Report on the trade of marine ornamental fishes into Switzerland
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The import of coral reef fishes (marine ornamental fishes) into Switzerland in 2009

Abstract
Although coral reefs are being lost at an unprecedented rate, and over half the coral reef fish species are unmonitored on the market, the trade in coral reef organisms is subject to very poor evaluation. This study investigates the commercial trade of coral reef fishes into and through Switzerland. The most imported fish species is *Chromis viridis* (rank one) with 1600 specimens, which is listed by the IUCN Red List as 'not evaluated'. *Labroides dimidiatus* (rank 3) with 597 specimens is a key species in coral reefs and *Pterapogon kauderni* (rank 6) with 413 specimens, is listed as 'endangered' on the IUCN Red List. More than half the coral reef fish species imported into Switzerland are not assessed by the IUCN and therefore marked as 'not evaluated' on the Red List. Overall 70 % of all 4000 known coral reef fish species have not been evaluated and very little is known about their biology.

Of the 151 import papers with species lists declaring marine ornamental fishes, less than half (68; 45%) remained in Switzerland, with the rest going to EU and Non-EU countries. The imports containing marine ornamental fishes that remained in Switzerland totalled 17 673 specimens and comprised 440 marine species from 45 families. The vast majority were from a few teleost families, with only six families representing 70.2% of the total number of individuals imported.

There is no proper data system in place in Switzerland or any other country for monitoring the trade of coral reef fishes, i. e. marine ornamental fishes. However, in view of the large trade volume, the database TRACES (Trade Control and Expert System) which is in use in Switzerland and in the EU for animal disease prevention, could be adapted in order to gather more complete species-based information. In collaboration with the US that holds a similar database (LEMIS), a monitoring system could be adapted and analysed.

As a precautionary measure it might be sensible to monitor trade through CITES (Convention on International Trade of Endangered Species) for several coral reef fish species that are endangered through trade (*Pterapogon kauderni*), traded in large, possibly unsustainable numbers (*Paracanthurus hepatus, Synchiropus splendidus*) and/or play a key role in coral reefs (*Labroides dimidiatus*).

Introduction
Coral reefs occupy less than 0.25% of the ocean floor (Miller & Spoolman 2011). However coral reefs are considered to be amongst the most biologically rich and productive ecosystems on Earth, often referred to as the 'rainforest of the seas'. Coral reefs support about 4000 species of fish (or a third of the world's known marine fishes) (Spalding et al. 2001), about 800 species of reef-building corals (stony corals) (Vernon 2000), and a great number of other invertebrates (Spalding et al. 2001). However, over one third of the stony corals are in elevated risk of extinction (Carpenter et al. 2008). The world has effectively

lost 19% of the original area of coral reefs, 15% are seriously threatened with loss within the next 10–20 years, and 20% are under threat of loss in 20–40 years (Wilkinson 2008).

Coral reef fishes and invertebrates are the most value-added „product" (Wabnitz et al. 2003) that can be harvested from a coral reef, hence making it a profitable target for trade. In 2000, one Kilogram of coral reef fish for the aquarium trade sold for US$500 where as food fish sold for US$6 (Green in Cato 2003). Overfishing of coral organisms for the aquarium trade is having a significant impact (Tissot 2010). According to a comprehensive study by the United Nations Environment Program (UNEP) and the World Conservation Management Centre (WCMC), the vast majority of fishes for marine aquariums come from the wild and only about 1% are captive bred (Wabnitz et al. 2003). The Food and Agriculture Organization of the United Nations (FAO) refers to only 25 of 8000 species of marine fish being captive bred (Bartley 2005).

The United States (US) is the main importer of marine ornamental fishes (MO) worldwide, followed by the European Union (EU) and Japan. The EU is the largest market for MO in the world (Livengood 2007). In 2001, Wood found 1000 species of coral reef fish in the international aquarium fish trade (Wood 2001). In 2003, the study by the UNEP recorded 1471 coral reef fishes in the aquarium trade (Wabnitz et al. 2003). In one year (2004-5) a study conducted on the US MO trade showed that over 1800 coral reef fish species were imported (not counting about 200 species from US waters) (Rhyne et al. 2012). However, hardly any laws or regulations are in place to control this animal trade. Most exporting countries have no specific management plans or they have written management plans that are rarely enforced or implemented on the basis of rigorous scientific baseline studies or monitoring activities. Many fishes die during capture, due to trauma, poor handling and stress or as a result of the use of illegal poison (sodium cyanide) (Wabnitz et al. 2003, Vagelli, 2011).

The UNEP report estimates that between 80% and > 90% of fishes may die during capture, handling and transportation. In comparison, industrial food fisheries have a bycatch of approximately 28% (FAO 2008). In addition, and although illegal, sodium cyanide is widely used for the capture of reef fish throughout Southeast Asia and causes extensive fish mortality as well as damage to many more coral habitat animals (Cervino et al. 2003).

There are about two million private (Wabnitz et al. 2003) and about 1000 major public (ConsultEcon 2008) marine aquariums worldwide. Globally, many cities are planning to build new public aquariums and entertainment films such as Walt Disney's 'Finding Nemo' offer the public incentive to own marine aquariums in domestic environments. Today, fashionable nano aquariums with as little as 4,5 litres of seawater are available on the market (Geck 2008).

The demand not only for fishes but also for other marine organisms is increasing. In 2003, an estimate of around 20 to 24 million coral reef fishes and around 30 million invertebrates (including corals) were traded annually by the aquarium industry (Wabnitz et al. 2003). There is very limited information on numbers of MO entering Switzerland (CH). In 1995, the Swiss Animal Protection Organization (Schweizer Tierschutz STS) estimated that the most commonly kept pets in Switzerland were fishes (seven million) (Stumpf 1995).

No MO is protected or monitored by the Convention on International Trade of Endangered Species CITES (with the exception of sea horses, *Hippocampus spp.*, and the

Humphead wrasse, *Cheilinus undulatus*). Thus, the only trade information on MO is collected through the trans-European veterinary health agreement (Trade Control and Expert System TRACES). The Swiss Federal Food Safety and Veterinary Office (FSVO) is in charge of the inspection of live wildlife shipments for animal disease prevention but is not instructed to keep any species-specific data. Records are kept for a non-specific group called 'ornamental fishes' which comprises freshwater as well as saltwater fishes.

FishBase labelled all fishes imported to Switzerland as 'for aquarium display' (5 were of 'no interest'). In Switzerland, all non-CITES-species are imported as 'live animals' (AVI = animaux vivants: live animals). An agreement with the EU requires the FSVO to inspect live animals upon entering the country but no border control is implemented between the EU and Switzerland and therefore no detailed information about the coral reef fish species imported into CH via the EU exists. The only instance in which the FSVO investigated the MO trade occurred in 2001 (Weber 2001). The study conducted by interviewing traders and by using the Swiss foreign trade statistics of the Swiss customs administrations did not reveal any concrete amount of MO entering Switzerland.

Declarations pertaining to shipments outside the EU are recorded on the 'common veterinary document' (Gemeinsames Veterinärdokument für die Einfuhr GVDE) and are required to list the species. The GVDE is used in Switzerland as well as the EU. Each importer or registered private person has to announce imports to the appropriate border veterinary control body prior to importation. A border customs officer executes random checks by inspecting two boxes per shipment.

Except for the above-cited work on the US MO trade, to date no other study has been completed on imports of MO for any country. This study focuses on the import of MO into Switzerland and their transit to EU and Non-EU countries through Switzerland in 2009. This study is the first of its kind for the European region and will hopefully motivate the EU to promote further research and action. This study contributes to a needed monitoring system for coral reef fishes in trade.

Materials and Methods

To assess the volume of MO imported into Switzerland, all MO were firstly sorted out of all the 2009 AVI papers ('Animaux VIvantes' contains all imports of live animals, dead specimens, hunting trophies, medical animal materials, etc. which are not under the jurisdiction of CITES).

Data collected through the GVDE is not intended to monitor the wildlife trade. Rather, the GVED serves to monitor animal diseases. The AVI papers are stored for three years, after which they are destroyed and a retrospective analysis is no longer possible.

The importation documents utilized for this study occasionally included invoices and species lists. The documents did not include information on captive breeding or origin of species. In addition, certain documents were illegible or manifested incorrect species names, or lacked particular pages. In all cases, species names were verified and double-checked using the World Register of Marine Species (Appeltans et al. 2011) and FishBase (Froese & Pauly 2014) when species names were misspelled, listed under a former synonym, or listed with common names. Species were tagged as 'incorrect' when the common name was used for several species, or if a species was marked as 'assorted' or 'genus' (e.g, *Chaetodon* sp.).

All shipment declarations from the GDVE documents and attached commercial invoices including species lists of 2009 were entered manually at species-level: species name (family, genus, species), number of individuals and if noted their size and their price. The information on the IUCN Red List status, food requirements and trophic level was gathered from FishBase (Froese & Pauly 2014).

The IUCN Red List of Threatened Species is the best-known worldwide conservation status listing and ranking system. Species are classified by criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation: Critically endangered (CR) – extremely high risk of extinction in the wild, endangered (EN) – high risk of extinction in the wild, vulnerable (VU) – high risk of endangerment in the wild, near threatened (NT) – likely to become endangered in the near future, least concern (LC) – lowest risk, data deficient (DD) – not enough data to make an assessment of its risk of extinction, not evaluated (NE) – has not yet been evaluated against the criteria (IUCN/Red List 2014).

Results

Shipments

For 2009 1478 import papers labelled ornamental fishes for the aquarium industry from non-EU countries were counted. Of those imports, 826 (55.9%) contained only freshwater ornamental fishes, 422 (28.6%) did not have a species list, 79 (5.3%) contained only marine invertebrates, and 151 (10.2%) contained both marine and freshwater ornamental fishes (Fig. 1).

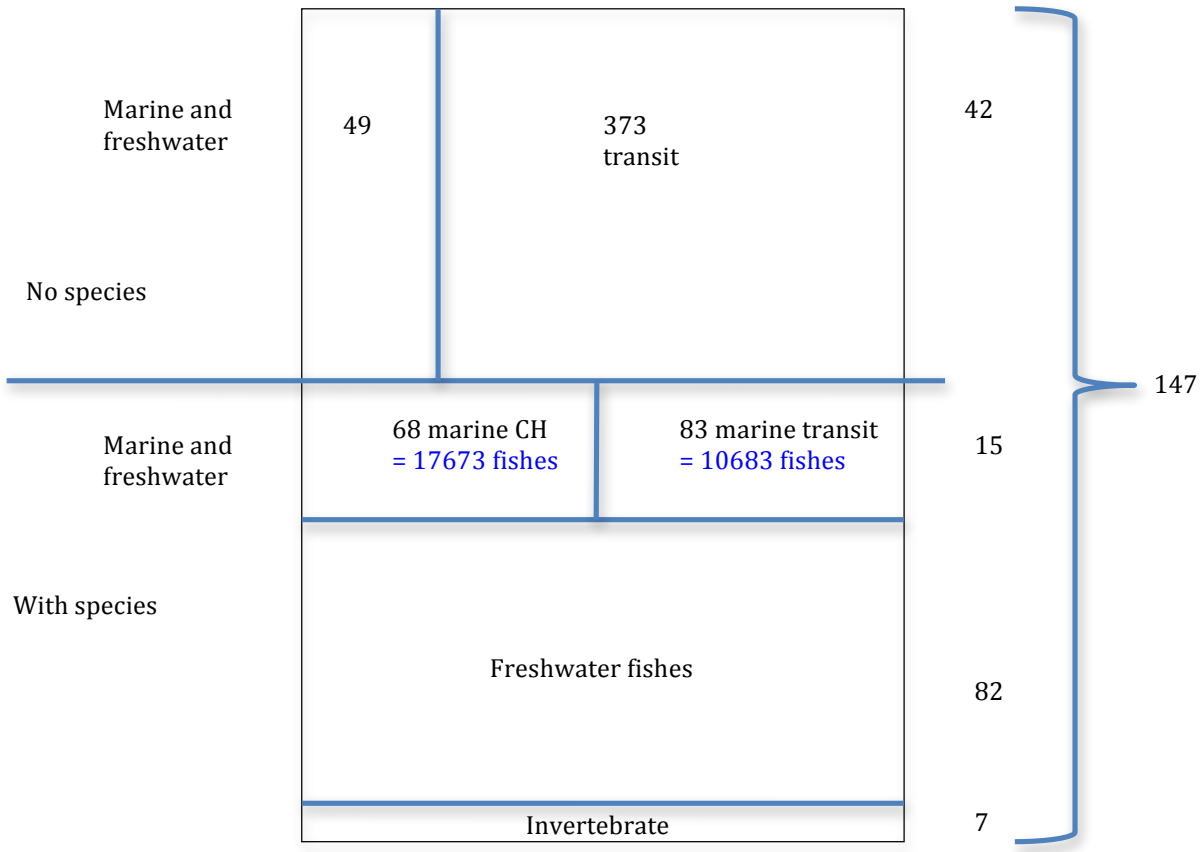

Figure 1: Distribution of shipments with or without species list. In black = import papers, in blue = number of fish specimen.

Of the 151 import papers with species lists declaring MO less than half (68; 45%) stayed in Switzerland. 83 (55%) were transhipments that went to EU and Non-EU countries. 32 went to Spain, 18 to Portugal, 11 to France. The rest went to Romania (6), Russia (4), Czech Republic (3), Poland (3), Canada (2), Germany (1), Ireland (1), Israel (1) and Serbia (1) (Tab. 1).

All imports came through the airport of Zurich. Basel and Geneva had no discernible imports of MO Imports from online buyers and private persons importing by car could not be accounted for.

Trans-shipping with species list	**Number of papers**
Spain	32
Portugal	18
France	11
Romania	6
Russia	4
Czech Republic	3
Poland	3
Canada	2
Germany	1
Irland	1
Israel	1
Serbia	1
Staying in Switzerland	**68**

Table 1: Number of shipments with species lists arriving in Switzerland and destination country.

Of the 422 import papers without species lists 49 (12%) were destined for Switzerland. Of the 373 (88%) transhipped import papers without species list 204 (55%) went to Canada followed by Israel with 47 (13%) and the US with 21 (6%). Other destinations were Serbia (19), Thailand (19), France (14), Japan (10), Germany (9), Czech Republic (9), Russia (9), Romania (6), Spain (3), Portugal (2) and Belgium (1) (Tab. 2).

Trans-shipping without species lists	**Number of papers**
Canada	204
Israel	47
USA	21
Serbia	19
Thailand	19
France	14
Japan	10
Germany	9
Czech Republic	9
Russia	9
Romania	6
Spain	3
Portugal	2
Belgium	1
Switzerland	**49**

Table 2: Number of shipments without species lists arriving in Switzerland and destination country.

In 2009 18 countries shipped MO to or through Switzerland. MO staying in Switzerland came from 8 of these 18 countries.

Species

The 83 import papers transhipped to EU and Non-EU countries included 10 683 MO (the species and families were not evaluated). The 68 imports staying in Switzerland and containing marine fishes totalized 17 673 marine specimens. They comprised 440 marine species from 45 families (Fig. 2 and 3). All shipments that contained marine fishes also contained freshwater fishes.

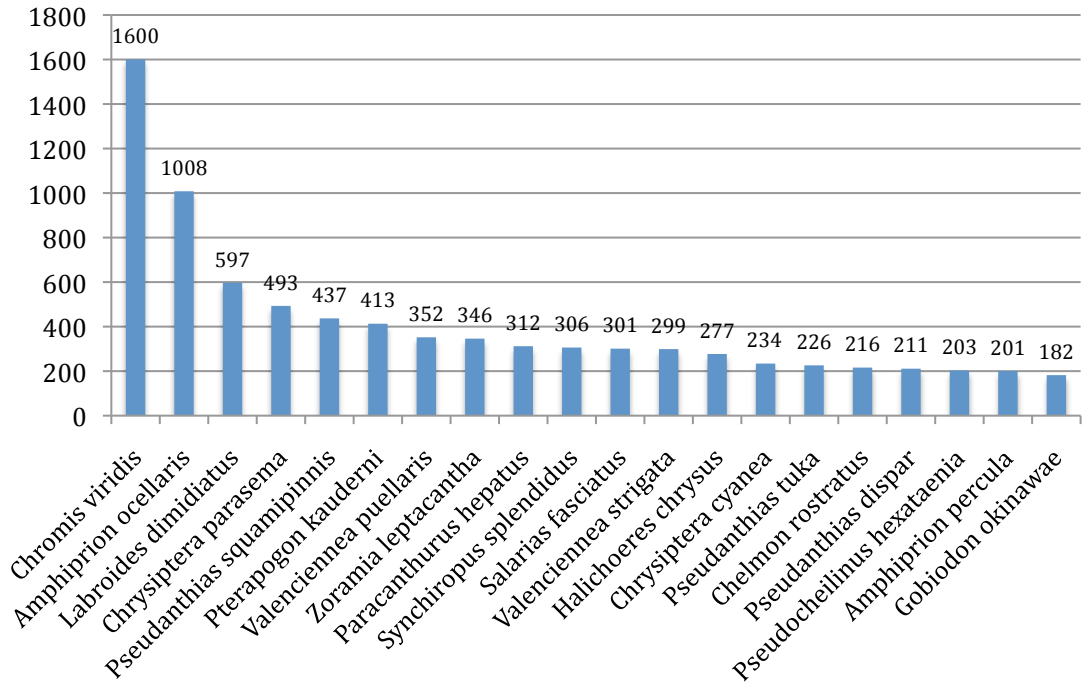

Figure 2: Number of specimens of each species imported and staying in Switzerland in 2009. Top 20 MO species imported.

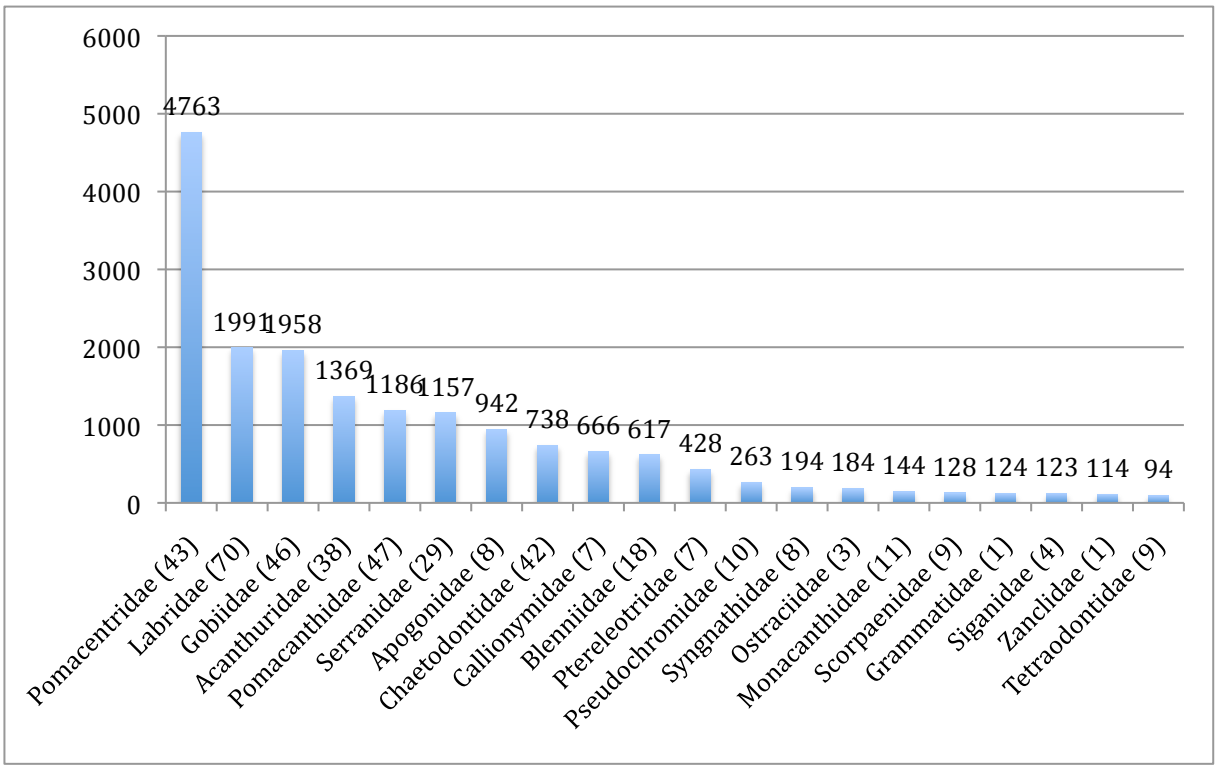

Figure 3: Number of specimens of each family imported into and staying in Switzerland in 2009. Top 20 families; number of species in brackets.

Of these 17 673 specimens, 710 (4%) had their names misspelled, using old or wrong names. Forty-seven (0.2%) were not identified to the species level and were removed from analyses where the species level was required.

The marine fishes destined for Switzerland came from eight countries; Indonesia being the main exporter (11 167 fishes from 320 species), followed by Sri Lanka (2179 fishes from 128 species), Singapore (1892 fishes from 142 species), Philippines (671 fishes from 65 species), Kenya (659 fishes from 61 species), the US (522 fishes from 80 species), Netherlands Antilles (364 fishes from 13 species) and Vietnam (219 fishes from 28 species) (Figure 4).

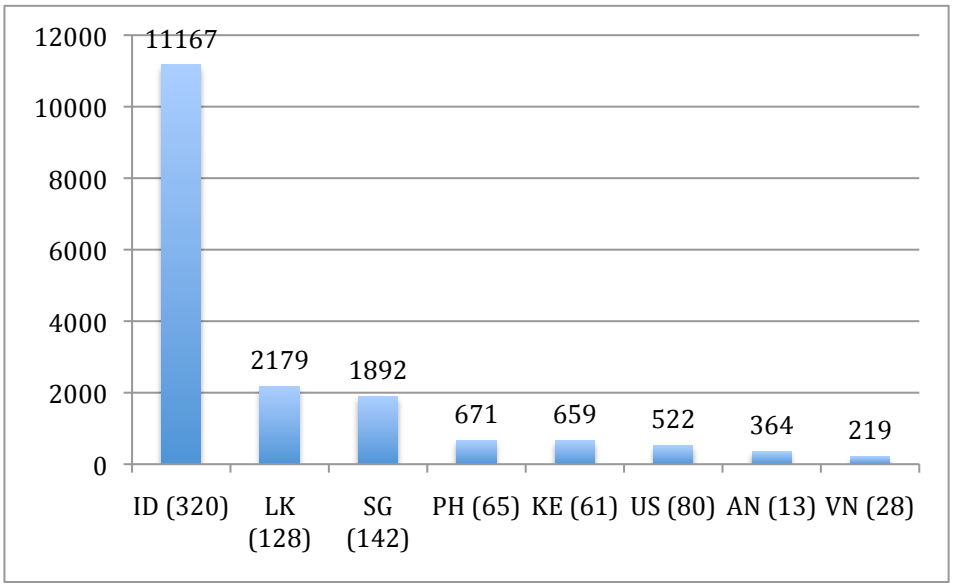

Figure 4: Number of fishes imported into Switzerland by country; number of species in brackets. ID = Indonesia, LK = Sri Lanka, SG = Singapore, PH = Philippines, KE = Kenya, US = United States of America, AN = Netherlands Antilles, VN = Vietnam.

Of the 17 673 individuals identified to the species level, the vast majority of fishes imported into and staying in Switzerland were from a few teleost families: Only six families represented 70.2% of the total number of individuals imported (Fig. 5).

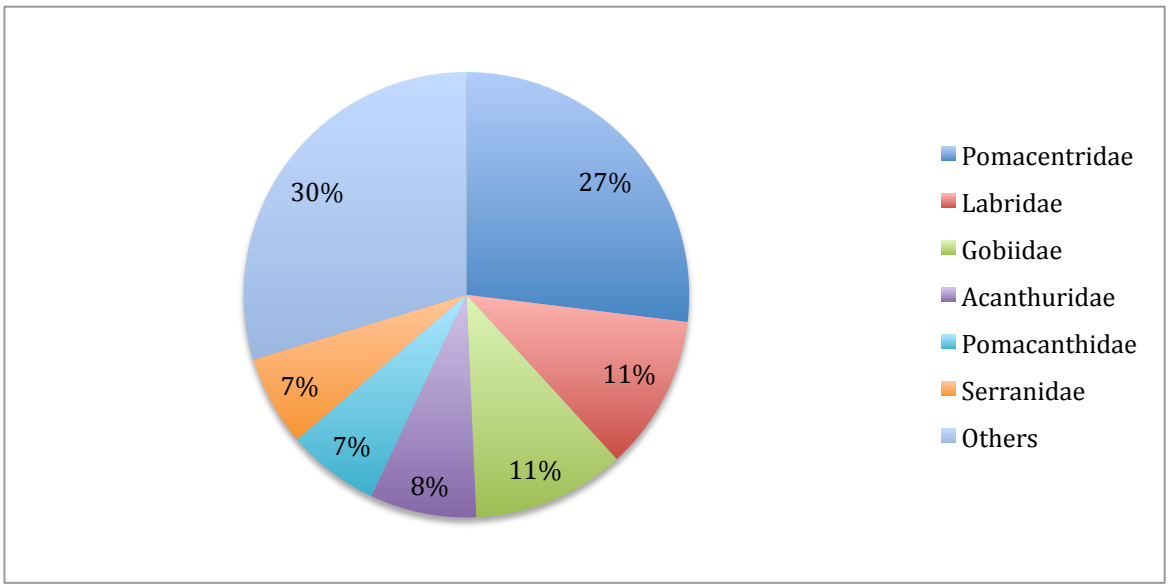

Figure 5: Six families represent almost ¾ of all fishes imported.

The 3 most frequently imported fishes were the Blue-green chromis (*Chromis viridis*; 10%) (Plate 1) followed by the Clown anemonefish (*Amphiprion occellaris*) (Plate 2) and the Bluestreak cleaner wrasse (*Labroides dimidiatus*) (Plate 3). 20% of the traded fishes were composed of 4 species from 2 families (Pomacentridae and Labridae) including the Clown anemonefish (*Amphiprion ocellaris*) and the Bluestreak cleaner wrasse (*Dimidiatus labroides*). At rank 6 was the endangered (IUCN Red List) Banggai cardinalfish (*Pterapogon kauderni*) (Plate 4, Tab. 3).


Plate 1: The Blue-green chromis (*Chromis viridis*) was the most traded coral reef fish.

Plate 2: Clown anemonefish (*Amphiprion ocellaris*) at rank 2
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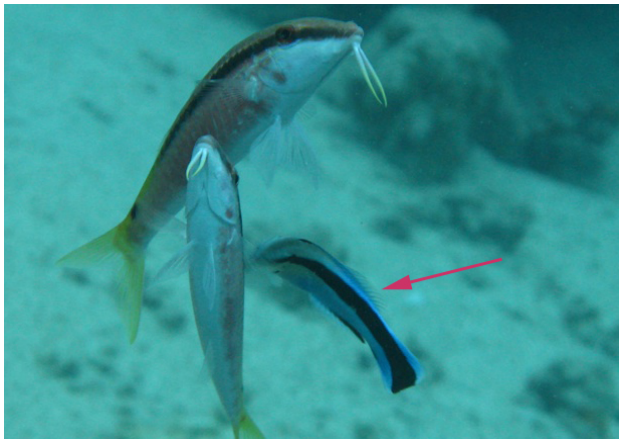

Plate 3: Bluestreak cleaner wrasse (*Labroides dimidiatus*) at rank 3

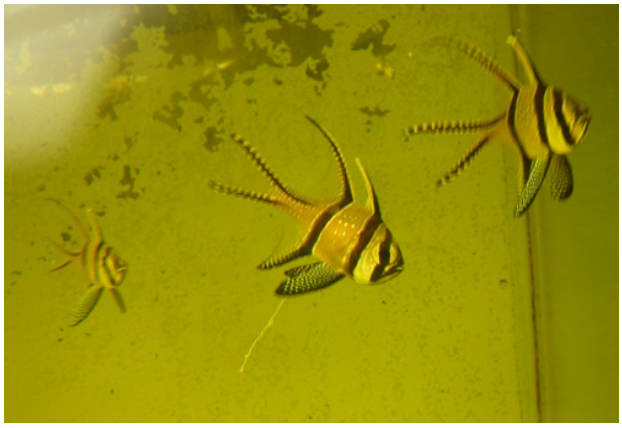

Plate 4: The endangered Banggai cardinalfish (*Pterapogon kauderni*) at rank 6.

The Goldtailed demoiselle (*Chrysiptera parasema*) (Plate 5) at rank 4, the Sea goldie (*Pseudanthias squamipinnies*) (Plate 6) at rank 5 as well as the Maiden goby (*Valenciennea puellaris*) (Plate 7) at rank 7 and the Threadfin cardinalfish (*Zoramia leptacanta*) (Plate 8) at rank 8 are not evaluated by the IUCN Red List.

Plate 5: Goldtailed demoiselle (*Chrysiptera parasema*) at rank 4
Brian Ong/Wikimedia Commons

Plate 6: Sea goldie (*Pseudanthias squamipinnis*) at rank 5
Nhobgood/Wikimedia Commons

Plate 7: Maiden goby (*Valenciennea puellaris*) at rank 7
Wikimedia Commons

Plate 8: Threadfin cardinalfish (*Zoramia leptacanta*) at rank 8
Chrumps/Wikimedia Commons

The Palette doctorfish (*Paracanthurus hepatus*) (Plate 9) at rank 9 is listed as 'least concern' and the brilliantly coloured Mandarinfish (*Synchiropus spendidus*) (Plate 10) at rank 10 is highly prized in the aquarium trade for its elaborate fins. This species is not evaluated by the IUCN Red List.

Plate 9: Palette doctorfish (*Paracanthurus hepatus*) at rank 9
Charles & Clint/Wikimedia Commons

Plate 10: Mandarinfish (*Synchiropus splendidus*) at rank 10

Genus Species	Common name	Rank	Amount	IUCN Red List
Pterapogon kauderni	Banggai cardinalfish	6	413	ENDANGERED EN
Acanthurus chronixis	Chronixis surgeonfish	176	12	VULNERABLE VU
Cromileptes altivelis	Barramundi cod	286	5	VULNERABLE VU
Chaetodon trifascialis	Acropora butterfly	38	102	NEAR THREATENED NT
Chaetodon rainfordi	Rainford's butterflyfish	360	2	NEAR THREATENED NT
Chiloscyllium punctatum	Brown spotted cat shark	410	1	NEAR THREATENED NT

Table 3: Reef fishes listed on the IUCN Red List (status of concern), rank and number of fish imported.

More than half the species entering Switzerland were listed as not evaluated (228), 11 were data deficient, 189 least concern, three were near threatened, two were vulnerable and one was endangered (*Pterapogon kauderni*). Six species were not listed by FishBase (Fig. 6).

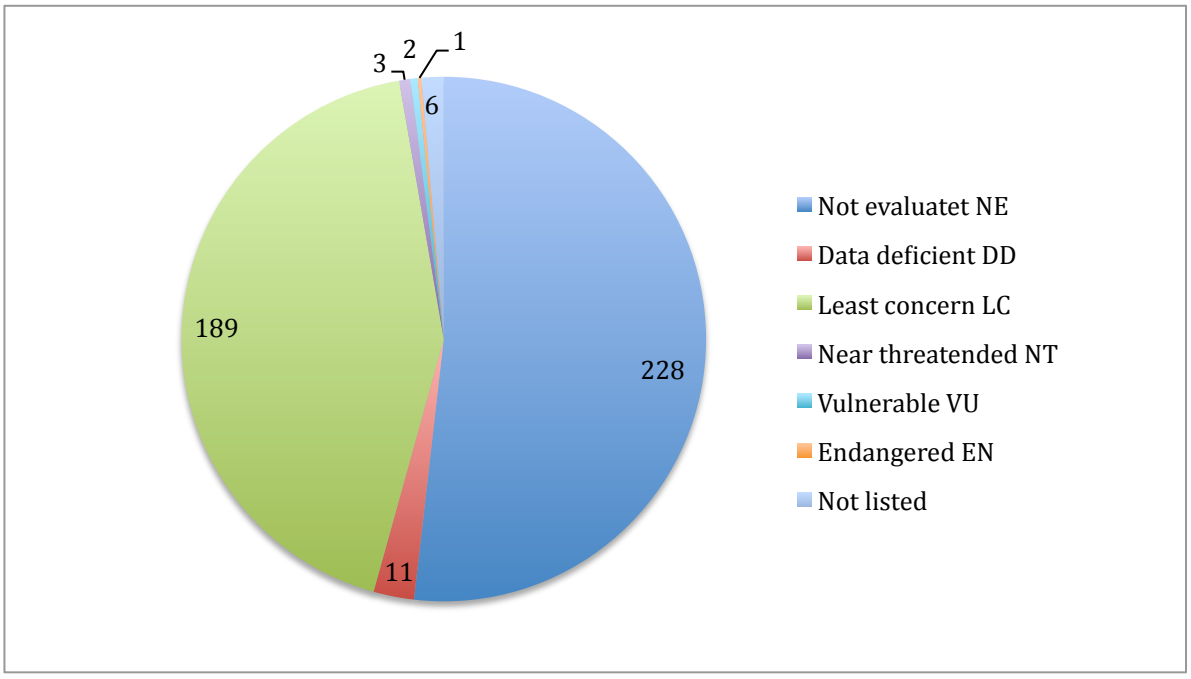

Figure 6: More than half the imported MO into Switzerland are not evaluated

FishBase record of 3711 coral reef fish species (Froese & Pauly 2014). An analysis of the conservation status of all known coral reef fishes results in 70% of them not being evaluated (Fig. 7).

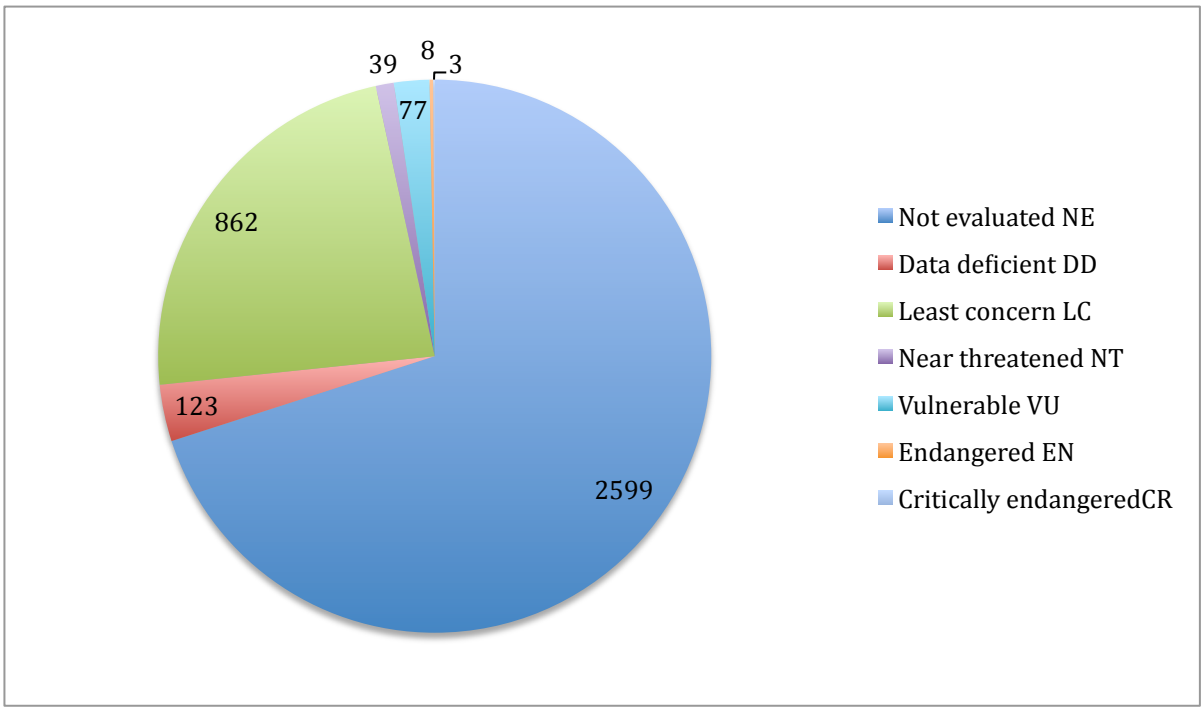

Figure 7: 70% of all marine ornamental fishes recorded in FishBase are not evaluated.

For 81% of the 17 673 fishes, there was no information on body size. From the 3343 fishes with body size information, 28% (940 fishes) were juvenile, 34% (1130 fishes) were medium sized (most probably sub-adults), and 38 % (1273 fishes) were adults.

Of the 940 juvenile fishes (from 84 genera), 902 fishes (from 55 genera) exhibited an ontogenetic dichromatism compared to the adult stage; specifically angelfish (Pomacenthidae) (Plate 11). Of the 1273 adult fishes (from 110 genera), 425 were Clown anemone fish (*Amphiprion ocellaris*) followed by the Longhorn cowfish (*Lactoria cornuta*) with 57 fish and the Bluestreak cleaner wrasse (*Labroides dimidiatus*) with 48 fish.


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Plate 11: The Emperor angelfish (*Pomacanthus imperator*), left as an adult, right as a juvenile.

The only one to occur at a minimum depth of >50 m was the Checked swallowtail *Odontanthias borbonius* (from 92 to 300 m). The biggest fish (max. 1 m) imported were the Bosch's reefeel (*Echidna nebulosa*) and the Giant sweetlips (*Plectorhinchus albovittatus*) (Plate 12).


© R. Field
Plate 12: The Giant sweetlips (*Plectorhinchus albovittatus)* can reach 1 meter in size.

Food
Food chains start at trophic level 1 with primary producers such as plants, move to herbivores at level 2, predators at level 3 and typically end with carnivores or apex predators at level 4 or 5

According to FishBase (Froese & Pauly 2014), 128 species (29%) of the MO imported in 2009 where herbivores (level 2-3) and 312 species (71%) were carnivores to predators (level 3-5) (Fig. 8). The highest ranked fish to exceed a trophic level of 4 was the Black leafnose morey eel (*Rhinomuraena quasita*), as well as the Argus grouper (*Cephalopholis argus*), and the Baramundi cod (*Cromileptes altivelis*), with a trophic level of 4.5.

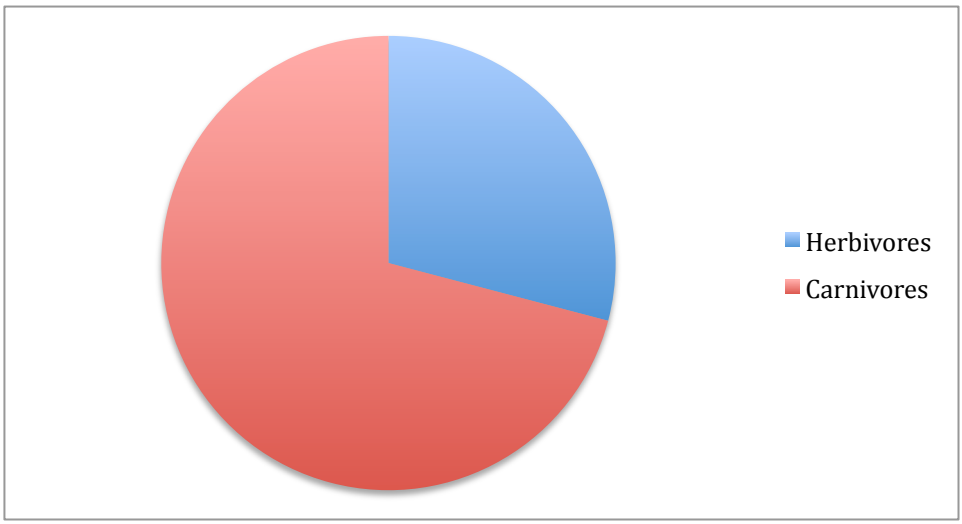

Figure 8: The trophic level reflects the food type of the fish imported.

Out of the 14 927 fishes (84%), 12 233 fed on 'mainly animals': 677 (from 41 species) on Nekton (including vertebrates, molluscs, and crustaceans) and 11 556 (from 261 species) on zooplankton or zoobenthos. The rest, 1594 fishes (44 species), were either plant or detritus feeders (Fig. 9).

For the remaining 2746 specimens (16% from 88 species), the food type was not identified on FishBase (six species were not on FishBase). Another 1100 fishes were only identifiable to the genus level and were not included.

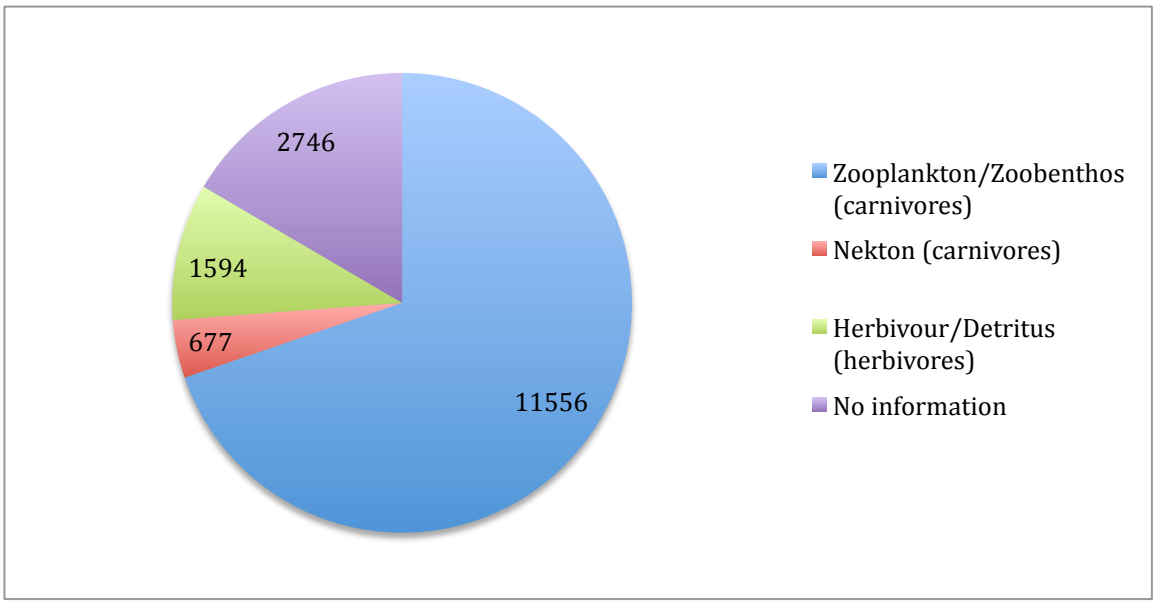

Figure 9: Most fishes in marine aquariums are carnivores.

FishBase stores information about 'human uses'. Almost all fishes were declared as for 'aquarium display'. For five species, the use was declared as 'of no interest'.

For 12 385 fishes (70%; of the 17 673), a price was specified on the import papers. The import prices ranged from US$0.20 to US$260 per fish. On average the price for a fish was US$3.

Discussion

The natural habitat of coral reef fishes, the coral reefs, are in a dire state. One problem is climate change, resulting in warmer surface water followed by coral bleaching, which affects the way fish larvae settle and how they are distributed (McCormick et al. 2010).

Another threat is ocean acidification, which compromises carbonate build-ups in corals which leads to a decrease in diverse reef communities. Furthermore, overfishing for food and overfishing of key species is increasingly driving reefs towards the tipping point of functional collapse (Hoegh-Guldberg 2007).

However, only a few of all coral reef fish species (of all 4000 known species) on FishBase are marked as threatened and the IUCN Red List committee did not evaluate 70 % of the coral reef fish species. Indeed, very little is known about the biology of most coral fishes.

More than half the coral reef fish species which were imported into Switzerland are not assessed by the IUCN and therefore marked as 'not evaluated' on the Red List. This does not mean that they are not threatened but that they have not been assessed. Therefore, it is unknown if the trade is impacting these species negatively. The other almost half of the species imported into Switzerland are listed as 'least concern', and only six species were marked as 'near threatened' or a higher category . Consequently, it is crucial to analyse species for which no IUCN Red List status is available.

Urgent action is required to analyse the impact of trade on coral reef fishes. Moreover, there are no controlling entities in place for sustainable trade. The Marine Aquarium Council MAC was established in 1998 in order to ensure responsible fishing, the use of nets and good husbandry as well as for paying fair prices, allowing consumers to choose

responsible operators and traders. Conforming companies were certified (MAC label) (UNEP 2009). However, this certification has not been active since 2008-9 (GuideStar 2014).

Ecological and ontogenetic aggravating factors affecting the most traded species in Switzerland

Contrary to pelagic fishes harvested for food that attain comparatively large sizes and typically produce many thousands or even millions of eggs, most coral reef fishes captured for the marine ornamental trade grow to a much smaller size, and possess a much lower fecundity, generally in the order of hundreds of eggs, and some species fecundity is considerably lower. Many coral reef fishes lay their eggs demersally and invest a significant amount of energy into caring for their brood (Birkeland 2008). Furthermore, the transition from larva stage to juvenile (recruitment) in coral reef fishes is much more challenging than of soft bottom (temperate) fishes (Sale 2006).

For over 80% of the imported fishes information on size class was not included. However, over 60 % (2070 specimen) of those fishes carrying size data were labelled as juvenile and sub-adults. As a consequence, the removal of these immature fishes denies them at least one reproductive cycle in the wild and this deprivation may increase the negative impact of collection on their populations.

Almost all juvenile fishes in the present study presented ontogenetic dichromatism, i.e. juveniles and sub-adults present a different colouration than adults, which may impart additional interest from the aquarium industry. In addition, some coral reef fishes are sequential hermaphrodites (they change sex during their life cycle), and fishing may result in a sex drift and ultimately in a reduction of size (Coleman et al. 2000).

High densities of grazing coral reef fishes such as parrotfish cause a fourfold reduction of algae on coral reefs (Mumby 2006). Their absence or removal has a negative impact on the coral reef. The experimental exclusion of large herbivorous fishes caused a dramatic explosion of macroalgae on a coral reef in Australia, which suppressed the fecundity, recruitment, and survival of corals (Hughes 2007).

All fishes larger than 30 cm were carnivores. Carnivorous fishes usually eat live animals which may not be readily available to private aquarium owners. Many small fishes require zooplankton, and many bigger (live) fishes. This can also be problematic since zooplankton is not readily available for private aquarium keepers and dried and frozen food is not of the same quality. Public aquariums usually have specific equipment to keep live feed (Moorhead & Zeng 2010). It may be harder to keep carnivores, especially nekton feeders, than herbivores. Most difficult would be large predators, as they may need live prey or freshly frozen food enriched with supplements (Smith et al. 2004).

One of the biggest fish imported into Switzerland, the Giant sweetlips (*Plectorhinchus albovittatus*), reaches one meter in size. On the Internet, it is only sold as a juvenile (10-15 cm) for US$40 to US$60. This is one example where no consideration is given to size. It is unclear what happens when/if the fish reaches its adult size, as it cannot be kept in a normal sized aquarium. On the internet, almost any coral reef fish or coral reef associated animal can be purchased, even a 3,5 meter long Zebra shark (*Stegostoma fasciatum*) (Swissriff 2015).

Peculiarities of the most traded species in Switzerland
The top two species imported into Switzerland, the Blue-green Damselfish (*Chromis viridis*) at rank 1 and the Clown anemone fish (*Amphiprion ocellaris*) at rank 2 both belong to the family Pomacentridae. These two species were also amongst the most commonly exported to the US, although *Chromis viridis* was on rank 1 and *Amphiprion ocellaris* on rank 5.

With the exception of *Pterapogon kauderni,* very little information is available on the ecology, life cycle, and population dynamics for the 10 most imported coral reef fish species into Switzerland (Tab. 4). This is a major problem affecting most coral reef fishes. The insufficient biological information on most MO makes it more difficult to evaluate the true impact of their collection pressure that may cause rapid and long-lasting negative effects on the fish populations, if overexploited.

	Family	Range	m	Distrib.	Biology	Food	Breeding	Life cycle	No. eggs	Incub. (d)	Pop. density	Sex changer
Chromis viridis	Pomacentridae	non-migratory; subtropical	1 to 20	Indo-Pacific	adults: aggregate above Acropora corals. Juveniles: tied to individual coral heads.	Phytopl.	Nest on sand, rubble	Oviparous, pairing during breeding. Eggs demersal. Males guard, aerate eggs	large number	2 to 3	n. i.	no
Amphiprion oceallaris	Pomacentridae	non-migratory	1 to 15	Indo-West Pacific	adults: amongst venomous tentacles of anemones.	Plankton	Nest on sand, rubble	Oviparous, distinct pairs, monogamous. Eggs demersal, adhere to substrate. Males guard, aerate eggs	several hundred to 1000	6 to 8	n. i.	Protandrous hermaphrodites
Labroides dimidiatus	Labridae	non-migratory; tropical to temperate	1 to 40	Indo-Pacific	Inhabits coral-rich inner lagoons, reef flats, seaward reefs. "Cleaning stations" are occupied by a pair of adults, a group of juveniles or of females with a dominant male.	Crustacean ectoparasite, mucus of other fishes	Pelagic spawner	Oviparous, distinct pairing during breeding. Monogamous. Males territorial.[1]	large number	n. i.	n. i.	Protogynous hermaphrodite.
Chrysiptera parasema	Pomacentridae	non-migratory, tropical	1 to 16	Western Pacific	Inhabits coral-rich areas in sheltered lagoons and inshore reefs. Small groups on Acropora corals.	n. i.	n. i.	Oviparous, distinct pairing during breeding. Eggs demersal, adhere to substrate. Males guard, aerate the eggs.	n. i.	n. i.	n. i.	Protogynous hermaphrodite
Pseudanthias squamipinnis	Serranidae	non-migratory, tropical	3 to 35	Indo-West Pacific	Adults above coral outcrops, patch reefs in lagoons, channels, or outer reef slopes. Large aggregations.	Zooplankton	Pelagic spawner	Oviparous. Successful males spawn nightly with successive females. Males are territorial and haremic.	n. i.	n. i.	n. i.	Monandric protogynous hermaphrodites
Pterapogon kauderni	Apogonidae	non-migratory, tropical	1 to 2 10	West Pacific (endemic Banggai Islands)	Adults and young amongst sea urchins (*Diadema setosum*), anemones, stony corals. Group of 2 to 60 indi.	Zooplankton	Mouthbrooder: Male incubate eggs and larvae	Oviparous,	60 to 70	30	~0.06 ind./m^2	no
Valenciennea puellaris	Gobiidae	non-migratory, tropical	to 30	Indo-Pacific	Sandy areas of clear lagoon, seaward reef. Occurs in pairs and use burrows as refuge. Dens aggregations often mixed with other species.	Probably zooplankton	n. i.	Monogamous.	n. i.	n. i.	n. i.	no
Zoramia leptacanta	Apogonidae	non-migratory, tropical	1 to 12	Indo-Pacific	Above branching corals, also in turbid bays and lagoons.	n. i.	Mouthbrooder	Oviparous, distinct pairing during courtship and spawning.	n. i.	n. i.	n. i.	no
Paracanthurus hepatus	Acanthuridae	tropical; uncommon, highly localized	2 to 40	Indo-Pacific	In clear, current-swept seaward reefs. Loose aggregations. Benthopelagic	Zooplankton, some algae.	n. i.	n. i.	n. i.	n. i.	n. i.	no
Synchiropus splendidus	Callionymidae	tripical, non-migratory	1 to 18	Western Pacific	Shallow protected lagoons, inshore reefs, silty bottoms with corals and rubble. Small groups, over small areas.	n. i.	n. i.	Oviparous. In aquariums pairs ascend to surface and release eggs and sperms.	n. i.	n. i.	n. i.	no

Tab. 4: General information on the ten most trades MO species into Switzerland. N. i. = no information, m = depth, Distrib. = distribution, Incub. = incubation time, Pop. Density = Population density, Phytop. = phytoplankton, ind. = individuals. Source: Fishbase (Froese et al. 2014).

Rank 1: Blue-green Damselfish (*Chromis viridis*)
Chromis viridis is the most traded MO imported into Switzerland as well as worldwide (Wabnitz et al. 2003, Rhyne et al. 2012). It is also the most imported into the US, where nearly one million individuals were imported in one year (2004-5) from 29 different countries (Rhyne et al. 2012).

It is only traded for the aquarium industry (Froese & Pauly 2014). Although it is widely distributed throughout the Pacific region, collection and transport methods are thought to claim high mortality through the chain of custody (Wittenrich 2013). In the main exporting countries Indonesia and the Philippines, though prohibited, the method of stunning with cyanide is often used. The toxicity of cyanide to *Chromis viridis* is 300 times stronger than that of the trace metal cadmium (Arifin & Hindart 2006). Collectors of *Chromis viridis* sometimes also bang on the coral, and break it, while trying to persuade fish to enter their net (Wood 2001).

Coral reefs are degrading worldwide and the natural habitat is becoming more and more fragmented. Connectivity among coral reef fish populations is a key factor in governing the structure and dynamics of marine communities and should therefore be taken into account in management and conservation plans of *Chromis viridis* (Ben-Tzvi et al. 2008). Another aspect to be taken into account is that *Chromis viridis* is described as a complex of two species (*Chromis viridis* and *Chromis atripectoralis*). They are distinct species with three deep evolutionary lineages of *Chromis viridis* in the Indo-Malay Archipelago and the Red Sea (Froukh 2007). This is an important factor if one considers the huge yearly amount of extraction.

As it is difficult to observe fish larvae in the wild, the behaviour of individuals at settlement has rarely been observed (Öhman et al. 1998). Nonetheless, in India Gopakumar was successful in rearing *Chromis viridis* in captivity under laboratory conditions (Gopakumar et al. 2009). Although they state that they are far from producing commercially, in 2013 Rising Tide was able to rear some in captivity. It is so easy and cheap to catch *Chromis viridis* in the wild that there is no incentive to try and raise them in captivity (Wittenrich 2013).

The Maldives, which derive their major source of foreign exchange earnings is tourism that depends on the rich diversity of marine life, banned the export of *Chromis viridis,* which was used as live bait in the pole and line tuna fishery (Saleem 2008).

Chromis viridis is listed as 'not evaluated' by the IUCN Red List (Froese & Pauly 2014). In view of the large amount of specimen traded as well as the possibility of multiple species and the destruction of coral reefs, a precautionary approach towards trade should be considered.

Rank 2: Clown anemonefish (*Amphiprion ocellaris*)
The second most traded species was *Amphiprion ocellaris.* Although anemone fishes belong to the few MO species that can be bred in captivity (Wabnitz et al. 2003), in this study it was not possible to determine which fishes came from captive breeding facilities as only few Swiss import papers gave this information on the invoice

Amphiprion ocellaris was one of the first fishes to be bred in captivity. One example is ORA farm in the US (ORA 2015). ORA breeds around 300 000 a year (Prosek 2010). The

US imported around 500 000 in one year (2004-5) but did not state how many are from the wild (Rhyne et al. 2012).

Nonetheless, demand seems to exceed the production of the different species of anemone fish and therefore it must be assumed that at least half of the individuals from the anemone fish species complex come from the wild (Jones et al. 2008).

Amphiprion ocellaris is listed as 'not evaluated' by the IUCN Red List (Froese & Pauly 2014). In view of the amount of trade and the destruction of coral reefs, a precautionary approach towards trade should be considered.

Rank 3: Bluestreak cleaner wrasse (*Labroides dimidiatus*)
The US alone imported about 180000 *Labroides dimidatus* in 2004-5 (Rhyne et al. 2012). Between 1997 and 2002, it was also one of the most imported MO into the EU (Wabnitz et al. 2003).

Trade data from GMAD (GMAD 2004) correlated with the aquarium suitability index[1] (Michael 1999), indicate that *Labroides dimidiatus* does not acclimatize well to aquarium conditions but is nonetheless very commonly traded. It tends to fare poorly in aquarium conditions unless kept with a large community of fishes, and is not likely to accept substitute foods, so aquarists are advised to avoid it (Michael 1999).

Labroides dimidiatus is significantly more numerous at sites where ecological factors such as the species richness of the fish community may promote their cleaning activity (Arnal et al. 2002). The extraction of *Labroides dimidiatus* therefore poses a problem: It is a key species in coral reefs as it removes ectoparasites and reduces parasite abundance, decreasing 4.5-fold within 12 hours (Grutter 1999). It is essential to the health of coral reefs and drives diversity. Studies have shown that the lack of this species is followed by a rapid degeneration of the coral reef community just 4 month after removal (Bshary 2003). In reefs that were experimentally maintained free of cleaner wrasses for over 8.5 years, resident damselfish species were smaller and fewer, and overall there was less fish diversity than in control reefs (Waldie et al. 2011).

Although the IUCN Red List lists *Labroides dimidiatus* as 'least concern' a monitoring of this key species should be considered also in view of the amount of trade, it is faring poorly in aquariums and the destruction of coral reefs.

Rank 4: Goldtailed demoiselle (*Chrysiptera parasema*)
On rank 4 in Switzerland and on rank 6 in the US, where over 400 000 were imported in one year (2004-5).

Habitat loss alone has a strong negative effect on the survival of transplanted damselfish recruits (Bonin 2011). Low levels of live coral significantly reduced the growth of *Chrysiptera parasema* by up to 25% of those living on undisturbed corals (Feary et al.

[1] Michael's aquarium suitability index: 1 - These species are almost impossible to keep and should be left on the reef, 2 - Most individuals of these species do not acclimatize to the home aquarium, often refusing to feed, and waste away in captivity, 3 - These species are moderately hardy, with most individuals acclimatizing to the home aquarium if species care is provided, 4 - These species are generally durable and hardy, with most individuals acclimatizing to the home aquarium, 5 - These species are very hardy with almost all individuals readily acclimatizing to aquarium confines (Michael 1999).

2009). In addition to habitat loss, mortality during transport puts an additional stress on the species, as has been shown by a study in Indonesia (Schmidt 2005).

This species is listed as 'not evaluated' by the IUCN Red List (Froese & Pauly 2014). In view of the destruction of coral reefs, a precautionary approach towards trade should be considered.

Rank 5: Sea goldie (*Pseudanthias squamipinnis*)
Between 1997 and 2002, *Pseudanthias squamipinnis* was also one of the most imported species into the EU (Wabnitz et al. 2003). The US does not seem to import *Pseudanthias squamipinnis,* although the US does imports small numbers of *Pseudanthias regalis* (rank 1666). The IUCN Red List lists *Pseudanthias regalis* as vulnerable.

A recent study in the Red Sea showed that *Pseudanthias squamipinnis* exhibited high genetic diversity and should therefore be seen as two populations in the Gulf of Aqaba and in the Red Sea regarding to trade (Froukh 2007). Studies suggest that the morphological diverse *Pseudanthias squamipinnis* likely reflects overlooked species, one in the Indian Ocean, a second in the Philippine Sea and a third in the South Pacific (Steinke et al. 2009).

Pseudanthias squamipinnis is listed as 'not evaluated' by the IUCN Red List (Froese & Pauly 2014). In view of the possibility of multiple species being handled as one, and the threats to coral reefs, a precautionary approach towards its trade should be considered.

Rank 6: Banggai Cardinalfish (*Pterapogon kauderni*)
Pterapogon kauderni is a very popular marine ornamental fish worldwide and only caught for the aquarium trade. It was described in 1933 and then forgotten until 1995, when trade started.

In 2007 the total population size was estimated at 2,2 million individuals and about one million were captured the same year (Vagelli 2008). The US alone imported about 200 000 in one year (2004-5).

It was estimated that the abundance of *Pterapogon kauderni* within its natural range suffered an approximate 90% decline with respect to what was considered its pre-harvest level (Allen & Donaldson 2007; Vagelli 2011). Some populations have already been overexploited (Lunn et al. 2004) and some populations were extirpated because of massive outtake (Vagelli 2011).

The most recent population assessment of *Pterapogon kauderni*, completed in 2015 and covering most of the species natural range, showed that no population had a density near to the one considered the baseline for the species (~0.60 ind./m2). In fact it had decline from 0.08 ind./m^2 in 2007 to 0.06 ind./m^2 in 2015 (Vagelli & Biondo 2015), with a total population size within its natural range of approximately 1,4 million individuals in a total actual area of occupancy of an estimate of ~ 23 km^2 (Vagelli & Biondo 2015).

The negative effect of fishing pressure on density of fish is significant and negatively effects group size in both sea urchins and fish (Vagelli & Biondo 2015).

The species has a special biology and a very limited range of just 23 square kilometres (Tab. 4) and plays an important role in its environment by preying on larval stages of

coral reef fish parasites, and by being a prey item for several fishes and a sea snake species (Vagelli 2002, 2008, 2011).

Although captive breeding is possible, wild caught fish are much cheaper and therefore are still widely traded (Vagelli 2011).

An attempted to restrict the trade through CITES in 2007 failed, the same year *Pterapogon kauderni* was listed as 'endangered' by the IUCN Red List. In light of the information available today, a listing of this species in CITES would be warranted.

Rank 7: Maiden goby (*Valenciennea puellaris*)
There is a lack of information on the international trade volume. In aquariums, *Valenciennea puellaris* is prone to jumping out of the tank (Michael 2015).

The species is listed as 'not evaluated' by the IUCN Red List (Froese & Pauly 2014). In view of the destruction of coral reefs and poor knowledge of the biology of the species, a precautionary approach towards trade should be considered, as the effect of trade cannot be evaluated.

Rank 8: Threadfin cardinalfish (*Zoramia leptacanta*)
The species is listed as 'not evaluated' by the IUCN Red List (Froese & Pauly 2014). In view of the destruction of coral reefs, poor knowledge of the biology of the species a precautionary approach towards trade should be considered, as the effect of trade cannot be evaluated.

Rank 9: Palette doctorfish (*Paracanthurus hepatus*)
The species ranks 12 in the US imports, where almost 200 000 specimens were imported in one year (2004-5) (Rhyne et al. 2003). Also, worldwide *Paracanthurus hepatus* is one of the most traded and valuable MO (GMAD 2004).

In Bali, collection began in the early 1970s, by the 1980s demand increased and more varieties were requested by the market and collectors had to travel farther away in search of new reefs. Today, collection shows that roving collectors may be away as long as three weeks at a time, travelling over wide expanses of open sea. (Reksodihardjo-Lilley & Lilley 2007).

Paracanthurus hepatus can easily reach 40 cm in length and can be too large for a private aquarium. It feeds on zooplankton and requires a continuous intake. It reacts aggressively toward other doctorfishes or coral reef fishes. The species is also notably susceptible to disease.

This fish species also became well known as a result of the Walt Disney's Film 'Finding Nemo' but contrary to anemone fishes, it cannot be bred in captivity. One cause is that very little is known of their very long larval cycle (Thaler 2008, 2015).

In light of the upcoming new Walt Disney Film 'Finding Dory', starring a female *Paracanthurus hepatus* as 'leading actress' in 2016, a surge in trade is to be expected (as was the case with the anemone fishes when Wald Disney's Film 'Finding Nemo' was screened). Although the IUCN Red List lists the species as 'least concern', which maybe should be reconsidered, it is reasonable to suggest that the trade of this species should at least be monitored.

Rank 10: Mandarinfish (*Synchiropus splendidus*)
The brightly coloured *Synchiropus splendidus* is high prized in the aquarium trade for its intricate fins. The species ranks 11 in the US MO trade where almost 200 000 specimens were imported in one year (2004-5) (Rhyne et al. 2003).

Hobbyists' preference for large male fish also raises concerns about disruption of the Mandarinfish mating system. Up to 70 % of fish caught are male (Wabenitz et al. 2003). Female Mandarinfish may refuse to mate with smaller males (Sadovy et al. 2001).

The species manifests a relatively secluded lifestyle, which has led collectors to develop a spear fishing method for their capture. Spearing can result in injury, paralysis, or even death (Thornhill 2012).

Synchiropus splendidus has a suitability index of 2, meaning that most individuals of these species do not acclimatize to the home aquarium, often refusing to feed, and consequently waste away in captivity (Michael 1999).

Furthermore, this species' specialized diet of live zooplankton makes it more difficult to reproduce in captivity. As a result, wild caught Mandarinfish often refuse to eat and starve to death within a few weeks of purchase (Wabnitz et al. 2003). Death in captivity increases demand, driving additional collection and damage to Mandarinfish populations (Thornhill 2012).

Synchiropus splendidus is listed as 'not evaluated' by the IUCN Red List (Froese & Pauly 2014). In view of being vulnerable to collection and difficult to maintain in captivity, as well as of the effects of the trade and the destruction of coral reefs, a precautionary approach towards trade should be considered.

Other species
Fortunately, the first step to monitor the international the trade in seahorses (*Hippocampus spp.)* was taken by listing this genus in CITES Appendix II in 2002. Despite being the only MO group being regulated through CITES, they continue to be affected by the aquarium trade. Declining catches suggest that seahorse populations had been over-exploited and are in need of additional protection measures in order to recover (IUCN 2014). This fact shows that it is most important to have monitoring measures in place.

Swiss trade
To date, no study has attempted to quantify the import volume of MO into Switzerland through the available import documents. All previous Swiss research on trade relied on (oral or written) information given by the Swiss importers or retailers (Weber 2001). The present analysis relies on the quantitative information contained on the shipping declarations (GVDE) and the species lists. This study found that in 2009, Switzerland imported marine fishes from eight countries that remained in Switzerland, totalling in 17 673 specimens belonging to 45 families.

The UNEP (Wabnitz et al. 2003) and the US study (Rhyne et al. 2012) state that the Philippines were the second largest exporters followed by Indonesia. Switzerland imported proportionally more fishes from Indonesia and Sri Lanka, probably because it is geographically closer and has a strong Sri Lankan community. Two thirds of the fishes were exported from Indonesia (11 167 individuals), which is four times the number of the second largest exporter Sri Lanka (2179 individuals). The UNEP study also states

that, according to importer information, the origin was not noted from over 80% of the fishes (Wabnitz et al. 2003).

Outlook

Worldwide trade is increasing

In 2001, Wood estimated that 1000 species of coral reef fish were traded (Wood 2001). Research by the UNEP reported 1471 coral reef fish species from 59 families in the ornamental trade (Wabnitz et al. 2003). Moreover, in one year (2004-5) the US, the main importing country, imported 10 million MO, representing 125 families and over 1800 species (not counting the domestic 200 species) from about 40 countries (Rhyne et al. 2012).

More than half the coral reef fish species (over 2000 of the 4000 known species) are already in the international trade of MO**.** The UNEP data similarly mirrors the amount of families imported into Switzerland (45), which is assumed to be an important import country, being one of the wealthiest countries in the world.

The number of MO in the aquarium trade most likely will increase, as demand for new species is increasing. All over the world, new public and private aquariums are being built or planned (Google search/aquariums 2014). As fishing and holding equipment becomes more sophisticated, it will also be easier to collect and maintain fishes. This is underlined by the fact that the marine aquarium hobby went from a fishes only tank to an entire coral reef aquarium in about 20 years, with people spending up to US$20 000 for uncommon organisms (Courchamp et al. 2006, Advanced aquarist 2014).

Worldwide monitoring of MO trade

The lack of an adequate information system recording all imported and (re-) exported (transit) MO renders the monitoring of trade of MO very difficult, if not impossible.

Since 2013, the electronic database TRACES (Trade control and Expert System) used by customs in Switzerland and the EU includes a list of over 1800 marine ornamental fishes but it is not suited to monitor the trade data accurately. To answer a lot of questions around this trade, additional information such as volume, origin, size of specimen, wild caught or captive bred should also be collected.

Smith et al. (2008) suggested the US database Law Enforcement Management Information System LEMIS could be adapted to incorporate more information on ornamental fishes and hence be a useful tool to collect coral reef fish trade data.

Also, with a CITES listing of some species threatened by international trade, a trade monitoring system would be established.

Recommendation

To conserve and manage reef fishes properly, it would be important to first identify those species that are susceptible to overfishing (Jenning & Polunini et al. 1999). This cannot be done reliably through assessments or development of abundance, as the scientific data is not available. Scientific data such as on the biology, population dynamics and recruitment patterns of traded species need to be collected in order to be able to assess the conservation status of the species concerned (IUCN Red List assessment).

Catch data to the species level is important when attempting to assess the effects of collection, developing management strategies and assessing their efficacy (Wabnitz et al. 2003). Impacts associated with the overall international trade remain unknown because data are only collected for organisms listed in the CITES appendices (Bruckner 2001). As this study and other publications show, collecting data through customs documents may be inaccurate and data deficient, though it gives a general overview on this trade. But more detailed information is necessary. Therefore, more data should be collected in order to be able to evaluate whether trade is having a negative effect.

As discussed above, there are several databases in place to monitor disease prevention. Holders of databases such as the US (LEMIS) or the EU and Switzerland (TRACES) should be encouraged to adapt and possibly merge the contents of their databases and/or make them available for analysis.

For the most vulnerable species, a CITES listing - in particular for *Pterapogon kauderni*, *Labroides dimidiatus* and *Paracanthurus hepatus* as well *as Synchiropus splendidus* - should be considered.

Literature

Advanced aquarist: www.advancedaquarist.com/blog/peppermint-angelfish-at-blue-harbor: Accessed 2014-10-24.

Allen, G., Donaldson T. (2007): *Pterapogon kauderni* Banggai cardinalfish IUCN RedList. http://www.iucnredlist.org/details/63572/0.

Appeltans W., Bouchet P., Boxshall G., Fauchald K., Gordon D., et al. (2011): World Register of Marine Species. Available: http//www.marinespecies.org: Accessed 2014, July.

Arifin Z., Hindart D. (2006): Effects of cyanide on ornamental coral fish (Chromis viridis). Mar. Res. Indonesia 30: 15-20.

Arnal C., Kulbicki M., Harmelin-Vivien M., Galzin R., Morand S. (2002): Patterns of Local Distribution of Labroides dimidiatusin French Polynesian Atolls. Environmental Biology of Fishes, Volume 63, Issue 1, pp 9-15.

Bartley D. (2005): Fisheries and Aquaculture topics. Ornamental fish. Topics Fact Sheets. In: FAO Fisheries and Aquaculture Department.

Ben-Tzvi, O., Abelson, A., Polak, O. and Kiflawi, M. (2008): Habitat selection and the colonization of new territories by *Chromis viridis*. Journal of Fish Biology, 73: 1005–1018. doi: 10.1111/j.1095-8649.2008.02003.x

Birkland Ch. (2008): Fish Life. Division of Aquatic Resources, Hawaii.

Bonin M. C. (2011): Contrasting effects of habitat loss and fragmentationon coral-associated reef fishes. Ecology, 92(7), 2011, pp. 1503–1512.

Bruckner A. W. (2001): Tracking the trade in ornamental coral reef organisms: The importance of CITES and its limitations. Aquarium Sciences and Conservation 3: 79–94, 2001.

Bshary R. (2003): The cleaner wrasse, *Labroides dimidiatus*, is a key organism for reef fish diversity at Ras Mohammed National Park, Egypt. Journal of Animal Ecology, 72, 169-176.

Carpenter K. E., Abra M., Aeby G., Aronson R. B., Banks S., Bruckner A., Chiriboga A., Corés J., Delbeek J. C., DeVatier L., Edgar G. J., Edwards A. J., Fenner D., Guzman H. M., Hoeksema B. W., Hodgson G., Johan O., Licuanan W. Y., Livingstone S. R., Lovell E. R., Moore J. A., Obura D. O., Ochavillo D., Polidoro B. A., Precht W. F., Quibilan M. C., Reboton C., Richards Z. T., Rogers A. D., Sanciangcol J., Sheppard A., Sheppard C., Smith

J., Stuart S., Turak E., Veron J. E. N., Wallace C., Weil E., Wood E. (2008): One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts. Science 321 (560-563).
Cato J. C. (2003): Marine Ornamental Species: Collection, Culture and Conservation. Blackwell Pub Professional.
Cervino J. M., Hayes R. L., Honovich M., Goreau T. J., Jones S., Rubec P. J. (2003): Changes in zooxanthellae density, morphology, and mitotic index in hermatypic corals and anemones exposed to cyanide. Marine Pollution Bulletin 46: 573–586 in hermatypic corals and anemones exposed to cyanide. Marine Pollution Bulletin 46: 573–586.
Coleman F.C., Koenig C. C., Huntsman G. R., Musick J.A . Eklund A. M., McGovern J. C., Chapman R. W., Sedberry G. R., Grimes C. B. (2000): Long-lived reef fishes: The grouper-snapper complex. Fisheries, Vol: 25, Issue: 3, p: 14-21, DOI: 10.1577/1548-8446(2000)025<0014:LRF>2.0.CO;2.
ConsultEcon (2008): Keys to economic sustainability of aquariums: Examples from the worldwide aquarium 'industry'. Conference presentation ConsultEcon, Inc.
Courchamp F., Angulo E., Rivalan P., Hall R. J., Signoret L., Bull L., Meinard Y. (2006): Rarity value and species extinction: the anthropogenic Allee effect. PLos biology 4:e415.
FAO, Food and Agriculture Organization of the United Nations/State world fisheries (2008): ftp://ftp.fao.org/docrep/fao/011/i0250e/i0250e.pdf30 FAO:Rome, Italy.
Froukh T. (2007): Genetic population structure, gene flow, and evolutionary history of selected ornamentalfish in the Red Sea. Doctoral thesis. Faculty of Biology and Chemistry University of Bremen.
Feary, D. A., McCormic M. I., Jones G. P. J. (2009): Growth of reef fishes in response to live coral cover, J. Exp. Mar. Biol. Ecol. (2009), doi:10.1016/j.jembe.2009.03.002.
Froese R., Pauly D. (2014): FishBase. World Wide Web electronic publication. www.fishbase.org, version (18/2014).
Geck J. (2008): Nano-Aquarium. Gräfe und Uzer Verlag GmbH; 7th edition.
GMAD Global Marine Aquarium Database (2004): http://www.unep-wcmc.org/marine/GMAD, not active anymore.
Google search/aquariums: 'New public aquariums planned'. Accessed 2014-10-24.
Gopakumar G., Madhu K., Madhu R., Ignatius B., Krishnan L., Mathew G. (2009): Broodstock development, breeding and seed production of selected marine food fishes and ornamental fishes. Marine Fisheries Information Service T&E Ser., No. 201.
Grutter A. S. (1999): Cleaner fish really do clean. Nature 398, 672-673 | doi:10.1038/19443.
GuideStar (2014): http://www.guidestar.org/organizations/52-2116916/marine-aquarium-council.aspx. Accesses 2014-11-08.
Hoegh-Guldberg O. (2007): Coral Reefs Under Rapid Climate Change and Ocean Acidification. SCIENCE Volume 318 (1737-1742).
Hughes R. P., Rodrigues M. J., Bellwood D. R., Ceccarelli D., Hoegh-Guldberg O., McCook L., Moltschaniwskyj N., Pratchett M. S., Steneck R. S., Willis B. (2007): Phase Shifts, Herbivory, and the Resilience of Coral Reefs to Climate Change. Current Biology, Volume 17, Issue 4, pages 360–365.
IUCN/Red List (2014): http://www.iucnredlist.org/static/categories_criteria_3_1. Accessed 2014-12-12.
IUCN/Red List: www.iucnredlist.org/details/10070/0. Accessed 2015-11-08.
Jennings R. J., Polunini N.V.C (1999): Predicting the Vulnerability of Tropical Reef Fishes to Exploitation with Phylogenies and Life Histories. Conservation Biology, Pages 1466-1475 Volume 13, No. 6.
Jones A. M., Gardner S., Sinclair W. (2008): Losing 'Nemo': bleaching and collection

appear to reduce inshore populations of anemonefishes. Journal of Fish Biology, Volume 73, Issue 3, pages 753–761.
Livengood E. J., Chapman F. A. (2007): The ornamental fish trade: An introduction with perspective for responsible aquarium fish ownership. University of Florida, USA. FA 124.
Lunn K. E., Moreau Æ. M.-A. (2004): Unmonitored trade in marine ornamental fishes: the case of Indonesia's Banggai cardinalfish (Pterapogonkauderni). Coral Reefs 23: 344–351.
McCormick M. I., Moore J. A. Y., Munday P. L. (2010): Influence of habitat degradation on fish replenishment. Coral Reefs (2010) Springer-Verlag.
Michael C. (1999): Marine Fishes. 500+ Essential-To-Know Aquarium Species. Microcosm Ltd.
Michael S. W. (2015): FishChannel: http://www.fishchannel.com/media/setups/saltwater/live-sand-guide.aspx.pdf. Accessed 2015-09-23.
Miller T. G., Spoolman S (2011): Essentials of Ecology. Brooks Cole.
Moorhead J. A., Zeng C. (2010): Development of Captive Breeding Techniques for Marine Ornamental Fish: A Review, Reviews in Fisheries Science, 18:4, 315-343. http://dx.doi.org/10.1080/10641262.2010.516035.
Mumby P. J., Dahlgren C. P, Harborne A. R., Kappel C. K. Micheli f.,Daniel R. Brumbaugh D. R., Holmes K. E, Mendes J. M., Broad K., Sanchirico J. N., Buch K., Bos S., Stoffle R. W., Gill A. B. (2006): Fishing, Trophic Cascades, and the Process of Grazing on Coral Reefs. Science 6 January 2006: Vol. 311, no. 5757, pp. 98-101. DOI: 10.1126/science.1121129
Murrey J. M., Watson G. J., Giangrande A., Licciano M., Bentley M. G. (2012): Managing the Marine Aquarium Trade: Revealing the Data Gaps Using Ornamental Polychaetes. PLoS ONE 7(1): e29543. doi:10.1371/journal.pone.0029543.
Öhman M. C., Munday, P. L., Jones G. P., Caley M. J. (1998): Settlement strategies and distribution pattern of coral-reef fishes. Journal of Experimental Marine Biology and Ecology 225: 219-238.
ORA Farm (2015): Captive bred ornamental fishes: http://www.orafarm.com/products/fish/clownfish. Accessed 2015-09-16.
Prosek J. (2010): Beautiful Friendship. http://ngm.nationalgeographic.com/2010/01/clownfish/prosek-text.
Reksodihardjo-Lilley G, Lilley R. (2007): Towards a sustainable marine aquarium trade: An Indonesian PC Live Reef Fish Information Bulletin #17.
Rhyne A. L., Tlusty M. F., Schofield P. J., Kaufman L., Morris J. A. Jr, Bruckner A. W. (2012): Revealing the Appetite of the Marine Aquarium Fish Trade: The Volume and Biodiversity of Fish Imported into the United States. PLoS ONE 7(5): e35808. doi:10.1371/journal.pone.0035808.
Sadovy Y., Mitcheson G., Rasotto M. (2001): Early development of the mandarinfish *Snchiropus splendidus* (Callionymidae), with notes on its fishery and potential culture. Aquarium Sciences and Conservation 3: 253-263.
Sale P. F. (2006): Coral Reef Fishes. Dynamics and diversity in a complex ecosystem. Academic Press Elsevier.
Saleem M. (2008): Management of the aquarium fishery in the Republic of the Maldives. Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, Session number 22.
Schmidt C. (2005): Post-harvest mortality in the marine aquarium trade: A case study of an Indonesian export facility. SPC Live Reef Fish Information Bulletin #13.
Smith K. F., Behrens M. D., Max L.M., Daszak P. (2008): U.S. drowning in unidentified

fishes: Scope, implications, and regulation of live fish import. Conservation Letters 1: 103–109.
Smith M., Warmolts D., Thoney D., Hueter R. (2004): The Elasmobranch Husbandry Manual: Captive Care of Sharks, Rays and their Relatives. Special Publication of the Ohio Biological Survey. xv + 589 p.
Spalding M. D., Ravilious, C., Green E. P. (2001): World atlas of coral reefs. Prepared at the UNEP World Conservation Monitoring Centre. University of California Press.
Steinke D., Zemlak T. S., Hebert P. D. N. (2009) Barcoding Nemo: DNA-Based Identifications for the Ornamental Fish Trade. PLoS ONE 4(7): e6300. doi:10.1371/journal.pone.0006300
Stumpf S. (1995): Zierfischhaltung für Anfänger. Swiss Animal Protection Organization (Schweizer Tierschutz) STS.
Swissriff (2015): http://swissriff.ch/de/home/380-stegostoma-fasciatum.html#/grosse-m. Accessed 2015-09-30.
Thaler, E. (2008): Doktorfische im Meerwasseraquarium. Natur und Tier Verlag, Münster
Thaler E. (2015): Denk ich an Dory … http://www.saia-online.eu/images/downloads/de/Palettendr%20Ellen%20Thaler.pdf.
Thornhill D. (2012): Ecological Impacts and Practices of the Coral Reef Wildlife Trade. Defenders of Wildlife.
Tissot B. N. (2010): How U.S. ocean policy and market power can reform the coral reef wildlife trade. Marine policy 34, Issue 6: 1385–1388.
UNEP (2009): Certification and Sustainable Fisheries. United Nations Environment Programme, Geneva, Switzerland.
Vagelli, A. A. (2002): Notes on the biology, geographic distribution, and conservation status of the Banggai cardinalfish *Pterapogon kauderni* Koumans 1933, with comments on captive breeding techniques. Trop. Fish Hobb. 51: 84-88.
Vagelli, A. (2008): The unfortunate journey of *Pterapogon kauderni*: A remarkable apogonid endangered by the international ornamental fish trade, and its case in CITES. SPC Live Reef Fish Info. Bull. 18:17-28.
Vagelli A. A. (2011): The Banggai cardinalfish. Natural history, conservation and Culture of *Pterapogon kauderni*). Wiley-Blackwell.
Vagelli A. A., Biondo M. V., (2015): Update on Populations' Condition of *Pterapogon kauderni*. Unpublished.
Vernon J. E. N (2000): Corals of the World, Vol. 1, 2, 3. Australian Institute of Marine Science.
Wabnitz C., Taylor M., Green E., Razak T. (2003): From Ocean to Aquarium. UNEP-WCM, Cambridge, UK.
Waldie P. A., Blomberg S. P., Cheney K. L., Goldizen A. W., Grutter A. S. (2011): Long-Term Effects of the Cleaner Fish Labroides dimidiatus on Coral Reef Fish Communities. PLoS ONE 6(6): e21201. doi:10.1371/journal.
Weber Ch. (2001): Zur Einfuhr von Zierfischen in die Schweiz. Bundesamt für Veterinärwesen.
Wilkinson C. (2008): Status of Coral Reefs of the World: 2008. Global Coral Reef Monitoring Network, IUCN, Australian Government, Australian Insitute of Marine Science and others.
Wittenrich M. L. (2013): Rearing Green Chromis. University of Florida Tropical Aquaculture Laboratory.
Wood E. (2001): One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts. Aquarium Sciences and Conservation 3: 65–77, 2001.

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