Socio-Economic Study
Of the Aquarium Fish Industry
In West Hawaii

Cesar Environmental Economics Consulting (CEEC)

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I. Introduction

The aquarium fish industry is an important nearshore fishery and an extractive user of Hawaiian coral reefs. Despite of it's economic importance and potential environmental impact the industry has been largely unregulated in Hawaii. Published information on the industry is largely based on data from catch reports that aquarium collectors are required to file by law with the Hawaiian State agency Department of Land and Natural Resources (DLNR), Division of Aquatic Resources (DAR).

Annual summaries were published by DAR until 1994, and a five year summary of Fiscal years 1995–1999 was published in 2000 (Miyasaka 2000). The last in depth socio-economic industry study was published in 1984 by van Poollen and Obara.

This study was designed to re-evaluate socio-economic characteristics of the industry. Data from detailed interviews of the industry were used to analyse and validate existing literature data. The focus of the study was the West coast, commonly called Kona coast, of the Big Island of Hawaii, which has been the most important catch area in Hawaii since 1994 (figure 1). Close to 90% of collectors and wholesalers live in the vicinity of the city of Kailua–Kona, offering an interviewer easier access and a more effective use of resources compared to other catch areas in Hawaii (own findings).

II. Material and Methods

Existing data, in particular published catch report information by DAR (e.g., Miyasaka 1994, 1995, 2000), available socio-economic studies of the industry (e.g., Wood 2000, van Poollen and Obara 1984) and biological research on topics related to the aquarium fish industry in Hawaii (e.g., Tissot and Hallacher 1999) were reviewed.

Taking into account the limited amount of available information, the fact that industry data for the years 2000 to 2002 has not been published, and the widespread non-compliance with catch report filing requirements (figure 1), primary industry information was then gathered.

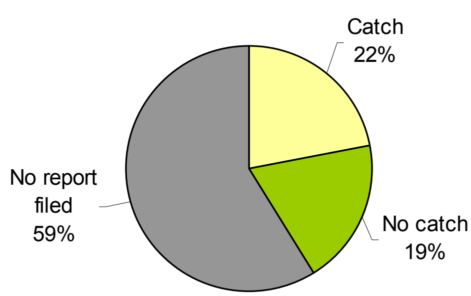

Figure 1
Catch report filing compliance of aquarium permit holders in West Hawaii between 1/98 and 7/99

The main study tool was the conduction of interviews with aquarium fish collectors and wholesalers. Before the beginning of actual interviews, in February 2002, letters describing the study and asking for participation were sent out to every person holding a valid aquarium collecting permit on the Big Island. Initially targeting collectors who had responded to the letters by declaring their willingness to be contacted, the interview phase of the study began in April 2002. The sample of collectors and wholesalers for the interview was chosen non-randomly, because willingness to participate was initially low (four respondents at onset of interview phase) and only increased when collectors who had been initially involved referred the interviewer to other collectors and endorsed the study. From April till July of 2002, a total of 15 permit holders was interviewed. Ten of the fifteen were active collectors; five of these ten were also wholesalers. Another wholesaler who did not go out on collections nor held a collecting permit also participated. Interviews followed a 21 page questionnaire (figure 2) consisting of two main sections, a fact section using mostly structured questions, and a perception section using semi-structured and open ended questions. Interviews lasted from 1 to 3 and a half hours.

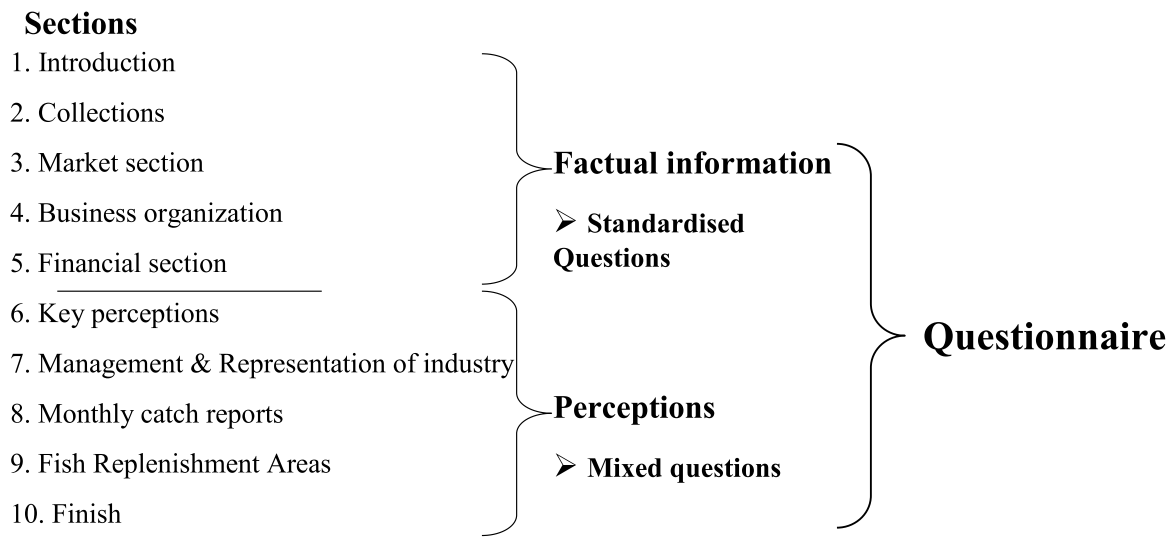

Figure 2 Structure of Questionnaire used for interviews with aquarium fish industry participants

III. Results

1. Characterisation of the Big Island aquarium fish industry

1.1 Comparison of the industries of the Big Island and the rest of Hawaii

Over the last 5 years of available data, the Kona fishery has consistently been the most important catch area in Hawaii (figure 3). Between fiscal year 1995 and 1999, the Kona fishery contributed between 49% and 67%, with an average of 58%, to the total catch in Hawaii.

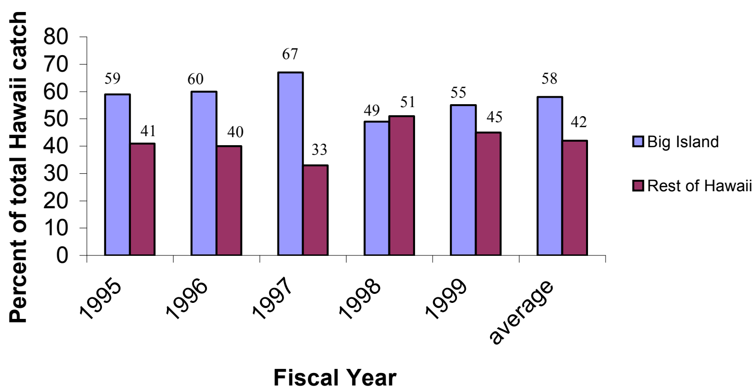

Figure 3 Relative Importance of the Big Island aquarium fish industry for the state – wide fishery (data from Miyasaka 2000)

1.2. Collectors and Wholesalers

1.2.1 Number of people in the industry

Collection of Aquarium Fish in Hawaii requires a permit issued by the Division of Aquatic Resources (DAR). Past studies indicate that although non-commercial licenses in Hawaii may be substantial in numbers issued, this does not translate into relevant catch amounts (e.g. van Poolen & Obara 1984 determined non-commercial at 1 – 2 % of total catch). This study therefore concentrates on commercial permit holders.

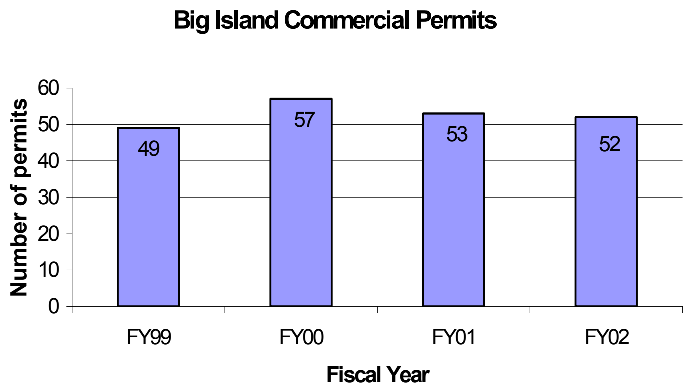

Figure 4 Big Island Commercial Permits issued by DAR (from DAR unpublished data)

The number of commercially active collectors is much smaller than the number of permits, which has been close to 50 on the Big Island over the last 4 years (figure 4). Active wholesalers and collectors have a good understanding who is presently active and who is not, who is selling to whom and other industry relations, which after repeated interviews and crosschecking of information was used to generate an estimate of the West Hawaii industry structure in the Spring of 2002 (Table 1).

Collectors	Count
Permit holders	52
Active collectors	22

Active collectors	Count
Independent contractors	16
Collector/Wholesalers	6

Wholesalers	Count
Total	8
Of these exclusively wholesaling	2

Table 1 Estimate of the number of collectors and wholesalers involved in the Aquarium fish industry on the Big Island in 2002 (DAR data and own findings)

It is important to recognize that the industry size and structure fluctuates. The numbers given here have to be treated with caution if they are used at a later point in time.

1.2.2 Basic categories of wholesalers and collectors

All collectors not involved in wholesaling operate as independent contractors. This means that they are technically not employed by wholesalers and do not work for fixed salaries, but are paid per catch that they bring in. This study found three basic categories of wholesalers (counts in brackets), and four broad categories of independent contractors, each of which will be briefly be defined below.

Wholesalers

1. Wholesaler/collector: a person buying fish from independent contractors and shipping and selling them to other buyers, but also going out on collections (6)
2. Wholesaler: a person not owning, or using, a collection permit, exclusively buying fish from collectors, shipping them on and selling them (1)
3. Manager of a wholesaling business: a person not going out on collections, receiving a salary in exchange for managing a wholesale business for the owner (1)

Collectors:

1. Independent contractor with own boat, paid per fish sold to a wholesaler
2. Independent contractor without own boat working on a collector/wholesaler’s boat, paid a certain amount per fish of a agreed on percentage of the total catch
3. Independent contractor using a wholesalers boat for own collections, paid per fish sold to the wholesaler minus a percentage of the catch in exchange for the use of the boat
4. Independent contractor using a wholesalers boat, paid per fish sold to the wholesaler but receiving a lower than market price for his fish in exchange for the use of the boat

1.3 Collections

1.3.1 Collection methods

The main fish collection method in West Hawaii is the use of fine meshed (<1 inch meshsize) barrier nets (also called fence nets). These nets are usually used to collect fish species that occur in abundant numbers. Additional equipment used in the method is scoop nets, long sticks called “tickle sticks” and catch buckets. Fish are either herded into the net by one or several scuba-divers using tickle sticks, or they are chased out of their territory, then the net is set, and the returning fish get caught in the almost invisible net. The mesh size is usually not more than a ¾ inch, and fish can be scooped out of this fine net with small handnets and placed in buckets. In addition to barrier nets, divers sometimes use their scoopnets without the use of the barrier net to catch rare species that they come across on dives. Sometimes, divers go on deep dives with handnets to specifically target rare species. Basic information about collections and collectors is assembled in Table 2. The use of chemicals (e.g. cyanide) for collections is forbidden in Hawaii. There were no indications that collectors are breaking this law. As noted by van Poolen and Obara (1984), mortality rates of fishes in aquarium fisheries that use chemicals are several times as high as those in a fishery using nets.

Collectors	Average	Range
Age (years)	45.2	32 – 60
Experience (years)	14.9	2.5 – 36
Collection method	barrier net	
Length (feet)	37.2	10 – 50
Divers/net	1.7	1 – 3
Boat length (feet)	20.5	17 – 26
Weeks/year	48	36 – 52
Days/week	3.3	1 – 4
Dives/day	3.3	
Depth (feet)	53	
Fish Mortality rate	<1%	0.5 – 2
Use of chemicals	No	No

Table 2 Average and range information about collections and collectors (own data)

1.3.2 Estimated mortality rates in Hawaii

Collectors and wholesalers were asked to give estimates of mortality rates on the different steps of the chain of custody. Results are summarised in Table 3.

Stage in chain of custody	Mortality rate (own interviews)	Mortality rate (survey results van Poolen and Obara 1984)
From collection to wholesaler	0 – 1%	1 – 2%
In the wholesaler's tanks	< 1% - 2 %	2 – 3%
During shipping	0.75% - 2%	2 – 3%

Table 3 Range of estimates of mortality rates by wholesalers and collectors (own findings).

Estimates of mortality rates in Hawaii have gone down since 1984. This change in perception may reflect real changes, as wholesalers' holding facilities have increased in quality since 1984. Up-to-date methods including UV-lamps, protein skimmers and filter towers are standard. Decreases in mortality during shipping can possibly be accredited to better flight connections and better know-how.

1.4 Catch composition and numbers

Collectors were asked for the species that they considered most important in their collecting operations. Answers showed similar perceptions throughout the industry (Table 4).
The Yellow Tang was mentioned by all collectors and is commonly referred to as the "bread and butter fish" of the industry. Estimates of the component of total catch of each collector made up of Yellow Tang ranged from 70% - 90% of their catch. The most commonly mentioned rare but more valuable species is Tinkers Butterflyfish (*Chaetodon tinkeri*). Potter's Angelfish (*Centrpyge potteri*) is commercially less valuable but more abundant. Interview findings support catch composition data from official catch report summaries (figures 5,6,7).

Species	Number out of 10 collectors interviewed mentioning this species
Yellow Tang (*Zebrasoma flavescens*)	10 (= 100%)
Kole (*Ctenochaetus strigosus*)	7 (= 70%)
Achilles Tang (*Acanthurus achilles*)	6 (= 60%)
Naso Tang (*Naso lituratus*)	6 (= 60%)
Other species mentioned (count in brackets): Moorish Idol (*Zanclus cornutus*) (1), Chevron Tang (*Ctenochaetus hawaiiensis*) (1), Goldrim Surgeon (*Acanthurus nigricans*) (1), Longnose Butterflyfish (*Forcipiger longirostris*)(1)	

Table 4 Species considered important for collectors' businesses (interview data)

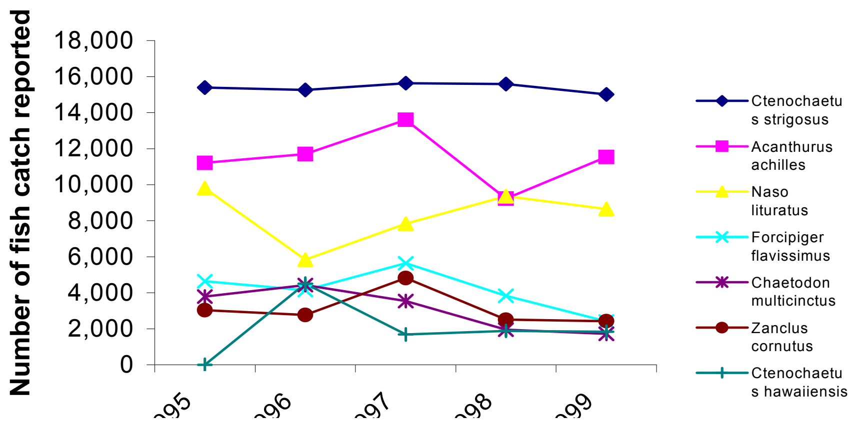

Figure 5 Catch composition for the Big Island of Hawaii, FY 1995-1999, four most important species by number (data taken from Miyasaka 2000)

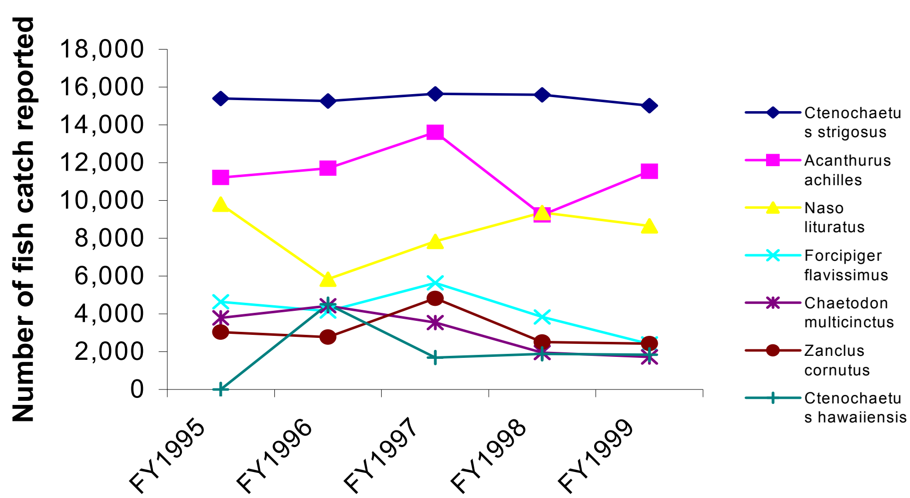

Figure 6 Catch composition Big Island displayed with Yellow Tang data for higher resolution, FY1995 – 1999 (data taken from Miyasaka 2000)

The four species mentioned by most collectors in the interviews are also the four that according to DAR data are collected in the highest numbers. In order of rank of importance, these species are Yellow Tang, Kole Tang, Achilles Tang and Naso Tang. These "Big Four" retain the same rank over the five years of official data used in this study. This distinguishes them from other species found among the top ten most caught species, which change in importance from year to year. Despite the dominant importance of certain species in terms of catch numbers, it is important to keep in mind that the total range of species caught is much larger. Furthermore, in theory low catch of a rare species can have as significant an effect on the population structure of that species and potential ecological consequences as can be the case for high catch of an abundant species.

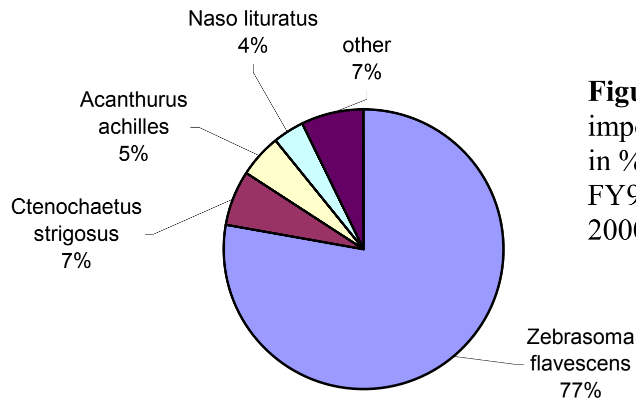

Figure 7 Average relative importance of common species in % of total catch number, FY95-99 (data from Miyasaka 2000)

The importance of the "Big Four" changes very little over the years and has been larger than 90% of the total in terms of numbers and over 80% in terms of value over the last 5 years of available data (figure 7; Appendix B). The difference is caused by the fact that rarer species usually have a higher than average price on the market. A good example is *Ctenochaetus hawaiiensis*, the Chevron Tang. This species is collected in strongly fluctuating and relatively low numbers. It obtains a high price on the market and in good catch years can generate as much income as *Ctenochaetus strigosus*, the species ranked second in importance in terms of numbers.

1.5 The Market

1.5.1 Market chain

Virtually all fish collected on the Big Island pass through one of the eight existing wholesale businesses. Only a very small percentage of these fish is sold on the Big Island, the overwhelming rest is shipped. Customers of wholesalers are found on Oahu, on the mainland, in Europe and in Asia. With few exceptions, shipments go to Oahu first due to uneconomic freight rates from Kona International Airport, concern about shipping delays that increase fish mortality, and limited agricultural inspections for international shipments. Commonly, customers of wholesalers are wholesalers/distributors. Although there is a local market for aquarium fish, Big Island wholesalers' estimates indicate that most fish are eventually shipped out of State (Table 5).

Wholesaler	Primary market mentioned	Estimated % out of State
A	Mostly mainland and international	98%
B	Exclusively mainland and Europe	100%
C	Mainland (some through Oahu distributor)	95%
D	Mostly mainland through Oahu distributor	95%
E	Mainland, 2% Oahu	98%
F	To Oahu distributor, but for export nonetheless	Greater 90%

Table 5 Big Island Wholesalers estimations of percentage of fish handled by their business being exported out of State (own findings)

The market chain on the Big Island therefore consists of two steps.

1. Fishes are collected by independent contractors and wholesaler/collectors and sold to wholesalers.
2. Wholesalers sell fish to wholesaler/distributors on Oahu, on the mainland and in international locations.

Oahu distributors sell fishes either to local retailers, or to customers on the mainland and in other countries. This study estimates that eventually over 90% of Big Island caught fishes are exported out of state. In terms of price the existing market structure leads to the existence of two market prices, one paid to independent contractors by wholesalers ("diver's price) and the other paid to wholesalers by their customers ("wholesale price). The wholesale price is on average more than twice as high as the divers price (own analysis).

1.5.2 Basic economic characteristics of the market

The Hawaiian industry is driven by the demand for marine aquarium fishes created by hobbyist aquarium owners. The biggest markets are the mainland US, Europe and Japan. In the Northern hemisphere summer demand for Hawaiian fish decreases by 20 – 30 % compared to the wintertime (estimate of two wholesalers), likely because of an increase in outdoor activities. Wintertime demand, particularly for Yellow Tang, can usually not be covered by the available supply generated by the Hawaiian industry. However, prices do not fluctuate with changing demand over the year. The long-term general trend in prices has been upwards (see figure 8).
Taking these industry information into account, the Hawaiian aquarium fish industry does not appear limited by missing demand for fish. Current limits are caused by biological and social factors determining the supply. The current value, and possible future development of the industry will be discussed in sections IV and V.

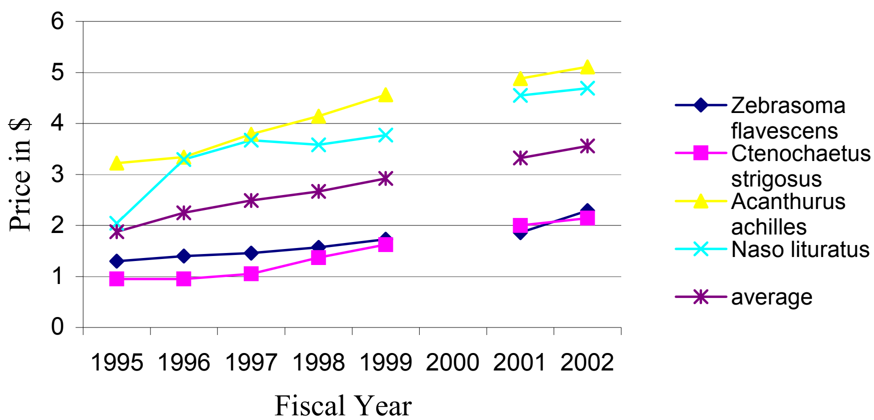

Figure 8 Price development of the four most important species in the State of Hawaii aquarium fishery (from Miyasaka 2000, DAR unpublished data and own findings); data for 2000 are missing

IV. Value estimation of the Aquarium Fish Industry

Fishery value is an important factor in resource management considerations, e.g., in decisions balancing different user groups impacts and benefits and for cost/benefit analysis of management actions. DAR catch report summaries contain value estimates for the catch from important catch areas in Hawaii. Since 1995, no yearly estimate has been published, although state law requires a monthly count of individual species to be reported. In addition, findings from this study indicate discrepancies between structure and economics of the industry and assumptions used in official estimates of industry value. Study data was used to re-evaluate the industry using up-to-date parameters and generate a value estimate for Fiscal Year 2002.

1. Questions

The following economic questions are addressed in the estimate:

1. *What is the Big Island industry gross value and profit, firstly on the divers level, secondly on the wholesaler's level, and thirdly the combined total industry value?*

2. *What is the state-wide industry gross value and profit?*

3. *What is the gross value and profit per collector and per wholesaler on the Big Island?*

2. Components of the estimate

In order to answer the questions under 1., published catch report summary information and unpublished data in DAR records and information from this study, in particular present price and cost information, price information from pricelists and industry structure information were used to determine values for the following parameters for the valuation:

2.1 Cost/Price:
1. *What are fish prices at each level of the market chain?*
2. *What are costs for at each level of the market chain?*
3. *What is the resulting profit margin for each step of the market chain?*

2.2 Catch:
1. *Which species and how many fish per species are caught per year?*
2. *What is the market chain from catch to the consumer?*

2.3 Collectors and wholesalers:
1. *How many people are involved in the industry?*

Each of these sub-questions will be addressed in the following sections.

2.1 Cost and price information

2.1.1 Fish prices

Fish prices at time of study were determined using interview and pricelist information and where available for 2002, DAR data (Table 6).

	From interview/pricelists		From DAR unpublished catch data	
Scientific name	**Divers Price ($)**	**Wholesale Price ($)**	**Divers Price ($)**	**Wholesale Price ($)**
Zebrasoma flavescens	2,30	4,15	2,29	n/a
Ctenochaetus strigosus	1,75	4,25	2,14	n/a
Acanthurus achilles	5,50	12,5	5,11	n/a
Naso lituratus	4,33	9,5	4,69	n/a
Ctenochaetus hawaiiensis(juvenile)	15,00	26	n/a	n/a
Forcipiger flavissimus	2,00	5,5	n/a	n/a
Chaetodon multicinctus	1,00	3,75	n/a	n/a
Chaetodon quadrimaculatus	2,00	5,75	n/a	n/a
Chaetodon tinkeri	75	140	n/a	n/a
Zanclus cornutus	2,37	6	n/a	n/a
Centropyge potteri	4,5	9,5	n/a	n/a
Coris gaimard	4	12	n/a	n/a

Table 6 2002 prices of common Hawaii aquarium fishes

2.1.2 Costs

Wholesalers and collectors experience different costs (Table 7, 8). The study data only allowed a qualitative analysis of components of total cost.

Independent contractors' costs
Boat (insurance, fuel, upkeep, repairs, storage)
Dive equipment (tankfills, upkeep, servicing)
Basic supplies (nets, buckets)
License

Table 7 Cost occurring to independent contractors, in order of importance (own findings)

Wholesale business costs
Cost for fish supply from independent contractors
Facilities (rent, electricity, insurance, upkeep, repairs, water)
Boat(s) (insurance, fuel, upkeep, repairs, storage)
Shipping (air freight paid by customers, usually no insurance, but smaller costs like packing and some material)

Table 8 Costs occurring to wholesalers, in order of importance (own findings)

Independent contractors operate in different degrees of independence (see section 1.2.2). Costs in Table 8 are for a contractor with an own boat. Less direct costs occur for divers working on someone else's boat, but through lower prices paid for their fish, or through receiving a lower share of the total catch than the owner of the boat, they experience indirect costs. Taking into account direct and indirect costs, this study finds that the profit margin range for all independent contractors is relatively narrow (section 2.1.3). Similarly, while wholesale businesses have different scopes and philosophies, profit margins nonetheless lie in a narrow range in wholesaler estimates (section 2.1.3).

2.1.3 Profit margins

For independent contractors, profit margin estimates range from 42.5% to 67.5%. The average profit margin is estimated at 60% of gross value of fish sold to wholesalers. For wholesalers, detailed numbers from one business showed a profit margin of 22.2% after taxes. Additional wholesaler estimates ranged from 20% - 30% of gross business sales. The average profit margin was of 25% of gross sales (all from own findings).

2.2 Catch

2.2.1 Catch composition and numbers

Information on catch numbers, catch composition and trends are given in section 1.4.

2.2.2 Market chain

Virtually all fishes collected are first sold to a wholesale business and then sold on to locations outside of Hawaii at a higher price (see section 1.5 for more information).

2.3 Collectors and wholesalers

The industry consists of an estimated 22 collectors and eight wholesalers (see section 1.2).

3. Fiscal year 2001/2002 value estimate

The findings from sections 2.1 – 2.3 were used to generate a 2002 Big Island industry value projection. Detailed information on the Big Island industry and past information on the relative importance of this industry compared to the overall industry were used for a statewide estimate.

3.1 Big Island estimate

For the Big Island industry, this study estimates a gross value of fish sold by the independent contractor segment of $633,000 and profits of $380,000.
The wholesale segment generates a gross value of $1,209,000 and profits of $302,000.
The industry gross sales are estimated at $1,842,000, industry profits are $682,000 (Table 9).

Industry Segment	Gross value	Profit
Independent contractors	$ 633,000	$ 380,000
Wholesalers	$1,209,000	$ 302,000
Total	$1,842,000	$ 682,000

Table 9 Estimated Gross value and profits of the Big Island industry

3.1.2 Hawaii State estimate

Industry Segment	Gross value	Profit
Independent contractors	$1,091,000	$ 655,000
Wholesalers	$2,085,000	$ 521,000
Total	$3,176,000	$1,176,000

Table 10 Estimated Gross value and profits of the state-wide industry

For the statewide industry, this study estimates a gross value of animals sold by the independent contractor segment of $1,091,000 and profits of $655,000.
The wholesale segment generates a gross value of $2,085,000 and profits of $521,000. The industry gross sales are estimated at $3,176,000, industry profits are $1,176,000 (Table 10).

3.1.3 Big Island estimate per contractor/wholesaler

	Independent contractor	Wholesaler
Gross income/ Person ($)	28,773	151,125
Profit/person ($)	17,273	37,750

Table 11 Gross income and profit per person, Big Island industry

With the value estimate from section 1.1, on average an independent contractor on the Big Island would have a gross income of $28,773 and a profit of $17,273, while the average gross income per wholesaler would be $151,125 and the profit $37,750 (Table 11).

4. Discussion

Most notably, values found by this study are much higher than recent official estimates. The official DAR industry summary for 1995 (Miyasaka 1997) contains the most recent published estimate of the industry value at $844,843. That and previous official estimates were used as basis of a number of publications that mention a Hawaii industry export value between $800,000 and $900,000 for the late 1990s (e.g. Woods 2001). The new valuation suggests that previous estimates were severely underestimating the industry value due to insufficient information about the industry market structure which led to underestimation of export ratio and price estimates. While the new value does appear to give a more accurate picture of the industry, there are a number of indications that the estimate is still conservative. Most importantly, the estimated numbers for income and profit per person lie on the lower side of the range of observations made in the field on the Big Island. For example, two full time independent contractors had gross incomes of $42,000 and $36,000, respectively. One of the larger wholesale businesses had a gross income of $225,000 and profits of $50,000. These comparisons suggest that the true industry value is higher than the estimate in this study.

In this context, it is important to realize that the estimate was made under a number of limitations. Most importantly, these were:

- Catch report data accuracy:
  Interviews did not allow a reevaluation of catch numbers for the industry. Therefore, catch estimates from official catch reports were used. It is likely that underreporting of true catch occurs, e.g., indicated by low filing compliance. However, the scope of underreporting is unknown. Since the estimate is using official catch numbers, underreporting would mean that the estimate too low. DAR is working on a revision of the catch report system. As soon as new information on underreporting becomes available, it must be incorporated in this estimate.

- Quality and quantity of interview data:
  While data and personal estimates that were obtained from wholesalers and collectors usually agreed well, additional data would allow the fine-tuning of estimates for profit margins and give further indication if profit estimates from this study are accurate or not.

- Accuracy of the projection from FY 1995 – 1999 reports to FY 2002 catch numbers:
  Based on the finding that over the last 5 years of available data overall catch numbers and catch composition of the most important species were relatively stable (see section 1.4), the projection seems viable. It would be better to avoid the projection by using FY2002 catch data from DAR. Data may become available in the fall of 2002 (personal communication Steve Cotton, DAR).

- Accuracy of the projection from Big Island to state-wide estimates:
  While ratios between Big Island and statewide data were stable over the last years of available data, it would be better to gather data on other catch areas than the Big Island for direct estimates.

After analysis of these limitations, the new valuation is likely a conservative estimate of the true industry value. However, it is based on the field and literature knowledge available in 2002 and should represent a better value approximation than old estimates. The valuation can be validated and improved when new data become available and are incorporated.

V. Maximum Sustainable Yield

1. Analysis of existing data

No conclusive data currently exist on maximum sustainable yield (MSY) of the aquarium fish fishery in Hawaii, including the catch area of the Kona coast of the Big Island. In the following, results of completed and ongoing biological studies and fishery management data will be described.

1.1 Biological studies/papers

Studies conducted in Hawaii have produced contradictory results (Table 12).

Study/Paper	Key conclusion
Taylor and Nolan, 1978	"No adverse affection of collections on Yellow Tang populations"
Pfeffer and Tribble 1985	"Heavy collecting caused local depletion"
Randall 1987	"Take by collectors "negligible" compared to "enormous" populations of top ten aquarium species"
Tissot and Hallacher 1999	"Collection of fish for the aquarium trade causes declines in populations"

Table 12 Studies about the impact of aquarium collections in Hawaii (Table derived from data in Woods 2001)

Currently ongoing is the West Hawaii Aquarium Project (WHAP), a large-scale and long-term monitoring study of sites in areas open and closed to aquarium collections along the entire Kona coastline of the Big Island. Preliminary findings show significantly lower fish abundances in collected compared to uncollected areas (personal communication Dr. Walsh, DAR). The WHAP study results will become increasingly more meaningful, the longer the study is continues.

In the broader context of all research previously conducted, the strong differences between studies are striking. Furthermore, apart from inconclusive results, most studies have only a limited fishery biology context. To give one example, the finding that fish populations are reduced does not necessarily indicate that catch is not sustainable.

1.2 Fishery biology data

The fishery management tool of monitoring size/age distributions of populations, commonly used in other fisheries, is useless in the aquarium fishery, because collectors specifically target small to medium sized individuals of most species due to higher market demand for these sizeclasses. Even overexploitation of populations would therefore not result in smaller average sizes of fish caught.

Another tool is the monitoring of catch per unit effort (CPUE), which commonly declines when populations are overexploited. In Hawaii, collectors have to give CPUE information as part of the monthly catch reports summaries.

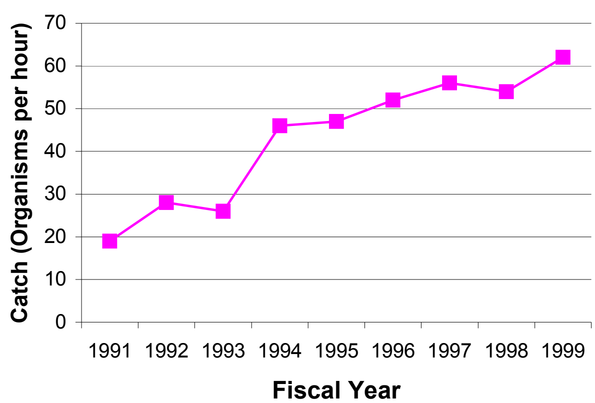

Figure 9 Catch per unit effort information for the Hawaii aquarium fishery (data taken from Miyasaka 2000)

CPUE data in Hawaii show a surprising development. In 1984, van Poolen and Obara found a CPUE of 13 animals per hour. In 1991, CPUE was 19 animals per hour, and until 1999 it increased to 62 animals per hour (figure 9). On average, collectors appear to have become more professional since 1984 (including use of advanced boats, overnight trips, life wells that allow storing of fish, use of scooters and Nitrox diving by some collectors), which may account for part of the increase in CPUE. Data also suggest that collections of rare, harder to catch, but more valuable species have decreased in favour of easier to catch species, especially Yellow Tang (review of data from Miyasaka 2000).

Nonetheless, a more than quadrupling of CPUE in less than 20 years would be enormous considering that no revolution in collection techniques has taken place. It is questionable that currently available CPUE data allows insight into MSY of this fishery without further analysis. In particular, changes in target species over time, possible inaccuracy of catch reports and lumping in of invertebrate catches with fish catch should be analysed.

2. Prediction of possible trends in the fishery

An evaluation of MSY is not possible at present, but a prediction of industry trends, though obviously subject to insecurity, especially in the longer term, may be viable.
In the eyes of experts it is unlikely that populations will suddenly crash, considering that a relatively constant number of collectors has generated a stable catch for about 10 years on the Big Island (e.g., personal communication Dr. Walsh, DAR). This does not say whether the catch is sustainable at present level or not. Nonetheless, it appears likely that in the near future mainly socio – economic factors, i.e., market and industry characteristics and social aspects, will determine catch numbers, as long as new regulations do not impose changes from outside the industry.

2.1. Short–term prediction

To the best of current information, indications exist that present collecting levels represent the level that will predominate in the near future (3-4 years). Most importantly, factors limiting upward as well as downward developments appear to be balanced at the point of study. These factors will briefly be addressed in the following sections.

2.1.1 Factors limiting an increase in catch

- Social situation in Kona:
  Public pressure due to the perception that fish populations were declining was a main reason for the 2000 closure of 32.5% of the Kona coast to aquarium collections as Fish Replenishment Areas (FRAs). Since then, tensions have declined and the public mostly accepts present catch effort. However, strong increases in numbers of collectors or industry effort would likely trigger new protests, as the public is still aware of the situation.

- Competition between collectors
  56% of collectors state that competition has increased strongly since the FRAs were implemented and that the remaining collection areas are harvested more intensively than before. Most collectors are consequently against a higher number of collectors and would support measures to limit the number of collectors.

- Management decisions made by the state:
  FRAs limit the size of reef area available to collections, but no regulations were put in place to manage open areas. DAR, conservation agencies and most collectors agree that a limited entry fishery would be desirable to limit the total amount of catch. Limited entry would restrict the scope of the fishery.

2.1.2 Factors limiting a decrease in catch

- Current market for aquarium fishes:
  The mainland and international markets for marine aquarium fishes are growing (Woods 2001). Demand for Hawaiian fishes is so strong that wholesalers throughout large parts of the year, especially in the wintertime, cannot satisfy demand. Therefore, demand is not likely to limit catch.

- Internal industry factors:
  The majority of active collectors and wholesalers is content with their incomes, jobs and lifestyles and is planning to remain in the industry in the near future.

2.2 Long-term prediction

It is important to understand that the current situation is transient. In 2000, the FRAs were implemented. As a consequence, the available catch areas were reduced by 30%, which meant that a total of 35.2% of the Kona coast was protected from aquarium collections (7.4% from previously protected areas and 27.8% from FRAs). Collectors have claimed that due to over-proportional closing of areas with habitat suitable for collections, effectively 80% of suitable collection areas are now closed (own findings). The number of active collectors in 2002 was only slightly lower than in 2000, with the result that areas that remain open to collections are more heavily collected than before (DAR unpublished data and own findings).

Considering that concern about depletion of populations existed before, and that the catch from the now much smaller catch areas appears to be as high as before, it seems plausible that the current state may not be sustainable. The fact that more than half of the collectors have observed increased competition, and the claim of 2 collectors that diminished fish stocks in their traditional collection areas had driven them out of business by higher competition, may be indicators. On the other hand, biologists hope that FRAs will eventually benefit the fishery through enhanced recruitment and possibly spillover, and counterbalance higher collection intensities per area and. If, when, and to which extent these positive effects will occur is not yet known (personal communication Dr. Walsh, DAR), but the WHAP study may enhance knowledge about these effects in the future.

An important industry internal factor is the current age structure of the industry. Several key industry collectors and wholesalers are in their 50s and plan to go on for only 3 – 4 more years. It will be interesting to see if new collectors step in.

Last, and also very importantly, in 2005 a review process of the FRAs is mandated by law. This process is likely to have implications for the fishery.

3. Conclusion

It is hard to make predictions due to insufficient information, especially insufficient scientific knowledge, and current management considerations that may change the fishery parameters. To sum up the previous section,

- indications exist that in the next three to four years, the Big Island fishery will generate a similar catch as in 2002.

- Value estimations for FY2001/02 can therefore be projected into the near future, with a possible increase in value due to a current upward trend in price.

- It seems unlikely that the FRAs will enhance the aquarium fishery in the short term, since negative effects of now limited catch areas have to be overcome first.

- For the more distant future, predictions are very hard. The key factor will be how beneficial the FRAs turn out to be for the fishery. As a hedge against depletion they are likely to work, as preliminary results from the WHAP study indicate. If enhanced stocks inside the FRAs benefit potential catch outside the FRAs remains to be seen (personal communication Dr. Bill Walsh).

- Current perception of many collectors that competition is getting stronger and that areas are overcollected may indicate that MSY is surpassed.

- MSY cannot be determined with the data available today. The WHAP will hopefully be a tool to gain better understanding of population development along the Kona coast. Further research, especially on the recruitment of reef fish species commonly caught by collectors, and on current patterns along the Kona coast, will be important.

VI. Acknowledgements

I want to thank all collectors and wholesalers of the Kona coast of the Big Island who participated in interviews or the survey. Without their willingness to share information, it would have been impossible to get such a close insight into the workings of the aquarium fish industry. I also thank all other industry insiders who agreed to interviews, and my „partner“ Steve Cotton, who accompagnied me in all interviews for his own project. Finally, I am grateful for the logistical and personal support supplied by Dr. Bill Walsh, Brent Carmen and Jan Marsh of the Division of Aquatic Resources in Kona, and for the help that I received from my academic advisor at the University of Hawaii, Dr. Charles Birkeland.

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VIII. Appendix A: Hawaiian Marine Aquarium Fish Species Occurring in this Report

Common Name	Hawaiian name	Scientific Name
Surgeonfishes		
Yellow Tang	lau´ipala	Zebrasoma flavescens
Goldring Surgeonfish	kole	Ctenochaetus strigosus
Achilles Tang	paku´iku´i	Acanthurus achilles
Orangespine Unicornfish	umaumalei	Naso lituratus
Chevron Tang		Ctenochaetus hawaiiensis
Butterflyfishes		
Longnose Butterflyfish	lau wiliwili nukunuku´oi´oi	Forcipiger flavissimus
Multiband Butterflyfish	kikakapu	Chaetodon multicinctus
Thompson's Butterflyfish		Hemitaurichthys thompsoni
Fourspot Butterflyfish	lauhau	Chaetodon quadrimaculatus
Tinker's Butterflyfish		Chaetodon tinkeri
Other		
Moorish Idol	kihikihi	Zanclus cornutus
Potter's Angelfish		Centropyge potteri
Yellowtail Coris	hinalea ´akilolo	Coris gaimard

Note: Underlined names are the names commonly used in the Aquarium fish industry.

IX. Appendix B: Additional Facts about Catch Composition

- Importance of species by value:

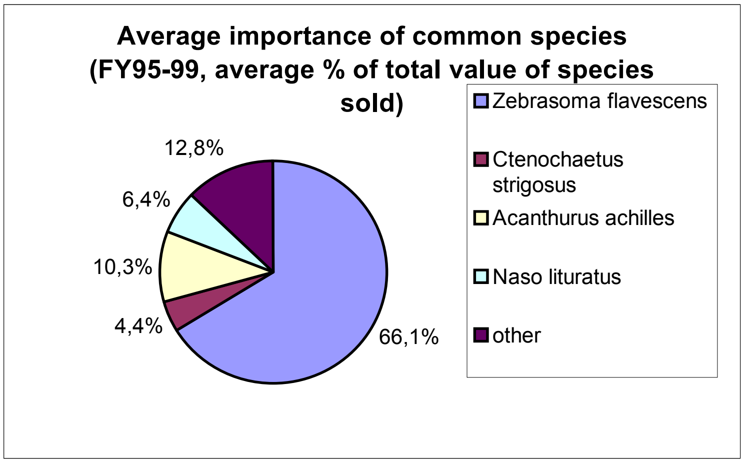

Figure 10 Average relative importance of common species by value (from DAR data).

- Figure 11 is taking a closer look at the importance of the four most important species over the 5 years of available data; this was described in writing in section 1.4. The stable ratio over the years was utilized in the generation of the industry value estimate.

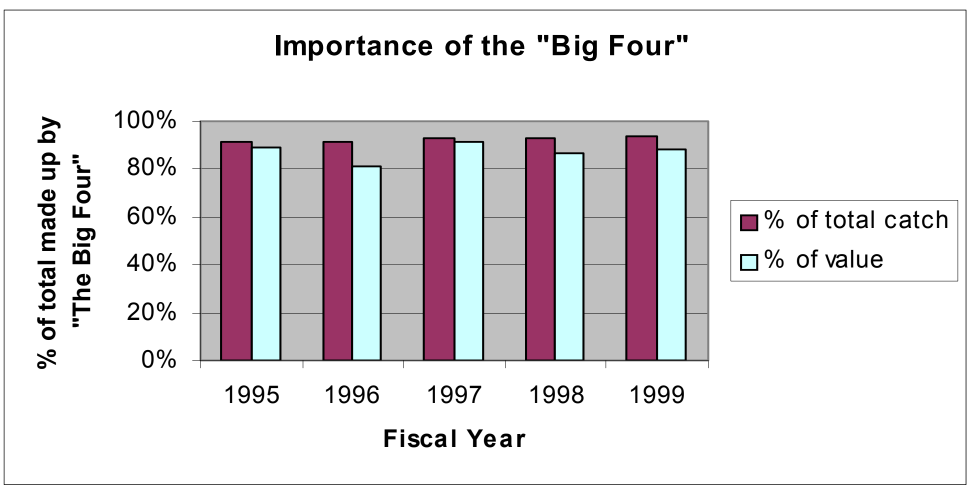

Figure 11 Relative importance of the top four ranked species on the Big Island.