

# COMMERCIAL SURVEY FOR ORNAMENTAL FISH SPECIES IN NAURU

prepared by  
Secretariat of the Pacific Community (SPC)  
for  
Nauru Fisheries and Marine Resource Authority (NFMRA)

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July 2013



## ACKNOWLEDGMENTS

The authors would like to thank the Nauru Fisheries and Marine Resources Authority for the in-kind contribution to this project – and all participating Fisheries staff for their hard work and logistical support, in particular Mr Delvin Thoma. Thank you for all your assistance, patience and perseverance to make this work possible.

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## LIST OF ACRONYMS

DAFF	Department of Agriculture, Fisheries and Forestry
IATA	International Air Transport Association
NMFRA	Nauru Marine Fisheries Resources Authority
SPC	Secretariat of the Pacific Community
USA	United States of America
EU	European Union
USD	United States Dollars
AUD	Australian Dollars
SCUBA	Self Contained Underwater Breathing Apparatus
OIE	World Organisation for Animal Health

## EXECUTIVE SUMMARY

At the 5<sup>th</sup> Head of Fisheries, held in Noumea in 2006, the Nauru delegate expressed a keen interest for his country to enter the marine ornamental trade and for SPC to provide the required assistance. In response, a number of studies were undertaken by SPC's coastal science and management section:

1. In June / July 2007, SPC conducted a survey of the fish species that have potential for the ornamental fish trade (Yeeting & Thoma 2008). The report concluded that there appears to be an adequate stock of certain ornamental fish species. The report also cautioned that a number of important requirements would need to be looked into before venturing any further into the trade;
2. In 2011 a feasibility study was drawn up by SPC to determine the financial, economic and logistical feasibility of entering into this market (Sharp 2011). This report concluded that the profitability of setting up a marine aquarium exporting business was questionable and certainly not feasible to all markets investigated;
3. In October 2011 SPC offered collector training to 10 NMFRA staff and qualified divers to prepare for the event that an aquarium trade industry was to develop on island. The in-country visit also allowed for a rapid commercial survey of existing stocks. Based on these and the two previous studies, the recommendation was put forward to conduct a full-scale, comprehensive commercial survey to determine the true potential and likely viability of operations for Nauru, if it were indeed to enter this industry.  
This report addresses the findings, main conclusions and recommendations to emerge from these.

Based on communications with well established and reputable importers in the region, Asia, Europe and the USA; exhaustive commercial surveys of the reef area around Nauru; and detailed analysis of all available data, it is not recommended that any further investment is made towards the development of the marine ornamental industry in Nauru; a finding that corroborates the conclusion reached by Sharp (2011).

Current major limitations toward the development of an aquarium industry in Nauru include, but are not limited to:

- “Our Airline” policy not to ship saltwater;
- Current freight rates out of Nauru;
- Uncompetitive published freight rates to all market destinations from Brisbane;
- Unfavourable wind and surf conditions for most of the year at sites identified as potential best collecting areas of Nauru;
- Limited diversity of fish on the lee side of the island;

- Increased collecting skills required due to high live coral cover (*Porites rus*) on the lee side of the island;
- Limited overall area of reef to collect fish from;
- Limited marketable species range and reliance on chiefly one species (*Centropyge loriculus*) with the risk that demand could decrease for this fish; and
- High projected operating costs resulting in negative profit projections.

We have no recommendations to achieve the successful development of this industry in Nauru as it is unlikely that the current AUD34.00 freight rate from Nauru to various destinations can be reduced to (or below) a competitive average rate of USD5.00 per kilo that would provide a profitable business in Nauru. However, should outside investors approach the government to set up a business on the island the report highlights a number of recommendations to abide by to ensure the sustainable development of this industry, including promotion of local employment and capacity building; fish collection size limits; the implementation of a management plan; and designation of closed areas.

## INTRODUCTION

In April 2006, during the 5th Head of Fisheries meeting held in Noumea, the Nauru delegate expressed his country's interest in joining the Marine Aquarium Trade Industry. A formal request for technical assistance following up on the expressed interest was submitted to SPC in early 2007.

An island-round survey of marine aquarium fish resources was organized from 29th June to 13th July 2007, and led to the publication of a report (Yeeting and Thoma 2008). The results of the survey showed a total of 93 fish species from 11 fish families with some potential for the marine aquarium trade. Four species with good market potential, two angelfish species (*Centropyge flavissima* - lemon peel - and *C. loricula* -flame angel), and two anthias species (*Pseudanthias barttleorum* and *Pseudanthias dispar*) were observed in good numbers. Although the report concluded that there appears to be an adequate stock of certain fish species with potential for export in the marine aquarium trade in Nauru, it also cautioned that a number of important requirements would need to be looked into before venturing any further, including basic infrastructure, airline connections and transit times.

As a follow up to this initial report, the Nauru Fisheries and Marine Resource Authority (NFMRA) requested that SPC conduct a feasibility study to determine the financial, economic and logistical feasibility of entering into this market (Sharp 2011). This second report concluded that the profitability of setting up a marine aquarium exporting business was questionable and certainly not feasible to all markets investigated. Major constraints that were highlighted included "Our Airline" policy that saltwater is not to be shipped; extremely high freight rates; limited connectivity to major markets; high projected operation costs. In parallel to Nauru's request that an economic feasibility study be conducted, NMFRA asked SPC to provide basic training to a few divers, to prepare for the event that an aquarium trade industry was to develop on island. Such training was offered to 10 NMFRA staff and qualified divers in October 2011. The opportunity was also seized at that time to conduct brief additional commercial surveys. Based on these, the conclusions emerging from the two previous reports, and the interest expressed by the Nauru delegate in developing the industry, the recommendation was put forward by the SPC Fisheries Scientist (Aquarium Trade) to Nauru to conduct detailed commercial surveys to determine the true potential and likely viability of operations for Nauru, if it were indeed to enter this industry.

## AIM AND OBJECTIVES

The overall aim of this study was to determine the likely viability of developing a marine aquarium trade industry on Nauru. The objectives of this report are therefore threefold:

1. To describe and present the results of the commercial in-water surveys undertaken while on island;

2. To outline the cost benefit analysis of setting up and ornamental fish industry on Nauru based on estimated sustainable catches of species with commercial interest as derived from (1), Yeeting and Thoma (2008) and rapid surveys conducted in October 2011; and
3. To present the overall conclusions and recommendations that emerged from the surveys and economic assessment.

## COMMERCIAL SURVEY FOR ORNAMENTAL FISH<sup>1</sup> SPECIES

For the purpose of this report, commercial surveys are defined as dive assessments conducted within the depth range from which ornamental species are typically safely collected (0-40m) and during which all species of potential interest for the marine aquarium trade are recorded and placed in one of three categories:

1. **Species of targetable size and high abundance** – in situations where and industry can be developed, these species would constitute the main target species
2. **Species with some market value, but not commercially viable to export** (as they are in sufficient abundance to collect incidentally and export or they are not viable to export due to freight expense) – such species would not be targeted *per se* but would be collected if encountered during a dive;
3. **Species with low or virtually no market value** (thus not viable to export) – individuals observed on the reef are typically observed at too large a size or at too low abundances for example.

Note that although the categories highlighted above form the integral part of commercial surveys irrespective of location, the actual species listed under these three categories will vary from one place to another. Factors affecting classification include, but are not limited to, freight rates, local abundances, observed sizes, habitat characteristics etc...

### ***Survey details***

Nauru, the world's smallest independent republic, is an island country in Micronesia, located 42km south of the Equator. It is an isolated, oval shaped, uplifted limestone island with a total land area of 21.1km<sup>2</sup> and a circumference of just 19km. Nauru is surrounded by a narrow coral fringing reef (120 to 300 meters wide) that drops away sharply to depths in excess of 4000m.

Commercial surveys were undertaken over the course of 7 days at a rate of 2 dives per day by two divers. All dives were at least 60 minutes in duration. Figure 1 provides an overview of sites surveyed, the GPS start and end locations of all dives and distances covered.

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<sup>1</sup> Yeeting & Thoma (2008) advised against the collection and export of coral and live rock. Based on this recommendation Sharp (2011) did not explore the feasibility of exporting these products. We agree with the previous assessments and therefore this report focuses only on fish.

The west side of the island tends to be exposed to the predominant winds (National Tidal Centre Data, 2013), and experienced moderate to very strong wave and surge while surveys were undertaken. On this windward side a high proportion of the habitat consists of high coralline cover encrusted reef rock with varying levels of massive, foliose and branching corals. Moving southward, between approximately 5 and 12m depth, there are vast expanses of high live coral *Porites rus*. The lee side of the island benefits from much calmer seas. Water clarity however was predominantly poor. The habitat consisted mostly of high live coral cover of *Porites rus* between depths of about 4 and 25m. This type of habitat makes collection of key species difficult, requiring greater skill to catch fish, and also resulting in extensive damage to nets. Although the habitat on the windward side is easier to collect in, catch potential is significantly reduced by persistent strong surge.

## DATA AND KEY ASSUMPTIONS

This project was approached with the underlying assumption that the government is keen to invest/support the development of aquarium trade activities in Nauru. Thus, all data were collected and calculations made as though a business venture was to be developed. Our conclusions were then drawn from our findings and our recommendations, in turn, were based on these results - including whether we felt the development of such an industry in Nauru given resources, projected revenue and costs appeared viable or not.

This section provides clarification on the data sources used and how target markets, demand, and price data were derived. Requests were only submitted to reputable and established importers for key species of fish identified during the commercial surveys (see above and Annex I) and calculations undertaken for positive responses. Note that pricing obtained is specific to the Nauru context.

### **Market**

Information was gathered on current markets, focusing specifically on four species (*Centropyge loriculus*, *C. flavissima*, *Pseudanthias dispar* and *P. barttleorum*), identified as key for potential exports during initial commercial surveys conducted in October 2011 and exhaustive follow-up commercial surveys undertaken within the remit of this study in June 2013.

### **Market Constraints**

The limiting factor should any aquarium trade operation be established on Nauru will be the size of the reef available for sustainable collection (i.e., based on available habitat to collect from and weather patterns). The other limiting factor will be freight and other associated business expenses that will not allow the shipment of a low value fish under an export value of USD1.00 to USD2.00.

## Target Markets, Market Demand and Fish Price Data

Market information was gathered by offering the four key species identified during commercial surveys at different landed costs and quality levels to a number of large well established and highly reputable importers in the UK, USA, and Asia as well as four additional exporters in the region<sup>2</sup>. A mock weekly order was then obtained for these fish at those price points.

Landed costs (i.e., the sum of export and freight costs) supplied by these importers for a list of species derived from the commercial surveys allowed us to determine export price. As export price varies based on specimen quality, estimates were derived for both high quality and low quality fish (see Table 1).

## Shipping and Freight Data

Nauru only has one serving Airline, “Our Airline”, which flies to Fiji (Nadi via Majuro, Marshall Islands), Kiribati (Tarawa via Majuro, Marshall Islands), and Australia (Brisbane). “Our Airline” currently has a policy that saltwater cannot be shipped that clearly would need to be addressed and revoked as otherwise export of marine aquarium fish obviously will not be possible.

Fiji is not an acceptable transfer point due to long transit times, the low incidence of flights, poor reliability of on-time departure with lack of back-up flights, and potential competition for freight to same destination with local aquarium exporters. Brisbane represents a connecting point for onward flights to Japan, Hong Kong, the USA, and the EU. For example:

Brisbane (BNE) to Los Angeles, USA (LAX)



Non-stop flights: 1–2 per day, 13h 10m duration

Airlines: Qantas, Virgin Australia

Schedule of non-stop flights

10:35 am	→	6:40 am	BNE-LAX	S - T W T F S	Qantas 15
11:15 am	→	7:30 am	BNE-LAX	S M - W - F -	Virgin Australia 7

Brisbane (BNE) to Hong Kong (HKG)



Non-stop flights: 0–3 per day, 8h 57m duration

Airlines: Cathay Pacific, Qantas

Schedule of non-stop flights

10:20 am	→	5:25 pm	BNE-HKG	S M T - T - S	Qantas 97
10:55 am	→	5:55 pm	BNE-HKG	S - T - T - -	Cathay Pacific 146
11:15 pm	→	6:05 am	BNE-HKG	S - T - T - S	Cathay Pacific 156

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<sup>2</sup>Pricing data was supplied on a confidential basis so it is not appropriate to make specific reference to individual suppliers.

To minimise mortality, industry guidelines recommend (for established, experienced businesses) a maximum transit time of 40 hours (or a total time between the first fish being packed and the last fish being unpacked of 48 hours). Per IATA guidelines the fish should be packed for up to a 24-hour delay. While compliance with IATA can be undertaken from Nauru, one must consider that packing for a 24-hour delay requires additional water, thereby significantly increasing freight costs.

The examples above of a Brisbane – Los Angeles flight result in a 35 hour transit time, which is acceptable. Flights to Japan and Hong Kong take even less time; therefore these markets are viable from the standpoint of air transport. Flights to the EU are also possible within IATA recommended transit times, but they involve an additional connection point, which increases the risk of delay and damage from handling.

### **Freight rates**

Industry norm is for the importer to pay for all freight-related charges (i.e., inclusive of airway bill, fuel surcharge etc...). However, as most airlines when providing a preferential rate for transport of live fish will wish to be protected from claims of mortality, the exporter usually pays freight expenses at the time of shipping. The exporter is then later reimbursed by the importer for these charges.

All freight data were sourced from air bills or contractual rates in place as of June 2013 for the transport of live aquarium fish. Based on the best available information at the time of writing, there are no through-rates in place from Nauru to the potential markets explored (see above). Consequently, a range of rates was used to determine the effect on fish export price.

Importers will preferentially buy from areas that have the lowest rates from origin to destination. If the freight rate is not competitive then fish must be sold at a lower price. Total transit times between origin and destination will also factor into overall costs (and thus preferential markets from an importer's perspective) as the longer the transit time the more water individual fish will need to be packed in, while competing countries with direct flights will be able to utilize less water. While individual fish weigh only  $\leq 10$  g, water and packing material for a single fish will easily amount to 0.5 kg. Note that the amount of water allocated per fish in all calculations was specific to the species targeted and considered as an average for the target sizes that would be exported. Also, even if water quantity per fish was to be reduced, landed price would decline, meaning potential profits wouldn't change. Water amount used has a proven track record of reducing mortalities to less than 1% for a transit period no greater than 40 hours (plus the 24 extra hours required by IATA to account for extraordinary circumstances such as weather delay, flight cancelation etc...).

## ***Key Assumptions***

As there are a variety of ways to approach the development of a potential enterprise on Nauru, a list of assumptions that guided the present assessment is provided below:

- Collectors will only collect aquarium fish and not also be exporting the fish;
- All freight costs (i.e., freight rate, airway bill, fuel surcharge etc...) are paid by the exporter at the time of shipping and later reimbursed by the importer;
- Quarantine & transfer charges (if and where applicable) are paid by exporter;
- A portion of the total packing cost (USD6-14 per box with the range depending on the size of the box and the number of fish packed per box) will be paid by the importer;
- Price per fish that collectors will be paid is relative to a combination of the price received by the exporter and the difficulty in collecting the fish (e.g., habitat in which fish is caught; fish behavior; abundance of fish on reef; skill level required by collector);
- All export documentation can be obtained for all markets (e.g., health forms for EU market, which means OIE membership and veterinary/official check up);
- Collectors have the following investment expenses: dive gears; all collection materials; and SCUBA as well as NAUI fish collection certification ;
- Collectors cover all daily operating costs involved in collection of the fish to the point of delivery at the harbour (e.g., fuel, oil, SCUBA tank air refill etc...)
- Daily estimated catch rates are based on a motivated collector with one year collecting experience;
- A total of four collectors used on a rotational basis, with three collectors working 3 days a week to fill order, for 50 weeks a year;
- Exporter launches and retrieves the boat 3 days a week, 50 weeks a year;
- Projected revenue generation is based on the assumption that all collectors are very proficient at catching fish and therefore capable of filling weekly orders with high quality fish without a problem. Failure to do so, or the sale of low quality fish, will quickly erode any revenue generated from this activity;
- The government would bear/front the cost of the infrastructure required to run an aquarium business venture on island. This investment cost would then be recouped through rental fees.

## **MAIN FINDINGS**

In 14 dives, covering a total distance of 9,620m, we recorded a total of 115 species belonging to 12 family groups with potential interest for the marine aquarium trade (please refer to Annex I for species specific details). Species within this list were then split into the three categories introduced on page 8:

1. **Species of targetable size and high abundance – viable to export:**

- a. Flame angelfish (*Centropyge loriculus*) – high densities of both adults and juveniles were found, indicating high recruitment. Abundance of juveniles appears slightly greater at depth. Distribution and abundance, although variable, seems to be pretty consistent around the whole island.
- b. Lemon peel (*Centropyge flavissima*) – Presence of this species was noted around the whole of Nauru. Unlike for *C. loriculus*, juveniles are found in shallow as well as deeper water. Given that abundance of preferred size classes for aquarium trade purposes seems to be quite variable, collection would need to target some specific locations. Note that this species is harder to catch and that demand on the market is lower than for *C. loriculus*.
- c. Anthias (*Pseudanthias bartlettorum*, *P. dispar*, *P. pascalus*, and *P. olivaceus*) – although four species were recorded, only three of these are of commercial interest (*Pseudanthias bartlettorum*, *P. dispar*, and *P. pascalus*). *P. dispar* and *P. bartlettorum* are extremely abundant and the size distribution of individuals observed seems to indicate good recruitment of both species. Good abundance and indications of recruitment were also noted for *P. pascuales*. This species was observed a little deeper than the other two and in closer proximity to higher drop-off areas (e.g., *Porites rus* wall), thus with higher prevalence on the leeward side of the island.
- d. Goldflake angelfish (*Apolemichthys xanthopunctatus*) – observations were made mainly of adult-sized individuals. Numbers recorded indicate it is present at very low (mostly) to medium (at one or two sites surveyed) abundances only. In general, smaller sizes valued in the aquarium trade tend to be found deeper than the surveys focused on, thus they may be somewhat more abundant than listed here. Due to fish behavior, this species is easily captured, meaning that most individuals spotted could be collected. To avoid over-collection of stock, particularly in shallower water, if an aquarium trade business were to be developed, a maximum size limit of 15cm should be imposed and enforced to allow for mature individuals to remain on the reef and provide a potential source of healthy recruitment in the future (e.g., Palumbi et al. 2004; Beldade 2012).  
Note that we observed two other species within the genus *Apolemichthys* (*Apolemichthys trimaculatus* and *A. griffisi*) and one within the genus *Pomacanthus* (*Pomacanthus imperator*). For all three species less than 10 individuals were spotted in a total of 28 over 60-minute dives, with specimens all being outside the desirable size range. Therefore, these species are not commercially viable to target for collection. However, should any individual be caught, the precautionary recommendation as noted for *A. xanthopunctatus* applies (i.e., collect individuals smaller than 15cm total length only).

- e. Pufferfish (*Arothron meleagris* and *A. nigropunctatus*) – Both species were observed in relatively large numbers on the reef, although the presence of smaller, more desirable sizes for the aquarium trade was noted as low. As a consequence, to avoid over-collection of stock, if an aquarium trade business were to be developed, a maximum size limit of 25-30cm (nose to tail) should be imposed and enforced to allow for mature individuals of these species to remain on the reef and provide a potential source of healthy recruitment in the future.
2. **Fish with some market value but not commercially viable to export** - (e.g., *Coris gaimard*, *Melichthys vidua*, *Odonus niger*, *Macropharyngodon meleagris*, *Labroides rubrolabiatus*, *Bodianus loxozonus*, *Valenciennea strigata*, *Balistapus undulates*, *Halichoeres melanurus*) – most species listed here are not likely to be targeted due to their high freight rate (i.e., would only be commercially viable to target if the rate was USD4/kg or less from Nauru to the USA or USD6/kg or less from Nauru to the EU). Should they ever contribute to exported catches, the recommended Total Allowable Catch<sup>3</sup> (TAC) should be based on Yeeting & Thoma (2008) (minus 20%, to account for potential marine protected areas<sup>4</sup>). If collected, we recommend a lower than suggested TAC for *L. rubrolabiatus* given its role as a cleaner fish (i.e., it creates 'cleaning' stations to which reef fish come to have crustacean ectoparasites, mucus and dead skin removed (Grutter et al. 2002)) and thus overall reef health (Waldie et al. 2011 and Wabnitz et al. 2003). Furthermore, they tend to do poorly in aquaria (Michael 1999 and John Brandt as cited in Wabnitz et al. 2003).
3. **Species with low or virtually no market value (thus not commercially viable to export)** – species identified as not marketable either because (i) importers are not currently looking to import these species or (ii) they are not found on the reef at the right size to be of interest. See Annex I for details.

## **Market**

We identified three potential markets:

1. Traditional Ornamental Fish Markets: Price data were obtained directly from importers in the USA, EU, Canada, Japan, and Hong Kong to assess demand for species found in Nauru and identified to be of possible interest. Answers received indicated that a market does exist for a very limited species range. Most species originally identified as having a potential market (Yeeting & Thoma 2008) were not of interest to importers due to size ranges observed around Nauru; do not have a current market; or are currently available at exceptionally low

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<sup>3</sup> Total quantity of estimated stock for each species that can be taken by commercial fishery interests and other sources of fishing-related mortality, to ensure sustainability of that fishery in a given period, usually a year.

<sup>4</sup> This recommendation (with the 10% stock estimate used as presented in Yeeting & Thoma (2008)) was abided to in calculations in Table 1

cost from competing export countries such as Indonesia (see Annex I for details on each species). Note that importers stressed they were only interested in receiving shipments **if** high quality specimens of *Centropyge loriculus* were included in each shipment (i.e., without *Centropyge loriculus* it would be very difficult to sell any other species retained in this assessment as of potential interest).

2. **Regional Ornamental Fish Markets:** We also considered Nauru as a supplier to exporters in Majuro, Fiji, Tarawa or Brisbane. Although exporters in these areas, with the exception of Tarawa, would be interested in fish from Nauru, the price offered would be 33% that of exporting directly to markets in the USA and EU for example. Therefore, revenue would need to be generated based on volume and low operating costs. Given Nauru's total reef area, the distance between Nauru and the aforementioned importers and involved freight rates, high volume-low cost exports are not possible (i.e., revenues from such exports would not cover overhead to collect and export the fish). Therefore, we do not believe that being a supplier to exporters in Majuro, Fiji, or Brisbane is financially interesting to Nauru. In addition, fish shipments that are not transiting, but entering Australia for re-export may face a number of quarantine issues that would need to first be addressed with DAFF (Department of Agriculture, Forestry and Fisheries) directly.
3. **Additional and Emerging Markets:** The Australian market requires small quantities of a large range of fish species. As a consequence, to date, central pacific exporters such as Fiji and Tonga have not been successful in developing markets in Australia. Nauru with its limited range of species is highly unlikely to find Australia a viable market. In addition, any potential quarantine issues for importing fish from Nauru into Australia would need to be addressed with DAFF authorities. As recommended by Sharp (2011) emerging markets in Malaysia, Korea, Taiwan, Thailand, Singapore, and other countries were considered as part of this study. However, these markets also generally require small quantities of a large range of species, or species that are not currently on the market. These markets also tend to be price orientated and purchase from those exporters that will offer a given species at the lowest export price and freight cost. Nauru is not well placed to compete in these markets; it lacks endemic species, has a limited variety of fish, and high freight costs.

### **Freight rates and associated charges**

The quoted freight rate per kilo from Nauru to Australia is AUD15.96<sup>5</sup>. Such a high freight rate, regardless of any other consideration, negates any potential of developing an aquarium trade industry on the island. As very little freight is carried from Nauru to Brisbane it is recommended that negotiations with "Our Airline" be undertaken to establish a live ornamental fish rate of

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<sup>5</sup> This is the livestock rate, with "Our Airline" suggesting that if saltwater was to be allowed on the aircraft "aquarium fish" would fall under this category

AUD1.00 per kilo. As Australia was not deemed a viable target market direct negotiations with airlines in Brisbane will need to be undertaken to obtain better freight rates to selected final destinations. Published rates to the USA are currently AUD14.8 per kilo, but Australian exporters have negotiated rates as low as AUD7.00 per kilo. Note - and it is important to underline this point - that negotiating such rates is not an easy feat and is likely to depend on shipment size, as well as regularity in and of supply. Moreover, even if these rates were achieved (i.e., AUD8.00 per kilo from Nauru to Los Angeles) they still amount to double the rate from Fiji, Tonga, and Majuro to Los Angeles.

Please refer to Table 1 to see how the freight rate affects the export price of individual fish species and establishes that profits are minimal even with an overall negotiated freight rate of AUD8.00 per kilo from Nauru to final destination.

In summary, Nauru is unfortunately not in a competitively advantageous situation compared to other markets given high freight rates and long transit times from origin to destination.

## Costs

### **Investment expenses**

Investment expenses were derived for both operator and collectors separately. All pricing was done in USD, as all reference material was available in USD. Should materials be sourced from Australia, then these calculations would need to be updated accordingly. Total investment cost for a collector was estimated at USD1,791 and represented outlay linked to the purchase of scuba diving equipment and fish collecting gear (i.e., nets, buckets, and rod), and obtaining certification (see Table 2 for actual equipment needs and estimated costs, as well as sources for quotations). This was considered as a one off sunk cost.

An operator would be expected to spend USD81,120 to set up his operation on Nauru. To be competitive Nauru would need to supply high quality fish at a premium price. Given the close availability of seawater and the need to keep expenses low, the system design considered here was a flow through warehouse. Details of costs and sources for quotations are listed in Table 3. We did not consider the option of an ocean conditioning system (Sharp 2011) as viable in the current market, as fish held in such setups typically suffer high mortalities or are of low quality. The price paid for low quality fish removes any potential profit in exporting.

**Table 1-** Estimates of total income generated based on key species and specimen quality. All prices are listed in USD

SPECIES	Species Price Based on Freight Rate & Specimen Quality						Weekly Sales	Yearly Sales
	5.00	6.00	7.00	8.00	9.00	30.76		
<b>Quoted Freight Rate Per Kilo USD - Based on 250 Kg</b>	<b>5.00</b>	<b>6.00</b>	<b>7.00</b>	<b>8.00</b>	<b>9.00</b>	<b>30.76</b>		
<i>Apolemichthys xanthonipunctatus</i> & <i>Arothron spp.</i> [USA - EU - Asia - Maximum Size 15 cm]	Net Fish Price After Packing & Freight							
Good Quality	40.00	38.30	36.60	34.90	33.20	(3.79)	12	600
Annual Income	24,000.00	22,980.00	21,960.00	20,940.00	19,920.00	(2,275.20)		
Low Quality (Up to 30% less per fish)	28.00	26.81	25.62	24.43	23.24	(4.93)		
Annual Income	16,800.00	16,086.00	15,372.00	14,658.00	13,944.00	(2,957.76)		
<i>Centropyge flavissima</i> (Lemon Peel) [USA - EU - Asia - Maximum Size 10 cm]	Price Fish Net After Packing & Freight							
Good Quality	4.50	4.00	3.50	3.00	2.50	(8.38)	75	3,750
Annual Income	16,875.00	15,000.00	13,125.00	11,250.00	9,375.00	(31,425.00)		
Low Quality (Up to 30% less per fish)	3.15	2.80	2.45	2.10	1.75	(10.89)		
Annual Income	11,812.50	10,500.00	9,187.50	7,875.00	6,562.50	(40,852.50)		
<i>Centropyge loriculus</i> (Flame Angel) [USA - Asia (CIF 8.50)]	Net Fish Price After Packing & Freight							
Good Quality	6.00	5.50	5.00	4.50	4.00	(6.88)	120	6,000
Annual Income	36,000.00	33,000.00	30,000.00	27,000.00	24,000.00	(41,280.00)		
Low Quality (Up to 30% less per fish)	4.20	3.85	3.50	3.15	2.80	(8.94)		
Annual Income	25,200.00	23,100.00	21,000.00	18,900.00	16,800.00	(53,664.00)		
<i>Centropyge loriculus</i> (Flame Angel) [EU (CIF 10.00-11.00)]	Net Fish Price After Packing & Freight							
Good Quality	8.00	7.50	7.00	6.50	6.00	(4.88)	120	6,000
Annual Income	48,000.00	45,000.00	42,000.00	39,000.00	36,000.00	(29,280.00)		
Low Quality (Up to 30% less per fish)	5.60	5.25	4.90	4.55	4.20	(6.34)		
Annual Income	33,600.00	31,500.00	29,400.00	27,300.00	25,200.00	(38,064.00)		
<i>Pseudanthias bartlettorum</i> (Average Price for Males and Females) [USA - EU - Asia]	Net Fish Price After Packing & Freight							
Good Quality	3.00	2.60	2.20	1.80	1.40	(7.30)	100	5,000
Annual Income	15,000.00	13,000.00	11,000.00	9,000.00	7,000.00	(36,520.00)		
Low Quality (Up to 30% less per fish)	2.10	1.82	1.54	1.26	0.98	(9.50)		
Annual Income	10,500.00	9,100.00	7,700.00	6,300.00	4,900.00	(47,476.00)		
<i>Pseudanthias dispar</i> (Average Price of Males and Females) [USA - EU - Asia]	Net Fish Price After Packing & Freight							
Good Quality	3.00	2.60	2.20	1.80	1.40	(7.30)	110	5,500
Annual Income	16,500.00	14,300.00	12,100.00	9,900.00	7,700.00	(40,172.00)		
Low Quality (Up to 30% less per fish)	2.10	1.82	1.54	1.26	0.98	(9.50)		
Annual Income	11,550.00	10,010.00	8,470.00	6,930.00	\$ 5,390.00	(52,223.60)		
<i>Pseudanthias pascalus</i> [USA - EU - Asia]	Net Fish Price After Packing & Freight							
Good Quality	3.50	3.00	2.50	2.00	1.50	(9.38)	33	1,650
Annual Income	5,775.00	4,950.00	4,125.00	3,300.00	2,475.00	(15,477.00)		
Low Quality (Up to 30% less per fish)	2.45	2.10	1.75	1.40	1.05	(12.19)		
Annual Income	4,042.50	3,465.00	2,887.50	2,310.00	1,732.50	(20,120.10)		
<b>Total Income - Good Quality Fish @ Freight Price Points</b>	<b>162,150.00</b>	<b>148,230.00</b>	<b>134,310.00</b>	<b>120,390.00</b>	<b>106,470.00</b>	<b>(196,429.20)</b>	<b>570</b>	<b>28,500</b>
<b>Total Income - Low Quality Fish @ Freight Price Points</b>	<b>113,505.00</b>	<b>103,761.00</b>	<b>94,017.00</b>	<b>84,273.00</b>	<b>74,529.00</b>	<b>(255,357.96)</b>		
<b>NET Income - Good Quality Fish @ Freight Price Points</b>	<b>60,618.88</b>	<b>46,698.88</b>	<b>32,778.88</b>	<b>18,858.88</b>	<b>4,938.88</b>	<b>(297,960.32)</b>		
<b>NET Income - Low Quality Fish @ Freight Price Points</b>	<b>11,973.88</b>	<b>2,229.88</b>	<b>(7,514.12)</b>	<b>(17,258.12)</b>	<b>(27,002.12)</b>	<b>(356,889.08)</b>		

Reference #1: Current average freight rates & fuel surcharge from Vanuatu, Fiji, Tonga, Majuro to UK & USA with average fish export price

Reference # 2 Is the best Target freight rate we feel is possible to achieve and illustrates even with this rate the projection for operating losses

Reference # 3: Livestock Freight Rate & associated charges from Nauru to Brisbane and Brisbane to USA. Freight rate & all associated charges were based on Sharp (2011)

**Table 2 - Investment expenses for collectors. All prices listed in USD.**

EQUIPMENT	QUANTITY	PRICE (USD)	TOTAL COST (USD)
<b>Scuba Diving Equipment</b>			
Regulators (Scuba Pro) <sup>1</sup>	1	210.00	210.00
BCD <sup>1</sup>	1	216.00	216.00
Fins (V6) <sup>1</sup>	1	90.00	90.00
Mask <sup>1</sup>	1	26.40	26.40
Pressure Gauge <sup>1</sup>	1	92.40	92.40
Dive Computer (Aeris XR1) <sup>1</sup>	1	210.00	210.00
Wetsuit 3 mm <sup>1</sup>	1	120.00	120.00
Snorkel <sup>1</sup>	1	12.00	12.00
<b>SCUBA Sub Total</b>			<b>976.80</b>
<b>Fish Catching Equipment</b>			
Scoop Net <sup>2</sup>	1	16.80	16.80
Barrier/Fence Net <sup>2</sup>	2	120.00	240.00
Bucket (Flow Troll) <sup>2</sup>	3	14.40	43.20
Stick <sup>2</sup>	1	14.40	14.40
<b>Equipment Sub Total</b>			<b>314.40</b>
<b>Certification</b>			
PADI Open Water <sup>3</sup>	1	320	320.00
NAUI <sup>3</sup> fish collector's certificate	1	175	175.00
<b>Certification Sub Total</b>			<b>495.00</b>
<b>Other Equipment</b>			
Needle <sup>2</sup>	10	0.50	5.00
<b>Other Equipment Sub Total</b>			<b>5.00</b>
<b>TOTAL INVESTMENT</b>			<b>1,791.20</b>

**FREIGHT & DUTY ON IMPORTED ITEMS HAVE BEEN CALCULATED AT 20%**

1 - Quote from [www.leisurepro.com](http://www.leisurepro.com)

2 -Quote from Marine Oceania Hawaii

3 - Quote from Dive Hawaii

**Table 3 - Investment expense for an operator. All prices listed in USD.**

DESCRIPTION	QUANTITY	PRICE (USD)	TOTAL (USD)
<b>System</b>			
Main System Pump – 1 HP (plus one backup) <sup>1</sup>	2	600.00	1,200.00
Gas Run Emergency System Pump <sup>1</sup>	1	840.00	840.00
Ammonia Tower-Bio Rings <sup>1</sup>	2	360.00	720.00
440 watt Ultra Violet Sterilizer <sup>1</sup>	1	2280.00	2,280.00
Replacement Bulbs <sup>1</sup>	8	30.00	240.00
Plexiglas Raceways 90 X15 X 15 cm with Lids <sup>6</sup>	50	390.00	19,500.00
Plexiglas Raceways 90 X 25 X 25 cm with Lids <sup>6</sup>	17	540.00	9,180.00
3/4 Inch Feed Valves <sup>1</sup>	90	6.00	540.00
PVC System Parts: Main Valves, Unions, Pipe & Fittings <sup>1</sup>			1,680.00
Reservoirs <sup>1</sup>	1	600.00	600.00
Wood stands & miscellaneous items (built locally) <sup>5</sup>		1000.00	1,000.00
Cartridge Filter Housing & Filter Bags <sup>1</sup>	2	180.00	360.00
<b>System Sub Total</b>			<b>38,140.00</b>
<b>Boat Outfitted For Aquarium Fish Collection</b>			
7 Meter Pacific Whaler & 75 HP Yamaha <sup>2</sup>	1	21,600.00	21,600.00
Trailer <sup>2</sup>	1	2,400.00	2,400.00
10 Bins with Dividers <sup>3</sup>	10	48.00	480.00
10 Scuba Bottles Catalina 80 Aluminium <sup>4</sup>	10	194.40	1,944.00
<b>Boat Sub Total</b>			<b>26,424.00</b>
<b>Truck For Airport Delivery &amp; Launch &amp; Retrieval Boat</b>			
Used Vehicle Purchased Locally <sup>5</sup>	1	15,000	15,000.00
<b>System Sub Total</b>			<b>15,000.00</b>
<b>Packing Equipment</b>			
Packing table & bag holder (Built Locally) <sup>5</sup>	1	300.00	300.00
Water Reservoir <sup>6</sup>	1	600.00	600.00
Shipping Water Filter & Filtration <sup>1</sup>	1	300.00	300.00
Pump <sup>1</sup>	1	240.00	240.00
Oxygen regulator <sup>5</sup>	1	120.00	120.00
<b>Packing Equipment Sub Total</b>			<b>1,560.00</b>
<b>TOTAL INVESTMENT</b>			<b>81,124.00</b>

**FREIGHT & DUTY ON IMPORTED ITEMS HAVE BEEN CALCULATED AT 20%**

1 - Sourced from Tropical Marine Centre & Quality Marine Catalogues

2 - Pacific Fibreglass Quote

3 - Endural Bins Catalogue

4 - Quote from Leisurepro Dive [www.leisurepro.com](http://www.leisurepro.com)

5 - Authors Estimate

6 -Quote from Quality Marine

## Operating expenses

Operating expenses were derived for both operator and collectors separately. All calculations were done in AUD, as Nauru operates in AUD. Total weekly operating costs for collectors were estimated at AUD148 and included fuel and SCUBA refill expenses, which were assumed to be borne by the collectors themselves and not absorbed by the operator. Details are presented in Table 4.

Total operating cost for an operator was estimated at AUD101,531 per annum. Packing costs were included in operating costs, in accordance with analyses by Sharp (2011). Given that there are no styrofoam and/or plastic bag manufacturers on island, packing materials will need to be imported, increasing operating costs. Although it was assumed that a portion of packing costs would be covered by the importer, expected losses due to packing expenses that wouldn't be recouped by the importer were included in the expense chart. All details are presented in Table 5.

**Table 4 - Operating costs and income for collectors. All prices in AUD.**

DESCRIPTION	QUANTITY	PRICE (AUD)	DAY (AUD)	WEEK (AUD)
<b>VARIABLE COST</b>				
Fuel for Boat / day (Litres) <sup>1</sup>	25	1.67	13.92	41.75
Engine Oil Mixture <sup>1</sup>	1	15.00	2.50	7.50
Refill Scuba Tanks <sup>1</sup>	3	10.00	30.00	90.00
<b>Total Variable Costs</b>			<b>46.42</b>	<b>139.25</b>
<b>FIXED COST</b>				
Interest (%)	10%	1,791.20	0.49	3.44
Maintenance <sup>2</sup>	15%	1,791.20	0.74	5.17
<b>Total Fixed Costs</b>			<b>1.23</b>	<b>8.61</b>
<b>TOTAL COST</b>			<b>47.65</b>	<b>147.86</b>
<b>INCOME</b>				
<i>Centropyge</i> sp.	35	1.50	52.50	157.50
<i>Anthias</i> sp.	27	1.00	27.00	81.00
<i>Apolemichthys</i> sp. & <i>Arothron</i> sp.	1	12.00	12.00	36.00
<b>Total Income</b>			<b>91.50</b>	<b>274.50</b>
<b>NET INCOME</b>			<b>43.85</b>	<b>126.64</b>

Recommendation is to utilise a total of four Collectors on rotational basis in the event one is not available on any given day

1 - Information Supplied in Nauru.

2 - Recommendation of Collector Price & Maintenance (15% of Investment) Expense by Authors

3 - Collection amount per day based on collection numbers of *Centropyge* & *Anthias* by experience Fiji Collectors at Aquarium Fish (Fiji) Ltd. (18 *Centropyge* - 40 *Anthias* per Scuba Dive per dive)

**Table 5 - Operating costs for an Operator. All prices in AUD.**

DESCRIPTION	QUANTITY	PRICE <sup>2</sup> (AUD)	WEEK (AUD)	YEAR (AUD)
<b>VARIABLE COST</b>				
Fish Purchases	570		823.50	41,175.00
Transshipment Fee <sup>1</sup>	1	65.00	65.00	3,250.00
Quarantine Fee <sup>1</sup>	1	250.00	250.00	12,500.00
Airway Bill <sup>1</sup>	1	20.00	20.00	1,000.00
Oxygen For Packing <sup>2</sup>	1	120.00	15.00	750.00
Boxes (Cardboard & Styrofoam & Tape) <sup>2</sup>	30	20.00	600.00	30,000.00
Plastic Bags with Liners <sup>3</sup>	1500	0.04	65.00	3,250.00
Box Liner <sup>2</sup>	30	0.39	11.70	585.00
Recovered Packing Cost-Importer <sup>4</sup>	30	12.00	-408.00	-20,400.00
<b>Total Variable Costs</b>			<b>1,442.20</b>	<b>72,110.00</b>
<b>FIXED COST</b>				
	<i>Per Day</i>			
Rental of Government Built Facility <sup>2</sup>		500.00	115.38	6,000.00
Labour (2 Employees @ 40 Hour/Week) <sup>2</sup>	2	24.00	168.00	8,736.00
Oxygen Tank Lease For Packing <sup>2</sup>	1	0.50	3.50	182.00
Fuel for Emergency Pump <sup>2</sup>	1	1.67	13.36	694.72
Electricity (Per Calculation Box Below)	1	10.00	70.00	3,640.00
Export License <sup>2</sup>	1		11.54	600.00
Marketing Expense <sup>1</sup>	1	2.63	18.41	957.32
Water <sup>1</sup>	1	1.37	9.59	498.68
Maintenance (10% of investment) <sup>1</sup>		8,112.40	156.01	8,112.40
<b>Total Fixed Costs</b>			<b>565.79</b>	<b>29,421.12</b>
<b>TOTAL COST</b>				<b>101,531.12</b>

**FREIGHT & DUTY ON IMPORTED ITEMS HAVE BEEN CALCULATED AT 20%**

1 - Michael Sharp 2011 Report

2 - Authors Estimate to be verified

3 - Quality Marine Catalogue

4 - Average Packing Charge By Exporter

WEEKLY PACKING REQUIREMENTS			
Weekly shipment	QUANTITY	No. BAGS	No. BOXES
<i>Centropyge</i> sp.	315	945	17
<i>Anthias</i> sp.	243	729	11
<i>Apolemichthys</i> sp. & <i>Arothron</i> sp.	12	36	2
<b>Total</b>	<b>570</b>	<b>1710</b>	<b>30</b>

*Shipment Expenses Based on 50 Shipments per year.*  
*Two employees at 40 hours weekly to undertake packing, accounting, warehouse operations, and fish care*

Monthly Electrical Expense Calculation			
		QUANTITY	COST
Kilowatt Hour First 300 per month	AUD 0.10		
Kilowatt Hour Over 300 per month	AUD 0.30		
Pump (1000 watts)	KWH	720	30.00
UV	KWH	317	270.00
Lights & Misc.	KWH	163	
<b>Total</b>	<b>KWH</b>	<b>1200</b>	<b>300.00</b>

## Revenue and Net Income Projections

All calculations for revenue and income projections were done in USD, as international trade in fish is priced in USD<sup>6</sup>. Net weekly income projection for individual collectors was estimated at AUD127 (Table 4, and based on the recommendation that a total of four collectors would be hired and utilised on a rotational basis, with only three fishermen working at any given time (3 days a week, 50 weeks a year).

Net income projections for the operator, based on key species identified during commercial surveys, freight rates and specimen quality varied widely (Table 1). Given yearly sales of 28,500 high quality fish, according to the species breakdown listed in Table 1, and the current freight rate and associated charges from Nauru to Los Angeles, the operator would make a deficit of USD297,960. Using the best target freight rate that looks achievable under current circumstances, an operator would only make USD4,939 a year (or a deficit of USD27,002 if the fish are considered low quality). Yearly net income estimates range between USD18,859 and USD60,619 if average freight rates of between USD8 and USD5 (current average freight and associates costs from Vanuatu, Fiji, Tonga, Majuro to the UK and USA) are used respectively.

Based on the above findings, we do not recommended for government to go forward investing into the development of such an operation given the slim potential profit margins. In other words, doing so is considered too risky and the enterprise could quickly flip into loss of revenue.

## RECOMMENDATIONS FOR SUSTAINABLE COLLECTION

Based on our findings we advise Nauru not to invest in the development of aquarium trade activities on the island. However, should outside investors approach the government to set up a business on the island we advise the authorities to follow a number of recommendations:

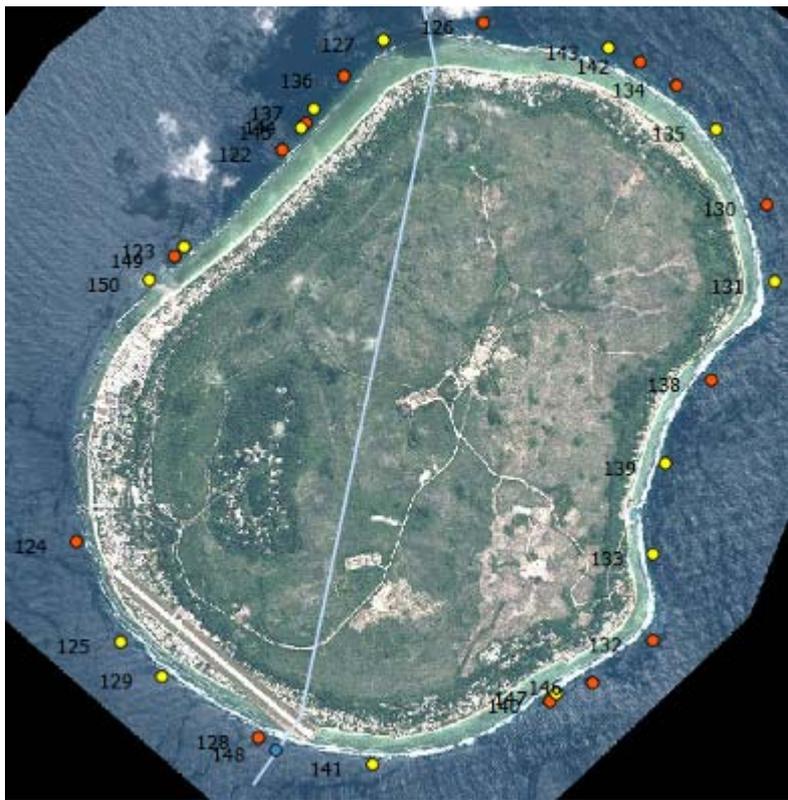
1. **Local employment:** Collectors and staff members to run the facility should primarily be locally sourced. If foreign labour was to be initially contracted, these individuals would need to have (i) appropriate background and recognised experience; and (ii) would need to train local employees in all steps required to sustainably and effectively collect, handle, hold, pack and ship aquarium fish according to a pre-defined, agreed to, approved and verifiable time schedule.
2. **Management plan:** Clear management guidelines would need to be developed prior to the development of any activity and to regulate operations once these are underway. Important considerations such a plan would need to address include licensing conditions and fees, quotas, size limits, closed areas, gear restrictions etc...;

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<sup>6</sup> At the time of the study USD to AUD conversion rates were pretty much on par; however this is subject to change and thus can boost or deflate profits rapidly

3. Quota/TAC: Due to the small total reef area it is recommended that extra caution be used in setting maximum collection quotas. These should be set at the species level and could be set by year, but it may be preferable to implement them on a monthly basis. For the purposes of this study we assumed that numbers of fish that could be collected sustainably were equivalent to the 10% stock estimate recommended by Yeeting & Thoma (2008), minus 20% to factor in the reduced fishing area for extra stock resilience in the form of a protected area (see below). For example, Being & Thoma (2008) list a 10% quota for *C. lorriculus* as 15,719. Using 15,000 as a yearly precautionary estimate, this would amount to 300 flames per week. Assuming that 20% of the reef area would be set aside as a protected area and/or considered unsuitable habitat to harvest from, this leaves an estimate of 240 flames per week. This approach was implemented for all species considered (see Table 1);
4. Protected Area: Twenty percent of the coastline should be set aside as Fish Replenishment Areas. It is suggested that these areas be closed to all forms of fishing, but if this is not possible they could be closed to just aquarium collecting as has been done in Hawaii (DNLAR 2010; Tissot et al. 2009, 2004). The SPREP team conducting fish, habitat, and invertebrate surveys while this study was underway on Nauru, indicated that their data would be contributing toward the information required for the designation and location of such an area, and in all likelihood would abide by the globally recommended target of providing between 10-30% protection (Wabnitz et al. 2010; Wood et al. 2008);
5. Size limits: Due to fish behavior, species of the genus *Apolemichthys* and *Pomacanthus* are easily captured, meaning that most individuals spotted could be collected. To avoid over-collection of stock, particularly in shallower water, a maximum size limit of 15cm should be imposed and enforced to allow for mature individuals to remain on the reef and provide a potential source of healthy recruitment in the future. The size limit should be 25-30cm for *Arothron* species. Larger females lay many more eggs than smaller individuals, and their young are more likely to survive (Green 2008). In many species, the offspring of big fish swim better, grow faster and live longer than ones from smaller mothers. Recent studies have further shown that the contribution of larger females to self-recruitment was significantly greater than expected on the basis of the relationship between body size and fecundity, underlining the importance and impact of female size on offspring traits (Beldade et al. 2012).
6. One operator license only: Given the limited reef area from which fish would be collected to supply the ornamental trade, only one operator should be granted a license. This would allow for more effective rotation of fishing grounds, would promote sustainable collection practices, and avoid the confusion and risk of focusing effort on specific areas by two operators. The operator would need to be someone with proven

experience and a verifiable track record of high quality shipments. Operation would need to be small, providing small-scale employment only, carefully managed and efficiently run.



Legend	
<span style="color: red;">●</span>	Start of dive
<span style="color: yellow;">●</span>	End of dive
<span style="color: blue;">●</span>	Swell break (south)
126	GPS points

Distance		
From	To	Distance (m)
122	123	1200
124	125	920
126	127	960
128	129	850
130	131	660
132	133	730
134	135	500
136	137	390
138	139	830
140	141	1600
142	143	290
144	145	80
146	147	320
149	150	290
TOTAL		9,620

Figure 1 - Dive locations, associated GPS points and distances covered

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