposure to DHT. Consumers will be more willing to accept Sparrowhawk's product if it is sold in a national chain. Also, the sheer number of customers these retailers get on a daily basis will increase exposure to the DHT.

5.3.7 Exit

EnPRO 358's sponsor, Augy Park, has made a decision to raise Sparrowhawk as a pig. Therefore, the main object is to fatten the pig as much as possible before selling it to a larger company. We have set the acquisition date at 3-5 years. In order to create the highest amount of value for the company, Sparrowhawk needs to develop its intellectual property (trademarks, patents, logos, etc…), manufacturing and distribution contracts, and product lines.

5.4 Problems and Obstacles

The Business Development team ran into a couple of problems during their progress throughout the Spring semester. The first problem arose when trying to administer angler surveys. Both Cabella's and Bass Pro Shops rejected our request to conduct surveys at their locations. The next problem that arose was getting information on manufacturing costs. We did not know exactly what processes would go into the manufacturing of a DHT hook, so many costs had to be estimated. Finally, staying in tune with the Product Development team seemed difficult at times, as the Business Development team did not always know what direction the Product Team was going.

6.0 Product Development

6.1 Research

6.1.1 Material

Using an SEM, an EDS (energy dispersive spectroscopy) analysis of 3 industry treble hooks (2 different Eagle Claw and 1 Southbend) was performed to investigate the composition of the shanks, bonding agents, and coatings already being used in the market. The microstructures of the shanks were also investigated to learn about what processes were done to them (i.e. what types of heat treating, quenching, tempering, annealing, etc). To do the shank and bonding composition analysis and to investigate the microstructure of the shanks, cross-sectional samples were mounted, polished, and etched for the SEM. Mounting was done by surrounding the samples with a nonconductive black molding compound. Once the compound set and dried, the sample and mount were ground down and polished start to bring out the crystal structure in the samples. The grinding was done on emery paper, starting with 200 grit paper and increasing to 300, 400, and ending with 600 grit. A constant light stream of water was allowed to flow over the paper during the grinding, which helped remove the tiny ground off particles from the mount and sample. Once the grinding was completed, the samples were polished on rotating circular polishing pads. Solutions of alumina (Al_2O_3) were used as lubricants during the polishing, starting with a .05 micron solution and ending with a .03 micron solution. After the polishing, the samples were observed under an optical microscope to determine how well the sample had been prepared (that there were no overly large scratches or residue left on the samples that would interfere with examination). If the samples were unsatisfactory, grinding or polishing was repeated as needed until they were acceptable. Once satisfactory, the samples were then etched with a nitric acid solution in order to reveal the microstructures. The samples were then observed under an optical microscope again to determine if the sample had been introduced to the acid long enough to satisfactorily reveal the microstructure. If not, the samples were subjected to the acid solution for a few more seconds and then observed again until satisfactory. After this the samples were placed in the SEM and the EDS analysis was performed. To investigate the coatings, clipped pieces of the hooks were mounted in the SEM to get the surface analysis.

It was found that all 3 shanks were comprised of mostly iron and some carbon, which indicates that they are made of steel. The exact percentages of carbon in the steel cannot be obtained with the SEM because the SEM has trouble giving accurate readings on elements with atomic numbers less than or equal to 6 (carbon is 6) due to the way it takes readings.

The joining agent of the both Eagle Claw hooks was found to be a copper-zinc compound (~60% Cu, ~40% Zn) which is believed to be a brazing or braze

welding material. The Southbend hook also was a copper-zinc compound, most likely also braze or braze weld, with a composition of ~66% Cu and ~33% Zn.

Based on the microstructure formations, it was found that the Southbend and one of the Eagle Claw hooks underwent a similar process to what the IPRO is using, namely heat treating followed by quenching and then tempering (tempered martensite structure). The other Eagle Claw hook had a bainite microstructure, which suggests a longer, more involved heat treating process. This process resulted in a hook that was slightly softer and tougher than the other two, more capable of being bent/shaped. The tempered martensite hooks were harder and slightly stronger, but more brittle.

The coating analyses gave a different result for each hook. One of the Eagle Claw hooks was nickel-plated. The other had a non-conductive coating that had a high percentage of carbon, which leaves the result inconclusive. Guesses are possibly a polymer, but it is impossible to be sure with this test. The Southbend hook had a coating comprised of sodium and potassium. There was also a good percentage of oxygen present, but it is unknown whether that was part of the coating compound or if it had just oxidized.

6.1.2 Academic

EnPRO 358 consulted with experts in the field of materials and steel in order to gain a better perspective of what materials and processes would be best to develop a fish hook.

Sheldon Mostovoy is an associate professor who has been with IIT for many years teaching materials engineering. His expertise includes mechanical engineering, metallurgy, mechanical properties of materials, fatigue and fracture. Because of his materials background, EnPRO 358 approached him initially for advice on the material selection of the DHT. Professor Mostovoy recommended a high-Carbon steel because it can be heat treated and tempered to give a desired strength. As the semester progressed, several more large issues were presented to him concerning the DHT—flexibility and joining. The issue with having a homogenous material throughout the entire DHT is that the DHT will have the same properties in every location of the hook. This presents a problem because the DHT requires flexibility in the upper portion of the hook (shank) and strength in the lower part. With the help of Russel Janota, the MMAE facility manager, two new possible solutions were added—coiling and rubber ball-method—which will be explained in detail in the “Flexibility” section. An already established theory EnPRO 358 had going into this semester about the flexibility in the shank was the theory of flattening the wire. However, it wasn’t

until Professor Mostovoy's cooperation did EnPRO 358 learn a consistent method of flattening via the tension/compression machine which will also be explained further in the flattening section.

The second major obstacle that Professor Mostovoy and Mr. Janota aided in was the joining of the hooks above the shank where the fishing line would theoretically be tied to the hook. Several methods were discussed ranging from brazing to spot welding to crimping, all of which will be addressed in their own section.

Professor Mostovoy also guided EnPRO 358 in the strengthening and normalizing methods for the steel wire as well as the strength testing methods. Russ Janota acted as the overseer of the testing processes, joining processes, and the strengthening/normalizing method.

6.2 Prototype Development

6.2.1 Material

1080 Steel

Steel is an alloy of iron containing between .2% and 2.1% carbon by weight. High carbon steels are steels containing .3-1.7% carbon by weight. 1080 steel is a high carbon steel containing .8% carbon by weight. High carbon steels are generally used for springs and high strength wires. The elastic modulus of steel is approximately 205 GPa. The elastic modulus of a material is a measure of the stiffness. The yield strength of heat treated and tempered (500 Celsius) 1080 steel is 855 MPa. 1080 steel was the first choice for our DHT prototypes because it is inexpensive, strong, and rigid. All of these things are what commercially available hooks should be.

Titanium 6,4 (Grade 5)

Titanium alloys contain titanium and other elements. Ti6Al4V, is a titanium alloy containing 6% aluminum and 4% vanadium by weight. This alloy is the most commonly used titanium alloy. It is commonly used in Aerospace, Medical, Marine, and Chemical Processing. The elastic modulus titanium is approximately 110 GPa. The yield strength of heat treated Ti6Al4V is 1100MPa. Ti6Al4V was another choice for our DHT prototypes because it is strong and more flexible than steel.

6.2.2 Bending

The main issue with the bending process was the issue of consistency; the hand bent hooks were not all the same especially when they were bent by different individuals. And we couldn't stop the testing while we waited to find a professional manufacturer so in an attempt to standardize our process we:

1. Measured treble hooks that we purchased, we measured a few hooks that were recommended for largemouth bass fishing and decided on an average set of dimensions that would work for bass fishing.

2. We applied these dimensions to our design drawings and scaled the drawings both larger and smaller than the decided dimensions by a scale of .05

3. These drawings were then analyzed by the team and three standard sizes were chosen, the one that reflected the average dimensions, one larger and one smaller.

4. This set of drawings then gave us a standard with which to bend the hooks.

5. In a further attempt to standardize the process we gathered the group to bend hooks together in order to monitor quality and technique.

These steps made for a more standardized hook which allowed our test results to be much more controlled due to the increased quality and decreased variables in our hooks.

6.2.3 Heat Treating

1080 spring steel without any change to it will simply unbend when up against the strength of a large mouth bass. To make sure that the hook is not the first point of failure we had to infuse the hook with enough strength to withstand the pull of a bass. To give our hook the strength that we needed we had to quench and temper our hooks.

Quenching is the method of hardening an iron ore, in our case 1080 steel. To quench a material it first has to be heated to the martensite phase which occurs at about 815°C for 1080 steel for 5-10 minutes and then dumped into a cooling fluid, water in our case, to quickly cool the material and lock the material in the martensite phase. At this point the steel is hard but very brittle and almost useless for most applications, including ours. That is why after quenching, it is essential to temper the steel to get the desired properties. We tested several different tempering temperatures in an attempt to hone in on the properties that we desired. We ended up choosing 500 °C for its strength without much sacrifice to ductility.

6.2.4 Testing

To meet our goal of having our fish hooks meet industry standard on strength we needed to a way to compare our hooks against standard available hooks. The summer 2009 section discovered an industry standard test that measures a hooks ability to withstand deformation called the unbending test.

The unbending test applies a vertical load on the hook which pulls the bend open; the test is over when the bend reaches a 90 degree angle as compared to the shank. We performed this test several times throughout the semester on different stages of the hook and different kinds of commercially available hooks.

Name	Wire Diameter (Inches)	Max Load (lbf)
Trokar J hook	0.0602	44.64
Baitholder	0.0536	42.25
Gamakatsu Worm Eye	0.0420	33.40
DHT 500 °C Tempering	0.0444	32.93
Lazer Sharp Treble	0.0410	32.47
Worm Hook	0.0747	29.67
TruTurn	0.0362	22.18
Aberdeen	0.0449	11.41
Lazer Sharp	0.0374	16.75
DHT 300 °C Tempering	0.0449	11.41

Our results show that with a tempering temperature of 500 °C we can achieve a strength that is excellent for the wire of similar diameter.

6.2.5 Joining

The joining of the 3 hooks has taken many forms over the semester. The first method was brazing. Brazing involves heating up the wire (red hot) and adding the filler (brass braze). Silver Soldering was also tried in the same method. Problems with both of these methods occur when trying to heat treat the metal wire. Silver Solder and Brass braze have a lower melting temp than the heat treatment temperature. Next, welding was explored. Spot welding can have minimal effects on the temper of the wire. The spot welder was found to be too small for our uses and other welder on campus were too large. Crimping is the method of joining that currently shows the most potential given the problems of

the other methods. The crimp can be placed after the heat treatment and tempering processes. Strength tests still need to be performed.

6.2.6 Crimping

Crimping is the primary hook joining method used for the DHT prototypes. It consists of a Brass cylinder rod with either a ¼ inch or 3/16 inch diameter. The center of the rod is then drilled out so that there is an inner diameter of 0.106 inches and 5/32 inches, respectively, making the rod a tube. Both diameter tubes are of the same length—3/8 inch. The three hooks and the eye-piece are then organized into the positions necessary for the design and held in place with clay. Once the hooks are stabilized in the clay, the Brass tube is positioned over the wires. The un-crimped DHT is then placed in the crimping machine, which essentially acts as a big vice grip that is tightened until the contents it is holding (the un-crimped DHT) is crushed. This leaves the hook with a tight, simple, cheap, and quick method of joining.

6.2.7 Spot Welding

The spot welding method is another method of joining the DHT hooks. A spot welder is a machine that sends a large electrical current through the two pieces of metal that are to be joined. The current is so large that it heats up the metal to its melting point and thus joins the two pieces in its momentary liquid phase. The metal cools down immediately, solidifying into one piece. This method was hypothesized to be a good solution to avoid re-tempering the already strengthened hooks. Re-tempering would cause brittleness at the join, which one loaded will be the location of the failure of the hook. This method, however, did not follow through because the two available spot welders were either too powerful or too weak.

6.2.8 Flexibility

Flattening

In order to achieve the flexibility required to allow the hook to engage we decide to attempt to flatten the hooks shanks. Early attempts at this flattening were done with a hammer on heated steel, or with blocks of steel. These methods proved to be un-reliable and very inaccurate. There were also issues with the steel blocks deforming instead of the wire. So in an attempt to solve these issues:

1. A set of carbide dies were ordered which were much harder than steel and would allow us to flatten in a much more controlled way

2. These dies were placed in a compression machine in the E1 lab where a force was applied to the wire placed in between the dies.

3. Pressure was applied (5,000-10,000psi) to flatten multiple hook shanks anywhere from 2/3 the original size to ½ the original size.

4. Approximately a ¾" length of the shank was flattened.

Although it seems all of our issues with the flattening were solved (accuracy, reliability, and control), the issue that we found was that this flattening did not make the hooks more flexible in any noticeable way. So while we solved the flattening problem the flexibility problem still existed.

Rubber Ball

The rubber ball prototype addresses the problem of flexibility. In the tradition design of the Delta hook, the source of the rigidity was the joint. The rubber ball takes the joint and makes it flexible. The 3 hooks are inserted into a gum rubber ball(gum rubber is flexible and tear resistant, both good for this application. weather resistance might be an issue. Tests will follow), which hold the hooks in position. The rubber hook design is still in a crude form.

Coiling

The process of coiling the wire shank into a helical spring was experimented with after it was discovered that flattening the shank would not give the shank the flexibility needed. The helical spring shank has significantly more length than a straight shank. Since the length is longer this allows for more deflection which creates a more flexible shank.

6.3 Problems and Obstacles

The Product Development team ran into many problems and obstacles this semester. The biggest problem is finding a material and technique that will give the DHT enough strength while still having the right flexibility. The right strength was gained with 1080 steel and enough flexibility was gained with titanium, but a combination of the two has not yet been found. Another problem was gaining

information on the anatomy of a bass and the forces that are put out when a bass feeds.

7.0 Observations and Recommendations

7.1 Sparrowhawk

EnPRO 358 recommends that Sparrowhawk create three different product lines, Pro, Family, and Memento, to capitalize on the largest amount of sales from different target customers as possible. Also, Sparrowhawk should take out advertisements and heavily promote each product line. Finally, Sparrowhawk should do everything in its power to develop its intellectual property, brand name, and manufacturing contracts in order to attract a larger company for acquisition at the end of 5 years.

7.2 Summer 2010 EnPRO

The final day of class, EnPRO 358 sat down and had a discussion on what direction Summer 2010 should take the project. From the business aspect of the project, Summer 2010 needs to keep developing promotional strategies for each product line. Advertisements should be ready to launch when a prototype is put into production. Summer 2010 should acquire quotes from newspapers, radio and TV stations, and magazines for the cost of an advertising slot. Also, more accurate manufacturing and overhead costs need to be developed.

From the product side of the project, there is a lot of work to be done. Research needs to be continued on materials and flexibility techniques. Likewise, more research and testing needs to be conducted on the properties of titanium and the rubber ball technique. Finally, fatigue testing needs to be done in order to compare the DHT to its competitor's hooks.

From the general team aspect, multiple fishing trips should be planned in order to build team chemistry and test mock-ups. The main goals of EnPRO 358 Summer 2010 should be to demonstrate the ability to catch fish on a regular basis with a DHT hook and to go to a manufacturer with a prototype ready for manufacturing.

8.0 Appendices

8.1 Team Information

Team Structure	
Business Development	Product Development
Phillip Lozanoski William O'Toole Kyuho Shin Michael Sowards Shaad Zaidi	Mathew Bednarz Bryan Benjamin Andrew Bonesz Joseph Cicero Nathan Howard Lucas Rodgers Westley Villalobos Alyssa Walther

Shaad Zaidi serves as team leader, while Michael Sowards served as the Business Development Sub-Group leader. Lucas Rodgers and Alyssa Walther served as co-leaders for the Product Development Sub-Group.

8.2 Angler Survey

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

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?

_____

_____

_____

_____

_____

11. Which do you fish with more, baited hooks with live bait or lures?

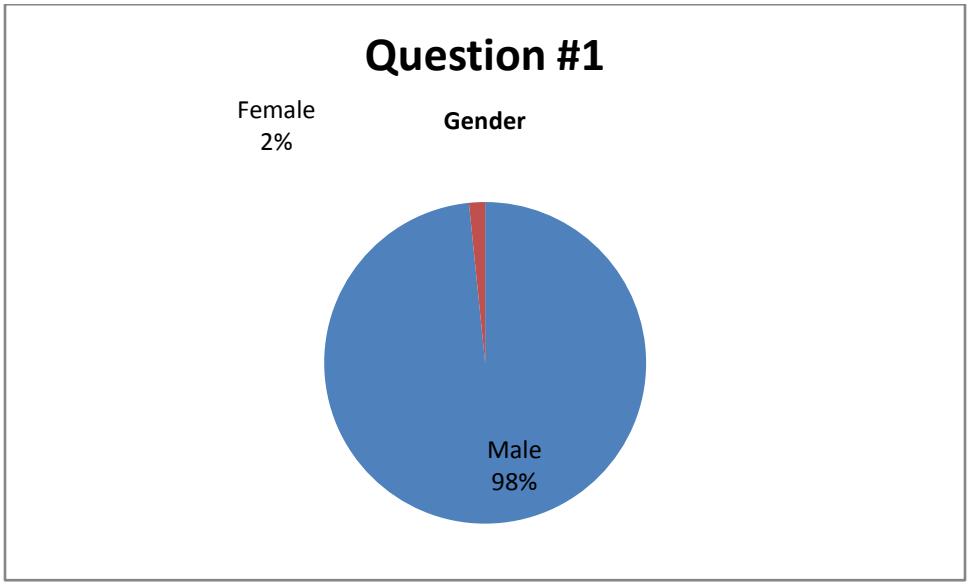
12. What type of lure do you fish with most often?

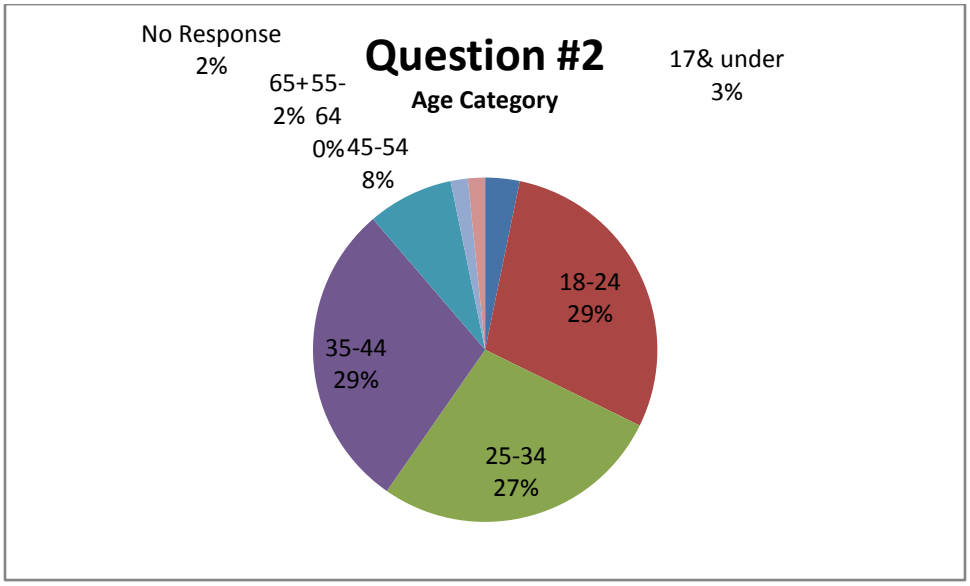
13. Which species of fish do you fish for most often?

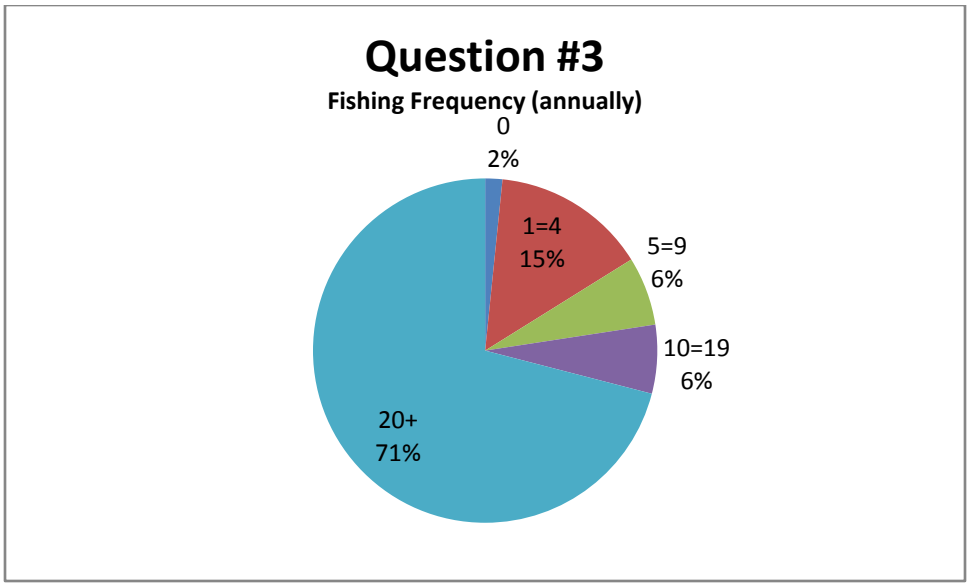
14. How often do you replace the hooks on your lures each year?

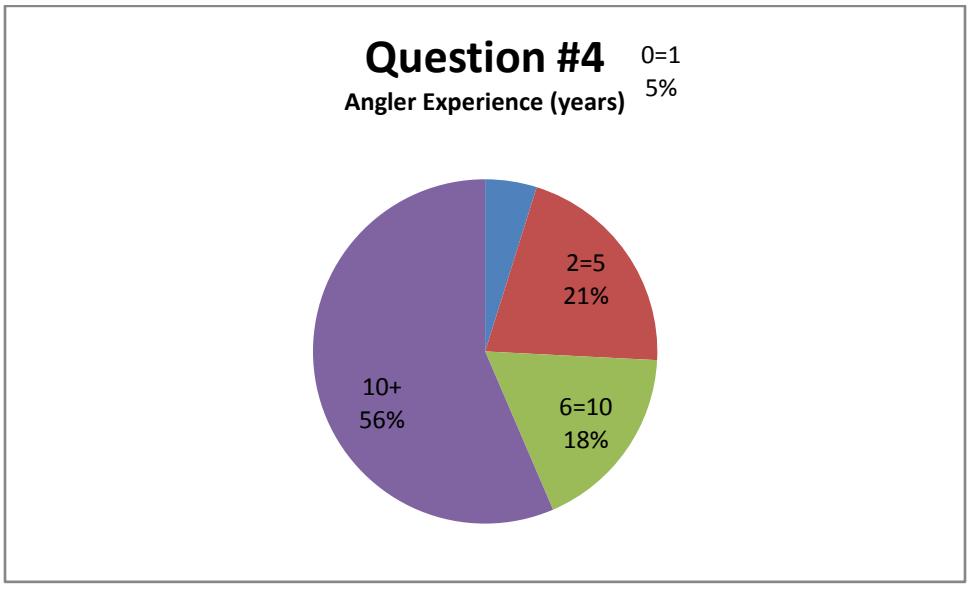
0 1-3 4-10 11+

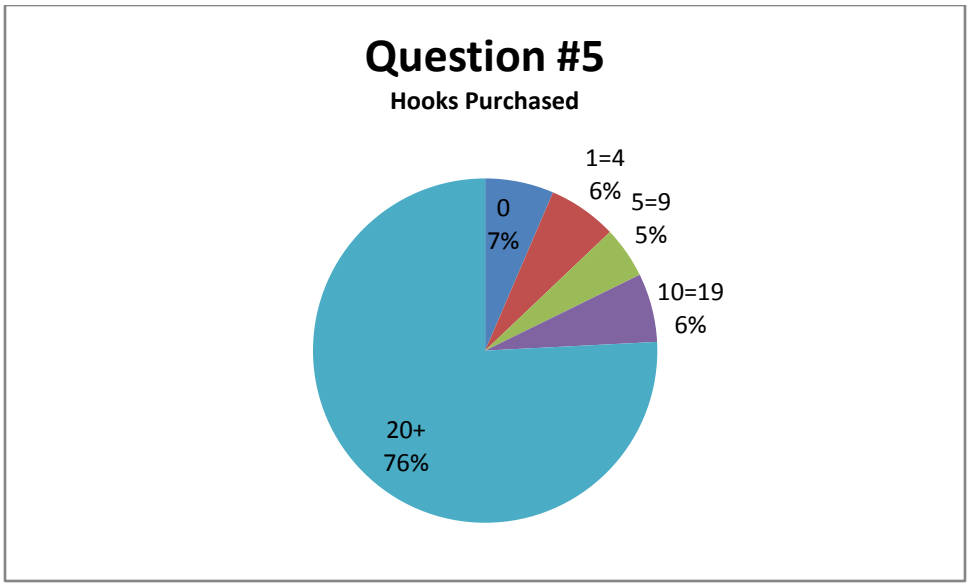
8.3 Angler Survey Results

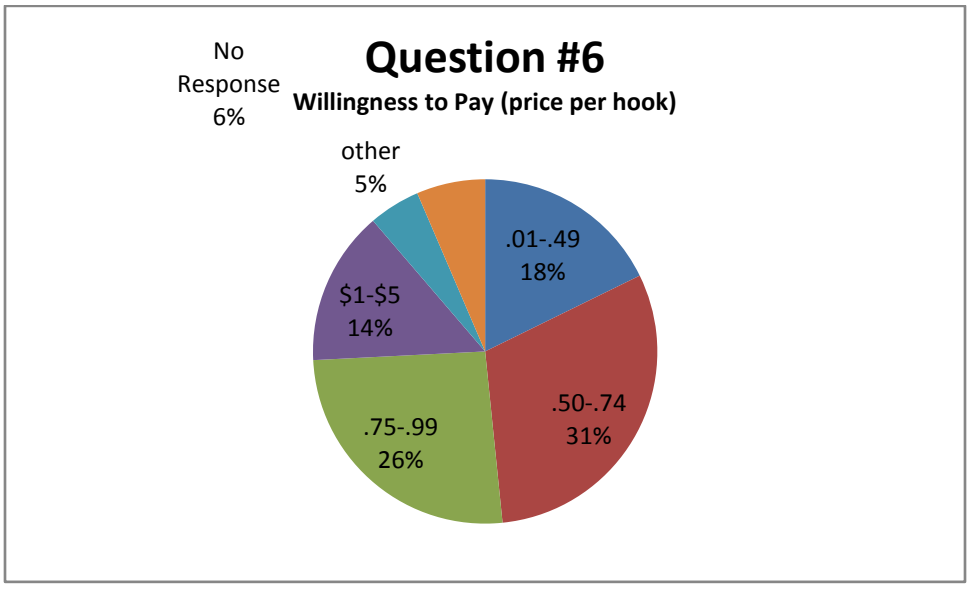


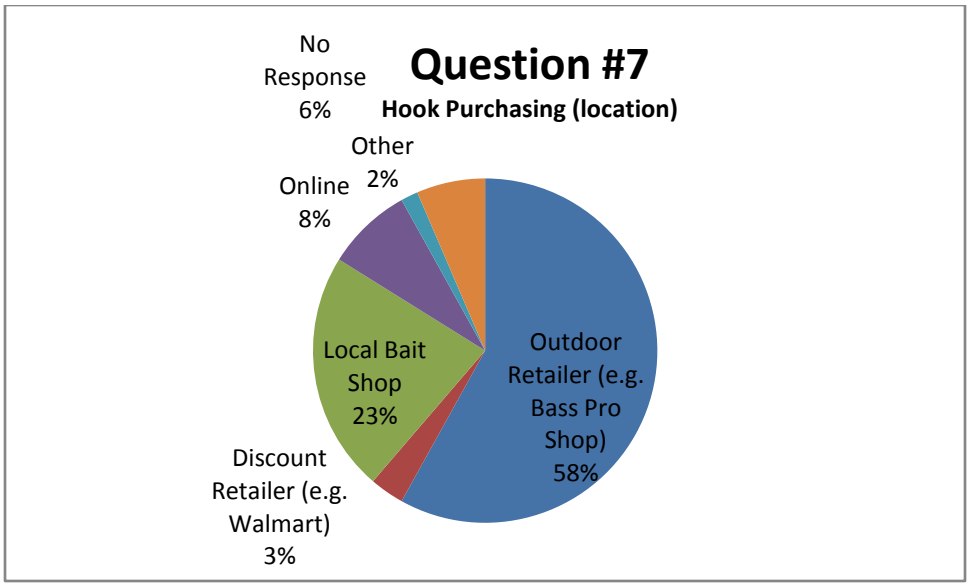


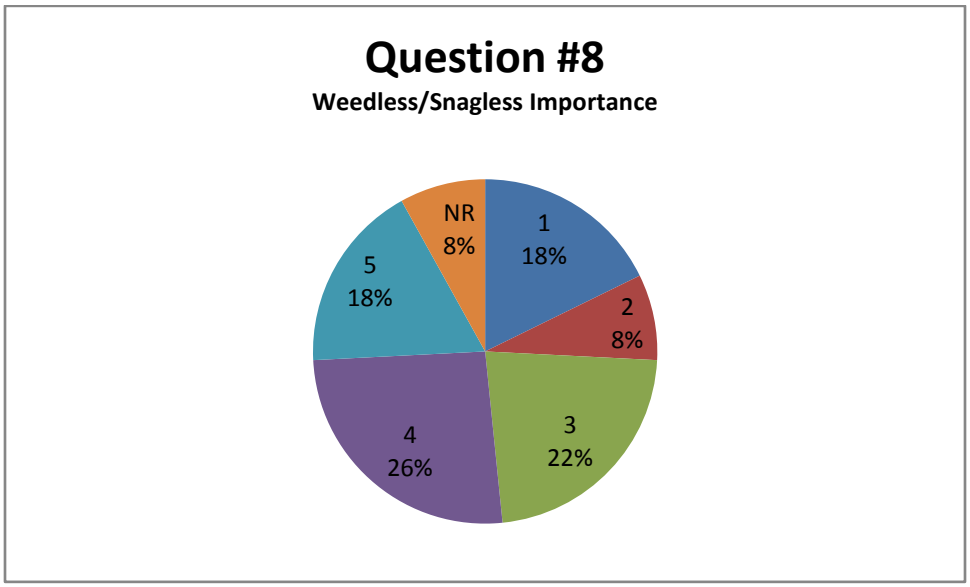

Question #3
Fishing Frequency (annually)
0
2%
1=4
15%
5=9
6%
10=19
6%
20+
71%

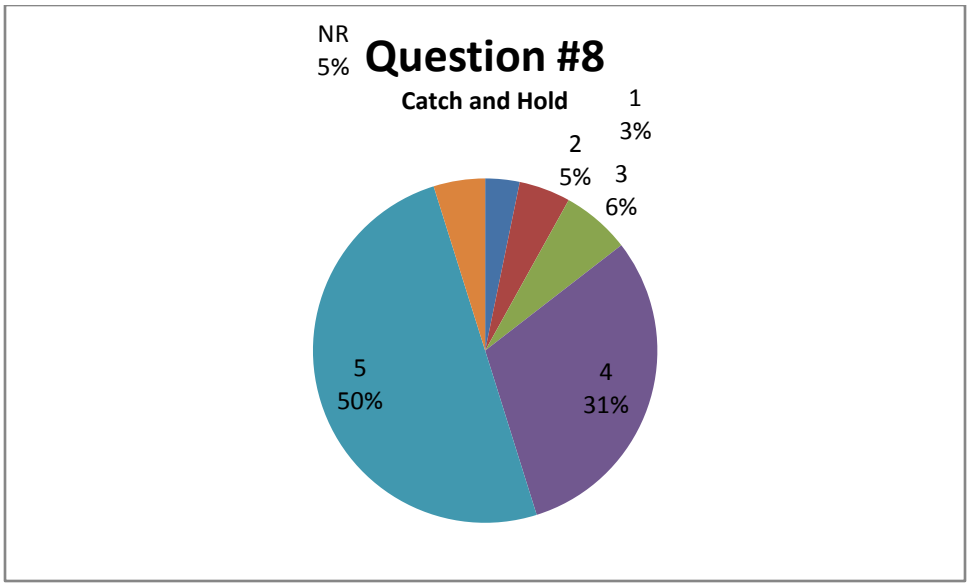

Question #4
Angler Experience (years)
0=1
5%
2=5
21%
6=10
18%
10+
56%

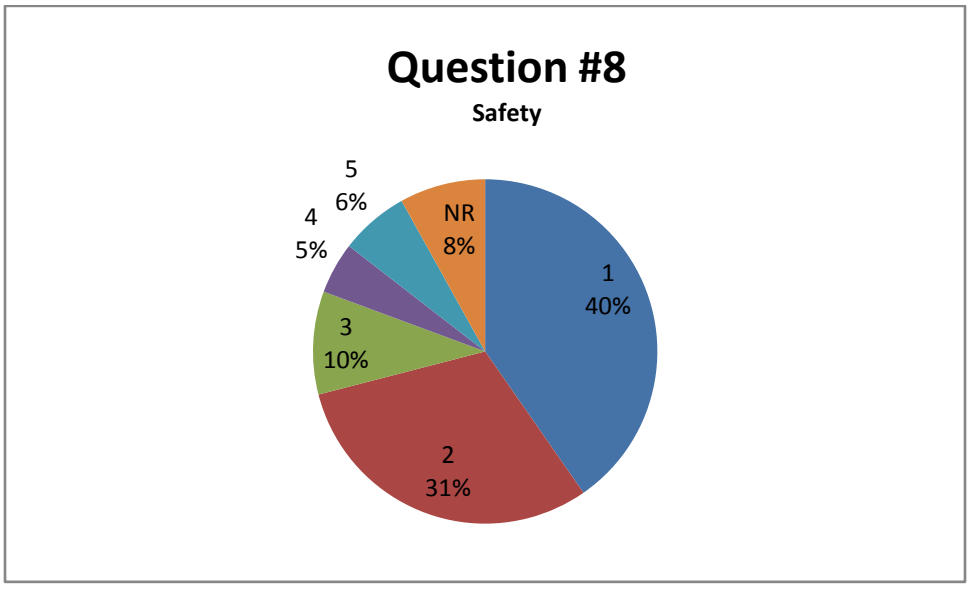

Question #5
Hooks Purchased
1=4
6%
5=9
5%
0
7%
10=19
6%
20+
76%

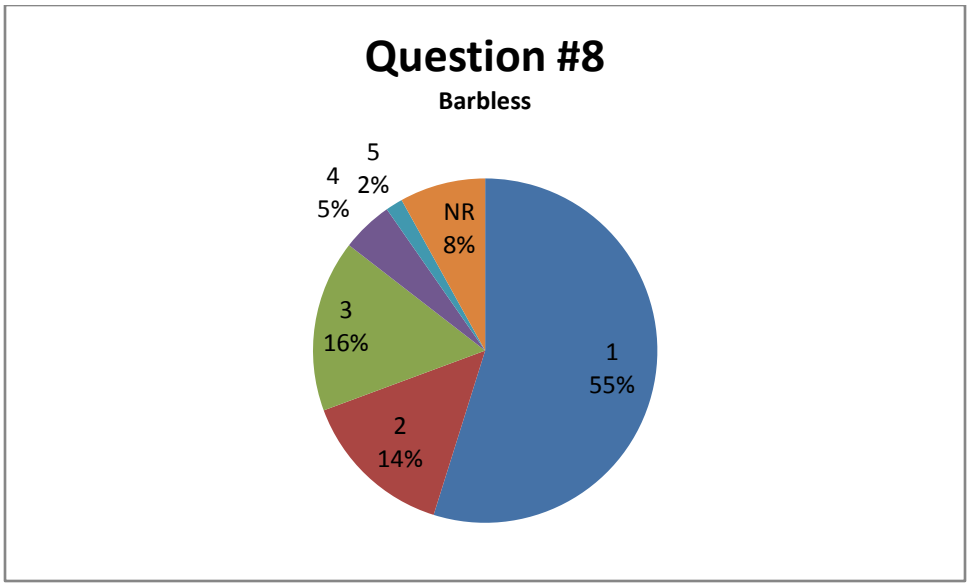

Question #6
Willingness to Pay (price per hook)
No
Response
6%
other
5%
.01-.49
18%
$1-$5
14%
.50-.74
31%
.75-.99
26%

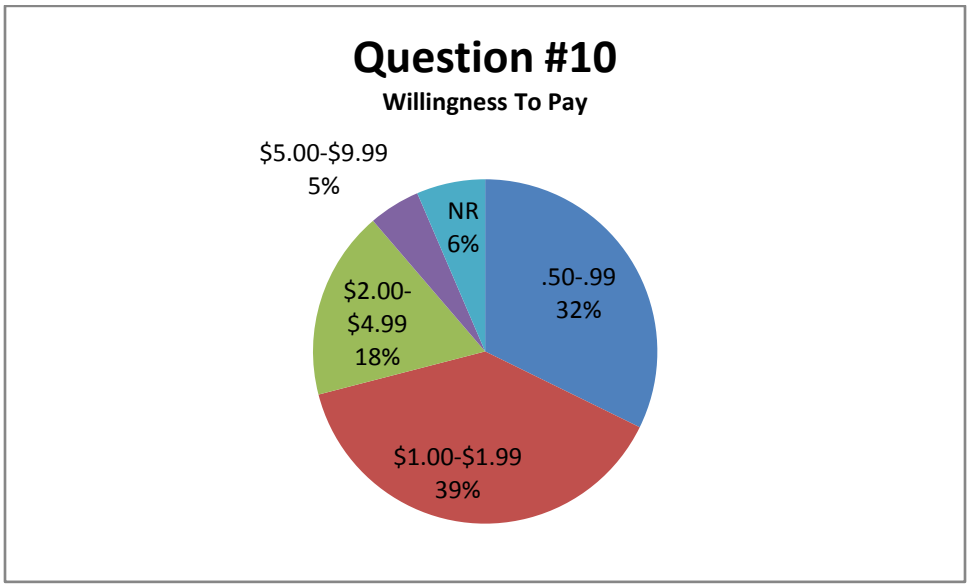

Question #7
Hook Purchasing (location)
No Response 6%
Other 2%
Online 8%
Local Bait Shop 23%
Outdoor Retailer (e.g. Bass Pro Shop) 58%
Discount Retailer (e.g. Walmart) 3%

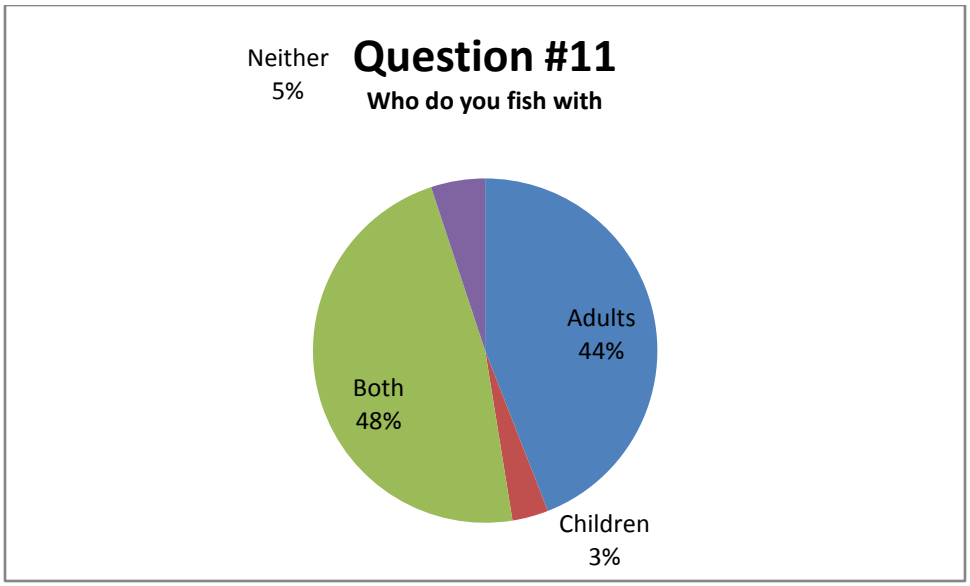

Question #8
Weedless/Snagless Importance
NR 8%
1 18%
5 18%
2 8%
4 26%
3 22%

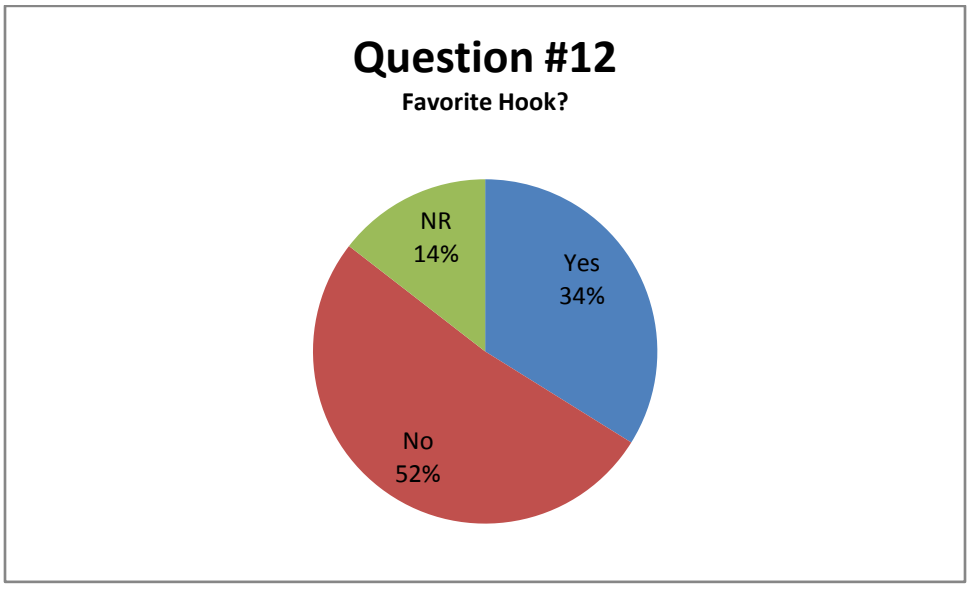

Question #8
Catch and Hold
NR
5%
1
3%
2
5%
3
6%
4
31%
5
50%


Question #8
Safety
5
6%
4
5%
NR
8%
1
40%
3
10%
2
31%

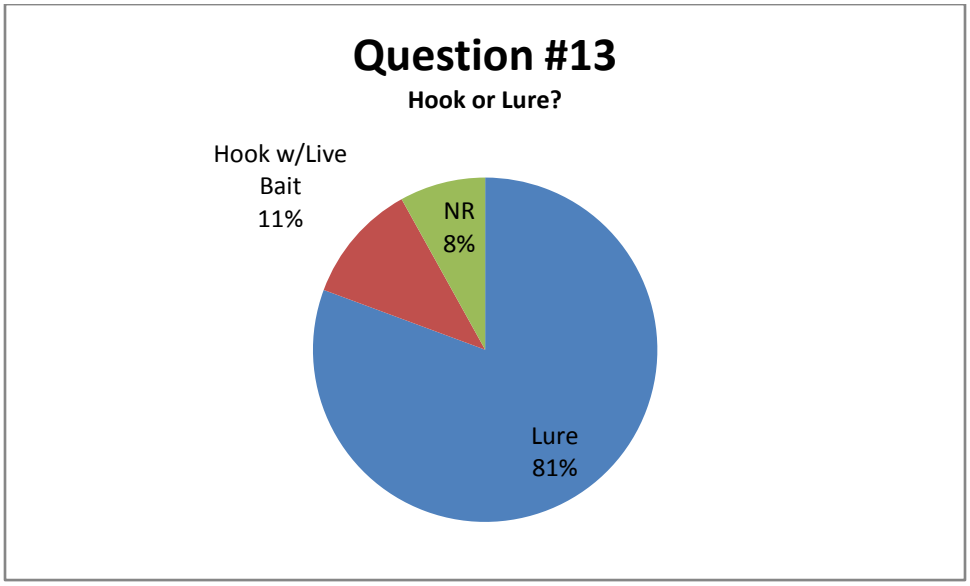

Question #8
Barbless
5
2%
4
5%
NR
8%
3
16%
1
55%
2
14%

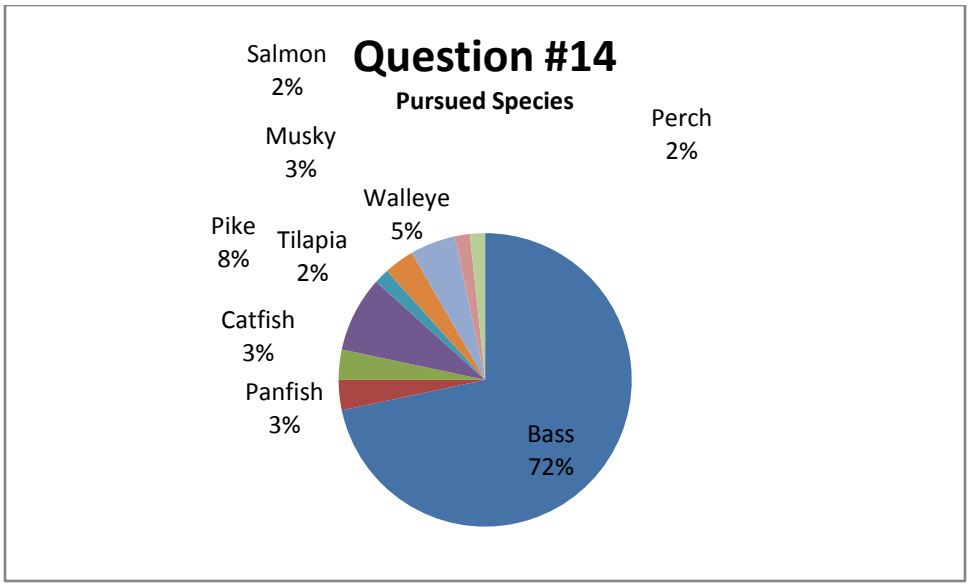

Question #10
Willingness To Pay
$5.00-$9.99
5%
NR
6%
.50-.99
32%
$2.00-
$4.99
18%
$1.00-$1.99
39%

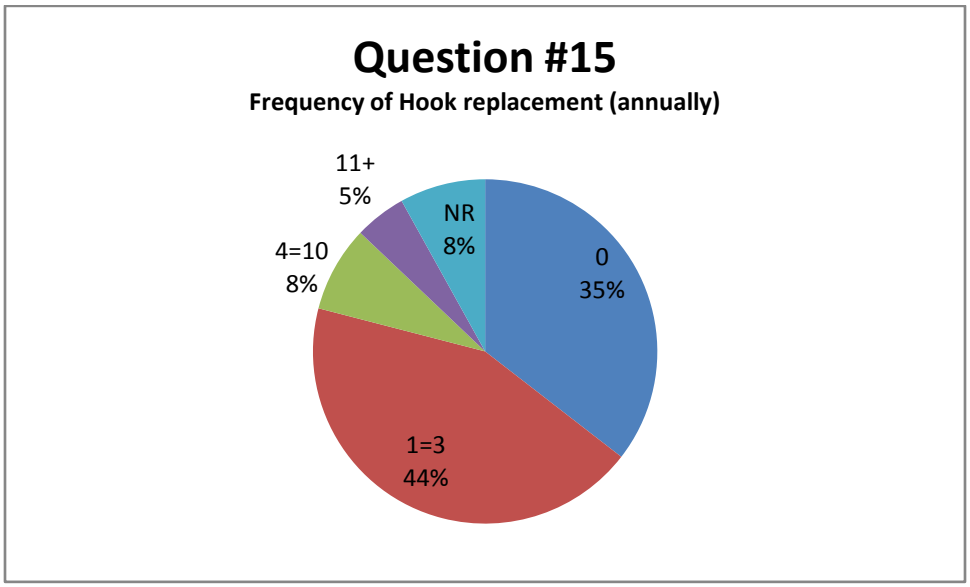

Question #11
Who do you fish with
Neither
5%
Adults
44%
Both
48%
Children
3%


Question #12
Favorite Hook?
NR
14%
Yes
34%
No
52%


Brand Loyalty
Number of Fishermen
12
10
8
6
4
2
0
Gamakatsu
Owner
Mustad & Sons
Falcon K
Eagle Claw
Hook Brand
Fishermen


Question #13
Hook or Lure?
Hook w/Live Bait 11%
NR 8%
Lure 81%

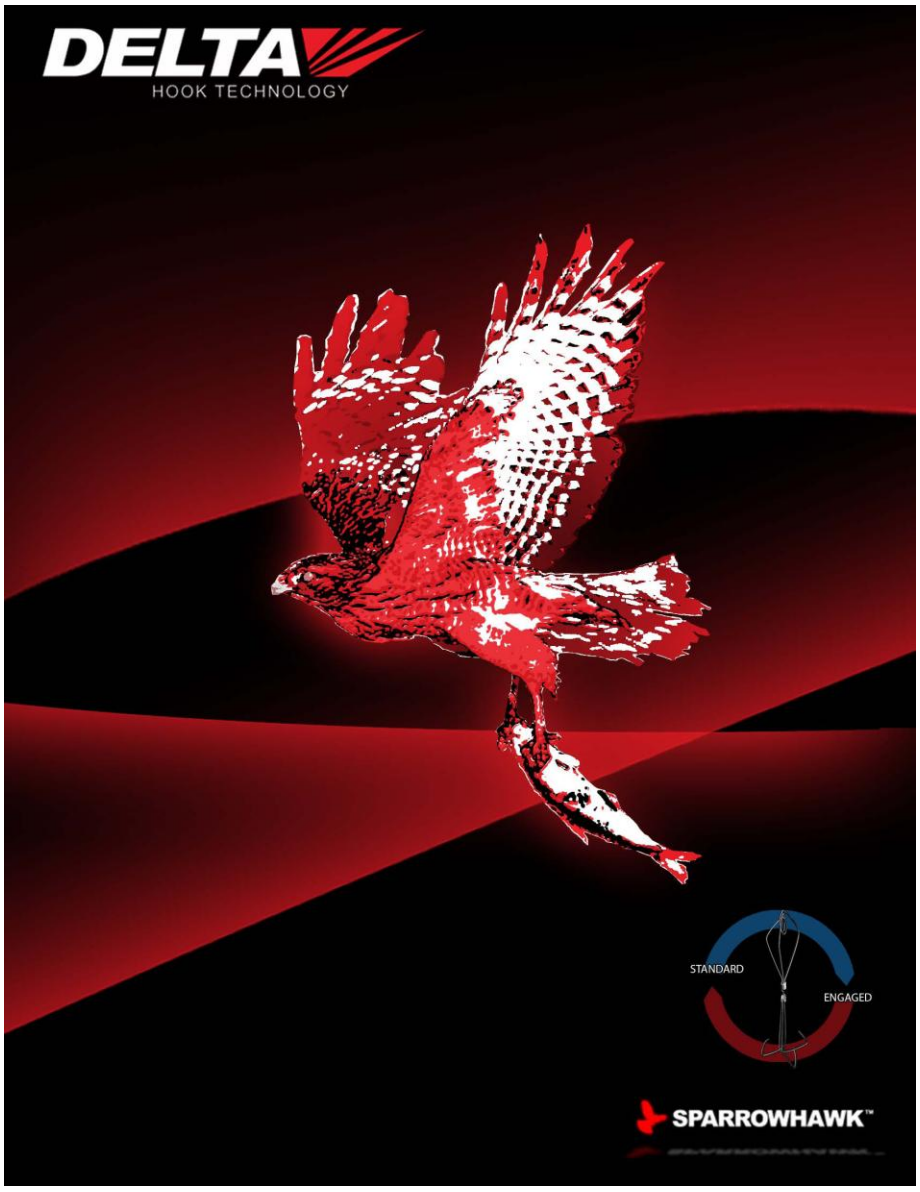

Question #14
Pursued Species
Salmon 2%
Musky 3%
Walleye 5%
Perch 2%
Pike 8%
Tilapia 2%
Catfish 3%
Panfish 3%
Bass 72%


Question #15
Frequency of Hook replacement (annually)
11+ 5%
NR 8%
4=10 8%
0 35%
1=3 44%

8.4 Use of Start-Up Funds

Start-up Expenses	
ICAST	$20,000
Initial Product Manufacturing	$5,500
Advertising	$20,000
Professional Fees	20,000
Dues and Subscriptions	$2,000
Website Development	$8,000
Total	$75,500

8.5 Packaging Image



8.6 Material Cost Table

Features	1080	Ti-6al-4v	Ball 1080	Ball Ti-64	Spring
Wire	0.024	0.72	0.024	0.72	0.09
Brass Crimping	0.042	0.042	0	0.083	0.042
Gum Rubber ball	0	0	0.25	0.25	0
Cost	0.0655	0.7615	0.274	1.053	0.1315

8.7 Sales Projections

Sales Forecast			
	Year 1	Year 2	Year 3
Sales			
Pro	$585,000	$730,000	$915,000
Family	$65,000	$81,000	$102,000
Total	$650,000	$811,000	$1,017,000
Direct Cost of Sales			
Pro	$350,000	$435,000	$550,000
Family	$40,000	$48,000	$61,000
Total	$390,000	$483,000	$611,000

8.8 Promotional Images

8.8.1 Pro

8.8.2 Family

8.8.3 Memento