AN ANALYTICAL APPROACH TO LIKELY SOURCES OF DISTRIBUTION FOR A HYPOTHETICAL TUNA FARM BASED IN HAWAII

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Introduction

When it comes to pristine water quality, few regions on the planet are able to boast that their waters are cleaner or are more pristine than those found around the islands of Hawaii. Access to deep water is not far from land; while access to either the North American or East Asian markets is a relatively quick plane ride away. These are just a few of the many reasons why Hawaii is an ideal setting to found the world’s first commercial, full life cycle ahi tuna farm. Among the many daunting tasks of making such a farm a reality is knowing exactly where, or more importantly, to whom should captively grown, Hawaiian tuna be sold to? While the Hawaiian market itself is a natural jumping off point, the small size and lack of major growth prospects found within such a market require a more geographically diversified approach to creating a profitable marketing and distribution scheme (McConnell, et al. 1998, 12). This paper will examine not only the geographical tuna sashimi markets of Hawaii, Japan and the United States, but will come to a definitive conclusion and ultimately, a recommendation as to what distribution channel within said regions are most likely to generate maximum revenues for a fledging tuna or ahi farm based in Hawaii. This recommendation will come after careful analysis of each market, their distribution mechanisms, their potential or actual growth prospects and the ability to readily consume such a product. It should be noted that in addition to the usual written sources, this paper relies heavily upon the opinions and thoughts of industry experts both in Hawaii and on the United States mainland in order to get both an academic view of the seafood distribution mechanisms in place, as
well as to gain a first hand glimpse into the industry as told by those who are currently making a living from within it.

_Ahi Characteristics_

Before a recommendation can be made as to which distribution network should Hawaii grown, captive tuna be sold into, some background information on the subject needs to be presented. This will begin with the fish themselves. Tuna are placed within the family, Scombridae, of which there are approximately fifty individual species, including mackerels and bonitos, in addition to tuna. Within the Scombridae family, there is a tribe called Thunnini, which contains the 19 species that are normally considered by academics to be “tuna” (Block and Stevens, 2001). Finally, the genus _Thunnus_ is consisted of those tuna which the average consumer can refer to by name. These include albacore, bluefin tuna (of which there are three distinct species), yellowfin tuna and bigeye tuna. While the northern Pacific bluefin tuna (_Thunnus orientalis_) is known to traverse the waters near Hawaii for portions of the year, the yellowfin (_Thunnus albacares_) and bigeye (_Thunnus obesus_) tunas are the only members of the genus _Thunnus_ that are considered to be true residents of Hawaiian waters. It is these two species that this paper will mostly be concerned with, and even then, only one will be chosen as the most viable species to farm and thus will be considered the most profitable candidate for captivity.

In the Hawaiian language, the term _ahi_ translates directly to “fire,” but is also the term commonly used for both bigeye and yellowfin tuna. This is probably due to the fact that both fish are fairly similar in physical appearance and that both of these fish have a
brilliant yellow coloration along their flanks and fins when pulled out of the water. In addition to similar coloration, both fish have the typical tear drop tuna shape, which is designed to facilitate constant, rapid speed through the water column. The main difference in appearance between these two fish comes from the eyes and fins. Yellowfin have smaller eyes than bigeye (hence the name) and large yellowfin typically have the characteristically large, sickle shaped dorsal and ventral fins. While somewhat enlarged on bigeye tuna, these same fins do not reach the proportions seen on the yellowfin.

![Yellowfin picture from http://www.freedive.net/yellowfin/yellowfin.htm](http://www.freedive.net/yellowfin/yellowfin.htm)

Clearly, the differences between the physical characteristics of each are not great, especially when comparing juvenile fish, as they are almost indistinguishable. Their life histories are somewhat similar, though each species has one very notable difference: While the geographic range of each species is almost identical (inhabiting warm tropical and subtropical locations of every ocean), it is their place within the water column that
allows them to co-inhabit the same oceanic waters with minimal competition. Yellowfin inhabit and hunt in the uppermost regions of the water column (<100m depth), while

**Figure 2 Yellowfin distribution, from fishbase.org**

bigeye in Hawaii tend to hunt in water that is in the 300-500m depth range (Musyl et al. 2003, 152). These forays into deep water are most likely the reason for the bigeye’s increased ocular size. At such great depths there is very little light, thus having oversized eyes would be a distinct advantage for these visually based predators. One final characteristic of note is the fact that both of these species have body temperatures that are elevated well above the ambient water temperature. Basically, *ahi* are warm-blooded, with bigeye being more able to withstand the lower temperatures commonly associated with an increased depth preference when foraging. This form of endothermic regulation will be a necessary piece of information when discussing capture and grading techniques of *ahi*.

There is also a fish called “daruma,” which is often confused with bigeye. Many sources online state that “daruma” is actually synonymous with juvenile bigeye. Local wholesalers, however, disagree (per. comm. Charles Umamoto and Shawn Tanoue). They
claim that the “daruma” has much larger pectoral fins (the size of albacore pectoral fins) than bigeye and are often caught around the local buoys in Hawaii. The meat of the “daruma” is also reputed to deteriorate much quicker than that of real bigeye; a trait very important to a potential tuna farmer. It turns out, however, that “daruma” are indeed juvenile bigeye tuna and their presence in broodstock capture should not be deterred (pers. comm. David Itano of JIMAR Pelagic Fisheries Research Program at UH Manoa).

Aquaculture

Aquaculture is simply defined as the culture of marine organisms. These organisms can be in freshwater or saltwater and can be anything from plants and algae, to shellfish or finfish. Aquaculture is becoming more and more prevalent each year and is often viewed as one remedy for the depleted state that the world’s fish stocks have become. As the world’s human population grows and the natural fisheries decrease, aquaculture is expected to take up much of the slack. In fact, according to the Food and Agriculture Organization of the United Nations (FAO), only 25% of the world’s fish stocks are considered to be either underutilized or moderately utilized. Additionally, from 1970 to 2000, worldwide aquaculture production has grown at an average annual rate of 9.2% each year (Ottolenghi 2004, 40)! There are few industries that boast such phenomenal global growth over such an extended period of time. Each year, species that were previously considered to be “impossible” to captively rear are now entering the realm of possibility (including mahi mahi, seabream, cobia, etc.) and tuna are one such group of fish. As stocks of these already expensive fish continue to rapidly decline, aquaculture is perfectly poised to take up the slack. New technologies are rapidly coming
online at an ever increasing pace and Hawaii will be at the forefront of captive tuna culture.

Bigeye or Yellowfin: Which Species Reigns Supreme?

When the word ahi is mentioned in reference to tuna, there are two species of fish that could be implicated. Would an aquaculture farm grow both types of fish at the same time, would they grow them separately or would they focus on one species? The answer can be a complicated one; however, most likely a tuna farm would specialize in one species. For the sake of this paper, it will be assumed that both yellowfin and bigeye are cultured in the same manner (as both fish have fairly similar life histories and cultural needs, this assumption is not without merit); therefore the cost of growing each species are expected to be the same. Under these circumstances, the fish that consistently sells for the highest price and is consumed at about the same rate (or has the potential to be consumed at the same rate) should be the fish that an ahi farm should focus on.

In their analysis of tuna auction prices at the Honolulu Fish Auction, McConnell, Strand and Curtis (1998) found that yellowfin and bigeye prices did not show any great variation. In fact, they even go so far as to say that yellowfin and bigeye tuna in Hawaii can be considered substitutes, thus making the process of dubbing the title "supreme ahi" to one fish or another difficult, at best. Their analysis, however, was conducted by combining all grades of meat (more about grading will be discussed later) from both species and lumping them together. During their study, McConnell et al. also found results showing that during one of the years when data were collected, yellowfin and albacore (the third species being tested for substitutability and one that is not usually
considered to be of sashimi quality) were positively correlated with regards to price, thus confirming substitutability between albacore and yellowfin. At the same time, however, bigeye prices were found not to be affected by the other two species in the study, therefore showing a conflicting non substitutive relationship between yellowfin and bigeye (McConnell et al 1998, 22). Ultimately, McConnell et al. concluded,

“Results from a market level analysis of the auction suggested that it is perhaps more useful to evaluate market demand for tuna on the basis of the grade of fish and not on a species basis as is typically done.”

It would seem that the substitutive quality between bigeye and yellowfin does not hold for high grade sashimi, however, as this paper is examining only sashimi grade tuna, the analysis from McConnell et al. (1998) can not be used as a definitive source about which species of fish will sell for a higher price. Additionally, the data from their analysis was collected during the summer, a time during which Hawaiian bigeye prices are typically depressed due to the poor quality of the meat during this part of the year. The authors do acknowledge their information deficiency and state that a year long survey of data would produce more relevant results by accounting for seasonality in both supply and worldwide demand. With all the deficiencies in their data, why even bother with this paper at all? The paper by McConnell et al. (1998) is a good jumping off point when comparing these species because, as a whole, both fish sell for a similar price when aggregated together across all grades. Basically, if the Hawaiian tuna farm grows fish across all grades, it probably does not matter, according to McConnell et al. (1998),
which species is being grown because both fish will sell for approximately the same price across all quality grades. This scenario, however, is not one that a farm owner is likely to strive for. Growing tuna is expensive, therefore, the ideal price target for such a fish will likely be equally high, thus necessitating production of high grade meat. Also, if all the fish are grown in the same water, fed the same food, allowed to grow for the same amount of time and are harvested in the same manner, it is likely that the meat of all the fish will be fairly consistent between individuals. Therefore the vast majority of fish harvested should be graded fairly equally; though whether or not they are consistently of high or low grade is another matter completely. It just means that having a plethora of different meat qualities between fish is unlikely, therefore, when analyzing the market, meat quality is a very important determinant of price that needs to be included when comparing species. This is consistent with the conclusion that McConnell et al. ultimately reached and gives credence to why their paper is relevant in this one. More information, however, will be needed to determine which species of fish should be the focus for the Hawaii based tuna farmer.

A more long term study done by Bose and McIlgorn (1996) concluded that yellowfin and bigeye, “could be appreciated as substitutes for each other,” within the Japanese market. This was the conclusion reached by analyzing Japanese market prices for yellowfin, bigeye and albacore from the years 1975-1994. Unfortunately, the prices were for frozen tuna, typically a lower grade of fish. Since the paper does not specify whether or not frozen means “super frozen,” it is likely that this tuna was merely frozen by conventional means (super frozen tuna can still be used as sashimi grade tuna, though it still sells for a slightly lower price than fresh fish) and was destined for either canning
or cooking, both of which are significantly different end products from sashimi. The Bose and McIlgorm (1996) paper again shows the substitutability of lower grade bigeye for lower grade yellowfin, however, the goal of the Hawaii based tuna farm is to generate a high grade product that will ultimately be used in the medium to high grade sashimi markets.

The data that McConnell, et al. use (1998) is taken directly from another paper that precedes it, entitled “Quality and Product Differentiation as Price Determinants in the Marketing of Fresh Pacific Tuna and Marlin” (Bartram, et al., 1996). Rather than simply lumping all fish together by species and determining a very simplified tuna price scheme, Bartram et al. (1996) differ from McConnell et al. (1998) in that they take into account the different grades of tuna and the meat quality factors that are assigned to each specific grade when determining pricing mechanisms for ahi in Hawaii. For example, when discussing the sashimi pay scale, Bartram et al. (1996) mention the fact that the levels of money paid for sashimi tuna are highly variable, ranging from “medium” grade all the way up to the “obscenely expensive and premium grade(s).” They then go on to discuss some of the qualities that define premium grade sashimi, “Discerning consumers prize tuna muscle that is bright red and translucent. Sashimi tuna with high oil content (toro) has a rich, ‘melting’ taste.” A high oil content fish is another way of saying that the tuna meat has a high fat content and is a particularly desirable quality when grading sashimi tuna. Higher fat content directly translates into a better tasting fish and consequently, a higher price will be paid for said fish (it should be noted that this is only one of several characteristics that increase the price of tuna, though it is a very important one).
Tuna Taste Preferences

Bigeye are known to have a higher fat content than the typically lean yellowfin tuna, thus are the preferred species of the highly discerning consumer, after bluefin (Bartram et al. 1996, 11). The Tokyo market definitely has a distinct preference for the higher fat content of the bluefin and bigeye over that of the yellowfin, therefore, yellowfin is discounted accordingly at the world’s largest fish market, Tsukiji. In fact, yellowfin is often not available at Tsukiji because of this. Since Tsukiji serves Japan’s largest urban center, it is often seen as a world price leader and trend setter of seafood across the globe (Sonu 2007, 16). Many of Tokyo’s favorite seafood trends are quickly picked up by the rest of the world and the preference for fatty tuna is no exception.

Several sources cite that the Hawaii market is very akin to Tsukiji in Tokyo with respect to its grading and preference and demand for fatty tuna (Bartram, et al. 1996, 19 and Pan, and Pooley 2004, 4). While yellowfin is a very common species to see on dinner plates in Hawaii, bigeye is the local species of tuna that is preferred at high end restaurants. Ex-vessel prices for bigeye in Hawaii will command a price premium of approximately $1.00/lb for those fish at the upper echelon of fat content (McConnell et al. 1998, 7).

Consumers in the United States also prefer the fattier flesh of oily fish, as seen with their preference for bluefin and bigeye over yellowfin at high end restaurants. This sentiment is backed up by high end American sushi chefs who have been known to substitute bigeye for bluefin when it is not available or out of season (Issenberg 2007, 15). In fact, tuna with high fat content are preferred so much at high and medium end retail sashimi venues, that a food writer by the name of Jeffery Steingarten states, “Boasting of
*ahi* (referring to yellowfin) on a menu is like featuring USDA Commercial grade beef at a steakhouse” (Issenberg 2007, 22). Americans in general prefer fatty fish, as seen with their ever increasing demand for salmon and farmed catfish.

To complicate matters, the same fatty, marbled meat that makes bluefin and bigeye so desirable in the Tokyo and American markets, makes these same fish somewhat undesirable in markets that prefer the lean, almost fat free quality of yellowfin meat. This is typified by the Kansai region or western part of Japan; including Kobe, Kyoto and Osaka (Bestor 2004, 197). Therefore, in these regions, yellowfin is the most desirable fish. If selling a product to Kansai, fat free tuna is certainly most likely to fetch the highest price. However, since this area in Japan is smaller than the Tokyo market, in terms of population, the Kansai’s preference for lean tuna is more of a side note, showing that there are regional preferences for food in different parts of Japan, not unlike the United States. Additionally, the most expensive yellowfin in Kobe will always sell for less than bluefin or bigeye in Tokyo.

**Ahi Pricing Trends**

While the qualities of high end tuna *sashimi* have been determined to favor bigeye, are Japanese consumers willing to pay a premium for such a fish? In short, yes. As the following two graphs show, there is a premium paid for bigeye tuna, on average, over yellowfin. Figure 3 shows the differences in prices being paid in Japan for different tuna species from 1975-1995, while figure 4 covers tuna prices from 1996-2003.
Figure 3- Monthly Average Prices of Bigeye, Yellowfin and Albacore from Jan, 1975 - Nov, 1994 (Bose, McIlgorn 1996, 11)

Figure 4- Annual Prices (yen/kg) of Sashimi Grade Tuna In Japan (1996-2003) (Catarci 2003, 41)
Clearly, pound for pound, the Japanese market will pay a premium for bigeye tuna. As bigeye tuna has more desirable characteristics to its meat (such as increased fat content), this premium seems justified. The American market, however, tells a somewhat different tale. The following two figures show average prices paid and volumes of each species over a four and a half year period, ending in July, 2007.

**Figure 5- US Import Volumes and Prices of Fresh Bigeye (FFA, 2007)**

![Graph showing import volumes and prices of fresh bigeye over time.]

**Figure 6- US Import Volumes and Prices of Fresh Yellowfin (FFA, 2007)**

![Graph showing import volumes and prices of fresh yellowfin over time.]

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Starting in the middle of January, 2004 and continuing through July of 2007, bigeye tuna tended to command a price that oscillated around $7.50/kg or $3.41/lb. Before bigeye reaches this price target, it was selling around the $7/kg or $3.18/lb price point. Yellowfin seems to sell at a discount to bigeye in the United State, though the margin of difference is very narrow throughout most of the time span covered in figures 5 and 6. Yellowfin also appears to catch up to bigeye in price per kilo during the first half of 2007. This trend probably reflects the fact that most high quality bigeye tuna tends to end up in the Japanese markets, while medium to low grade yellowfin and bigeye are lumped together as "ahi" and sent to the United States. The Japanese palate is much more attuned to the quality of sashimi and tuna in general, while the American palate is not as refined and prefers its tuna to be cooked, thus not requiring a high a grade of tuna, as compared with the Japanese (Bartram et al. 1996, 7 and pers. comm. Howard Woolf of Jana Brands). By taking the top tier of bigeye out of the American market and sending it to Japan, tuna suppliers are inflating both the price and quality of fish being sent to Japan, while simultaneously reducing the price and quality of bigeye in the United States. This likely accounts for the large price differences between bigeye and yellowfin in Japan, while prices for both fish in the U.S. are fairly similar. Since most Americans cannot tell the difference between lower quality yellowfin and bigeye, tuna suppliers have a tendency to send their less premium fish to the United States. At medium and low grades, yellowfin and bigeye begin to take on many of the substitutive qualities discussed earlier in this paper. Essentially, a price premium on higher grade bigeye as compared with a yellowfin is not necessarily applicable to the American market because: 1. for the most part, high grade fish are not being consumed in the United States, and 2. medium and low
grade bigeye is consumed in conjunction with similar grades of yellowfin and are often sold under the name “ahi,” no matter which species is being sold.

The lack of a price premium for bigeye in the US market, however, is a blanket statement. There are restaurants in sashimi savvy markets that will pay for a higher grade fish. “The Sushi Economy,” by Sasha Issenberg, profiles one chef in Austin, Texas who uses bigeye tuna as a substitute for bluefin tuna when he cannot get it. In fact, that same chef claims that approximately one third of his sashimi revenue is derived directly from high grade tuna. Issenberg also claims that during the mid 1990’s, the American consumer became much more discerning and began paying higher prices for top grade tuna. He also claims that in recent years, as much as 90% of the North Atlantic’s bluefin tuna catch has been destined for domestic markets; rather than Japan; as has been the case for decades. Since bluefin tuna get to claim the title of the world’s most expensive fish, clearly there is a more educated and discerning market base that is growing in the United States, and they are demanding high quality fish.

Now, back to the question of whether or not tuna farm should produce bigeye or yellowfin tuna. Considering that both species are the same in terms of cost per pound to produce and that high grade bigeye wins in taste tests, it would seem that bigeye has beat yellowfin. In the Japanese market, this is true. However, in the American market medium and low grade bigeye are indistinguishable from their yellowfin brethren and even show a high degree of substitutability in terms of price paid when viewed purely on a species to species level. In fact, the American market as a whole does not pay a premium for bigeye tuna; therefore, it would seem that yellowfin is gaining some ground in terms of being crowned, “supreme ahi.” Again, it should be noted that the farmer in this analysis will
have a goal of producing high grade fish. This fish will command a price premium in Japan and will probably do the same in select markets around the United States. Additionally, a high grade sashimi product will need to have a higher fat content in order to win the category of taste. Even if the American market were to pay the same price for both fish, the cost for producing both types of ahi is the same, thus neither fish has any revenue disadvantage. The mere fact that bigeye tastes better than yellowfin would also be the foundation for a potentially successful marketing campaign to differentiate the fish in the American market; though this will be discussed further in later sections. As mentioned earlier, the Japanese certainly prefer the bigeye over the yellowfin, as signified by the price premium being paid for bigeye, as well as the fact that yellowfin are rarely auctioned off at Tsukiji, the world’s largest fish market. These conclusions point to the bigeye as the tuna that should be focused upon by the Hawaii based tuna farmer: they cost the same to produce, they win in a taste test for most consumers, and bigeye are more expensive in Japan and possibly in the United States.

A quick aside, worthy of note when discussing the potential superiority of bigeye over yellowfin is that bigeye have the ability to dive down into deep water (approx. 500m, ambient temp. approx. 5°C) and stay there for extended periods of time while foraging for food (Brill et al. 2005, 3). Yellowfin, however, tend to stay in much shallower water when foraging and return to warm surface waters much quicker than do bigeye. Not only is water temperature a limiting factor for yellowfin, but so are oxygen levels because bigeye are not nearly as limited by low saturated oxygen levels in the water, as are yellowfin. Basically, bigeye can maintain a higher body temperature in colder water and are able to withstand low oxygen levels much better than can yellowfin. Why is this
important to a tuna farmer? It shows that bigeye probably have a lower metabolic rate than do yellowfin, thus bigeye are more conservative with their energy output, metabolically speaking. This means that it is likely (though not proven) that bigeye require less food to grow than yellowfin. Using a von Bertalanffy growth rate, it is possible to see similar growth rates for wild caught specimens of both species after two years; with yellowfin achieving a length of 98.344cm and bigeye growing to 94.29cm (Sun, 2001 and Lessa, 2004). See Appendix C for exact calculations and for the explanation of the von Bertalanffy growth equation. Less food for the same amount of growth (holding all other factors constant) allows a farmer to grow bigeye tuna for less money than a yellowfin, thus clinching the status of bigeye as “supreme ahi.” Remember, this theory is mere conjecture and has not been proven under scientifically controlled conditions. Since, however, this theory may save money for a tuna farmer, it should be included within the confines of this paper and then tested in the future for veracity.
Industry Trends and Techniques

Bigeye Grading Techniques

A lot of mention has already been made regarding grading of tuna. It is only appropriate then, that modern techniques for determining tuna meat quality be discussed here. Basically, there are three influences which can affect meat quality:

1- Nature. What a fish eats in the wild can affect flavor. Also, different species of tuna have different flavors and different meat consistencies. How often a fish eats and how hard a fish has to work in order to capture food or escape predators will also affect the composition of fat and muscle. What time of the year a fish is caught can have an effect on meat quality because different water temperatures and seasonal spawning activity have a strong influence on fat content of the flesh. For example, bigeye caught in Hawaii during the summer tends to sell for less money than those caught and sold at other times of the year. This is simply because the flesh quality of bigeye tuna caught in Hawaii during the summer decreases (Bartram et al. 1996, 28). In fact, Pan and Pooley (2004) estimate that for each degree of sea surface temperature increase (Fahrenheit), prices paid for bigeye caught in Hawaii decrease by $0.21. One hypothesis for this is that the warmer waters of summer cause the fish to lose much of their fat content. These tuna could be finding less food, spending more energy on spawning or simply do not need to accumulate fat stores for various other reasons.

2- Handling of captured fish. A high quality tuna with the potential to be sold at high prices on the market can quickly become worthless if it is handled incorrectly. This holds
true for every stage of the distribution process, from capture all the way down to consumption by human beings in a restaurant.

As mentioned previously, tuna have some degree of endothermy, thus they are able to raise their internal body temperature to a point that is much higher than their surrounding environment. For example, continuously swimming bluefin tuna (*Thunnus thynnus*) are able to maintain a body temperature that is up to 21°C or 69.8°F above ambient water temperature (Block 2001, 326). In nature, this elevated temperature serves to keep the brain, eyes and muscles in a constant state of readiness in order to capture prey and/or flee from predators. This same warm-blooded characteristic is found in some sharks, as well as billfish, and can actually work to significantly decrease the value of tuna meat being sold on the market. This is because as a tuna works itself into a frenzy, it can actually raise its body temperature so much that the flesh actually “melts” or becomes “burnt.” Core temperatures of captured tuna have been recorded at 38°C or 100.4°F (Williams 1986, 34)! Combine these high temperatures with large quantities of lactic acid and “burnt” tuna flesh actually appears to be cooked. Poor quality meat derived from high internal core temperatures is called *yake* in Japanese (Williams 1986, 34). The difference between *yake* and normal meat can be seen in the photograph depicted in figure 7.
Capturing tuna in the most stress free manner is the best way to avoid yake meat and different fishing techniques can bring in different market prices due to the amount of stress that each method induces. The faster a fish is brought to the boat and killed, the higher the potential market price will be. Quick killing techniques, called shime in Japanese, are essential in maintaining the quality of the meat (Williams 1986, 34). This is done by quickly bringing the fish the to the boat, coring or spiking its brain instantly and then running a metal wire along its spine to ensure that electrical signal misfires in the muscles are not taking place after the fish is dead. These misfires can cause muscle spasms and contractions, even after the brain has been removed, thus keeping the body temperature high. The fish is then bled in an effort reduce body temperature and increase the shelf life of the meat. Finally, the innards are removed and the fish is put into an ice slurry right away in order to bring the body temperature of the fish down to 0°C (Williams 1986, 41). This temperature is considered just right, as 0°C is as cold as the
fish can possibly be without actually freezing and is the temperature at which the fish’s core must be stored and sold at. A core temperature much above 0°C will prematurely age the fish, thus decreasing the value of the tuna at market.

Additionally, any blemishes on a tuna will most likely cause the value of the fish to drop. Bruising, skin rips, holes, shark bites, etc. mean that there is a good chance the underlying flesh has been damaged and that the usable yield of meat will be less than it otherwise would be, had it not been damaged. The Japanese are also notoriously finicky about blemishes on their food. To them, the kata or outward appearance of their food must be perfect, as any defects on the outside could signal defects on the inside as well (Bestor 2004, 160). Since perfect kata is what the end user or retail consumer desires, this translates to tuna purchasers that are just as picky about their product. This is why even after the tuna has been captured and processed correctly, care must still be taken not to offend the kata of the tuna. An exact scoring system for the condition of the tuna itself can be found in Appendix A (Williams 1986, 56).

3- Time is the third influence that affects the quality of tuna meat. For fish that are to be eaten raw, timeliness of capture, storage, delivery and consumption is very important. While some sources claim that tuna should be chilled for ten days for the best quality and flavor (Williams 1986), most consumers would argue that if they could, they would eat the fish the same day it is caught! Therefore, to err on the side of caution, the less time taken to deliver a fish to market, the better.

Once all of these handling precautions have been taken and the tuna arrives in the market for either purchase or auction, then it is graded. Bartram et al. (1996) report that there are three observable characteristics that can affect selling price: Species (where
bigeye is more desirable than yellowfin and only less desirable than bluefin), size (where bigger is better) and body defects (pertaining to kata). Then an evaluation of how much shelf life each fish has left is conducted. In addition to looking at the core temperature of the tuna (which should be 0°C) and determining whether or not there are any body defects, characteristics commonly used in the evaluation of how much “freshness” each fish still retains include a review of fishing and handling techniques, as well as a visual and tactile examination of the flesh itself.

The examination of the flesh itself is the culmination of the inspection process and is done in several ways. In Hawaii, a wedge is cut in the tail of the tuna in order to determine its quality and some of the meat is actually picked up and rubbed between a potential buyer’s fingers (Bartram et al. 1996, 14). Expert graders are then able to more precisely predict how much fat is contained within the flesh of the animal through this tactile examination. The visual inspection looks for texture (where firm is better than soft), color (where bright red is better than brown), and clarity (where translucent is better than opaque) (Bartram et al. 1996, 14). Color is often considered the most important visual component of this inspection and a more detailed meat coloration scoring system is presented in Appendix B (Williams 1986, 54). Whole fish also tend to fetch high grades due to the fact that only those fish with suspected defects tend to be headed and gutted. A whole fish signifies confidence in the value of the tuna as a whole and the premium for whole fish in Hawaii is as high as $1.247/lb (McConnell et al. 1998, 7).

Fish size and presentation plays an important role in grading as well. Large fish tend to have more fat in their meat, have larger premium cut yields and have larger loin cuts for the grilling market (Bartram et al. 1996, 12). These characteristics allow a higher
price to be fetched for large tuna on a per pound basis. While relatively unprocessed fish are preferred, each market has their own preferences for just how much is too much or not enough. The Hawaiian market likes their tuna to be whole, while the Japanese market looks for fish that are gilled and gutted. The American market, on the other hand, prefers the head and guts to be removed before being brought to market (Bartram et al. 1996, 12). While small, these differences must be paid attention to in order to get the highest possible price for a product. Sending fish to Japan with no head will lower the per pound price for the tuna and sending a bigeye to the mainland with its head on will most likely be a waste of money that lowers margins because the added weight of the heads will simultaneously increase the price of shipping while decreasing the amount of available space in each cargo container.

After the visual, tactile and fish capture/handling techniques are evaluated, only then can a grade be assigned to a fish. It should be noted that this inspection process (or some permutation thereof) goes on for the majority of fish at tuna auctions all around the world. In Hawaii, grades are numbered 1 through 4, with 1 being the highest and 4 being the lowest possible grade. Grades 1 and 2 are further broken down into + and – categories, so the very best grade of fish is 1+, then 1 and then 1-. Number 2 grade is broken down similarly, while no such breakdown is needed for grades 3 and 4 because they are only good for cooking or canning purposes (Bartram et al. 1996, 17). All tuna graded 1 or 2 is acceptable for raw consumption, either as sashimi, sushi or poke. Most people in Hawaii would probably be interested to find out that their favorite poke probably comes from a fish that is rated at very bottom of the sashimi grade scale (No. 2-). In fact, the inexpensive or previously frozen poke found at most grocery stores is likely to be an even

23
lower quality meat that has been treated with carbon monoxide to preserve the red
coloration as the meat ages (Pan 2007, 5). Figure 8 shows the flesh quality grade
relationships in detail (Bartram et al. 1996, 17).

Figure 8- Tuna grade scale, with the uses for each grade (Bartram et al., 1996)

<table>
<thead>
<tr>
<th>Quality Grade</th>
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<tbody>
<tr>
<td><strong>No. 1</strong></td>
</tr>
<tr>
<td>1+</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1-</td>
</tr>
<tr>
<td><strong>No. 2</strong></td>
</tr>
<tr>
<td>2+</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>2-</td>
</tr>
<tr>
<td><strong>No. 3</strong></td>
</tr>
<tr>
<td><strong>No. 4</strong></td>
</tr>
<tr>
<td>Sashimi</td>
</tr>
<tr>
<td>Poke</td>
</tr>
<tr>
<td>Specialized Cooking</td>
</tr>
<tr>
<td>Cooking</td>
</tr>
</tbody>
</table>

According to Bartram et al. (1996), the only place in the world that will pay full
price for No. 1+ grade tuna is Japan. No other location on the planet will pay as much for
this grade of tuna because of the highly refined palates of high end sashimi consumers in
Japan. Even No. 1 grade tuna usually goes to Japan or stays in Hawaii because of the
limited market in the U.S. for this high quality type of fish. There are, however, only a
handful of sashimi bars and high end restaurants on the mainland United States that
would be willing to pay full price for No. 1 grade tuna. Another problem for a bigeye
producer trying to sell to the mainland United States is that consumers there tend to be
wary of bigeye tuna because of its softer texture. They are used to the harder texture
found in yellowfin, the most common species of tuna consumed in the USA (Bartram et
If you notice in the citations, the quantitative information from Bartram et al. is from 1996 and is most likely somewhat out of date. The popularity of tuna sashimi in America has risen steadily and so have the standards of quality for high end consumers. It is likely that the market for No. 1 bigeye has increased throughout the United States mainland over the past twelve years. This might be true for markets along the west coast that been consuming tuna sashimi for a very long time. In fact, Issenberg (2007) reports that, “sushi is not only in the mainstream of Los Angeles cooking, it is the mainstream.” This long term familiarity with sashimi in California, however, does not necessarily translate directly a desire for high grade fish. Howard Woolf of Jana Brands (Seafood Distributor) in San Francisco believes that the California consumer is more price conscious than quality conscious; as compared with the Japanese (pers. comm.). He also sees the California consumer (thought by many to be very quality oriented with regards to sashimi) possibly lowering their standards because they consistently consume tuna meat that is treated with carbon monoxide, thus giving the false illusion of freshness. These conflicting points of view will be discussed more thoroughly in the section of the paper regarding the American market.

Toro Grades

The term toro is directly translated as “melting,” and refers to the fatty pink belly meat that is highly prized by those consumers who prefer fatty fish (Tokyo, USA, Hawaii). Bluefin and bigeye are known to have this prized cut while the lean yellowfin does not. Good toro commands the highest prices because of its unique melting quality as the fish is placed inside the mouth of a lucky sashimi patron. O-toro is on the bottom side
of the fish and just behind the head and is considered the best cut. *Chu-toro* is slightly less desirable cut from the ventral region of the fish down to the area just below and in front of the tail. The meat from the top half of the fish is much more red in color and has less fat. It is not as tasty as *toro* due to its lean nature and is called *akami* (Williams 1986, 5). Just as with *toro*, *akami* cuts are graded higher closer to the head of the fish.

Maximizing *toro* cuts by creating fatty fish would be the goal of an aquaculture enterprise selling tuna to the Tokyo, American and Hawaiian markets. Aquacultured fish tend to contain more fat than their wild cousins because they are constantly fed high quality feed and do not have chase down their prey or escape from predators. Tuna that do not expend lots of energy swimming around the ocean tend to accumulate fat. Simply feeding the fish excessive amounts of food to fatten them up, however, is not as simple as it sounds. Too much fat will create a flesh that will be mushy and undesirable for consumption. On the other hand, too little fat will create lean, low quality meat more akin to yellowfin than to bigeye. Creating the optimal fish will take time and is not simply a matter of cramming as much food in the fish’s face as possible. A fine balance must be struck when farming fish so that they are plump and not obese. Figure 9 shows fat content of the Amberjack (Kahala or Kona Kampachi®) cultured at Kona Blue Water farms vs. their wild cousins. The pictures of the fish show how much more plump the cultured fish is compared with a fish taken from the wild. The graph also shows the fat content of both fish as a percentage of total body weight. The wild fish has a fat content under 5% by weight, while the cultured fish has a fat content slightly above 40%. A similar occurrence of fatty fish would occur with captive tuna as well. A 40% fat content
by weight, however, might be too high for tuna, thus making the flesh too mushy for either sashimi or for grilling.

Figure 9- Cultured vs. wild caught Amberjack. Courtesy of Clyde Tamaru.

Consumption Trends

Overall, tuna consumption has decreased over the past few years. Bigeye stocks, as with bluefin and yellowfin, seem to have reached their maximum fishing capacity throughout the globe as worldwide catches are on the decline, either because of a lack of fish or because of a reduction of fishing quotas (Globefish, 2007). Worldwide supply of large tuna peaked from 1998-2000 and have been on the retreat ever since (Catarci 2003, 1). Bigeye stocks have declined so much in recent years that TRAFFIC, a wildlife trade
network partially run by the World Wildlife Fund (WWF), came out with a report stating that bigeye stocks are on the verge of collapsing (Evans, 2007). Oversupply during the 1990's worked very efficiently to drive down the prices of bigeye tuna around the world (Josupeit, 2004). Figure 10 shows world bigeye catches increasing until 2000, after which they start to decline. A corresponding decrease in price follows the increase in supply, as would be expected.

Figure 10- The World Market of Bigeye Tuna (Josupeit, 2004)

Figure 11 is a follow up chart that shows the decreasing worldwide catch pattern for bigeye tuna from 2000-2005 (info. from FAO, 2008). While volatility in catch patterns is evident, so is the downward trend in landings over the course of six years. The trendline shows an average decrease of 5,996,200 metric tons (over 13 million lbs) per year over that time period.
While worldwide consumption has been hampered somewhat by lack of supply, overall demand has increased, thus working to drive up prices of several species of tuna very recently. Yellowfin prices are at an all time high around the world, mainly due to the introduction of tuna sashimi into new markets across the globe, even as supplies decrease. As markets such as Europe, Korea, Russia and China become more affluent, they are demanding more sashimi products. As yellowfin is the most inexpensive of the big three sashimi tuna types (bluefin, bigeye, yellowfin), this is a natural jumping off point for new sashimi enthusiasts to begin their journey. In 2001, The New York Times posted an article entitled, “Russians Go Mad For Sushi” (Tavernise, 2001), and espoused the fact that newly wealthy Muscovites are flocking to sushi taverns; so much so that the number of sushi restaurants in the city had quadrupled in from 2000-2001! China is also expected to produce fifty million new sushi enthusiasts over the next several years as their population continually gets wealthier. Tom Asakawa, a trade fisheries specialist, was quoted as saying,
“At this moment, the Japanese pay more for the best products on the market (referring to sashimi). Probably, the Chinese are to pay more than what the Japanese can pay very soon. That means exporters will be looking into the China market, not Japan. Five years from now, Japanese consumers will not be able to eat good-quality sashimi. You’ll have to go to China for that” (Issenberg 2007, 268).

Though both price and supply of sashimi grade bigeye (and other tuna) continues to fluctuate, the demand for these products will be a continuous increase as the world realizes the agreeability of raw fish on both the palate and the waistline.

Japanese Bigeye Consumption

Yellowfin stocks in the Pacific and Indian Oceans have recently been disappointing (Globefish, 2007), bigeye stocks are rumored to be crashing (Evans, 2007) and bluefin stocks around the world are under severe pressure. This situation has recently caused many countries to sign on to drastically curtailed tuna catch quotas that will significantly lower catch levels. These compounded tuna quota restrictions have combined with high worldwide demand to produce a tuna sashimi shortage in Japan that has not been seen in decades. Many sashimi restaurants in Japan are considering replacing tuna sashimi with horse and venison sashimi as a red meat substitute for tuna. Tadashi Yamagata, vice chairman of Japan's National Union of Sushi Chefs, says, "It's like America running out of steak" and "Sushi without tuna just would not be sushi" (Unknown, 2007).
In Japan, bigeye tuna is mainly used for sushi and sashimi (Sonu 2007, 15). While Japan is still the world’s largest consumer of tuna sashimi (devouring 28,604 metric tons or 63 million lbs of bigeye alone), it is thought that the demand for this product has reached a peak, for several reasons. In addition to the conflict of lower supply and increased prices, the younger generations of Japanese are eating less tuna sashimi as they diversify their diet away from raw fish and more towards land based meat (Bartram et al. 1996, 8). As Western food becomes more common place, traditional Japanese foods, such as sashimi, have been pushed aside for burgers, pizzas and fried chicken (Bestor 2004, 150, 155).

Japanese Bigeye Price Trends

During the early 1990’s, the world saw Japan as the primary destination of sashimi grade tuna. As prices were fairly high during this period, a very significant portion of all tuna caught were sent directly to Japan. Excellent worldwide catches of bigeye tuna from 1991-2001 meant that there was a glut of bigeye being sent to Japan from foreign fleets for most of the 1990’s. Additionally, as bluefin were being ranched (a term used to denote bluefin that are caught as juveniles and fattened for a short period of time in net pens) in greater quantities during this period, supplies of this fish were at all time highs. This oversupply of bigeye being sent to Japan, coupled with an increasing supply of a similar product (medium grade bluefin) caused prices for bigeye tuna in Japan to peak in 1994 and then fall precipitously to their current levels (Catarci 2003, 38). Figure 12 shows this trend very well; as Tsukiji prices for fresh bigeye continue to fall
from a high of just under $12/lb in 1996, to more current levels of approximately $6.45/lb in 2006 (Josupeit 2004, 18).

Consumers in Japan are dealing with a desire for inexpensive sashimi tuna, coupled with a severe lack of supply. This is very counterintuitive, as what happens normally with a decrease in supply is an increase in prices. However, the decrease in both price and demand for expensive tuna in Japan is most likely the result of a price correction that is still going on from the 1990’s. Expectations for a good quality product at a low price have effectively served to create a situation in which a fairly elastic product during the 1990’s has become inelastic in nature during the latter half of the 2000’s. In fact, 2006 saw overall tuna sashimi consumption in Japan marked by a 20% reduction over the previous year (Globefish, 2007). This single year decrease in demand for most species of tuna was attributed to increased prices at the retail consumer level (though fresh bigeye consumption increased somewhat).
Figure 12 shows bigeye prices increasing somewhat due to a lack of supply during 2003 and then peaking in 2004 at approximately $7.38/lb (wholesale). Even though prices at Tsukiji fell somewhat during 2005 and 2006, people in Japan were still not willing to pay $6.45/lb (wholesale) for fresh bigeye tuna. It would seem that the appropriate wholesale price for bigeye tuna in Japan is somewhere between the price of $6.11 (the lowest yearly average price that was seen in 2002) and $6.45, the 2006 market price. If this market equilibrium is reached, it is likely that the decline in bigeye prices will come to a stop and the price oscillations that began around 1998 will come to a halt as well. Normal market conditions should prevail in the Japanese bigeye market once again, however, this might never happen as worldwide decreases in the bigeye supply have combined with a rising demand for sashimi elsewhere in world. This coupled with a marked decrease for raw fish by the Japanese consumer in favor of more “western” foods continue to wreak havoc on the predictability of the Japanese tuna market.

Even with the overall trending of the Japanese consumer away from sashimi, demand for fresh bigeye tuna in Japan is still very high when compared with other countries. Figure 13 shows the levels of fresh bigeye consumption over the course of seven years in Japan, with an average yearly consumption of about 507 million lbs (Ferdouse, 2008). Even with the decline in demand, Japan remains as the world’s largest consumer of tuna sashimi (Bartram et al. 1996).
American Bigeye Consumption

The overall sashimi market for the United States is approximately 30,000-50,000 metric tons (66-110 million lbs) per year and considered the world’s second largest market for fresh tuna imports, after Japan. During 2007, more domestic catches of American bluefin were being sold at home due to a simultaneous increase in demand and price which is in stark contrast to previous years where most of the bluefin were exported to Japan. This shows that the high end tuna sashimi market is growing in popularity within the borders of the United States. Fresh yellowfin, however, remains the most widely used tuna for sashimi within this market, accounting for 4,500 metric tons (10 million lbs) worth of imports for the first three months of 2007 alone (Josupeit, 2007).

Most consumers in the United States do not realize there is a tuna that fits somewhere between the expensive bluefin and the more common yellowfin that can be bought at just about every grocery store. This statement is confirmed by the fact that yellowfin and bigeye were only officially separated in the U.S. Customs and Border...
Protection (USCBP) trade database in 2001 (Pan 2007, 10). Assessing the American market for bigeye is difficult, mostly because bigeye specifically has not been an important player in the American market. Figure 14 shows the amount of bigeye imports into the US from 2001 until 2007 (Dept. of Commerce, 2001-2007). The United States has a very modest bigeye consumption rate; averaging only 7,348 metric tons (or 16 million lbs, fresh and frozen) each year over the period described (compare this with 4,500 metric tons of yellowfin for the first three months of 2007).

Figure 14- Bigeye Imports USA (Josupeit, 2007)

If it can be assumed that the United States consumes approximately half of their fresh and frozen tuna raw (Bartram et al. 1996, 6), then it stands to reason that only 3,674 metric tons (8 million lbs) of bigeye are being consumed as *sashimi* or *sushi* in the United States. Compare this with Japanese fresh bigeye consumption levels averaging 28,604 metric tons per year (63 million lbs), over the past seven years. Clearly the market for bigeye tuna is much larger in Japan than it is in the United States, though it would seem
that there is more room to grow with regards to demand within the United States than there is in Japan.

American Bigeye Price Trends

Prices for bigeye have been fairly stable in the American market. From 2001 to 2007, fresh/frozen bigeye prices went from a low of $5.22/lb (2001) up to a high of $6.45/lb (2003), with an average price of $5.86 over the whole time period. Compare this with Japanese prices that have fluctuated from over $11.65/lb in 1996, down to $6.45/lb, just ten years later. A visual comparison of the price fluctuations can be seen in Figure 15. Unfortunately, bigeye tuna was only separated from yellowfin tuna in the United States in 2001, therefore a price comparison with U.S. numbers can only go back as far.

Figure 15- Japanese vs. American Bigeye Prices

![Japanese vs. American Bigeye Prices](image)

It is unlikely that the price for bigeye tuna in the United States will appreciate substantially unless the American public is made aware of the differences between
bluefin (the most expensive fish on the planet), yellowfin (the low end of the tuna sashimi scale), and bigeye, which falls somewhere between the two. As most bigeye is sold in the United States under the name “ahi,” it is merely lumped together with yellowfin and is priced fairly similarly. Product differentiation (which will be discussed further in a later section) is possible with this fish, as the quality of the flesh is significantly different from yellowfin.

American Tuna Quality Issues

Grading of tuna on the United States mainland is much less rigorous than in Hawaii and Japan. In the Gulf of Mexico, fishermen sell their fish by the boatload, rather than by the fish at an auction. This means that the grade of the fish from every boat is estimated as an aggregate rather than by the individual and this estimate is done based on the experience and past history of the fishing boat. A situation is then created where the fish being sold into the wholesale market can be of any grade because the dock operators are estimating the grade of the fish without even cutting them open individually and physically inspecting them. On top of that, the dock operators are on the “side” of the fishermen, thus they try to get the best price possible for the boat operators and in doing so often artificially inflate the grade the tuna in order to get a better price from the wholesalers. Downgrading entire boatloads of tuna by wholesalers into lower quality grades is fairly common practice (Bartram et al 1996, 19). The tuna coming into the American market from the Gulf of Mexico tend to be variable in quality and fish of comparable grades are of much better quality when coming from Hawaii than from the Gulf. A study that compared mainland tuna graders with graders based in Hawaii found
quantitative evidence showing that Hawaiian graders are stricter with their standards than are their counterparts in the lower forty eight (Bartram et al. 1996, 22). Basically, American standards for their tuna are much lower than are the standards set in Japan or Hawaii. Americans away from the east and west coasts (Middle America) tend to accept an even lower grade tuna as sashimi quality; often deeming No. 2- or 3+ to be acceptable grades for raw, non poke consumption (Bartram et al 1996, 20). Therefore it is unlikely that these regions will be as accepting of higher quality fish, which are priced accordingly.

The trend of lower grade sashimi being served in Central United States may be changing, however. The California Sushi Academy (a sushi chef school) is reporting that some of the highest demand for their graduates is coming from places like Salt Lake City, Utah and Stillwater, Oklahoma (Issenberg 2007, 146). In fact, Stillwater, Oklahoma is now considered a “sushi hotbed” by the academy. Places like Denver and other large cities in the Midwest are also increasing their sashimi consumption and are attracting suppliers more now than they ever were before (pers. comm. Kelly Coleman, Kona Blue Water Farms).

Large cities along the American east and west coasts tend to be places where sashimi consumption is high and tastes are more refined, though not to the extent that the Hawaiian and Japanese consumers are. California, for example, has been eating tuna sashimi for several decades and many people now consider raw fish to be as mainstream as hamburgers and fries (Issenber 2007, 80). Places like San Francisco, Los Angeles and San Diego are major markets for sashimi and have been so for many years. Even in these regions, however, tuna quality problems do exist. The advent of tuna treated with carbon monoxide (CO) has created a situation where an uneducated sashimi consumer will buy
tuna that is treated with CO thinking that he has just purchased fresh fish, simply because the CO has made the meat more red than it otherwise would be. This allows lower quality fish to be masqueraded as high quality fish simply because it is glowing red from the CO treatment. Many countries (Canada, Japan and many European countries) have banned the use of CO treated tuna because of the duplicity created in the market when CO treated tuna is available (Pan and Ming 2007, 6). Glowing red sashimi masks the true quality of the meat, thus allowing old and even spoilt fish to be sold as fresh. Even Hawaii is not immune to low quality, CO treated tuna being sold in the market. Most poke sold in Hawaii that is “previously frozen” or sells for around $6-7/lb is treated in this way (Pan and Ming 2007, 7). Some might say that CO treated tuna has actually “dumbed down” the tastes of American palates, even in “refined” markets such as California and Hawaii (pers. comm. Howard Woolf, Jana Brands).

While American sashimi palates are not as discerning as those found in Japan (and probably never will be), there are large regions of the country that will pay up for a good quality fish. The American east and west coasts have had long histories of sashimi consumption and their tastes reflect that familiarity of raw fish, even in the face of CO treated tuna. In fact, bluefin tuna (the world’s most expensive fish) that is caught in American waters is increasingly being sold in the U.S. During the mid 1990’s, Americans began paying higher prices for good quality tuna, and not just in large cities near ports where bluefin were regularly caught. As much as 90% of the North Atlantic’s American bluefin catch is now sold domestically. In fact, Issenberg (2007) reports that keeping most of the bluefin catch at home is due to several reasons:
“The top price American buyers can offer Kliss (Massachusetts bluefin fisherman), in the $8 to $10 range, is almost always lower then the bottom price a Boston bluefin can fetch at Tsukiji auction, but once freight costs, tariffs and auction listing fees are added, that gap narrows considerably (if not entirely). Perhaps more importantly, domestic sales are largely free of the market risk that defines Tsukiji transactions since Kliss can find a buyer immediately.”

The lack of market risk points to a growing demand for high quality fish in the United States. While Americans are not paying as much for their sashimi as the Japanese are, they are beginning to pay ever higher prices for good fish. Places like Stillwater, Oklahoma show that sashimi consumption is becoming more mainstream throughout the nation, despite the frivolous grading standards of the Gulf and CO treated fish infiltrating traditional sashimi hotbeds like California and Hawaii. The fact that most of the American bluefin catch is being consumed domestically shows that the markets are becoming more sophisticated as well. These conditions bode well for an aquaculture venture because no matter what the quality of the fish, there is a growing market for tuna throughout the United States. In fact, sashimi consumption in the U.S. is growing at about 20% per year, as compared with other foodstuffs which are growing at around 2-3% per year (pers. comm. Kelly Coleman, Kona Blue Water Farms). Lower quality fish is accepted in growing sashimi markets in the middle of the country and higher grade fish are consumed in the larger urban markets where consumption of raw tuna has been occurring for years.
Hawaii's Bigeye Consumption

Hawaii has a well developed sashimi market with a broad spectrum of tuna sashimi consumption preferences. Most of the tuna caught in Hawaii is actually consumed within the local market (Pan 2004, 5). Hawaii's average daily consumption of tuna (all species) is in the range of 10 metric tons or 22,000 lbs! This translates to an annual consumption rate of approximately 3,500 metric tons, or 7.7 million lbs of tuna consumed in Hawaii, per year (Bartram 1996, 6). The Hawaiian market is a highly competent one and is able to fully utilize a wide variety of tuna products at every level of price, thus accounting for the near complete local consumption rates of tuna caught in Hawaiian waters. Beginning in the early 1990's, landings of bigeye in Hawaii have increased significantly on a seemingly linear scale, as shown by Figure 16 (NOAA, 2008). The trendline running through the middle of the chart indicates that for each month, an average of just over five thousand pounds of bigeye is being added to the landings in Hawaii. As the seasonal oscillations for bigeye landings in Hawaii are very large, this number is only an average of a highly variable, month to month catch rate. The long term trend of increasing catch yields, however, is unmistakable.
Local catches of tuna in general are not enough to satisfy demand in the Hawaii market and imports must make up the rest. Although the amount of imports to Hawaii is typically fairly low, the amount of imported tuna may occasionally reach a level of two-thirds of local production in short term spurt (WESPAC, 1). On average, less than 1.5 million pounds per year of fresh and frozen tuna is imported directly to Hawaii from other countries, however, this number is not stable and does tend to fluctuate significantly.

Figure 17 shows the relationship between imports of bigeye vs. landing of bigeye over the past seven years. Imports do not significantly impact total consumption trends of bigeye in Hawaii. It does appear that imports of bigeye specifically have been increasing over the past seven years and that landings over the short term in Hawaii have increased fairly substantially, which seems to mirror the long term trend for bigeye capture in Hawaii fairly accurately.
Hawaii's Bigeye Pricing Trends

Prices for locally caught bigeye tuna in Hawaii have shown a ten year trend that appears to be positive. Figure 18 shows bigeye prices increasing at a rate of approximately $0.03 per pound each month from 1995-2005. The local catch of bigeye tuna has shown both a long and short term trend of increased production, while simultaneously showing a long term price increase for the this fish. These factors point to demand for bigeye in Hawaii growing at a faster pace than the growth in the supply, which bodes well for a tuna farmer looking to sell a product at the local market.

Additionally, McConnell et al. (1998) report that fatty fish in Hawaii sell for as much as $1.001 more than their fat free counterparts.
Bigeye Market Recap

Worldwide demand for sashimi consumption is currently very high, though the stocks of all species of tuna are falling rapidly. As more countries begin consuming raw tuna, more pressure will be put upon the already exhausted wild stocks to produce more. This will most likely serve to drive down the supply of bigeye, while simultaneously increasing prices.

Taking in approximately 28,604 metric tons or 63 million lbs of bigeye per year, Japan is still the largest consumer of fresh tuna on the planet. This is contrasted, however, by Japan’s consumption trends that are plagued by a lack of tuna supply, as well as a decreasing amount of demand for fresh tuna. Prices have fallen precipitously over the 10-15 years, reaching levels today that are around half of what they used to be, on a pound to pound basis.

The United States has a thriving tuna sashimi market, the vast majority of which consists of yellowfin and bluefin tuna. Bigeye has a minimal presence on the continental
United States because good quality bigeye was typically directed towards Japan, while the lower grades have traditionally been lumped together with yellowfin and sold as "ahi." The price of bigeye in the United States reflects this bias and is sold only marginally higher, on average, than the less fatty yellowfin. Even though Japanese prices of bigeye have taken a nose dive, they are still slightly higher than those typically found for bigeye on the continental United States.

Finally, the Hawaiian market for tuna is large on a per capita basis, but is small in comparison to the overall tuna market seen on the American mainland or in Japan. When dealing specifically with bigeye, the Hawaiian market actually captures and consumes more bigeye than all of the rest of the American market put together. Bigeye tuna catches by local fishermen have also bucked the worldwide trend of decreasing landings by showing both short and long term trends of increased production, while simultaneously having consistent increases in the price of fish. It would seem that the Hawaiian market for fresh fish is not one to be overlooked just because it has a small population. The amount of fish consumed within the State of Hawaii is high due to an elevated level of consumption on a per capita basis, as well as having a large influx of tourists from both the United States mainland and Japan. These tourists tend to consume vast quantities of seafood, both raw and cooked.
Distribution Channel Analysis

Analyzing the distribution channels for each of the three topic regions (Japan, USA and Hawaii) is important when discussing which market to sell a product into. Merely looking at the market conditions and determining which country has the highest prices or the most amount of potential growth is not a complete assessment of whether or not a particular firm should engage in market activities. It is important to know whether or not an industry is fragmented or consolidated, whether it is capable of distributing the product in a timely fashion, whether or not there are import fees or barriers, etc. For example, both the Hawaiian and Japanese markets rely heavily on the fish market system of distribution for seafood; though these are not the only mechanisms in which a firm must utilize for product delivery in these regions. Issues like these need to be thoroughly analyzed before showing up to the Japanese or Hawaiian markets and unloading a product.

Japanese Tuna Distribution System

The Japanese seafood market is highly complex and it is easy to get “lost” within its confines. Compared with the conventional American distribution system, the Japanese system is fraught with middlemen and personal connections that might go back generations. The Japanese distribution sectors tend to value close, personalistic ties that help cement long term relationships between customers and suppliers over short term relationships that would otherwise be profit motivated in nature (Bestor 2004, 35). It is
for this reason that jumping from dealer to dealer is generally not recommended when dealing with Japanese purchasers and wholesalers. A relationship must be developed over time between the exporter of tuna in Hawaii and the importer in Japan. Additionally, while competing firms might appear to be locked in mortal combat with one another, there is a good chance that information regarding market conditions is flowing between the two companies because of the "old boy" network that tends to characterize this industry (Williams 1986, 51). Therefore, if one Japanese wholesaling company gets burned by a foreign tuna supplier, there is a good chance that all of the wholesalers will be aware of the offender’s actions fairly quickly. If a foreign supplier is constantly switching to different purchasing agencies or contractors, then a close relationship can not be built and the reputation of the foreign tuna supplier can be ruined within the distribution networks, thus making life very difficult for the supplier who wishes to do business in Japan. Conversely, if the supplier does business in an appropriate manner and is able to establish a firm relationship with the wholesaler, then the service provided to the supplier tends to be highly beneficial indeed. Often a wholesaler will introduce a valued customer to other contacts within the industry, helping to cement the supplier within the "old boy" network for mutual gains (Williams 1986, 52). These continued relationships will prove especially useful considering the highly consolidated and vertically integrated nature of the few large firms, known as keiretsu, that dominate the distribution industry in Japan (Bestor 2004, 35). Since these firms are so imposing, they are able to squash any smaller firms trying get established, thus making a good reputation as a reliable supplier extremely important because as there are only a few outlets in which to sell one’s product.
Typically, there are two main avenues to sell imported tuna in Japan. One is through the auction system and the other is by selling directly to private retailers, such as supermarkets and convenience stores. The first of these two options is the main way in which seafood in Japan enters into the market.

Tsukiji

There are many seafood auction markets in Japan (54), approximately thirty of which deal specifically with high grade tuna; each with its own local peculiarities and desired qualities for each type of food bought and sold (Issenberg 2007, 40). Even with these individual peculiarities, for the purposes of this paper, Tsukiji will serve as the auction market with which all other markets in Japan are compared with. As Tsukiji handles approximately 1/6 of all the seafood that is bought and sold within the auction system, handles 87% of all seafood sold in Tokyo and is the largest marketplace for fish in the world, the reason for using Tsukiji as the model for the Japanese auction system is not unwarranted (Bestor 2004, 30). Tsukiji is also the largest mover of chilled bigeye tuna in Japan, thus making it a very important not only for seafood in general, but for the distribution of this particular species of fish as well (Williams 1986, 26). While there are other markets in Japan which move very impressive amounts of seafood, they all tend to operate in a similar fashion, though each market will have its own tweaks on the common theme.

A tuna supplier typically has two avenues for selling his wares to the auction at Tsukiji: either 1- on consignment to a wholesaler (either to a Tsukiji wholesaler or third
party wholesaler) or 2- directly purchased by one of the seven auction houses (Bestor 2004, 190).

1- Most fresh fish and high value frozen fish (such as high grade tuna) is sold on consignment to a wholesaler in order to be sold at auction (Bestor 2004, 190). Even within this single category, a tuna supplier has three options within which to sell a product. A wholesaler can supply one single market (such as Tsukiji) or act as an “outside” wholesaler that can sell to many different markets. Both of these wholesale options have their potential advantages and disadvantages.

Wholesalers that only deal with one market are obliged by law to make sure that all dealings are considered fair and equitable. For example, wholesalers that deal only with Tsukiji are required by law to, “accept and sell all product consigned to them without discrimination and irrespective of quality and quantity” (Williams 1986, 52). Payments to suppliers tend to be quick and details of the sale within the market itself are made readily available. The downside to dealing with the Tsukiji wholesaler is that the market potential is limited to only one market, even if it is the largest seafood market on the planet (Williams 1986, 52). Switching from market to market is considered a sign of bad business is severely frowned upon.

Outside wholesalers are those individuals who are not locked into one particular market and can therefore sell tuna to whichever market looks most promising for the greatest returns. As these dealers have contracts with many different markets throughout the country, selling to outside wholesalers is not considered bad form for a foreign supplier and is a highly flexible alternative to simply selling within one market. Also, since these particular fish dealers work with many different markets, they can be a highly
valuable source of information about the overall market conditions, especially considering the fact that these wholesalers tend to specialize in one type of seafood (rather than dealing with many types of seafood as the Tsukiji dealers do), thus making their interpretation of the bigeye tuna market highly insightful. The downside, however, is that outside wholesalers charge an extra commission for their tailored services, usually in the 5% range (Williams 1986, 52).

The final method of selling tuna on consignment is to have a trading company buy entire boatloads of fish at a single time. This can reduce the risk for the supplier, but will probably also limit the upside potential as well. Many trading companies can be persuaded to send some of the profits back to the suppliers if the prices of the fish sold in the auction fetch suitably high prices, thus extending the profit level of the supplier somewhat (Williams 1986, 53). The main downside to this form of contracting (aside from reduced upside potential) is the fact that these types of contracts tend to require huge quantities of fish be delivered at regular intervals to the trading companies and many aquacultural firms simply cannot provide the required quantity of fish to maintain these types of contracts.

Selling on consignment does have one final advantage. If large enough quantities are provided on consignment to auction houses, then a certain percentage of the commission gets refunded (Bestor 2004, 195). The current commission for fish sold on consignment is 5.5%, but portions of that will be refunded by both the auction house under which the consignment contract was written, as well as from the auction market itself (Tsukiji). Combined, these rebates for fresh tuna can be as much as 1.15%, thus allowing the tuna supplier to have an effective commission payment of only 4.35%
(Williams 1986, 53). This is a substantial amount of money when dealing with large quantities of fish and is designed to give the supplier further incentive to deal exclusively with only one auction house. For example, if a supplier of tuna is selling tuna to two separate auction houses, they might not be able to take advantage of the bulk sales rebates that would otherwise be offered if the supplier was only dealing with one auction house.

2- Direct selling to the auction houses tends to occur with products that have similar consistency of quality, well known cost factors and low risk of market clearance. Frozen fish, aquacultured products and processed fish tend to fall into this category (Bestor 2007, 354). High value fish such as tuna tend to be the exception to this rule and are usually sold on consignment. An aquacultured bigeye tuna could easily sell at Tsukiji either on consignment or through direct selling. If the farmed bigeye are of high quality, they will probably be consigned and if they are of low quality but are very consistent in their quality, they will probably be sold directly to the auction houses.

Selling fish to the Japanese auction system does have one final quantitative drawback. Once a fish enters the auction system, its origins are effectively erased long before reaching the final consumer (Issenberg 2007, 278). This means that any chance to differentiate one’s product is simply not possible. A high quality fish being grown sustainably in Hawaii may be able to fetch a higher price to those environmentally conscious consumers who do not wish to participate in the highly publicized decline of wild tuna stocks. In addition to the environmental differences of wild vs. aquacultured tuna, the “Hawaii mystique” is a well known phenomenon in Japan, whereby many products from Hawaii are deemed to be superior because of their origins in a pristine environment. Combined, these two qualities that might positively differentiate
aquacultured bigeye from their wild caught brethren and thus possibly increase their value would be effectively eliminated in the auction system due to the commoditization of the end product to the consumer. The opportunity cost of selling to the auction system may or may not be high enough to warrant other means of distribution outside of the Japan’s fish auctions. A more in-depth study of Japanese thought processes and environmental values would need to conducted after the quality of the tuna was accurately determined in order to know what type of price premium such a fish might be able to obtain through product differentiation.

Selling to Private Retailers

Supermarkets in Japan have reached the point where they are now large enough to pass over the urban fish markets as suppliers of seafood, in favor of setting up their own supply systems and dealing directly with seafood producers directly (Sonu 2007, 20). Supermarkets tend to sign large contracts with suppliers to deliver a given quantity of seafood over the course of the year. For example, a supermarket chain might sign a contract with a trading company to deliver 1,000 metric tons (2.2 million lbs) of frozen tuna over the course of a year (Bestor 2004, 199). Auction markets, like Tsukiji, tend to focus on high end, seasonally variable products that command high prices. Supermarkets, on the other hand, prefer a predictable supply of seafood that does not experience large fluctuations in price (Bestor 2004, 200). If an aquaculture venture or co-op were to gain critical mass, supermarkets in Japan would be a good place to unload their product en masse without massive price fluctuations and consignment fees. However, if a tuna farm
were to generate a product of sufficiently high quality, it is likely that the auction markets would pay higher prices for good quality tuna.

Transportation of Tuna To Japan

Hawaii is one of the most geographically isolated regions on the planet. As such, transportation costs, whether to Japan, the mainland United States, or anywhere else, will be a major factor when deciding which market looks most promising for any Hawaii based company. Essentially, there are two ways to get tuna from Hawaii to Japan: by air or by boat.

Shipping by boat means getting the product to Japan in a matter of days or weeks, rather than the desired timescale measured in hours. Essentially, shipping fresh tuna by sea is not possible because spoilage would be rampant. The obvious alternative to shipping fresh tuna would be to freeze it and send it that way. The problem with freezing Hawaiian tuna in large quantities is threefold. First, freezing large quantities of tuna is expensive. The amount of money needed to operate such a large freezing facility would be prohibitively expensive. Second, freezing facilities large enough to accommodate a tuna farm do not exist in Hawaii (pers. comm. Kelly Coleman of Kona Blue Water Farms). That would mean that in order to freeze entire netpens of tuna, they would have to be shipped elsewhere. Finally, frozen tuna commands a lower price on the market than does fresh tuna. When put together, shipping frozen tuna to Japan (or anywhere) would require spending extra money on the freezing process while simultaneously receiving less money for the product. Additionally, the bigeye would have to be sent to a freezing facility outside of Hawaii, thus requiring the use of air transportation so that the tuna does
not spoil before being frozen. Clearly, air travel is the best option for getting tuna to Japan.

There are many airlines that travel non-stop from Hawaii to Japan. A quick peek at the travel site, expedia.com, reveals that the 3850 mile journey (one way) from Honolulu to Tokyo can be traversed on many airlines, including JAL, US Airways, Delta, All Nippon Airways, United, Northwest, etc. These airlines typically have freight services that will ship products between the two countries for a fee. Japan Airlines (JAL) has been associated with tuna shipping since the early 1970's and is therefore the logical choice for the purposes of the bigeye farmer (Issenberg 2007, 1). Their standard shipping rates from Honolulu to Tokyo in their largest, refrigerated shipping containers (RAP(LD7)) are $1.73/lb. If the tuna farmer were on the Big Island, standard shipping rates from Kona to Tokyo in the same container rate $2.01/lb.

Costs of Shipping to Japan

There are several important costs associated with shipping tuna to Japan that would not be experienced if shipping the same product to the United States. As Japan is a member of the World Trade Organization (WTO), tariffs imposed upon bigeye tuna shipments from American suppliers are held steady at a rate of 3.5% of cost, including insurance and freight (Sonu 2007, 9). Additional fees include Tsukiji auction house fees of 5.5% if selling on consignment through one of Tsukiji’s exclusive wholesalers. If a supplier is dealing with an outside wholesaler, another 5% is tacked on for them. Table 1 shows the fee system imposed on an American importer of bigeye tuna into Japan.
Table 1- Auction Fees in Japan

<table>
<thead>
<tr>
<th>Without Using Outside Wholesaler</th>
<th>Fees (%)</th>
<th>Rebate (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selling to Tsukiji Auction House</td>
<td>5.5%</td>
<td>1.15%</td>
<td>4.35%</td>
</tr>
<tr>
<td>Import Tariffs (% of Cost)</td>
<td>3.5%</td>
<td>3.5%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9.0%</td>
<td>7.85%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>With Outside Wholesaler</th>
<th>Fees (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selling to Tsukiji Auction House</td>
<td>5.5%</td>
</tr>
<tr>
<td>Selling to Outside Wholesaler</td>
<td>5.0%</td>
</tr>
<tr>
<td>Import Tariffs (% of Cost)</td>
<td>3.5%</td>
</tr>
<tr>
<td>Total</td>
<td>14.0%</td>
</tr>
</tbody>
</table>

These fees represent the amount of money that will automatically be lost when dealing with auction market distributors in Japan, without shipping costs. In order for the Japanese market to be just as profitable as selling in the American market, prices in Japan must be at least 7.85-14% higher (depending upon which distribution system is chosen) than those in the United States. Note the reason that selling to an outside wholesaler precludes any rebates from the auction houses is that those rebates are given to those suppliers who are able to meet a certain minimum quantity of supply. Dealing with an outside wholesaler means that it is not likely that one aquacultural supplier will be able to meet the minimum supply necessary to participate in a rebate because outside wholesalers tend to sell into several different markets at a time.

The figures in Table 1 are the fees added before any shipping costs are added in. Table 2 looks at the expected costs of selling to the Japanese market when all fees and transportation costs are added in. It should be noted that some shipping costs can be passed along to the purchaser of the tuna when shipping to Japan and the American mainland (per. comm. Gary Ishimoto of Diamond Head Seafood Wholesale Inc.). However, for the purposes of this paper, it will be assumed that none of the shipping costs can be shared. For these calculations, a $6.50/lb price tag has been given to fresh...
bigeye tuna being sold at Tsukiji market because that is what the 2006 prices averaged. Table 2 shows that when the tariffs, auction fees and transport costs are calculated, the tuna farmer will automatically lose 72-98% for doing business in Japan! That is why it is so important to sell a high grade to product to Japan. A low grade fish will most likely not be able to cover the costs of selling fish in Japan. Even a high grade fish with higher initial margins for the farmer will lose a lot of value by selling to the Japanese auction system. The shipping rates were calculated as $3.92/kg or $1.73/lb and this information was gathered from a Japan Airlines (JAL) representative in Honolulu. Another 17.5% was taken out of gross revenues for shipping materials, such as bags, boxes, etc. The actual container information requested was for the RAP (LD7) refrigerated container which holds a maximum of 5,000 lbs. While refrigerated containers are expensive to use, the alternative of packing your tuna with cooling material (usually gel-packs) is also expensive, as shown later in this paper.

Table 2- Total Shipping Costs to Japan

<table>
<thead>
<tr>
<th>Ship From Honolulu</th>
<th>Ship From Kona</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sell to Auction House</td>
<td>Sell to Auction House</td>
</tr>
<tr>
<td>$6.50 Selling Price</td>
<td>$6.50 Selling Price</td>
</tr>
<tr>
<td>Less Auction House Fee (5.5%)</td>
<td>$ 6.14 Less Auction House Fee (5.5%)</td>
</tr>
<tr>
<td>Less Shipping Fee (from HNL) ($1.73)</td>
<td>$ 3.28 Less Shipping Fee (from KOA) ($2.01)</td>
</tr>
<tr>
<td>Less Shipping Materials (17.5%)</td>
<td>$ 2.14 Less Shipping Materials (17.5%)</td>
</tr>
<tr>
<td>Less Tariffs (3.5%)</td>
<td>$ 1.81 Less Tariffs (3.5%)</td>
</tr>
<tr>
<td>Loss</td>
<td>72% Loss</td>
</tr>
<tr>
<td>Sell to Outside Wholesalers</td>
<td>Sell to Outside Wholesalers</td>
</tr>
<tr>
<td>$6.50 Selling Price</td>
<td>$6.50 Selling Price</td>
</tr>
<tr>
<td>Less Wholesaler/Auction Fees (10.5%)</td>
<td>$ 5.82 Less Wholesaler/Auction Fees (10.5%)</td>
</tr>
<tr>
<td>Less Shipping Fee (from HNL) ($1.73)</td>
<td>$ 2.95 Less Shipping Fee (from KOA) ($2.01)</td>
</tr>
<tr>
<td>Less Shipping Materials (17.5%)</td>
<td>$ 1.14 Less Shipping Materials (17.5%)</td>
</tr>
<tr>
<td>Less Tariffs (3.5%)</td>
<td>$ 0.81 Less Tariffs (3.5%)</td>
</tr>
<tr>
<td>Loss</td>
<td>98% Loss</td>
</tr>
</tbody>
</table>

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Even selling to a grocery chain and thus bypassing the auction system altogether is expensive. Table 3 shows the cost of doing just that. Automatically, the bigeye farmer will be losing between 59-63%, depending on where the transport flight originated from.

Table 3- Shipping Costs to Grocers in Japan

<table>
<thead>
<tr>
<th>Ship From Honolulu</th>
<th>Ship From Kona</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sell to Grocer</strong></td>
<td><strong>Sell to Grocer</strong></td>
</tr>
<tr>
<td>$6.50 Selling Price</td>
<td>$6.50 Selling Price</td>
</tr>
<tr>
<td>Less Shipping Fee (from HNL-$1.73)</td>
<td>$3.63 Less Shipping Fee (from KOA-$2.01)</td>
</tr>
<tr>
<td>Less Shipping Materials (17.5%)</td>
<td>$3.00 Less Shipping Materials (17.5%)</td>
</tr>
<tr>
<td>Less Tariffs (3.5%)</td>
<td>$2.67 Less Tariffs (3.5%)</td>
</tr>
<tr>
<td>Loss</td>
<td>59% Loss</td>
</tr>
</tbody>
</table>

Shipping Within Japan

Japan is a highly industrialized country with excellent distribution networks. As one of the world’s leading economies, Japan has the capabilities to distribute any product at any technologically feasible pace. However, once the tuna from Hawaii has reached Japanese shores, there are no longer any costs associated with this product, as all distribution costs become the liability of the purchasing company. The same concept applies to Hawaii and the mainland U.S.A., therefore, this paper will not cover the actual distribution networks within and of the covered regions.

American Tuna Distribution System

The American distribution system is much simpler than the Japanese one. There are almost no auction markets to speak of; therefore it is most likely that any company supplying tuna to the American market will be selling their wares to wholesalers and distributors. The relationships between suppliers and distributors are much less
(formalized than those found in Japan and the fragmented nature of the seafood industry network means that one fresh seafood supplier will likely be dealing with many different wholesalers around the country. For example, Kona Blue Water Farms (KBW), an open ocean aquaculture company operating off the Big Island, sells their Kahala or Amberjack, mostly to markets within the United States (pers. comm. Kelly Coleman). In doing so, they deal with approximately 80 different wholesalers around the country. As sales in FY 2006 for KBW were in the $2 million range, they are no means a large company. This example of a small, yet successful Hawaii based company dealing with so many wholesalers throughout the United States goes to show just how fragmented the seafood industry in the U.S. really is. The National Oceanographic and Atmospheric Administration (NOAA) estimates that there are approximately 3,500 seafood dealers within the United States alone (Engle and Quagrainie 2006, 95).

There are several layers of individuals and services within the American seafood distribution regime. There are also approximately five steps in the American distribution process from fishing boat to consumer: Fisherman, Large Wholesaler, Small Wholesaler, Retailer and Consumer. The purchasers can be broken down into the following four macro categories: Seafood Brokers, Distributors, Wholesalers, and Retailers (Engle and Quagrainie 2006, 101). Each one serves a unique purpose, though a Hawaii based tuna farm will most likely only deal with one or two of these categories.

Seafood Brokers

Seafood brokers are independent agents that serve suppliers and by finding a buyer for their product (Engle and Quagrainie 2006, 101). These individuals are
compensated by a commission and their services very similar in nature to the outside wholesalers in Japan who match suppliers with buyers around the country. As sashimi grade tuna is a fairly well established market that is in high demand throughout the United States, it is unlikely that these seafood brokers or agents will be needed to procure buyers for aquacultured tuna.

Seafood Distributors

Distributors are those companies who are contracted to transport and store products around the country (Engle and Quagrainie 2006, 101). They usually do not own the products they distribute and therefore are of little concern to a tuna supplier as they are usually contracted by the initial buyers of the product. Trucking companies and freight companies usually occupy this space.

Seafood Wholesalers

Wholesalers are the third category within the seafood distribution network typified by the United States and are the most important group of distributors to the Hawaii based bigeye supplier. Most likely, wholesalers will be the layer of distribution that will deal with nearly all of the bigeye supply coming out of the bigeye farm in Hawaii. According to Engle and Quagrainie (2006), wholesalers can be broken down further into five separate categories.

Integrated grocery wholesalers are those companies that purchase seafood in bulk to be distributed to their own retail outlets throughout the country. They also tend to own the distribution channels between their storage facilities and retail outlets (Engle and
Albertson’s, Safeway and Wal-Mart are examples of this type of wholesaler. Integrated grocers would be a good way in which to distribute bigeye tuna around the country en masse. However, it might be difficult to differentiate one’s product at these particular outlets and the actual tuna would probably be sold under the generic name “ahi.” If the tuna coming off the farm are of lower sashimi grade, these large grocers would most likely be a good way to distribute the product in a quick and easy manner. If, however, the bigeye were of higher sashimi grade, product differentiation would be the best bet to maximize revenues for the supplier and integrated grocers would not be able to offer the necessarily higher prices and it would be doubtful if they would be willing to market the tuna in an appropriate manner. There are some integrated wholesalers that might prove profitable for quality fish, however. High end health food stores such as Whole Foods might be willing to promote a high end product at an appropriate price. They might also be willing to help promote the brand name and history of aquacultured tuna if it’s grown in a manner that is deemed sustainable by the company.

The next category is the nonintegrated grocery wholesaler. These wholesalers typically purchase grocery products for those retail chains which focus exclusively on their retail outlets and therefore do not have large storage and distribution facilities. The non integrated wholesaler can be thought of as independent purchasing agents for the smaller retail grocery chains and individual stores. These wholesalers usually do not have retail outlets of their own; however, some do have a small percentage of their turnover coming from their own retail stores which tend to be few in number (Engle and Quagrainie 2006, 102). Once again, this type of wholesaler would probably be utilized if the quality of the tuna was marginal. Cooking grade and lower sashimi grade fish might
be sent to these types of wholesalers as an alternative to the integrated wholesalers. As with integrated wholesale grocers, there may be an exception to this rule. Nonintegrated grocer wholesalers that supply high end health food stores or local, high end grocers might be willing to buy and sell high end tuna. They might also work with the farm to promote the brand of the sustainably grown, Hawaiian bigeye as well.

Integrated foodservice wholesalers are similar to integrated grocers in that these buyers own retail outlets, distribution networks and their own storage facilities. McDonald’s is a prime example of this type of wholesaler (Engle and Quagrainie 2006, 102). Large restaurant chains with massive purchasing programs are usually slotted as integrated foodservice wholesalers. As these companies tend to fall into the lower to mid end of the restaurant category, integrated wholesalers might be a good way to unload large quantities of product into the American market for low quality tuna with commodity designation.

Nonintegrated foodservice wholesalers are those companies which do not own any retail outlets, but instead sell food products to those companies that do have retail stores. These wholesalers sell to restaurants, hotels, hospitals, schools, etc. Examples of large nonintegrated foodservice wholesalers include such large companies as Sysco, U.S. Foodservice and Alliant (Engle and Quagrainie 2006, 102). It would be through these nonintegrated wholesalers that selling a differentiated product to restaurants throughout the nation would be most likely. Fine dining establishments and high end sushi bars would be the desired destination for a high grade sashimi product and most nonintegrated foodservice wholesalers are fairly localized geographically, thus making many of them fairly small operations. These smaller operations are likely to work with the Hawaii tuna
farm to differentiate a high quality product from other forms of tuna, thus effectively
promoting not only the product (high grade *sashimi*), but possibly the company as well.
People at restaurants are likely to be comforted by the fact that they are consuming
sustainably raised tuna that is from the pristine waters of Hawaii. This promotion at the
restaurant level must first be created by the producer/farmer and the initial buyer as the
product is passed on down the distribution network. Regionalized, non integrated
foodservice wholesalers are the most likely of the distributors to make this happen.

Finally, specialized wholesalers are the last category of wholesaler that Engle and
Quagrainie (2006) recognize. Basically, specialized wholesalers are those companies that
specialize in one food or food group and are really more of a subset of the nonintegrated
foodservice wholesalers rather than a separate category of their own.

Seafood Retailers

Seafood retailers are those outlets which sell their product directly to the public;
mainly restaurants and grocers. The integrated retailers purchase their product
exclusively for themselves, while the nonintegrated retailers tend to purchase their
products from a variety of sources; both in the wholesale and retail realm. Unless
shipping costs can be passed on to the customer, it probably does not make sense to sell
tuna to each individual restaurant, as shipping costs would eventually drive margins to
zero. Selling to the American mainland using a wholesaler that buys in bulk makes much
more economic sense than otherwise.

Once again, there is an exception to this rule. Having well known chefs and
restaurants purchasing and then promoting an aquacultured bigeye in their restaurants

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might incur high shipping costs, but the word of mouth promotion from being a favorite dish at Sam Choy’s or Nobu (a famous high end, global *sushi* chain) would be well worth the added shipping costs. Many new products are promoted in this way and demand for them eventually snowballs larger and larger. This type of promotion, however, must only attempted if the farmed bigeye is of extremely high quality. Just as good word of mouth can be a blessing, a bad reputation can spread amongst the foody community at an alarming speed. Sending fish to well known chefs must only be attempted if the tuna is of near perfect quality. Fat content, consistency, flavor, etc. must all be working together in a harmonious fashion for these chefs to say good things about a product. Clearly one slip-up or bad experience with a prominent chef can have lasting consequences for a fledgling aquaculture operation.

Cost of Shipping to the U.S. Mainland

Shipping to the U.S. Mainland is considerably cheaper than shipping to Japan. There are no tariff fees, shipping rates are cheaper and no auction house fees to pay. Table 4 shows the shipping rates for Hawaiian Airlines from both Honolulu and Kona into the western cities of Los Angeles, San Francisco, San Diego, Las Vegas, Sacramento, Portland, Seattle, Phoenix and Anchorage. Like the JAL flights, Hawaiian Airline flights originating from Kona tend to be more expensive than shipping from Honolulu. Unlike the JAL flights, carriers to the mainland and within Hawaii do not offer refrigerated containers. Other means of refrigeration are usually in the form of gel-packs. These small packages are consisted of water and water retentive crystals that are frozen and wrapped in plastic; not unlike similar packages thrown in the freezer to place on muscle injuries. A
price of $0.35 per 1.5 lb gel pack will be added (the going price from the Pacific Allied
Products Ltd. website) to the cost of shipping and approximately 5-8% (6.5% for this
paper) of all shipping weight will be from these gel packs (per. comm. Gary Ishimoto of
Diamond Head Seafood Wholesale Inc.). These gel packs can also be made on site by the
farmer after purchase of the appropriate equipment for approximately $5,500-$6,000
(prices taken from the Roshgo Corporation website) at a considerable discount over
commercial gel-pack suppliers (pers. comm. Lyndsey DeSilva of Big Island Abalone).
The “homemade” method of gel-packs would be recommended for the tuna farm because
of the necessity to create custom shape gel-packs and the savings likely when done on
site rather than purchasing from a manufacturer. For the purposes of this paper, however,
the $0.35 cost per 1.5 lb gel-pack will be used for the shipping calculations. Additionally,
per pound prices tend to decrease dramatically when shipping in bulk. Smaller shipments
(500+lbs) are approximately double the price (per pound) of shipping in bulk. In addition
to gel-packs, shipping materials such as boxes, tape, plastic bags etc, need to be factored
in. Gel-packs and other shipping materials tend to take approximately 15-20% of gross
revenues (per. comm. Gary Ishimoto of Diamond Head Seafood Wholesale Inc.). For this
paper, 17.5% is the number used for all shipping material calculations. A more detailed
calculation for how rates in Table 4 were calculated can be found in Appendix D.
Table 4- Shipping Rates to Major American West Coast Cities

<table>
<thead>
<tr>
<th>Shipping Costs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>From Honolulu</strong></td>
<td></td>
</tr>
<tr>
<td>General Freight 500+lbs</td>
<td>$2.03</td>
</tr>
<tr>
<td>Priority 500+lbs</td>
<td>$3.03</td>
</tr>
<tr>
<td>Container (2,000 lbs)</td>
<td>$810.00</td>
</tr>
<tr>
<td>Container (5,000 lbs)</td>
<td>$3,120.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>From Kona</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Freight 500+lbs</td>
</tr>
<tr>
<td>Priority 500+lbs</td>
</tr>
<tr>
<td>Container (2,000 lbs)</td>
</tr>
<tr>
<td>Container (5,000 lbs)</td>
</tr>
</tbody>
</table>

Clearly, it pays to send large packages of tuna to the mainland at any given time.

There is also a significant difference between priority shipping and general freight.

Shipping with priority means that the package will get onto the desired flight for sure, while general freight means that a package can get bumped onto a later flight if the desired one is full already. During the busy season, priority shipping will probably be necessary to secure rapid delivery times. Since Hawaiian does not have climate controlled cargo containers, dry ice or gel-packs will have to be added to the tuna shipments in order to keep the temperature of the fish as close as possible to 0°C.

Valuable space and weight will be taken up by these items, so minimizing their use while still keeping the fish cool will be crucial.

Using a selling price of $5.86/lb (the average price of fresh/frozen bigeye imports from 2001-2007), table 4 also shows what percentage of the price received from wholesalers goes to shipping (titled "Margin Erosion"). It seems that shipping in bulk...
pays off, but not too much. The 2,000 lb containers have the most attractive shipping costs and seem to have a cheaper rate than does the 5,000 lb container. General freight charges seem to run in the range 24-67% cost range for mainland flights. Priority shipping of smaller packages is very expensive and should only be utilized in dire situations or for special customers.

Hawaiian Tuna Distribution System

The Hawaiian seafood market is much more akin to the Japanese system than the American system. In Hawaii, the auction system plays a much more significant role in distributing seafood than on the mainland United States. Approximately 90-95% of all tuna caught in Hawaii is sold directly through the auction system (pers. comm. Charles Umamoto of the Hilo Fish Company and Shawn Inoue of Tropic Fish and Vegetable Center). Since this auction is the only one in the islands, a 10% commission is able to be levied by the auction. This cost is charged to the suppliers of tuna and is not passed on down the supply chain to those purchasers of tuna. The remaining 5-10% of tuna not sold into the Honolulu Fish Auction are those animals which are caught on the neighbor islands. Not all fishermen are able to get their catch to the auction, so some will sell entire boatloads to local wholesalers on their respective home island. It would be possible, however to sell tuna directly from the farm to wholesalers in Hawaii, thus skipping the auction entirely (pers. comm. Gary Ishimoto of Diamond Head Seafood Wholesale Inc.).

The vast majority of Hawaii’s wild caught tuna is sold at the fish auction. Restaurants in Hawaii consume 10-15% of all fresh fish landed in Hawaii and can buy from either a wholesaler or fish auction. Many restaurants tend to prefer buying from wholesalers
because of the variety of fish they can offer at a reasonable price (WESPAC). Like the American seafood distribution system, there are approximately five links, with a slight variation in the Hawaiian market. The links are: Fisherman, Auction, Wholesaler, Retailer and Consumer. Notice there is only one wholesaler link in this chain, as opposed to the two links in the American system.

Shipping within Hawaii has now gone from strictly air travel, to travel by both air and sea. Since the Superferry started operations (an interisland ferry service), quick transportation of tuna by the truckload is now possible. Currently, the Superferry only runs between Oahu and Maui, but is expected to begin services from Oahu to Kauai and from Oahu to the Big Island. This will help diversify the tuna farmer’s options for shipping the product within the State. Using a price of $3.37/lb (the average price for bigeye caught in Hawaii from 2000-2005), table 5 shows how much interisland shipping costs when using sea and air transports. It should be noted that a $3.37/lb average price for bigeye seems very low. However, the data for ex-vessel prices was taken directly from the Pacific Islands Fisheries Science Center website; which is run by the NOAA National Marine Fisheries Service and is a highly reputable source. It is likely that there are a large number of small fish (thus low grade) being caught which tends to lower the overall average price for bigeye in Hawaii (pers. comm. of Diamond Head Seafood Wholesale Inc.). It is highly likely that the price paid in Hawaii for farmed fish will be higher than the ex-vessel price, therefore margins should be high and the per pound cost of shipping should decrease as a percentage of revenue as the price increases. None the less, the numbers taken from the NOAA site are those that will be used for this paper. An estimate of 5,000 lbs and 10,000 lbs for cargo trucks that are 30’ and 55’ long was used
to determine the per pound cost of shipping a truckload of tuna on the Superferry. While sending tuna to the other islands is quicker using the airlines, sending a refrigerated truck onto the Superferry is much less expensive and the fish will certainly not spoil in a refrigerated truck. Also, the overall shipping material cost of 17.5% is used in this paper by averaging the 15-20% shipping material cost estimate given by Hawaii based wholesalers.

Table 5- Interisland Shipping Rates

<table>
<thead>
<tr>
<th>Hawaiian Airline</th>
<th>Total</th>
<th>Total Cost/lb</th>
<th>Revenue/lb</th>
<th>Margin Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>General (500+lbs)</td>
<td>$1.04</td>
<td>$2.33</td>
<td></td>
<td>31%</td>
</tr>
<tr>
<td>Priority (500+lbs)</td>
<td>$1.49</td>
<td>$1.88</td>
<td></td>
<td>44%</td>
</tr>
<tr>
<td><strong>Superferry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30' Truck (w/ fuel surcharge)</td>
<td>$958.00</td>
<td>$0.78</td>
<td>$3.18</td>
<td>6%</td>
</tr>
<tr>
<td>55' Truck (w/ fuel surcharge)</td>
<td>$1,778.00</td>
<td>$0.77</td>
<td>$3.19</td>
<td>5%</td>
</tr>
</tbody>
</table>

Cost/Revenue Comparison

Table 6 shows a side by side comparison of shipping costs for shipping to Japan, the USA mainland and interisland. Not surprisingly, sending tuna in bulk around Hawaii is cheapest, followed by bulk shipping to the mainland and then to Japan.
Table 6- Shipping Cost Comparison

<table>
<thead>
<tr>
<th>To Japan</th>
<th>Per Pound Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Honolulu</td>
<td>$ 2.87</td>
</tr>
<tr>
<td>From Kona</td>
<td>$ 3.15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To USA Mainland</th>
<th>Per Pound Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Honolulu</td>
<td></td>
</tr>
<tr>
<td>General Freight</td>
<td>$ 2.03</td>
</tr>
<tr>
<td>Priority 500+lbs</td>
<td>$ 3.03</td>
</tr>
<tr>
<td>Container (2,000 lbs)</td>
<td>$ 1.43</td>
</tr>
<tr>
<td>Container (5,000 lbs)</td>
<td>$ 1.65</td>
</tr>
<tr>
<td>From Kona</td>
<td></td>
</tr>
<tr>
<td>General Freight</td>
<td>$ 2.48</td>
</tr>
<tr>
<td>Priority 500+lbs</td>
<td>$ 3.93</td>
</tr>
<tr>
<td>Container (2,000 lbs)</td>
<td>$ 1.43</td>
</tr>
<tr>
<td>Container (5,000 lbs)</td>
<td>$ 1.65</td>
</tr>
</tbody>
</table>

Interisland

<table>
<thead>
<tr>
<th>Hawaiian Airline</th>
<th>Per Pound Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>General (500+lbs)</td>
<td>$ 1.04</td>
</tr>
<tr>
<td>Priority (500+lbs)</td>
<td>$ 1.49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Superferry</th>
<th>Per Pound Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>30' Truck (w/ fuel surcharge)</td>
<td>$ 0.78</td>
</tr>
<tr>
<td>55' Truck (w/ fuel surcharge)</td>
<td>$ 0.77</td>
</tr>
</tbody>
</table>

Table 7 shows the average amount of revenue (per pound) that will be brought in at each region and by using each form of distribution. Wholesale prices for the Hawaii and mainland markets were averaged over several years. Since these prices have been fairly stable, averaging them out seems to be the best way to get an accurate idea of what future prices might be. The mainland market averaged a price of $5.86/lb from 2001-2007, while the Hawaiian ex-vessel price averaged $3.37/lb from 2000-2005. More recent numbers are not currently available for the Hawaii market. A price of $6.50 was reached for the Japanese market by using the average price of bigeye for 2006 at Tsukiji market. This author believes that the $6.50 price range is an accurate reflection of approximately where the future prices for bigeye tuna will flatten out. Remember, bigeye prices in Japan are highly variable year to year and are possibly in the midst of a price correction from the extreme values seen during the early to mid 1990's. The acronym HNL is shown where flights to Japan originate in Honolulu and the acronym KOA is used to denote a Kona departure.
### Table 7 - Regional Revenue Comparison

<table>
<thead>
<tr>
<th>Region</th>
<th>Price Distribution</th>
<th>Total Revenue/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>Auction House-HNL</td>
<td>$1.81</td>
</tr>
<tr>
<td></td>
<td>Auction House-KOA</td>
<td>$1.52</td>
</tr>
<tr>
<td></td>
<td>Third Party-HNL</td>
<td>$0.81</td>
</tr>
<tr>
<td></td>
<td>Third Party-KOA</td>
<td>$0.80</td>
</tr>
<tr>
<td></td>
<td>Grocer-HNL</td>
<td>$2.67</td>
</tr>
<tr>
<td></td>
<td>Grocer-KOA</td>
<td>$2.43</td>
</tr>
</tbody>
</table>

#### Mainland

**From Honolulu**

- General Freight 500+lbs: $3.83
- Priority 500+lbs: $2.83
- Container (2,000 lbs): $4.43
- Container (5,000 lbs): $4.21

**From Kona**

- General Freight 500+lbs: $3.38
- Priority 500+lbs: $1.93
- Container (2,000 lbs): $4.43
- Container (5,000 lbs): $4.21

#### Hawaii

**Hawaiian Airline**

- General (500+lbs): $2.33
- Priority (500+lbs): $1.88

**Superferry**

- 30' Truck (w/ fuel surcharge): $3.18
- 55' Truck (w/ fuel surcharge): $3.19

According to this table, shipping tuna in 2,000 lb containers to the mainland will generate the least amount of cost (thus generating the most revenue) on a per pound basis. While prices being paid for bigeye are higher in Japan, shipping costs to the western United States are lower than to Japan and there are no import fees or auction costs to deal with, therefore revenue is maximized in the mainland market. While the lack of tariffs and low cost shipping in Hawaii make the local market fairly attractive, the prices being paid to tuna suppliers are very low. Selling to the Hawaii market is actually the least profitable means of doing business for the tuna farmer. Factor in a 10% commission fee
when selling to the Honolulu Fish Auction and suddenly the Hawaii market looks less attractive. Remember, however, that a high quality fish will most likely get more than $3.37/lb for bigeye, thus making the local market look much more attractive than it currently does. It is also likely that wholesalers in Hawaii would be willing to purchase fish directly from the farm, thus bypassing the 10% auction fee levied at the Honolulu Fish Auction (per. comm. Gary Ishimoto of Diamond Head Seafood Wholesale Inc.).
Recommendations

Marketing Tools

There are several marketing tools that a Hawaiian tuna farm would find useful when distributing his or her product around the world. There is currently a fear, mainly among Americans, that tuna meat is full of mercury and that ingesting this tuna will cause irreparable damage to one’s nervous system. While mercury contamination is a legitimate point of concern for the average American, most residents in the United States do not consume enough tuna to show the adverse effects of mercury poisoning. None the less, the fear that mercury can harm those who consume tuna is very real and must be addressed by those who supply it. Mercury scares (such as those in Japan decades ago or today’s concern in the United States) can cause the demand for tuna to decrease radically, therefore any supplier that can ease some of those fears will most likely profit enormously. Since mercury in tuna comes from the meat of those fish which the tuna consume, aquacultured fish that are fed from mercury free sources will not contain any mercury in their systems. Leonard Young of the Hawaii State Aquaculture Development Program (ADP) said that mercury testing of an aquacultured tuna would be possible through the use of atomic absorption spectrophotometer (pers. comm.). This device would be purchased by the State of Hawaii and would be used to test individual tuna for mercury toxicity. The tested tuna would then be “State Certified” mercury free, thus helping to differentiate locally raised tuna as free of mercury. The State would charge a small fee (unknown amount) for this service and could help elevate the status of the locally grown tuna above all others. As mercury poisoning is currently the main concern
for Americans with regards to tuna consumption, such a device would certainly alleviate those fears when consuming aquacultured tuna from Hawaii.

Another marketing tool for aquacultured bigeye would be to promote the product as Hawaiian bigeye, rather than as ahi. In the United States, ahi is used interchangeably for both bigeye and yellowfin. However, most ahi in the U.S. is actually the lower quality yellowfin. Most Americans do not know there is a sashimi grade tuna that falls somewhere between the expensive bluefin and the ubiquitous yellowfin. Marketing bigeye as bigeye will get sashimi consumers in the United States more accustomed to this “new” tuna. The excellent flesh quality of bigeye as compared with yellowfin will help to propel bigeye into higher class retail establishments, such as fine dining restaurants and specialty grocery stores. As this fish will not be inexpensive to grow, selling bigeye to high end retail establishments will be a must in order for the Hawaiian tuna company to stay solvent. In the beginning, however, there is likely to be a slower adoption of bigeye over “ahi” because of the relative unfamiliarity with this fish and its softer, more toro like flesh qualities. Once tried, however, it is likely that people will recognize the superiority of bigeye tuna over yellowfin. Adding the word “Hawaii” will also add to the differentiable qualities of this product. The Hawaii label has always had a certain mystique to it; most prominently with the Japanese market, but with the American market as well. Naturally, this differentiation of bigeye away from the ahi stigma will only be possible if the quality of the fish coming off the farm exceeds that of wild caught yellowfin. If this is not the case, then there is little point in differentiating the bigeye from the yellowfin because the substitutive qualities of lower grade bigeye and yellowfin are well known.
Promoting the fact that the product is farm raised will have both positive and negative repercussions. Some locations around the United States, such as the Pacific Northwest, have shown some resistance to accept Hawaiian aquacultural products due to the perceived negative connotations with aquaculture (pers. comm. Kelly Coleman Kona Blue Water Farms), though this attitude is slowly changing. Aquacultural products in Japan are also widely thought to be inferior to those which are wild caught. Since much of Japan’s aquaculture takes place in polluted coastal waters, the perception is that all aquacultural products are suspicious because they are likely contaminated with toxins (Bestor 2004, 149). The Japanese are also very up to date with events that have to do with seafood and were quite shocked and even appalled to learn that their favorite bluefin tuna sashimi might start coming from farmed sources (Issenberg 2007, 220). As the Japanese consume vast quantities of seafood, their media coverage of the topic is very extensive and many Japanese feel that wild caught tuna are superior in flavor to their domestic cousins (this refers specifically to ranched bluefin tuna being grown in Mexico, Europe and Australia). This is mainly due to the errors made in the diet of these fish early on which caused the flavors of the tuna to be quite unappealing. This, however, is changing and the quality of the European and Australian ranched tuna is nearly indistinguishable from the wild caught fish. It is possible that the Japanese might be somewhat offset by aquacultured bigeye as well. This would certainly be true with low grade bigeye.

On the other hand, the younger generations of Japanese are beginning to appreciate very fatty tuna and now that the bluefin ranchers have gotten their act together with regards to tuna diet and its meat flavor, it seems that the idea of farmed bluefin is not quite as appalling to the average Japanese consumer. The Japanese have shown to be
very forgiving of farmed tuna if the quality of the meat is high and bigeye will probably be no exception. People in the United States are beginning to accept farmed fish more and more as well. Salmon aquaculturalists, responsible for most of the bad press against finfish aquaculture in the U.S., have since cleaned up their act and are now producing a product is in many respects better than the wild caught version. Americans consume literally tons and tons of farmed catfish and tilapia as well. The stigma that aquacultured fish are inferior in flavor to their wild brethren is rapidly fading and so is the stigma that farmed fish are environmentally unsustainable. Offshore farms in Hawaii, such as Kona Blue Water Farms, are constantly being praised for their flavorful fish and their devotion to growing a product in an environmentally friendly manner.

Sustainability is another topic that needs to be addressed by a tuna farmer. As more and more people are becoming environmentally aware of the products they consume, many people are now researching the food they buy in order to ensure that they (the consumer) are not contributing to a product or process that is environmentally detrimental. Growing tuna in an environmentally conscientious way means that the food for the fish are sourced from sustainable stocks and that the offshore cages are placed in deep water so that effluent from the tuna is disbursed in the water column and is carried away in the currents. Fishmeal in food for farmed fish is a major point of contention between the industry and environmentalists. Fishmeal that comes from well managed stocks (such as the Peruvian anchovetta fishery) or fish trimmings and by-catch from human fishing activities are the most acceptable sources for fish food. Using land based proteins to grow tuna, however, is the goal of both environmentalists and the aquaculture industry as this is deemed to be the source of protein for fish that has the least
environmental impact. Environmentalists claim that aquaculture is supposed to take pressure off of wild stocks of fish and using wild caught fish to feed captive fish is not good practice because it does not alleviate capture rates from nature. This is a tall order to fill because proteins coming from land are different than those coming from aquatic sources, thus fulfilling an aquacultured fish’s nutritional needs becomes problematic. While reducing ocean based proteins in fish feed is the goal of sustainable aquaculture, weaning farmed fish completely off of wild fish stocks is simply not possible with today’s technology. Efforts to reduce fishmeal in fish food, on the other hand, are possible and should be done continuously.

Additionally, sustainable aquaculture practices mean that the water surrounding fish pens does not become polluted with effluent coming from the cages. This was a major blunder for early salmon farmers because they would place cages in shallow areas of the ocean with little to no water exchange, thus effectively turning their region of water into a giant cesspool. This situation was not good for the fish, the environment or the community surrounding the fish farm and the finfish aquaculture industry is still reeling from the negative press and opinions formed from early salmon farming. Today, many people still believe that fish farming will turn their local patch of the ocean into a filthy mess, even though this situation was remedied many years ago. Placing cages and netpens in deep water is the best way to ensure that the local environment stays pristine. Strong currents in Hawaii’s deep water keep a continuous flow of clean water coming into the local environment around the netpens currently in place on Oahu and the Big Island. Continuous monitoring of water quality around these sites have shown that there
is no measurable impact on the local environment around these farms due simply to the fact that they are placed in deep water regions with strong currents.

Finally, it would be the goal of any finfish farm in Hawaii to be certified with the sustainable label by a recognized institution. There are many environmental organizations that monitor both the aquaculture and fisheries industries. One of the most prominent fishery monitoring agencies is called the Marine Stewardship Council (MSC). This organization looks at different fisheries around the world labels them as eco-friendly or not. People are then able to know whether or not the fish they are buying comes from a well managed fishery or from one that will soon be completely devoid of fish; before they purchase that night’s dinner. Getting an eco-friendly label from such an organization as the MSC would be very valuable in any marketing campaign for farmed tuna.

It should be noted that many industry experts have mentioned that promoting the farmed bigeye product as a sustainably sourced fish at the expense of the fisheries is not a good idea. At no time should the farmed bigeye be deemed “more sustainable” than the fisheries. No negative comparisons of farmed fish against wild caught fish should be made either. This has a tendency to infuriate many fishermen and their lobbying groups, which will then turn around continue to badmouth aquaculture as an unsustainable and environmentally unfriendly way to obtain protein from the ocean. There is no doubt that most fisheries around the world are under considerable pressure, but that does not give aquaculturalists the right to promote themselves as somehow “better” than fishermen. For example, when promoting mercury free tuna, the low to absent mercury levels should be compared to EPA standards, not to fish caught from wild stocks. Bad mouthing fishermen in the press as a way to market bigeye tuna will only end up hurting an
aquaculture business, for several reasons. Those involved with the fishing industry have considerable knowledge about the animals they harvest and that knowledge can prove valuable to any aquacultural operation. These same fishermen also have considerable power and influence around the world and can work to promote bad press about an aquaculture venture and can even work to destroy any given business. Getting along with one's neighbors can be a valuable relationship and aquaculture needs to do just that with those who work to ply the oceans alongside them.

Respecting Market Conditions

There is an established market for *sashimi* grade tuna with well defined guidelines that a supplier must meet in order to offload their product. All too often, aquaculturalists will show up to market with a product that they feel is of sufficient quality and will try to charge top dollar for it. What they fail to understand, however, is that the market realities of the product should dictate how the product is presented and sold, not vice versa. It is simply not enough to create a product without the market desires as an end goal. For example, aquaculturalists started farming *mahi mahi* (*Coryphaena hippurus* or dorado) in Hawaii and then tried to sell their product at the local market (pers. comm. Brooks Takenaka of the United Fish Agency which owns the Honolulu Fish Auction). On the surface this sounds ok, but a more in-depth analysis revealed that these farmers were trying to sell their fish at 12 lbs, when the market wanted a minimum of 15 lbs. The palatability of the fish was also sub par because of the pelleted feed that was being given to the fish (thus causing an off flavor in the meat). The formulation had not been matched to create a fish that tastes like its wild cousins and these farmers then tried to sell their
wares at an inflated price. Needless to say, they did not do well. Careful study of the market desires needs to be conducted before a product can be sold on said market. With the case of tuna, the guidelines for a quality fish are very strict (at least for a high grade product) and are well known by industry insiders. As grading tuna is more of an art than a science, employing the expertise of industry professionals would prove invaluable.

Getting professional tuna graders to sit down and explain their how they grade fish in detail to the staff the tuna farm would not only prove invaluable, it would be absolutely necessary for creating any sort of a product that will be accepted on the market. Also, even if the bigeye farmer decides to skip the auction market in favor of utilizing the wholesale distribution network, it would be a good idea to send some portion of each harvest to the auctioneers in Honolulu. The information on the grades and prices of each tuna sold are sent back to the supplier. This data could then be used by the farmer as an objective form of quality control. Since the purchasers at the auction are highly trained and objective, their assessment of the bigeye could be used to improve the quality of future fish being sold in the market and could also be a way to spot any problems on the farm. For example, if the grade of the tuna decreases because of overly fatty fish (which causes a mushy meat), then the farmer knows that the tuna are either being fed too much or are being fed a diet that is overly fatty. Corrections can be made and fish from the next harvest being sent to the auction will determine if the corrective actions were successful.

Tailoring the conditions of the tuna growth and harvest process (eg. type and amount of food given, harvesting techniques, size of fish being sold, etc.) to suit what the market demands and then using these desires as an end goal for meat quality will help to insure that a product that is readily accepted and a steady demand is created. Hawaiian
tuna farmers need to remember the folly of the *mahi mahi* farmers and tailor their operations accordingly.

**Marketing Plan Scenarios**

For the final recommendation there are two scenarios that need to be considered. This is because of a very important unknown variable which will dictate two separate courses of action, depending on what the variable might be. This wild card variable concerns the quality of the meat being produced at the fish farm. High quality *sashimi* and low quality *sashimi* will have two separate forms of distribution.

Both scenarios, however, do have one common thread of similarity: The Japanese market should not be the primary country of distribution. This particular market, while large, has stagnated for some time now. Prices paid in Japan to suppliers of bigeye tuna are not significantly higher than those found in the United States and Hawaii. In fact, it is doubtful that the slightly higher prices being paid in Japan will be able to offset the high costs of getting the product into Japan and distributing it, as demonstrated earlier in this paper. The cost of doing business in Japan is currently too high to consider this country a viable market. This is simply due to the fact that 37-51% of the revenue received from the bigeye would go directly to shipping costs, dealer commissions, and tariffs. While selling high grade tuna to Japan would certainly increase the reputation of the bigeye farmer, such ego driven motives would not translate into long term financial success.

While there is an established market in Japan for bigeye tuna, there are more growth opportunities in the United States. The *sushi* industry in the U.S. is currently growing at the breakneck speed of 20% per year (pers. comm. Kelly Coleman of Kona Blue Water 80
Farms), while the same industry in Japan has been slowly shrinking for over a decade. The lack of familiarity with bigeye in the United States might mean a somewhat longer adoption time by the masses, but it will also give the Hawaiian farmer a “first mover status” to reward him or her for their product. If the product is of sufficiently high quality and all of the marketing tools mentioned above are implemented, the standard for bigeye will be set fairly high. After all, how many high grade tuna suppliers can be marketed as sustainably grown in Hawaii that are State certified mercury free? These tuna should be sold in Hawaii first, then to the mainland United States.

Additionally, when selling into the Hawaiian market, there are two strategies that can take place with regards to wholesalers. A multi distributor tactic can be taken where multiple local wholesalers buy the tuna in smaller quantities and try to sell the product that way. This is the way the Kona Blue Water sells their Kona Kampachi® to the market, both in Hawaii and on the mainland. This approach is good for a product that is relatively new to the market and which large wholesalers are probably not willing to buy in large quantities because of the high risk involved with such a purchase. After all, fresh fish is highly perishable and buying a new product in large quantities might not make much sense because there is no mass market for Kona Kampachi® yet.

Another method would be to go with one main distributor who will sell the product throughout the islands and a few larger partners on the Mainland. This is the recommended strategy given by local wholesalers (pers. comm. Charles Umamoto of the Hilo Fish Company and Shawn Inoue of the Tropic Fish and Vegetable Center) for several reasons. The first is that selling small quantities does not give the wholesaler any incentive to really “push” the product. Since the wholesaler will not be deriving
significant amounts of revenue from such a product, why spend extra time and effort to sell it? If one wholesaler in the islands were to have the contract to sell farmed tuna, the possibility for profitability for the wholesaler will increase dramatically. This will be the incentive for the holder of the wholesale contract to really go out and market the product. Additionally, the market for tuna is well established, therefore buying large quantities of it will not be as risky because demand for tuna is strong. In fact, a single large wholesaler on the mainland can easily absorb 10,000 lbs of tuna per week (pers. comm. Charles Umamoto of the Hilo Fish Company and Shawn Inoue of the Tropic Fish and Vegetable Center). This is probably not true for Kampachi®. The Hawaii based bigeye farmer should be able to sell farmed tuna to several large wholesalers on the mainland and one or two wholesalers in the Hawaiian market rather than dozens of wholesalers around the U.S. and multiple wholesalers in Hawaii.

Scenario One

In this scenario, the quality of the fish is average to low; essentially No. 2 or 2-grade and lower. Basically, this tuna is suitable for grilling, poke and the low grade sashimi that is typically found in markets that are just beginning to consume raw fish such as those in Middle America. Tuna this low on the scale will not be sent to Japan, no matter what. That leaves the local market in Hawaii and the market on the American mainland. As the price per pound of medium and low grade bigeye is not very high, it would make the most sense to sell as much of tuna in Hawaii as possible, mainly to keep shipping costs low.
Hawaii can and does absorb a huge quantity of tuna for local consumption and the market will take in all grades of tuna. Selling these fish whole will help to increase the price being paid on a per pound basis. As mentioned earlier, there is a $1.247/lb premium paid in Hawaii for whole fish. Large fish are also able to get higher per pound prices than smaller fish. The Hawaiian market looks for fish that are >100 lbs as their upper echelon for size preference and this should be the size supplied to the market. The low grade tuna should stay out of the auction system because of the large price fluctuations that tend to characterize this form of market distribution. The Honolulu auction has a monopoly on its services in Hawaii and can take a significant commission (10%) from those suppliers they deal with. A low grade tuna will already sell for less than a high grade one and then to send to the fish market where an automatic 10% gets lopped off the top is simply not worth the hassle. Going straight to the wholesalers who will buy entire batches of tuna in bulk will help to smooth out some of the price variability that is typified at fish auctions. Prices of the tuna being purchased in bulk will be well known in advance, thus reducing some pricing risk for the supplier. It is also very possible that saving money on commission fees by selling only to wholesalers will increase the bottom line as well.

Any excess capacity tuna should be sent to the mainland. Whether selling to Hawaii or the lower forty eight, this bigeye should not be differentiated extensively and should probably be sold under the generic title of “Hawaiian ahi.” Even though Hawaii has a high per capita consumption pattern for seafood, the market as a whole is still fairly small. For this reason it is likely that the bulk of the tuna will be sent to the mainland. Since most mainland Americans are not used to bigeye yet, branding the tuna as bigeye rather than as ahi might frighten many potential customers away. This is simply due to
the fact that they are not used to the softer texture of bigeye and will probably shy away from it if they know that they can buy “ahi” for the same price and enjoy the same quality of fish. Additionally, spending extra time and money promoting a product of the same quality and flavor as an established product (ahi or yellowfin) is simply not a good idea. As No. 2- quality bigeye will sell for the same price as yellowfin, there is no sense in eroding margins by promoting a commodity that is not much different than the stuff that is already on the market. Additionally, it would probably make sense to sell the bigeye to wholesalers in large, urban markets along the West Coast, again to save money on shipping costs. Remember, growing captive tuna is a very expensive process, so trying to keep margins as high as possible becomes much more important when selling an average grade commodity. Even though the seafood wholesale industry is so fragmented, it is likely that only a few different companies will be utilized when selling the bigeye to the mainland. Since low grade bigeye will be sold as a commodity, working to differentiate bigeye from ahi is not necessary; therefore trying to establish new markets for bigeye by utilizing wholesalers in multiple markets is simply not worth the extra money. Unloading the mid to low quality tuna in bulk on a few large buyers makes more sense than sending the fish to multiple buyers in small quantities, thus spending more money on shipping costs.

Size of tuna also matters on the mainland and large fish receive higher prices than small fish. Tuna that are >80 lbs are the fish most likely to get the highest amount of money on a per pound basis. Contrary to what the Hawaiian market prefers, the mainland market prefers their tuna to be without head or guts. The mainland is also much more accepting of fully processed tuna than either the Hawaiian or Japanese markets (pers.
comm. Howard Woolf of Jana Brands). Unprocessed tuna take longer to begin spoiling, therefore the preference on the mainland is still for unprocessed fish and price paid to suppliers reflects this.

Any differentiation of the low grade Hawaiian bigeye should rest solely with the fact that the fish will be mercury free. Doing mercury tests on batches of fish and obtaining a State Certificate that mercury levels are well below EPA guidelines will definitely help to sell the product. It may even boost the price a bit, especially when combined with the Hawaii brand mystique. While State certified mercury free ahi may or may not increase the price of the fish at the supplier level, it will definitely go a long way to ensure that the demand for the fish is there, even if it is at the lower end of the pay scale. Since mercury is such an important issue for American consumers, there are plenty of people out there who would choose “Certified Mercury Free” tuna over a fish that may or may not be contaminated with unsafe levels of the heavy metal.

Finally, if scenario one were to happen and an average or low grade product were produced, it should be goal of the farmer to significantly increase the quality of the fish as high as possible. Again, growing these fish in captive conditions is very expensive, thus selling farmed tuna for high prices is a must. This simply will not happen if the quality of the product is low.

Scenario Two

In this scenario the quality of the bigeye meat is very high, with No. 1- grade being the lowest. Ultimately, this scenario is the goal of the bigeye farmer in Hawaii because creating a quality product will help to generate more income to cover the high
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Scenario Two

In this scenario the quality of the bigeye meat is very high, with No. 1- grade being the lowest. Ultimately, this scenario is the goal of the bigeye farmer in Hawaii because creating a quality product will help to generate more income to cover the high
fixed costs associated with an offshore fish farm. A high grade bigeye can and will be the star of many white tablecloth restaurants and specialty grocery stores. This is the type of product that can be sold in Hawaii and across the entire USA. As with scenario 1, large fish get the highest prices (>100 lbs for Hawaiian market and >80 lbs for the mainland) and fish sent to market should reflect those preferences. Again, tuna in Hawaii should be sold whole and tuna sent to the mainland should be headed and gutted.

First, getting local sponsorship by one or more of Hawaii’s celebrity chefs (think Sam Choy, Bev Gannon, Alan Wong, etc.) will help establish farm raised bigeye in Hawaii as a luxury product. This can be done by sending these chefs samples of fish or by meeting them at local food events. Purchasers at the Honolulu Fish Auction, including graders and wholesalers, are another group of people that would be tough critics of the bigeye and need to be sufficiently impressed before coming on board as possible promoters. It is likely that their promotion would come in the form of word of mouth to their customers, rather than as a public extolment. Word of mouth in an island community such as Hawaii can have a very influential effect on sales. If the auction is bypassed, using one or two local wholesalers would be the best alternate distribution route, as mentioned previously.

Selling on the mainland should start in large, urban markets with many fine dining and sushi establishments. Places like Los Angeles, San Francisco, Phoenix, Las Vegas, Houston, etc. should be targeted first. Wholesalers in these regions would be the most likely candidates as customers. It would be important to find those dealers which would help to promote this high grade bigeye as a separate product from the regular ahi that they normally get. Differentiation of the product as a “new tuna” would be a worthwhile
goal. Since Americans are fairly unfamiliar with bigeye as a separate product from ahi, they will need to be told and then shown exactly why this fish deserves culinary respect and why paying a higher price for it is not out of the question. The bigeye should be promoted as a sashimi that lies between bluefin and yellowfin. It will also be grown in Hawaii's pristine waters in a sustainable manner and is certified by the State of Hawaii to be well below the EPA standards for levels of mercury. This type of promotion can be done at food trade shows around the nation. Now that the blogosphere is the new word of mouth, inviting some of the well known foody bloggers to try farmed bigeye at these trade shows might be a relatively inexpensive form of promotion as well. Like celebrity chefs, these bloggers can really help make or break a product's public perception. Mainland celebrity and high profile chefs should also be recruited to help promote the product. As these folks are more familiar with the intricacies of the sashimi world, they will be more familiar and thus accepting of bigeye tuna and will not shy away from the softer texture of the meat and will recognize the higher level of quality when compared with yellowfin.

Once there is a demand from sushi bars and fine dining restaurants, high end grocery stores and health food stores should be targeted. As Hawaiian bigeye should be fairly well known at this time, expanding from restaurants into people's homes is the next logical step. Selling to health food stores and high end grocery stores will help to keep the Hawaiian bigeye reputation as a premium food alive and well. This market is also a very large and is growing rapidly. For example, Whole Foods, the nation's largest health food chain, has 276 locations and grossed $6.6 billion in sales during FY 2007 (Whole Foods, 2007). Clearly, the health food business has grown from niche market to a
multibillion dollar industry that is becoming more mainstream each year. In addition to the many local health food stores, large brands such as Safeway and Albertson’s are trending towards becoming luxury grocery chains as well. These types of stores will help Hawaiian bigeye become a household title across the country.

Over time, more market penetration will occur in smaller *sushi* markets and those that are currently growing in size, such as the Midwest. This strategy will continue as the amount of fish raised by the tuna farm increases accordingly. It is likely that if the bigeye branding mechanism works well, other sources of bigeye will pop up. Some fish may even be diverted from Japan to satisfy the new market in the United States. These fish, however, will be wild caught and will be subject to strict catch quotas and regulations, thus the low supply of high grade, wild caught bigeye will not compete with the differentiated bigeye that are sustainably grown, cultured in Hawaii’s pristine waters and are certified mercury free. Strong branding of the farmed tuna will help to keep people asking for this product, even in the face of high grade bigeye from wild sources. Additionally, it is likely that the branding process for the cultured tuna will have been underway for several years before any wild caught bigeye are redirected from Japan into the United States. Hopefully, the bigeye farmer will be able to use the momentum of the first mover status in the market to drive demand for cultured fish and expand operations to be the largest market player of high grade bigeye tuna to the United States. As this market is currently very small, this goal is not as far fetched as it may seem.

Sending fish to the Japanese market might occur after 5-10 years of successful sales in the United States. If the quality of the fish are very high and the prices in Japan increase to their previous levels, sending fish to Japan might be a profitable venture again.
While the market for sashimi has shrunken somewhat, Japan is still the world’s largest consumer of raw fish and should not be ignored. If the Hawaiian bigeye brand becomes successful enough, it is likely that a Japanese company will approach the owners of the farm and try to make a deal to secure some trade agreements. As the farmed fish from Hawaii will be a luxury product, it might make sense to send fish to the auction houses, as they pay the most money for high quality tuna. Tsukiji in Tokyo would be the most likely fish auction to send Hawaiian bigeye to because they have an established market for such fish and would be able to take larger quantities of fish in at one time. Sending tuna to Japan is expensive, so sending in bulk would be logical. A lower quality product would most likely be sent to wholesalers for grocery markets in Japan. These wholesalers prefer lower priced products with consistent supply patterns. An aquaculture venture should certainly be able to provide consistency in quality and possibly supply throughout the year.

Combining Scenarios One and Two

In all reality, a brand new, full life cycle tuna farm would probably have to move down a fairly large learning curve in order to begin producing high grade bigeye sashimi. Currently, there are no commercially viable farms like this anywhere in the world, though the Japanese are just beginning to get a commercial bluefin farm up and running and the Australians have just reported early success with their bluefin farming venture. Having to move down a learning curve means that there will most likely be errors in the growout process that will cause the first few batches of bigeye to be of lower quality. Since the goal of producing high grade tuna will still exist, it is probable that the producers of
aquacultured bigeye will face both scenario 1 and 2. Initially, various kinks in the diet and harvesting process will most likely create a product of medium to low grade. After some trial and error, however, it is equally likely that a high grade product will be produced, thus moving the marketing strategy from that of scenario 1 into scenario 2. Distributing the initial batches of bigeye in Hawaii under the *ahi* pseudonym will help move the product until it is ready to be differentiated as a separate, high grade product. Any excess meat will also be sent to the mainland as *ahi* in order to create a continuous revenue stream if the Hawaiian market cannot handle all of the fish being distributed.

Conclusion

As many countries around the world are currently in the midst of unprecedented economic growth and social change from formerly developing countries into economic powerhouses, their citizens are demanding more expensive food from all corners of the globe. *Sushi* and *sashimi* restaurants are quickly becoming the most in-demand types of establishments in these countries. For example, the New York Times reported in 2001 (Tavernise), that the number of *sushi* restaurants in Moscow has exploded. Additionally, the most difficult restaurant to get a weekend reservation at in Dubai is a *sushi* lounge called Cho-Sho and the Chinese are expected to create 50 million new *sashimi* consumers within the next several years (Issenberg 2007, 266). In fact, some industry experts expect that in five years, the Chinese will be willing to pay more for their *sashimi* that the Japanese and that exporters will be looking to China instead of Japan to send their products (Issenberg 2007, 268). Europe has also begun to emerge as a destination for *sashimi* exports. Due to government regulations, the quality of fish in Europe tends to be
fairly high (pers. comm. Howard Woolf of Jana Brands). The South Koreans are increasing their sashimi consumption and were already consuming 20,000 MT (44 million lbs) in 1996, though most of this quantity was supplied by domestic fisheries (Bartram et al. 1996, 8). Clearly, the world is demanding more raw fish a source of luxury protein. The vast majority of wild stocks are either fished at maximum capacity or more and it is unlikely that more fish are available in the ocean to supply the growing demand. As more people around the world are gaining appreciation for the value of sashimi, more markets are beginning to appear for this product. Very soon, new markets will be siphoning off sashimi grade tuna and other fish from Japan and the United States. It is for this reason that any Hawaii based tuna farm be poised to take advantage changing market conditions and not be afraid to take the leap into unfamiliar territory. Staying up to date with regards to East Asia, Europe, Russia and others will be crucial to tuna ventures in Hawaii and will most certainly pose as expansion opportunities for these farms. Until then, however, Hawaii and the mainland United States are the most likely regions for bigeye penetration and expansion into the new frontier of high grade bigeye. If prices increase significantly, Japan may even be a viable market for farmed Hawaiian bigeye in the future as well.
Appendices

Appendix A

Condition scores for yellowfin and bigeye

1 Very good (50)
   - no apparent defects/damage (no rips, tears, cuts abrasions)
   - scales intact
   - fish looks as though it has just been lifted from the water, natural body colors bright
   - flesh notch very firm (springs back quickly) on pressing lightly with fingertips, no soft spots present on carcass surface

2 Good (40)
   - slight apparent defects/damage (a few minor rips, tears, cuts abrasions)
   - some scales lost
   - body colors a little dull
   - flesh notch very firm (springs back slowly) on pressing lightly with fingertips, one or two soft spots present on carcass surface

3 Medium (30)
   - noticeable defects/damage (maximum 2 rips, tears, cuts abrasions which could affect meat yield)
   - small patches scales lost
   - body colors dull/dark
   - flesh notch very firm (springs back slowly) on pressing lightly with fingertips, one or two soft spots present on carcass surface

4 Poor (20)
   - more than 2 rips, tears, cuts or abrasions which could affect meat yield
   - large patches of scales lost
   - body colors dark
   - bleaching, red staining very important
   - flesh at notch soft, does not spring back at all on pressing lightly with fingertips, large soft areas on carcass surface

5 Very Poor (10)
   - severe body damage, distortion
   - severe scale loss
   - body colors dark
   - severe bleaching, staining
   - flesh at notch very soft, falling apart, carcass surfaces breaking up
   - meat has evidence of parasites or disease
Appendix B

Color Scores For Bigeye

1. **Very good score (50)**
   - meat is transparent, glossy
   - colors are bright
   - large amounts of fat present, penetrating into the inner muscle layers

2. **Good score (40)**
   - meat is a little translucent and less glossy
   - colors are less bright
   - large amounts of fat present penetrating into the inner muscle layers
   (Note: some carcasses are too fat!)

3. **Medium score (30)**
   - meat is translucent and has lost gloss
   - colors are a little dull
   - fat is present, but with little or no penetration into inner muscles
   - meat may be a little brownish

4. **Poor score (20)**
   - meat almost opaque
   - color of meat is distinctly brownish and dull
   - little or no visible fat in outer muscle layers - meat same color throughout

5. **Very poor score (10)**
   - meat opaque
   - color of meat is brown, whitish or grey
   - little or no fat visible in outer layers
Appendix C

von Bertalanffy eqn: $L_t = L_\infty [1 - e^{-K(t-t_0)}]$, where

$L_t$ = Length (cm) after time (t)
$L_\infty$ = Asymptotic length (cm)
$K$ = Growth coefficient/yr
$t_0$ = Age at zero length

Yellowfin

$L_2 = 230.7(1-e^{(-0.267)(2+0.081)})$
$L_2 = 98.344$

Bigeye

$L_2 = 208.7(1-e^{(-0.201)(2+.9906)})$
$L_2 = 94.29$
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