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Literature review and data availability for Splendid Alfonsino stock assessment

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Introduction

Splendid Alfonsino (*Beryx splendens*) are captured in bottom trawl and bottom gillnet fisheries conducted by Japan, Korea and Russia in the Emperor Seamounts of the North Pacific Ocean. The fishery is conducted in International waters which are managed by the North Pacific Fisheries Commission (NPFC), a Regional Fisheries Management Organization (RFMO). Currently, there is no estimate of stock biomass for these species that could help determine a sustainable harvest. The Splendid Alfonsino is a priority species for the NPFC in the NW Pacific Ocean and has exhibited some characteristics of overharvest (recruitment overfishing, declining size, and declining catches over the last few decades). The Small Science Committee on Bottom Fish and Marine Ecosystems of the NPFC has committed to initiating a sustainable and precautionary approach to managing its bottom fish fisheries including the fishery for Splendid Alfonsino as part of its five-year workplan (2020-2025).

Objectives

The objectives of this document are to briefly summarize the existing literature on Splendid Alfonsino with regards to its important life history processes, to identify data availability for the stock in the NPFC Convention Area and to identify critical data gaps for assessing the status of the stock. The document is meant as a working paper that will form the basis of a common starting point from which to discuss appropriate management steps for the Splendid Alfonsino in the NPFC Convention Area. The paper will be discussed at the 1st Bottom Fish and Marine Ecosystems Small

Scientific Committee meeting (November 16-18, 2020).

Review of research on important life history processes

The Splendid Alfonsino and its congener the Broad Alfonsino (*B. decadactylus*) have a pan-global distribution in waters from 25-1300 m along continental margins and oceanic islands and seamounts. They support fisheries in four of the world's oceans (Atlantic, Pacific, Southern and Indian) and in both the northern and southern hemispheres. Their global biology, fisheries and management have been reviewed and summarized most thoroughly in FAO (2016). Their fishery, biology and management in the Emperor Seamounts has been summarized in numerous NPFC working and informational documents since 2008 (e.g. Fisheries Agency of Japan 2008, Sawada et al., 2018, Sawada and Yonezaki 2019, Sawada and Ichii 2020). Here, we focus on summarizing the current knowledge that may be important for future management directions, including factors affecting recruitment, mortality and distribution, as well as any previous stock assessments that have been completed for the species.

Factors affecting recruitment

Little is known of the factors affecting recruitment for Splendid Alfonsino. The information in Table 1 presents an overview of studies to date from which the rest of this paragraph is drawn. Eggs are thought to be spawned in batches over extended spawning periods (lasting multiple months and possibly related to temperature). Egg production is related to body size, with larger females producing proportionally more eggs. Spawning is thought to occur in specific depth zones and females may be serial spawniers throughout the extended season. Male Alfonsino are smaller than female Alfonsino for the same age. Larval duration is uncertain, but is suspected to last 10-12 months before recruitment to demersal stages. Upon recruitment to demersal stages (at ~age 1), the juveniles settle in different (shallower) habitats than adults. At some unknown time (possibly at age 5 and ~30-35 cm in length), the juveniles mature and recruit to the adult populations.

Based on their life history (extended spawn timing, followed by extended egg/larval stages before recruitment to the demersal stage). It is likely that Splendid Alfonsino recruitment, as with similar species, might have complex relationships to the environment, where water temperature and currents would play a strong role in controlling recruitment. Since the juveniles settle to “nursery” habitats separate from adults, there may be density dependent effects that occur upon settlement that might result in some of the global observations of near constant recruitment.

Table 1. Summary of studies that examined recruitment processes for Splendid Alfonsino in both global waters and in the NW Pacific Ocean.

Relationship	Description	Source/citation
Recruitment to commercial fishery and age	Reasonably consistent annual recruitment was found mainly without very strong or weak year classes.	Massey & Horn, 1990
	Full recruitment to the commercial fishery is probably not complete until age 5.	Massey & Horn, 1990
	Age at time of recruitment to fishery was calculated at L_t= 22 cm to be 2.8 years and L_t= 35 cm to be 8.4 years.	Shotton, 2014
Fecundity and size of fish	Fecundity increases with size of fish. A 40 cm female is estimated to have 300000-500000 eggs.	Masuzawa, Kurata & Onishi, 1975
	Maximum potential fecundity was estimated to be between 270000-675000 eggs for fish between 34-40 cm in length.	Lehodey, Grandperrin & Marchal, 1997
Number of oocytes	Number of oocytes per gram of gonad is not correlated with length. Number of oocytes was proportional to the size of ovaries, which in turn was a function of fish length. Evolution of fecundity can therefore be described by $Fecundity= aL^b$.	Lehodey *et al.*, 1997

Oocyte development	Asynchronous oocyte development indicates batch spawning.	Masuzawa *et al.*, 1975; Alekseev, Alekseeva, Trunov & Shilibanov, 1986
Gonadosomatic index (GSI) and fish size	GSI was found to be independent of body size and thus is a good marker for sexual maturation. In the Azores, the highest GSI values occurred in larger fish.	Lehodey *et al.*, 1997 Pereira & Pinho, 2012
Reproductive cycle	For New Caledonia, reproduction was found to follow a cycle; gonad maturation was followed by spawning, which peaked several months later. Post-spawning stage followed and continued until the next gonad maturation cycle.	Lehodey *et al.*, 1997
Spawning *B. decadactylus*	Spawning of *B.decadactylus* is generally known to occur over a period of four months, dependant on climatic variation.	Shotton, 2016
Spawning episodes: by zone	There are clear differences in habitat by age. Nursery zones are inhabited by juvenile fish and are the areas where adults reproduce. A lack of spawning fish with increasing depth suggests a non-reproductive zone. Immature stages of Alfonsino develop in “vegetative zones”	Masuzawa *et al.*, 1975; Humphreys, Tagami & Seki, 1984; Horn & Massey, 1989; Massey & Horn, 1990; Lehodey, Marchal & Grandperrin, 1994 Alekseev *et al.*, 1986, Lehodey *et al.* 1994; Lehodey *et al.*, 1997

	before recruiting into deeper waters.	
	Spawning on the banks of the Southwest Indian Ridge (SWIR) was presumed to occur along slopes in benthic layers, where water temperature is 10-13°C.	Ivanin & Rebyk, 2012
Spawning episodes: frequency and duration by region	The spawning season varies geographically; in Japanese seas and Northwest of Hawaii, spawning occurs during "summer" (between June and October). Spawning peak is suggested to be July-September.	Flores *et al.*, 2012; Masuzawa *et al.*, 1975; Uchida & Uchiyama, 1986
	Spawning varies in Japanese seas among spawning locations.	Honda *et al.*, 2004
	Summer spawning season also indicated in the Emperor seamounts from otolith analysis and GSI patterns.	Mundy, 1990; Takahashi, 2018
	In the Atlantic ocean, spawning was found to be intermittent and individual spawning periods were estimated to last up to two months.	Alekseeva, 1983
Growth rate and temperature fluctuations	Growth rate derived from annuli on sagittal otoliths found to be strongly related to	Lehodey & Grandperrin 1996a

	temperature fluctuations in intermediate-depth water masses. El Niño Southern Oscillation (ENSO) events influence temperature with a several month lag time. El Niño events increase growth rates while La niña events decrease growth rates.	
Reproduction: current systems, eddies	Vegetative and reproductive zones in the Atlantic ocean are located inside large oceanic eddy systems. Currents carry eggs and larvae from reproductive to vegetative zone and maturing fish back to reproductive zone. This larval/juvenile recruitment was found also in New Caledonia eddy system. When spawning occurs in the New Zealand EEZ, larvae and juveniles are likely entrapped in an eddy (Wairarapa eddy) and recruit onto banks off the South Wairarapa coast. Epipelagic larvae are passively distributed by surface currents until demersal existence at 10-12 months. Larvae are thought to be distributed from Japanese	Alekseev *et al.*, 1986 Lehodey & Grandperrin, 1996a, Lehodey *et al.*, 1994, Lehodey *et al.*, 1997 Shotton, 2016 Chikuni, 1971

	waters to the SE-NHR via the Kuroshio current and the Kuroshio extension.	
	The wide dispersal of pelagic juveniles in the Indian Ocean is suggested to promote gene flow among geographically isolated adult stocks.	Yanagimoto, 1996
	Little is known about the pelagic larval phase and settlement in the Emperor seamounts.	Ivanin, 1987
		Sawada, Nishida, Yonezaki & Kiyota, 2018

Factors affecting mortality

The factors affecting natural mortality for Splendid Alfonsino are generally unknown, but the available studies have been summarized in Table 2. Mortality in the pelagic early life history stages has not been studied. Natural mortality for demersal stages of Splendid Alfonsino is generally thought to be caused by predation from sharks and large piscivorous fishes, however little is known about the mechanisms of natural mortality of Alfonsino. The maximum age and maximum body size of Splendid Alfonsino have been shown to vary with factors such as latitude (for the same region) and have been shown to vary across regions. For example, the maximum age in the North Pacific is thought to be ~20 years, while in the eastern Atlantic Ocean the maximum ages have been observed to be closer to ~10 years (see section below on biological parameters).

As a species that is relatively slow growing and reaches a fairly large body size and may live up to 20 years, it is expected that natural mortality would be relatively low. Sebastes in the North Pacific with a similar size and maximum age would be expected to have a natural mortality rate of ~0.22-0.25. However, no reliable estimates of natural mortality for Splendid Alfonsino in the Pacific seem to be available in the literature.

Table 2. Summary of information on the mortality of Splendid Alfonsino both globally and within the NPFC region.

Study topic	Description of results	Source/citation
Mortality and prey availability	Mainly only general information is available on preferred prey. Main prey are reported to be migrant and non-migrant midwater fishes. Due to the wide range of prey, it is unlikely that alfonsino would suffer from lack of food due to a decrease in abundance from one prey species.	Shotton, 2016
Mortality and aggregating behaviour	Effects of overfishing are greater due to alfonsino spawning aggregation behaviour. Seamount fishing causes disruption of spawning processes and reduced reproductive success, though this is rarely documented. Aggregations on seamounts or ridge peaks are more vulnerable to overfishing and rapid depletion than species dispersed on shelf or slope. Several-year periods of absence of alfonsino aggregations over seamounts were suggested by Russian investigators to be caused by heavy fishing over these areas.	Clark, 2009 Klimenko, 1983; Melnikov, Ivanin & Piotrovsky,1993; Vinnichenko, 1995, 1998.
Mortality: catch size	After exploitation at the SE-	Sasaki, 1985

composition	NHR fishing grounds began, a decrease in large-sized alfonsino was detected around the flat summits of seamounts. In New Zealand, trawl survey data from 1991-2000 shows a declining proportion of fish in larger length classes. Survey biomass estimates from this data are however highly variable.	Shotton, 2016
Mortality and discovery of North Pacific Armorhead (NPA) in the North Pacific	The 1967 discovery of large concentrations of NPA in the Southern Emperor Seamounts by the then- Soviet Union was followed by Japanese trawling beginning in 1969. Alfonsino catch suddenly increased in 1976 with the discovery of the Northern seamount fishing grounds Koko and Yuyaku, and the southern Emperor Kammu seamount. The increase in Alfonsino catch coincided with a dramatic drop in NPA catch. Captures by Japanese vessels are not well known. Expansion of the Southern Emperor seamount fishery encompassed the Northern Hawaii Ridge (NHR) guyot-type seamounts (Colahan, C-H	Boehlert & Sasaki, 1988; Yanagimoto & Nishimura, 2007; Shotton, 2016 Sasaki, 1986 Sasaki, 1986

	and Hancock seamounts). SE-NHR Japanese trawl fishing grounds mainly between 300 and 400 m depths. Fish taken from the Milwaukee Seamount by Japanese trawl fishery were mainly uniformly distributed in a 22-34 cm length range and predominantly harvested at a depth of 320 m.	Chikuni, 1971
Mortality and Japanese EEZ	Several fishing grounds and landing ports are along the Pacific coast of central and Southwest Japan and are managed by local governments. Catches in the Japanese prefectures increased in the 1970s and peaked in the 1980s. A period of decreased catches and stable CPUE followed. Line fishing regulations vary between prefectures (Izu Islands). Bottom-gillet statistics are available since 2000 when a limited-license system was implemented by the Japanese Government.	Honda, Sakaji & Nishida, 2012 Honda, Nikigani, Yonezawa, Akimoto, Iida, Myojin & Shimizu, 2004 Honda *et al.*, 2004 Yanagimoto & Nishimura, 2007
Mortality & the US EEZ	Catches by Japanese vessels in	Clark, Vinnichenko, Gordon,

	the SE-NHR ceased with declaration of USA EEZ. Japanese trawlers subsequently began fishing the Hancock seamounts, which continued until 1985.	Beck-Bulat, Kukharev & Kakora, 2007
Mortality & USSR/Russian demersal fishery	The USSR/Russian fishery for demersal species in the Northwest Pacific began in the late 1960s. Bottom and midwater trawling mainly over the SE-NHR seamounts targeted NPA while Alfonsino were usually bycatch. Total landings increased from 1969 to 1971, then increased to 202 000 tonnes in 1972 followed by a rapid decline in landings from 1974-1977. No USSR fishery for high seas was undertaken after 1977.	Baitaliuk & Katugin, 2012
	In the late 1970s, the proportion of alfonsino increased in commercial catches. CPUE increased rapidly from 1981-1983, then declined over following years. Bottom longliners fished mainly on the Jungu and Ojin seamounts where previously there were no fisheries.	Shotton, 2016
	Total Russian fishing vessel catch varied from 10 to 926 tonnes in the past decade. No	Shotton, 2016

	fishery has operated since 2008 and catch for alfonsino has been the lowest on record. Trawl and gillnet data have been available on a regular basis since 1999.	Shotton, 2016
Mortality and Republic of Korea trawl	After an experimental trawl and longline fishing operations in 2004, the fishery for alfonsino in the North Pacific peaked in 2005. A gradual catch decline followed until 2010 using trawls (at depths of 100- 500 m) and long-line (at depths of 250-1050 m). The catches between 1998-2011 were variable from 4-658 tonnes. Catch amounts in recent years since 2004 are as small as 16-513 tonnes per year.	Seok, 2012 Sawada *et al*., 2018
Mortality and development of fishing gear	The development of navigation systems and the move to sophisticated plotting software eliminates the need for experimental trawls and allows very precise and consistent placement of gear. Scanning sonar is now often used to locate aggregations. Significant personal fishing experience in New Zealand skippers is known to increase	Shotton, 2016 Shotton, 2016

	sea-bed fishing efficiency. Alfonsino are caught by bottom trawls, bottom longline and handline, but rarely enter baited traps. Implementation of regulations for mesh size in trawl gear were aimed to mitigate catch of individuals younger than 2 years old, which previously accounted for most of the catch.	Uchida & Uchiyama, 1986 Sawada & Yonezaki, 2019
Composition of catch	NPA recruitment in 2010 and 2012 was strong and catches of Alfonsino were low, while low recruitment in NPA since 2013 increased the catch of Alfonsino to 2284-3783 per year. The proportion of immature individuals in catches since 2009 seems to be high upon comparison with data from other regions. A decreasing trend in size-composition of catch from 2009-2016 is apparent.	Sawada *et al*., 2018

The distribution of Splendid Alfonsino

The global range of Splendid Alfonsino is from temperate to tropical waters in Atlantic, Indian and Pacific oceans on seamounts, continental shelf edges and slopes. Table 3 summarizes the findings of studies on Splendid Alfonsino distribution. In the NW Pacific Ocean, Splendid Alfonsino are found along the Pacific coast of the Japanese archipelago (Izu, Ogasawara (Bonin) and Nansei islands) and on the southern Emperor Seamounts and northern Hawaiian Ridge. The Emperor seamounts between Hancock and Koko are the important areas that have been historically fished. These seamounts are occupied by Splendid Alfonsino at depths from 300 - 1010 m, both on the flat summits and slopes. Smaller (younger) fish tend to occur in shallower water, while the mature fish occur deeper.

Splendid Alfonsino are thought to have relatively limited migration throughout their adult life. Tagging studies indicate that most fish are recaptured near their tagging location, but in some instances migrations of > 1000 km did occur. Within seamounts, diurnal feeding migrations have been commonly observed, with large schools observed at depth during the daytime moving shallower (presumably to follow prey items) at night. There is limited information or studies about the particular habitat characteristics of Splendid Alfonsino habitats that might provide insight into their potential distribution.

Table 3. Information on the distribution of Splendid Alfonsino from the literature (global and regional distributions) at different spatial scales are included.

Study topic	Description of results	Source/citation
Spatial: Depth and age: eggs	It is assumed that the epipelagic, freely-floating eggs originate in benthic layers and rise as development occurs. Eggs have been caught in waters near seamounts and ocean open waters. Newly-hatched eggs float for about 2-3 days and hatch on the fourth day. Eggs are pelagic for about four months before settling above seamounts. Descriptions of drifting eggs do not exist.	Shotton, 2016; Sawada *et al.*, 2018 Onishi, 1967; Chikuni, 1971; Uchida & Uchiyama, 1986 Lehodey *et al.*, 1997 Alekseev *et al.*, 1986

Depth and age: Larvae/juvenile stages	Pelagic larvae adopt a demersal existence probably at around one year old. The size at settlement in Japanese waters is estimated at 12-18 cm in fork length, corresponding to 150-300 days old. Observations of larvae and juveniles are primarily from the upper 50 m in the central North Pacific ocean. Juveniles near the Izu Islands were reported from depths 0-300 m and offshore of the Kuroshio Current.	Chikuni, 1971 Akimoto, 2007 Mundy, 1990; Boehlert & Mundy, 1992 Yanagimoto, 2004
Depth and age: Mature individuals	Larger fish are likely found in deep waters where trawling is difficult or impossible. Individuals older than 12 years rarely caught (in Chile).	Gálvez, Flores, Chong, Cespedes, Ojeda & Labrin, 2011 Gili *et al.*, 2002
Spatial distribution and foraging behaviour	Alfonsinos' daily vertical migrations are primarily determined by vertical migrations of prey, which are closely related to variations in ambient sunlight and moonlight and oceanographic conditions around seamounts. Fish were found to rise at night	Shotton, 2016

	into shallower waters where temperature fluctuates seasonally. Contrarily, on some days fish were found to exhibit a reverse pattern. Vertical migration therefore could not be attributed to one single behaviour in New Zealand. Ontogenetic shift was demonstrated from planktivoruous food sources to micronektiorous diets.	Lehodey & Grandperrin, 1996b Horn & Massey, 1989 Nishida, Murakami, Yonezaki, Miyamoto, Okuda & Kiyota, 2016
Spatial distribution and aggregation	Widespread studies all show well-developed schooling behaviour that is evident throughout the alfonsino lifespan. During the day the fish are in dense aggregations at depth, while at night they are more scattered above the bottom. Time and duration of school formation likely varies globally.	Alekseev *et al.*, 1986; Galaktionov, 1984; Shotton, 2016
Spatial distribution: horizontal movement limited	Adult alfonsino are thought not to migrate over wide distances. A tagging experiment showed only 26 out of 146 recaptures had moved from tagging sites and distances traveled were small.	Masuzawa *et al.*, 1975

	Horizontal migration is suggested to be more or less limited to seamount areas (ie. not to exceed a few miles). No reports exist of mature alfonsino migrations in the high seas.	Galaktionov, 1984; Vinnechenko, 1996a
	Reproduction is thought not to involve large migrations and to occur in areas that Alfonsino inhabit due to observations of both females and males in spawning grounds.	Lehodey *et al*., 1997
	Non-representative data on length-age composition and the theory that large mature and small immature fish exclusively inhabit the Corner Rise and Azores area respectively was previously used to support the theory of migration.	Shotton, 2016
	Data and exploratory cruises show both older and younger Alfonsino to permanently inhabit both the Corner Rise and the Azores (providing further evidence against the theory of long migrations).	Sherstyukov and Nostov, 1986; Vinnechenko, Gorchinksy and Shibanov, 1994; Vinnechenko, 1996a, 1996b; Menezes, Rosa, Melo and Pinho, 2009
Spatial distribution: horizontal movement	Length-frequency distribution analysis suggests alfonsino	Lehodey *et al*., 1994

	migrate between seamounts and that seamounts do not each have separate stocks in New Caledonia. It was suggested that Alfonsino undergo lengthy migrations of more than 1000 nm in northeast Atlantic and 700 nm in southeast Atlantic. Spatial differentiation is of ontogenetic character due to findings of geographically distinct areas for functionally different stages of the life cycle.	 Alekseev *et al*., 1986
	Tagging research in Japan showed tagged fish could be captured in the same region 9-12 years later, while other fish were found to have moved 120 km over 9 years.	Ikegami, 2004
	Alfonsino are suggested to have high dispersal abilities (potential migrations of over 1000 km).	Levy-Hartmann, Roussel, Letourneur & Sellos, 2011; Sawada *et al*., 2018
	Mark and recapture in Japanese waters showed dispersal distances of over 1000 km away from the release area, suggesting large-scale horizontal migrations within the Kuroshio region.	Wateri *et al*., 2017, Sawada *et al*., 2018

	High mobility was observed during a fishing experiment on a seamount in the Azores area of Portugal's EEZ.	Silva and Menezes, 1996
	The distances between banks were described as "not insurmountable barriers" for alfonsino. The depths between banks can be 1500- 2000 m, and alfonsino have been observed and caught down to 2000m. The appearance of Alfonsino after years of absence on Gololobov Bank also points to migration.	Shotton, 2016

Information from previous stock assessments

Stock assessments for Splendid Alfonsino have been attempted for a number of regions throughout the world; some of the results and key findings are summarized in Table 4. There are many difficulties in assessing these stocks, but in general they suffer from being a low value fishery that occurs in distant waters and as such there is a dearth of quality data by which to assess the stocks. The primary data available for assessing the stock is CPUE data from the fishery. In addition, most stocks were overexploited during the development of their fisheries in international waters and the data from the initial period of exploitation is sparse at best and some assessments have indicated that catch reporting during the early periods of the fishery were low. In addition, in the NW Pacific, Splendid Alfonsino appears to be targeted only during periods when the North Pacific Armorhead is at low abundance. However, the target species has not been consistently recorded throughout the history of the fishery. This reduces the value of CPUE data in the assessment for the species captured in a fishery where they are not always the target species.

Several important attempts have been made in the NW Pacific to assess the Splendid Alfonsino stock, including application of a surplus production model (Nishimura and Yatsu 2008) and more recently a yield-per-recruit analysis (Sawada and Yonezaki 2019). A brief summary of these results can be found in Sawada and Ichii (2020).

Table 4. Information on previous stock assessments of Splendid Alfonsino from around the world.

Northwest Pacific	In the SE-NHR, the Japanese NPA fisheries began in 1969 and catch of alfonsino increased in the late 1970s. Alfonsino catch was at a maximum of 11831 tonnes in 1980 and then declined in mid 1980s. Over the last two decades of continuous fishing pressure, alfonsino catches fluctuated between 1000 and 6000 tonnes, mostly with dominant catches of alfonsino apart from large catches of NPA in 1992 and 2004. The SE-NHR fishery is therefore characterized by continuous catches with dominant catches shifting between the two species depending on its strength of recruitment in the area. A highly productive regime was defined during 1969-1982, while ordinary regime lasts until present.	Nishimura & Yatsu, 2008
	CPUE adjusted as raw figures did not distinguish between when vessels were targeting NPA versus alfonsino.	Nishimura & Yatsu, 2008
	Maximum sustainable yield (MSY) was estimated and APSIC model was applied and determined to fit data well.	Nishimura & Yatsu, 2008

	Model estimates suggest average fishing rates over the last decade were over acceptable ranges (average fishing morality 20-28% higher than MSY). Several issues undermine reliability of analysis. Four production models from two analyses estimated biomass trajectories and showed similar trends; estimated biomass was highest in the 1980s and suddenly decreased in the early 1990s. Lowest biomass was observed in 1996 by both analyses and biomass increased steadily during last decade. The catch of alfonsino exceeded 10000 metric tonnes in 1991 off Japan's central coast by vertical longlines, while recent catches have shown a significant decrease in this area. Fishing pressure from Japanese trawling on small, young and immature fish is a significant concern.	Shotton, 2016 Shotton, 2016 Alabsi, 2011 Sawada *et al.*, 2018

Yield-per-recruit analysis	Yield-per-recruit (YPR) analysis of an SWIR alfonsino population concluded an increase of age at recruitment from 2.8 to 8.4 years old would result in 10 times increase of yields.	Shotton, 2014
	YPR analysis was conducted and YPR was found to depend on age of entry and fishing mortality. New mesh size regulations were suggested.	Sawada & Yonezaki, 2019
Azores	Abundance was found to be low and stable from 2000-2008 (with the exception of 2003), with an increasing trend in the last two years towards 2015. The annual mean length has declined slightly over time.	Shotton, 2016
Russia	Many investigators believe stock structure in the Atlantic consists of independent populations over seamounts due to genetic investigations and aggregation absences due to exploitation.	Titova, 1981; Shotton, 2016
North Atlantic	No explicit estimation of stock size exists, however there are grounds to believe stocks in open oceans have recovered to some extent compared to the 1990s.	Vinnechenko, 2012
Sierra Leone Rise	An experimental demersal	Salméron *et al.*, 2015

	fishing survey of seamounts was conducted January to July 2001. CPUE was found to show a clear time trend with a 12-day periodic pattern in CPUE. After 70 days, a pronounced CPUE decrease with no subsequent recovery during the survey was noted. Uncertainty remains surrounding whether the rapid CPUE decline represented local stock depletion or general stock depletion. Results do not support longer fishing periods and large-scale longlining on these seamounts.	(Spanish Institute of Oceanography experiment)
Southern Indian Ocean	Biomass estimates were subject to considerable fluctuations explained by mobility and survey imperfections. Reported biomass estimates are warned to be closer to a relative index than to an absolute one.	Paramonov, 2012 Niklitschek & Patchell, 2013
New Zealand	All alfonsino catch curves for Palliser bank showed a steep decline with increasing age. There are no successful biomass surveys of alfonsino in New Zealand. Current annual yield is calculated.	Shotton, 2016 Stocker & Blackwell, 1991

Chile	A routine sampling program since 1999 by IFOP-Chile, acoustic surveys in Juan Fernandez Islands and stock assessment programme since 2004 have been undertaken for biomass estimates. CPUE rapidly decreased through time until an increase in 2010. Basic knowledge on growth, natural mortality and maturation is available, and uncertainty exists on exploitation status due to high interannual variability.	Shotton, 2016 Wiff, Quiroz, Flores & Galvez, 2012 Shotton, 2016
Stock assessment: short time series/ CPUE & depletion	A stock assessment model was employed that assumes the existence of older fish, non-linearity between standardized CPUE and abundance, and variations of the relative importance of length structures. The main caveats to stock assessment in Chile were noted. Uncertainty remains surrounding the exploitation status of alfonsino as the available information cannot verify the assumptions of the model.	Wiff *et al.*, 2012 Shotton, 2016

Data availability

The data on Splendid Alfonsino collected on the Emperor Seamounts are fairly extensive (Table 5). The data includes a fairly complete catch and effort history since the initiation of the trawl fishery by Russia in 1967. The recent data includes spatially explicit (by seamount) catch and effort available from the NPFC annual reports for each gear type and Member (Japan, Korea, and Russia). Historical catch data from Japan also appears to indicate catch and effort for individual seamounts, while the early data from Russia does not include a spatial component.

A number of surveys have been primarily targeting North Pacific Armorhead. These are summarized in Table 6, it is assumed that these surveys also recorded some information on Splendid Alfonsino where observed.

There are associated biological data from fisheries catch and surveys since 2009 (Table 7), however, this data is likely part of the data holdings of individual NPFC Members. There are some biological data that can be inferred from previous stock assessments or stock assessments conducted globally. These parameters are found in Table 8.

Table 5. Data available on the catch and effort history of Splendid Alfonsino (some inferred from publicly available reports where the catch data was previously summarized).

Data type	Members	Data description	Years available	Data source/holder
Catch - trawl	Japan, Russia, Korea	Total catch reported to NPFC	2002-2019 - Japan, 2004-2019 - Korea, 2001-2019 - Russia	NPFC
Catch - gillnet	Japan	Total catch reported to NPFC	2002-2019	NPFC
Catch - longline	Korea, Russia	Total catch reported to NPFC	2004 - Korea, 2001 - 2019 - Russia	NPFC
Effort - trawl	Japan, Russia, Korea	Number of fishing days,	2001-2019	NPFC

		number of vessels		
Effort - gillnet	Japan	Number of vessels, number of fishing days	2002-2019	NPFC
Effort - longline	Korea, Russia	Number of fishing vessels, number of fishing days	2002-2019	NPFC
Seamounts fished	Japan, Korea, Russia	The seamounts where gear was deployed by gear type; trawl, longline, gillnet	2017-2019	NPFC
Effort- trawl	Japan, Russian	Number of hours fished	1967-2001	Japan, Russia
Catch - trawl	Japan, Russia	Total catch (tons)	1967-2001	Japan, Russia
Seamounts fished	Japan	The seamount where gear was deployed	1969-2001	Japan

Table 6. Surveys of Seamounts in the NPFC Convention Area and adjoining EEZ's. These surveys were conducted primarily targeting North Pacific Armorhead, but observations of Splendid Alfonsino may be available from the participants.

Survey type	Description	Years	Area surveyed	Data source
Acoustic survey	Acoustic survey of seamounts for NPA	2016-2020		Japan
Monitoring survey for NPA	Monthly monitoring	2018-2019, modified in 2020	Specific spatial blocks	NPFC

	survey from Japan fishing vessels to assess recruitment			
Trawl survey	Bottom longline and trawl surveys (n = 10) of seamounts in southern Emperors for NPA	1985-1993	Hancock Seamount	USA (Somerton and Kikkawa 1992)
Trawl Survey	Trawl survey of major seamounts for NPA	2005-2007	Colohan, Milwaukee, Kimmei, Koko Seamounts	Korea?

Table 7. Biological data (age, length, sex ratios, weight) available from studies and observers in the Emperor Seamounts.

Data type	Member nation	Data description	Years available	Data source/holder
Individual length and weight (known for NPA, possible for SA?)	USA	Lengths and weights collected by US observers on board Japanese fishing vessels on Hancock Seamount	1978-1984	PIFSC? (Somerton and Kikkawa 1992)
Catch lengths, maturity, ages, weights	Japan, Korea	Data collected by observers on fishing vessels	2009-2020	Japan, Korea

Table 8. A summary of biological parameters from assessments conducted for Splendid Alfonsino both globally and within the NPFC Convention Area

Parameter	Description and conclusions	Source
Maximum age	Maximum age was found to be slightly different globally.	Shotton, 2016
	Maximum age is indicated to be about 20 years in the South Pacific.	Lehodey & Grandperrin, 1996b
	Oldest specimen was found to be 18 years old in New Zealand.	Massey & Horn, 1990
	Maximum average lifespan found by Japanese vessels in the Atlantic was 17 years.	Nishida, 2012
	Maximum age was estimated to be 10 years in the Azores at a length of 50 cm. The higher (than the Canaries or Madeira) maximum age found in the Azores could be due to sampling greater lengths or sampling older or younger fish in the Canaries and Madeira.[1] Fish from 0-11 years (and a range of 15.3-43.0 cm) were found off the Azores.[2]	[1]Krug, Carvalho & González, 2011; [2]Rico *et al.*, 2001
	In Madeira, maximum age was estimated to be 11 years old,	[1]Krug *et al.*, 2011;

	with a length of 45 cm.[1] Fish from 0-12 years were found off Madeira (15.2-41.0cm).[2]	[2]Rico *et al.*, 2001
	In the Canary Islands, 9 years was the estimated maximum age, with a length at the maximum age of 44 cm.[1] A range of 18.2-38.9 cm FL was found for fish 1-9 years old.[2]	[1]Krug *et al.*, 2011; [2]Rico *et al.*, 2001
	9 and 11 years were suggested to be the ages attainable on the New Year and Corner Rise seafloors respectively.	De Leon & Malkov, 1979
	On the Kit Range, Naska Range and Error Seamount, 5, 6 and 8 year olds were found respectively.	
	Fish up ages 2 to a maximum of 14 years old were found in the North Atlantic.	Kotlyar, 1987
	In New Caledonia, fish of up to 15 years old were found.	Vinnechenko, 2012
	In New Zealand, 16 year old fish were recorded.	Lehodey & Grandperrin, 1996b
	Individuals of ages 1-14 years were studied in the South-west Indian Ocean.	Massey & Horn, 1990
	Offshore the Izu Islands, specimens from 2-23 years old	Santamaria *et al.*, 2006

	were found. In the SE-NHR, males and females of at least 15 years old were found. In Chile, ages were determined to be 1-15 years for males, and 1-19 years for females. For small fish that had low probability of being sampled, a linear back-calculation was used. Longevity was estimated to be greater for female alfonsino than males. The maximum age for males was estimated to be 9 years versus 18 years for females on the SWIR. An individual in the Japanese Kochi prefecture was found to be 26 years old by otolith ring count. A tagged individual showed longevity that exceeded 20 years in Japanese waters.	Adachi *et al.*, 2000 Yanagimoto, 2004 Gili *et al.*, 2002 Ivanin & Rebyk, 2012 Myojin & Ura, 2003 Watari *et al.*, 2017
Mortality rates	Natural mortality (M) was estimated using five methods in Chile.[1] Estimates were represented in a table.[2]	[1]Gili *et al.*, 2002; [2]Shotton, 2016

	Age-frequency catch composition showed a steep decline at Palliser Bank.[1] Mortality rates could not be calculated from the data due to evidence of age-specific migration.[1,2]	[1]Massey & Horn, 1990; [2]Masuzawa *et al.*, 1975
	Reliable estimates of instantaneous mortality for New Zealand or elsewhere were suggested not to exist. M was estimated using Hoenig's (1983) equation: $M = -(\log_e 0.01)/A$, (0.01= population that reaches A or older).	Horn & Sutton, 2009
	The use of maximum age 20 and 18 (N/S Pacific, NZ) gives M estimates of 0.23 and 0.26 respectively using Hoenig's (1983) equation.	Shotton, 2016
	None of the aging studies reviewed examine unexploited populations, so there is the possibility that the true A is slightly more than 20 years.	Shotton, 2016
	M was assumed to be in the range of 0.20 to 0.26.	Massey & Horn, 1990
	M=0.20 and 0.23 was used, but values were not explained.	Stocker & Blackwell, 1991

	Estimates of M were suggested to have generally increased with time. This was not explained. M was noted to be difficult to estimate directly. $M= 4.118K^{0.73}L_{\infty}^{-0.33}$ was suggested as a growth-based empirical estimator of M for fish stocks. M= 0.20 was found derived from Djabali *et al.* (1994) model for M estimation. Takahashi (2018) Von Bertalanffy parameters for body length were used in Then (2015) above function for M, resulting in M=0.195. Uncertainty of M was incorporated using YPR calculations. This analysis was preliminary and other methods for stock assessment should be used.	Shotton, 2014 Then, Hoenig, Hall & Hewitt, 2015 Takahashi, 2018 Sawada & Yonezaki, 2019
Weight-length relation (W-L)	W-L was represented on the SWIR from 1980-1988. Smaller fish were used to derive a relation then used by other authors. In the western Central Atlantic, W-L equations were calculated for the Corner Rise	Ivanin & Rebyk, 2012 De Leon & Malkov, 1979

	and the New Year Rise. A table with parameters for the relation W= aL^b is presented. W-L dependence from Ivanin & Rebyk (2012) was modelled. Parameters used by Stocker and Blackwell (1991) for W= aL^b are presented. W_∞ was estimated. Von Bertalanffy growth function parameters were estimated for Emperor Seamount alfonsino. Wt represented weight (g) at age t in $W_t = 1852.35\{1 - e^{-0.148(t+2.926)}\}^3$. A sex-combined model was used aand isometry was assumed *a priori*.	Shotton, 2016 Shotton, 2016 Shotton, 2014 Takahashi, 2018
Growth	Using age-length curves, no evidence was found of asymptotic growth. Thus, fish grow for their entire lives until they die of old age unless large fish are sampled by trawl gear (L_∞). The estimation of von Bertalanffy parameters and methods were found to be unsatisfactory in Sagami Bay tagging experiment.	Massey & Horn, 1990 Ikenouye & Masuzawa, 1968

	Examination of fish near Sagami Bay for estimation of growth parameters found that the estimated L_∞ was probably too low and that the previously used equation only describes growth of young fish adequately. Multiple studies report L_∞ values that are larger than maximum observed alfonsino sizes.	Ikenouye, 1969 Ikenouye, 1969; Masuzawa *et al.*, 1975; de Leon & Malkov, 1979
Growth rate through time	Growth rate is probably rapid for juveniles. It was estimated that a fork length of 15-20 cm was reached in the 1st year, and that at 1 year 50% of their maximum length is attained. Growth rate then drops rapidly. Fastest growth was found to be in the first year on the SWIR, where a length of 16.8 cm was attained. The estimated annual increment of the length in the first year from the hatchling is about 17 cm, and appears to be much greater than that of the other age intervals.	Shotton, 2016 Ivanin & Rebyk, 2012 Adachi, Takagi, Tanaka, Yamada & Kitakado, 2000
Growth rate and sex	A highly significant difference was found between growth	Lehodey & Grandperrin, 1996a; Adachi *et al.*, 2000

	rate of males and females, as well as slower growth rates for males than previous studies. Other studies did not include effects of sexual dimorphism, did not validate interpretation of otoliths and were often based on small samples from various size ranges. Age-at-length was generated and a significant difference between sexes was found in Chile. Females were found to attain a larger size than males, especially at old ages in most, though not all populations globally. This sexual size dimorphism was observed for the Emperor seamounts.	Lehodey & Grandperrin, 1996b Gili *et al*., 2002 Sawada *et al*., 2018
Growth rate and sex	No significant differences in growth parameters were found between males and females for fish aged 1-9 years. No significant differences were found between sex or region for New Caledonia and the SWIR. Differences in growth rates between the two sexes were not possible to confirm.	Rico *et al*., 2001 Santamaria, Lopez and Gonzales, 2006 Anabil, Esteves, Krug &

		Marques de Silva, 1998; Kotlyar, 1987
Growth rate and global distribution	Growth appears to be similar in areas such as the East and West Atlantic and North and South Pacific.	Lehodey & Grandperrin, 1996b; Rico *et al.*, 2001; Gili *et al.*, 2002
	Estimation by otolith analysis showed growth for the SE-NHR to be slightly faster than in Japanese waters.	Gili *et al.*, 2002
	Growth was found to be similar between Japan and NZ.	Massey & Horn, 1990
	Growth of males was similar between Izu Islands and Japan, but different for males between New Zealand and SWIR stocks.	Santamaria *et al.*, 2006
	Comparison of growth curves between studies led to a tentative report that growth was slower in New Zealand than Japan (growth may vary between regions).	Massey & Horn, 1990
Growth rate and body proportions	On the SWIR and Northern Equatorial Ridge, body proportions were found to change with growth of the alfonsino.	Ivanin, 1989
	No differences were found in meristic characters of fin-ray counts, lateral-line scale count	Masuzawa *et al.*, 1975

	and vertebral count between three fishing grounds in eastern Japan. Differences in morphometric characters were found between the fishing grounds. Specimens from Kyushu-Palao and Hawaii ridges had a lower body depth in relation to body length than those from the Izu Islands. Kyushu-Palao was broader in proportion to their weight than those from the Izu Ridge and Hawaii Ridges. The significance of findings was not commented on.	
Population structure	Morphometric data was analysed from SE-NHR, Izu Islands and New Zealand. Statistical differences were not found within the SE-NHR, but were found among these three separated regions. This indicates that the SE-NHR forms a single population, which may form a meta-population with the Japanese stock. Adult stocks from a common larval pool among which there is suggested to be little exchange following recruitment. Adults may be distinguished by phenotypic characters determined later in	Yanagimoto, 1996; Yanagimoto, 2004 Shotton, 2016 Chikuni, 1971; Yanagimoto,

	life.	2004
	A meta-population hypothesis was proposed for the North Pacific alfonsino based on three points: 1) there was no genetic differentiation; 2) larvae can be drifted from Japanese waters to SE-NHR via the Kuroshio Current and Kuroshio extension and 3) morphological characters can be affected by local environmental conditions.	Ohkawa, Akimoto & Myojin, 2008
	Microsatellite DNA found no differentiation among populations in Japanese waters	Sawada *et al.*, 2018
	Other mtDNA analyses found differentiation between populations in the Atlantic.	Alekseev *et al.*, 1986
	Within eddy systems, no significant genetic differences between spatially isolated samples of juveniles and adults were found, suggesting that samples were drawn from the same genetic stock.	Schőnhuth, Álvarez, Rico, González, Santana, Gouveia, Lorenzo & Bautista, 2005
	Distinctive haplotypes were found to be maintained by Macaronesian currents that serve as geographical barriers. Local currents act as effective	

	dispersal filters. This is consistent with the hypothesis of an extended larval pelagic stage, but not long-distance dispersal.	
Size at maturation	Fork length at which half the population attain sexual maturity (FL_{50}) is 30-35 cm in Japan. Maturation was suggested to begin in the second year of life. Most fish are mature at 5-6 years in japan. In the Pacific ocean, females were found to begin maturation in their first year at length 16.2 cm, while males matured in their second year at standard length 16.3 cm. Sexual maturity was also found to start at age 3 or 4 years and at a length of about 28-32 cm in Japanese waters. In Chile, the female population was found to mature at a larger size than males The smallest size at sexual maturity was found where fishing intensity is the highest in the Azores, while the largest	Akimoto, Kuboshima, Mitani & Saitou, 2005 Masuzawa *et al.*, 1975 Kotlyar, 1987 Honda *et al.*, 2012 Flores *et al.*, 2012; Gili *et al.* 2002 González *et al.*, 2003

	size at sexual maturity was found where pressure is lowest in Madeira. Bias may play a role. Differences in L_{50} (length at maturity) estimates are not thought to be due to sampling protocol differences as previous studies used specimens caught by commercial vessels. Size at first maturity of *B. decadactylus* in the Azores was 32 cm (4 years) Variations in estimate of size and age at maturation may be caused by different methodologies and criteria used by different authors to define maturity.	Shotton, 2016 Estácio, Medonça, Krug, Menezes, Branco & Pinho, 2001 Sawada *et al.*, 2018
Sex ratio	In the Azores, of 2019 fish taken, 40.1% were male and 59.9% were female. The sex ratio was thus found to be 1:1.5, which significantly differed from 1:1. The ratio by length class showed an increasing proportion of females for sizes over 32 cm. For *B. decadactylus*, of n=705, 48.9% were male and 51.5% were female. Differential growth or a natural mortality	Pereira & Pinho, 2012

	between sexes indicated by results.	

Data gaps and next steps

The primary data gaps for the NPFC Convention Area stock of Splendid Alfonsino that could be useful for a stock assessment are:

- Time series of spatially explicit catch and effort dating to the initiation of the fishery in 1967
  - If possible, a standardized index that accounted for differential targeting among Splendid Alfonsino and North Pacific Armorhead
- Age, length and weight data from the fisheries catch for each seamount if possible
- Age, length, and weight data from surveys if possible (by year and area, if possible).
- A time series of survey abundance for either individual seamounts or combined seamounts
  - If possible, a standardized biomass estimate for the entire population
- A time series of recruitment (or proxy) for Splendid Alfonsino
- A model or map that indicates the distribution of juvenile and adult Splendid Alfonsino by size
- Evaluation of data quality and suitability for use in assessing and managing SA.

The proposed next steps for assessment/management of Splendid Alfonsino stocks might be:

1. The formation of a small working group that could determine the location/availability of data holdings from each Member
2. Discussion of data sharing agreements
3. Discussion of data quality for catch, effort, survey(s), biological data. Develop a list of data, including biological parameters that could inform stock assessment or management (i.e. values or reasonable ranges for age at 50% maturity, fecundity, growth rates, M, etc).
4. Engaging an external expert in data limited assessment that could direct the BFME on potential directions that could be taken based on data availability and quality.

Literature Cited

Adachi, K., Takagi, K., Tanaka, E., Yamada, S. & Kitakado, T. 2000. Age and growth of alfonsino *Beryx splendens* in the waters around the Izu Islands. *Fisheries Science,* 66: 232-240.

Akimoto, S. 2007. Studies on the population genetic structure of alfonsino *Beryx splendens* and the distribution in pelagic egg and larval stages by mitochondrial DNA analysis. Special report Kanagawa Pre. Fish. Tech. Cen, 1: 1-64. (in Japanese).

Akimoto, S., Kuboshima, Y., Mitani, I. & Saitou, M. 2005. Maturation of female alfonsino *Beryx splendens* in water around Izu Islands, central Japan. Nippon Suisan Gakkaishi, 71(3): 335-341. (in Japanese with English abstract).

Alabsi, N. 2011. Studies on the behaviour of a deep-water fish, the splendid alfonsino (*Beryx splendens*) using micro data loggers. [Masters Thesis, University of Tokyo].

Alekseeva, E.I. 1983. Maturation of ovaries, nature of spawning and local specific character of genital cycles of Alfonsino Beryx splendens Lowe from the Atlantic Ocean. *In: Problems of early ontogeny of fish – theses of reports,* pp. 72-73. Kaliningrad, USSR, AtlantNIRO. (in Russian).

Alekseev, F.E., Alekseeva, E.I., Trunov, Y.A & Shilibanov, V.I. 1986. *Macroscale water circulation, ontogenetic geographical differentiation and population structure of alfonsino,* Beryx splendens *Lowe, in the Atlantic Ocean*. ICES CM86/ C:10. Hydrographic Committee. 16 pp.

Anabil, J., Esteves, E., Krug, H. & Marques de Silva, H. 1998. Age and growth in the Alfonsino, *Beryx splendens*, (Berycidae) from the Azores (central eastern Atlantic). *Ital. J. Zool.,* 65(Suppl.): 215-218.

Baitaliuk, A. & Katugin, O. 2012. *Report on management of alfonsino fisheries by the Russian Federation in the NW Pacific Ocean.* Vladivostok, Russian Federation, Pacific Scientific Research Fisheries Centre (TINRO-Centre). 6 pp. (manuscript prepared for FAO).

Boehlert, G.W. & Mundy, B.C. 1992. *Distribution of ichthyoplankton around Southeast Hancock Seamount, central North Pacific in summer 1984 and winter 1985: data report.*

NOAA Technical Memorandum NMFS-SWFSC-176: 109 pp.

Boehlert, G.W. & Sasaki, T. 1988. *Pelagic biogeography of the armorhead,* Pseudopentaceros wheeleri*, and recruitment to isolated seamounts in the North Pacific Ocean*. Fishery Bulletin, 86: 453-466.

Clark, M.R. 2009. Deep-sea seamount fisheries: a review of global status and future prospects. Lat. Am. *J. Aquat. Res*., 37(3): 1-12.

Clark, M.R., Vinnichenko, V.I., Gordon, J.D.M., Beck-Bulat, G.Z., Kukharev, N.N. & Kakora, A.F. 2007. Large scale distant water trawl fisheries on seamounts. *In* T.J. Pitcher *et al*., eds. *Seamounts: ecology, fisheries and conservation*, pp. 361-399. Fish and Aquatic Resources Series 12. Oxford, UK, Blackwell Publ.

Chikuni, S. 1971. *Groundfish on the seamount in the North Pacific*. Bull. Japanese Soc. Oceanography No. 9. 14pp. (in Japanese).

De Leon, M.E. & Malkov, A. 1979. Estudio preliminar de la edad y crecimiento del *Beryx splendens*, Lowe del Atlântico entrooccidental. *Rev. Cub. Inv. Pes.,* 4(4): 62-72.

Djabali, F., Mechailia, A., Koudil, M. & Brahmi, B.1994. A reassessment of equations for predicting natural mortality in Mediterannean teleosts. Naga 17:33-34.

Estácio, S., Medonça, A., Krug, H., Menezes, G.M., Branco, J. & Pinho, M.R. 2001. *Aspects of the reproduction of six demersal fishes captured in the Azores Archipelago.* Arquipelago. Life and Marine Sciences. Supplement 2(B): 83-94.

Flores, A., Wiff, R., Gálvez, P. & Díaz, E. 2012. Reproductive biology of alfonsino *Beryx splendens*. *J. Fish. Biol.,* 81(4): 1375-1390.

Galaktionov, G.Z. 1984. Features of the schooling behavior of the alfonsina, *Beryx splendens* (Berycidae) in the thalassobathyal depths of the Atlantic Ocean. *J. Ichthyol.,* 24(5): 148-151.

Gálvez, P. Flores, A., Chong, L., Céspedes, R., Ojeda, V. & Labrín, C. 2011. *Asesoría integral para la tome de decisions en pesca y acuicultura.* Rescursos de Aguas Profundas. Inform Final Subpesca.

Gili, R., Cid, L., Pool, H., Young, Z., Tracey, D., Horn, P. & Marriott, P. 2002. Estudio de edad crecimiento y mortalidad natural de los recursos Orange roughy y Alfonsino. Fondo de Investigaciones Pesqueras. FIP 2000-12. Instituto de Fomento Pesquero. 107 pp.

González, J.A., Rico, V., Lorenzo, J.M., Reis, S., Pajuelo, J.G., Dias, M.A., Medonça, A., Krug, H.M. & Pinho, M.R. 2003. Sex and reproduction of the alfonsino *Beryx splendens* (Pisces, Berycidae) from the Macaronesian archipelagos. *Journal of Applied Ichthyology*, 19: 104-108.

Honda, H., Nikigani, N., Yonezawa, J., Akimoto, S., Iida, M., Myojin, T. & Shimizu, M. 2004. Biological characteristics and status of fisheries of alfonsino, *Beryx splendens* Lowe, around Japan. *Fisheries Biology and Oceanography in the Kuroshio*, 5: 111-119. (in Japanese).

Honda, H.., Sakaji, H. & Nishida, T. 2012. Overview on the fisheries biology of Alfonsino, *Beryx splendens*, inhabiting the North Pacific Ocean, the Atlantic Ocean and the South-Western Indian Ocean. FAO Workshop on Management of Alfonsino, 10-12 January 2012, Rome, Italy.

Horn, P.L. & Massey, B.R. 1989. *Biology and abundance of alfonsino and bluenose of the lower east coast, lower North Island, New Zealand.* N.Z. Fish. Tech. Rep. 15. 32 pp.

Horn, P.L. and Sutton, C.P. 2009. Commercial catch sampling for length and age of gemfish, alfonsino and rubyfish in QMA 2 in the 2006-07 and 2007-08 fishing years. New Zealand Fisheries Assessment Report 2009/19. 38 pp.

Humphreys, Jr., R.L., Tagami, D.T. & Seki, M.P. 1984. Seamount fishery resource within the southern Emperor-northern Hawaii Ridge area. *In* R.W. Grigg and K.Y. Tanoue, eds. *Proc. Second Symposium on Resource Investigations in the Northwestern Hawaiian Islands, May 25-27, 1983,* Vol. 1, pp 283-327. Honolulu, USA, University of Hawaii Sea Grant College Program.

Ikegami, N. 2004. Estimation of migration of alfonsino *Beryx splendens* Lowe based on the result of tag-and-release experiment. *Fish. Biol. Oceanogr*. Kuroshio 2004; 5: 65-70.

Ikenouye, H. 1969. Age determination by otolith of a Japanese alfonsino *Beryx splendens*, with special reference to growth. *J. Toko. Univ*. Fish., 55:91-98.

Ikenouye, H. & Masuzawa, H. 1986. An estimation of growth equation basing on the results of tagging experiments of the Japanese alfonsino fish. Bull. Jap. Soc. Sci, Fish., 34(2): 97-102.

Ivanin, N.A. 1987. On the discovery of a juvenile beryx-alfonsino, *Beryx splendens*, in the region of the North Australian Trough on the Indian Ocean. I. Ichthyol. (Engl. Trans. Vopr. Ikhtiol.) 27: 171- 172.

Ivanin, N.A. 1989. Morphometric characteristics of *Beryx splendens* from the ridges of the temperate zone of the Indian Ocean. *Problems of Ichthyology,* 29(1): 160-163. (in Russian).

Ivanin, N. and Rebyk, S. 2012. Age, growth parameters and some aspects of reproduction of alfonsino *Beryx splendens* Lowe on the Southwest Indian Ridge. YugNIRO, Ukraine. Working Paper. Workshop on Assessment and Management of Alfonsino Fisheries. FAO, Rome, Italy, 10-12 January 2012. 4 pp.

Klimenko, A.P. 1983. Biological aspects of fishery on the seamounts in the open ocean. *In: Biology, fish stocks and perspectives for fishery on fish and invertebrates,* pp. 18-23. Moscow, VNIRO. (in Russian).

Kotlyar, A.N. 1987. Age and growth of alfonsino, *Beryx splendens*. *J. Ichthyol*., 27(2): 104-111.

Kotlyar, A.N. 1996. Oceanic fish of the Berycidae family. Moscow, VNIRO. 368 pp. (in Russian).

Krug, H., Carvalho, D., & González, J.A. 2011. Age and growth of the alfonsino *Beryx decadactylus* (Cuvier, 1829) from the Azores, Madeira and Canary Islands, based on historical data. *Arquipelago. Life and Marine Sciences*, 28: 25-31.

Lehodey, P. & Grandperrin, R. 1996a. Influence of temperature and ENSO events on the growth of the deep demersal fish alfonsino, *Beryx splendens,* off New Caledonia in the Western tropical South Pacific Ocean. *Deepsea Research I.,* 43(1): 49-57.

Lehodey, P. & Grandperrin, R. 1996b. Age and growth of the alfonsino *Beryx splendens* over the seamounts off New Caledonia. *Mar Biol.,* 125: 249-258.

Lehodey, P., Grandperrin, R. & Marchal, P. 1997. Reproductive biology and ecology of a deep demersal fish, alfonsino Beryx splendens, over the seamounts off New Caledonia. *Marine Biology*, 128: 17-27.

Lehodey, P., Marchal, P. & Grandperrin, R. 1994. Modelling the distribution of alfonsino, *Beryx splendens*, over the seamounts of New Caledonia. *Fishery Bulletin*, 92(4): 748-759.

Lévy-Hartmann, L., Roussel, V., Letourneur, Y. & Sellos, D.Y. 2011. Global and New Caledonian patterns of population genetic variation in the deep-sea splendid alfonsino, *Beryx splendens*, inferred from mtDNA. *Genetica* 139: 1349-1365.

Massey, B.R. & Horn, P.L. 1990. Growth and age structure of alfonsino (*Beryx splendens*) from the lower east coast, North Island, New Zealand. *N.Z. J. Mar. & Freshwat. Res*., 24: 121- 136.

Masuzawa, T., Kurata, Y. & Onishi, K. 1975. *Results of group study on demersal fishes in water from Sagami Bay to southern Izu Islands: population biology of Japanese alfonsino and other demersal fishes*. Pap. Fishery Res. 28. Tokyo, Japan Aquatic Resources Conservation Association. 105 pp. (English translation: Fisheries Research Centre Library, Ministry of Agriculture and Fisheries, Wellington.

Melnikov, Y.S., Ivanin, N.A. & Piotrovsky, A.S. 1993. Present status of fish stocks on the seamounts of the West-Indian Ridge. *In: Main results of complex investigations of YugNIRO in the Azov-Black Sea basin and in the ocean*, 105-108. Kerch, Ukraine, YugNIRO. (in Russian).

Menezes, G.M., Rosa, A., Melo, O. & Pinho, M.R. 2009. Demersal fish assemblages off the Seine and Sedlo seamounts (northeast Atlantic). *Deep-Sea Research II*, 56:2683-2704.

Mundy, B.C. 1990. Development of larvae and juveniles of the alfonsins, *Beryx splendens* and *B. decadactylus* (Berycidae, Beryciformes). *Bull. Mar. Sci.,* 46(2): 257-273.

Myojin, T. & Ura, Y. 2003. Age and growth of alfonsino *Beryx splendens* Lowe off Kochi Prefecture. Fish Biol. Oceanogr. Kuroshio, 4: 11-17. (in Japanese).

Niklitschek, E. & Patchell, G. 2013. Acoustic abundance indexes for orange roughy and alfonsino in the Indian sea from Industry Acoustics 2004-2008. 1st Meeting of the Scientific Committee, La Jolla, United States of America, 21-27 October 2013. SC-01-INF-14.

Nishida, T. 2012. Presentation, FAO International Workshop on Assessment and Management of Alfonsino Fisheries. January 10-12, 2012 FAO HQ, Rome, Italy.

Nishida, K., Kurakami, C., Yonezaki, S., Miyamoto, M., Okuda, T. & Kiyota, M. 2016. Prey use by three deep-sea fish in the Emperor Seamount waters, North Pacific Ocean, as revealed by stomach contents and stable isotope analyses. *Environ. Biol. Fish*., 99(4): 335-349.

Nishimura, A. & Yatsu, A. 2008. *Application of surplus-production models to splendid alfonsino stock in the Southern Emperor and Northern Hawaiian Ridge (SE-NHR).* Appendix C. 11p.

Ohkawa, T., Akimoto, S. & Myojin, T. 2008. Population structure of alfonsino *Beryx splendens* from the coast of Japan based on microsatellite analysis. Fish. Biol. Oceanogr. Kuroshio, 9:73-78. (in Japanese).

Onishi, K. 1967. Experiment on artificial fertilization and rearing of larvae of alfonsin (Kinmedai jinko fuka oyobi fuka yogyo shi-iku shaken). [In Jpn.] Shizuoka Prefect, Fish. Exp. Stn., 1996 Oper. Rep., p. 198-201.

Paramonov, P. 2012. *Ukrainian alfonsino fishery on the Southwest Indian Ridge*. International Workshop on Assessment and Management of Alfonsino Fisheries, 10 to 12 January 2012, FAO HQ, Rome, Italy. Ukraine, YugNIRO. 8 pp.

Pereira, J.G. & Pinho, M.R. 2012. Statistics and biological data on the Alfonsinos, *Beryx decadactylus* and *Beryx splendens* from the Azores. MS presented at the FAO International Workshop on Assessment and Management of Alfonsino Fisheries, 10 to 12 January 2012 FAO, Rome, Italy. 15 pp.

Rico, V., Lorenzo, J.M., González, J.A., Krug, H.M., Medonça, A., Gouveia, M.E. & Dias, M.A. 2001. Age and growth of the alfonsino *Beryx splendens* (Lowe, 1834) from the Macaronesian archipelagos. *Fisheries Research,* 49(3): 233-240.

Salmerón, F., Báez, J.C., Macías, D., Fernandez-Peralta, L. & Ramos, A. 2015. Rapid fish stock depletion in previously unexploited seamounts: the case of *Beryx splendens* from the Sierra Leone Rise (Gulf of Guinea). *African Journal of Marine Science*, 37(3), 405-409.

Santamaría, M.T.G., López, L.J., & González, J.F. 2006. Growth of alfonsino, *Beryx splendens* (Lowe 1934) in the South-West Indian Ocean. *African Journal of Marine Science.* 28(1): 33-40.

Sasaki, T. 1985. Progress and current status of the Japanese trawl fishery in the seamounts. *Bull. Jap. Fish. Oceanogr.* 47/48: 161-166. (in Japanese).

Sasaki, T. 1986. Development and present status of Japanese fisheries in the vicinity of seamounts. In R.N. Uchida, S., Hayasi, and G.W. Boehlert, Eds. *Environment and resources of seamounts in the North Pacific*, 21-30. NOAA Tech. Rep. NMFS 43. 113 pp.

Sawada, K., Nishida, K., Yonezaki, S. & Kiyota, M. 2018. Review of biology and fisheries of splendid alfonsino *Beryx splendens,* especially in the Emperor seamounts area. NPFC-2018-SSC BF01-WP03, 26 pp.

Sawada, K. & Yonezaki, S. 2019. Field-per-recruit of splendid alfonsino in the Emperor Seamounts. NPFC-2019-SSC BF02-WP01, 10 pp.

Schönhuth, S., Álvarez, Y., Rico, V., González, J.A., Santana, J.I., Gouveia, E., Lorenzo, J.M. & Bautista, J.M. 2005. Molecular identification and biometric analysis of macaronesion archipelago stocks of *Beryx splendens*. *Fisheries Research*, 73:299-309.

Seok, K. 2012. An overview of the Korean alfonsino fishery. Working Paper. Workshop on Assessment and Management of Alfonsino Fisheries. FAO, Rome, Italy, 10 to 12 January 2012. Busan, Republic of Korea, National Fisheries and Research and Development Institute. 4 pp.

Sherstyukov, A.I. & Nostov, A.S. 1986. Collection of juvenile alfonsino, *Beryx splendens* (Berycidae), in the region of Uglovoya Submarine Rise. *J. Ichthyol.* (USSR), 26(5): 123-124.

Shotton, R. 2014. Yield per Recruit analysis of Alfonsino and implications for their management in the Southern Indian Ocean. SIODFA Technical Paper 14/01, 17 pp.

Shotton, R. 2016. Global review of Alfonsino (Beryx spp.), their fisheries, biology and management. FAO Fisheries and Aquaculture Circular, 153 pp.

Silva, H.M. & Menezes, G. 1996. *An intensive fishing experiment in the Azores*. Final report, Commission of the European Communities (DG XIV/C/1 – Study contract 94/028). 57 pp.

Stocker, M. & Blackwell, R. 1991. *Biomass and yield estimates for alfonsino in BYX for the 1991-92 fishing year.* New Zealand Fisheries Assessment Research Document 91/12. New Zealand Fishing Industry Board. 13 pp.

Takahashi, Y. 2018. A study on age, growth and harvest strategy of the alfonsino *Beryx splendens* in the Emperor seamounts water. Master Thesis, Tokyo Univ. Mar. Sci. Tech., 74 pp. (in Japanese with English tables and figures).

Then, A.Y., Hoenig, J.M, Hall, N.G. & Hewitt, D.A. 2015. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES J. Mar. Sci. 72(1): 82-92.

Titova, N.V. 1981. Differentiation of *Beryx splendens* Lowe from the Atlantic Ocean thalassobathyal by frequency of esterase locus alleles. *In: Genetics, selection and hybridization of fish*, pp. 135-137. Theses of reports. Rostov-on-Don, USSR. (in Russian).

Uchida, R.N. & Uchiyama, J.H. 1986. *Fishery atlas on the North-western Hawaiian Islands*. NOAA Technical Report. NMFS, 38: 1-42 pp.

Vinnichenko, V.I. 1995. On commercial stock of alfonsino in the open North Atlantic. *In: Theses of Reports of the 4th All-Union Conference on problems of commercial forecasting.* Murmansk, Russian Federation, PINRO. 32 pp. (in Russian).

Vinnichenko, V.I. 1996a. *Results of investigations and fishery of Alfonsino in the North Atlantic open areas in 1994-1995*. Materials of the Report Session om results from PINRO research in 1995. Murmansk, Russian Federation, PINRO. 95-106. (in Russian).

Vinnichenko, V.I. 1996b. Russian investigations on fishery of deep-water fish in the North Azores area. Working document for the Study Group on Biology and Assessment of Deep-sea Fisheries Resources. ICES Headquarters, Copenhagen, Denmark, 15-21 February 1996. 13pp.

Vinnichenko, V.I. 1998. *Alfonsino (*Beryx splendens*) biology and fishery on the seamounts in the open North Atlantic*. ICES CM 1998/O: 13. 115 pp.

Vinnichenko, VI. 2012. Investigations and fishery of splendid alfonsino (*Beryx splendens*) in the open North Atlantic. Presentation at the FAO International Workshop on Assessment and Management of Alfonsino Fisheries, 10 to 12 January 2012, FAO HQ, Rome, Italy.

Vinnichenko, V.I., Gorchinksy, K.V. & Shibanov, V.N. 1994. *Fishery and biological features on some seamounts of the North Atlantic Ridge by data from September-October 1993 cruise of the trawler "Ramoen".* Materials of the Report Session on results from NIR PINRO research in 1993. Murmansk, Russian Federation, PINRO. pp 181-189. (in Russian).

Watari, S., Yonezaki, J., Takeuchi, H., Kato, M., Yamakawa, M., Hagiwara, Y., Yonezaki, S., Fujita, K., Saki, T., Ihara, R., Shishidou, H. & Tanaka, E. 2017. Fisheries biology and resource management of splendid alfonsino *Beryx splendens*. *Bull. Jap. Res. Edu. Agen*. 44: 1-46. (in Japanese with English abstract, tales and figures).

Wiff, R., Quiroz, J.C., Flores, A., & Gálvez, P. 2012. An overview of the alfonsino (*Beryx splendens*) fishery in Chile. MS presented at the FAO International Workshop on Assessment and Management of Alfonsino Fisheries, January 10-12 FAO, Rome, Italy. 25 pp.

Yanagimoto, T. 1996. *Reports on the research and stock assessment of groundfish in the North Pacific in 1996.* Shimizu, Japan, Nat. Res. Inst. Far Seas Fisheries. 15 pp. (in Japanese).

Yanagimoto, T. 2004. Groundfish fisheries and the biological properties of alfonsino *Beryx splendens* Lowe in the Emperor Seamounts. *Fish. Biol. Oceanogr. Kuroshio*, 5: 99-109. (in Japanese).

Yanagimoto, T. & Nishimura, A. 2007. *Review of the Japanese fisheries in the Emperor Seamount Area*. First Meeting of the ESM Scientific WG (Jan 2007). SG1/J1.