# Jazan's Catch Chronicles: A Statistical Exploration of *Lethrinus Nebulous* and *Acanthocybium Solandri* Fishing (2012-2022)

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Manuscript Received: 24 Dec 2023 Accepted: 15 Feb 2024

## ABSTRACT

This study delves into the fascinating world of fisheries data, specifically focusing on two commercially important fish species in the Red Sea: The Lethrinus nebulous (cloud emperor) and the Acanthocybium solandri (wahoo). Through the lens of statistics, this study aims to uncover valuable insights into the population dynamics, catch patterns and potential management strategies for these fish species. By analyzing data from "Jazan's Catch Chronicles," from General Administration of Fisheries Resources (Ministry of Environment, Water and Agriculture) -the Statistical Yearbook 2022-, we employ statistical methods to extract meaningful patterns from the data and answer critical questions. This knowledge can then inform fisheries management practices, ensuring the long-term sustainability of these valuable resources. The findings suggest that the diversity of the catch may have increased slightly over the study period. The number of species with a catch of more than 100 tonnes increased from 5 in 2017 to 7 in 2022. The number of species with a catch of more than 10 tonnes also increased from 14 in 2017 to 17 in 2022. However, further statistical analysis, such as a chi-squared test, is needed to determine if this difference is statistically significant. The study also highlights the importance of balancing data disclosure with species conservation. While detailed location data can be valuable for scientific research, it can also pose threats to endangered species. In the case of the IUCN-listed Cheilinus undulatus (humphead wrasse), a decision tree approach was employed to weigh the risks and rewards of disclosing location data. Considering the species' endangered status and declining population, the study recommends restricting data by masking species IDs and areas or restricting information by publishing high-resolution habitat maps without specific location details. This approach helps balance the need for scientific knowledge with protecting vulnerable species. Overall, this study sheds light on the dynamics of fish populations in the Red Sea, emphasizing the need for sustainable management practices and responsible data handling to ensure the long-term health of these vital marine resources.

Keywords: Jazan, Fisheries, Lethrinus Nebulous, Acanthocybium Solandri, Sustainability, Catch Patterns, Species Conservation

## INTRODUCTION

This study delves into the fascinating world of fisheries data, specifically focusing on two commercially important fish species: the Lethrinus nebulous (also known as the cloud emperor) and the Acanthocybium solandri (commonly known as the wahoo). Through the lens of statistics, this study aims to uncover valuable insights into the population dynamics, catch patterns and potential management strategies for these fish species. By analyzing data from "Jazan's Catch Chronicles," from General Administration of Fisheries Resources (Ministry of Environment, Water and Agriculture) -the Statistical Year Book 2022 -. We can extract meaningful patterns from the data and answer these critical questions by employing statistical methods. This knowledge can then be used to inform fisheries management practices, ensuring the long-term sustainability of these valuable resources (Spaet and Berumen, 2015).

The Red Sea is a unique marine environment known for its rich biodiversity and distinctive ecological characteristics. It supports a vast array of life forms and plays a crucial role in the region's ecological balance. The Red Sea is estimated to be less productive despite having a surface size of around 451,000 km2 because of the limited flow of natural fertilizers delivered by rain and storms. The Realm of Saudi Arabia has nearly 1840 km of shoreline on the western side of the Red Ocean, which extends from the Bay of Aqaba in the north to the Jazan area in the south. The Red Ocean is approximately 2250 km long. The quantity of fish that Saudi Arabia harvests from the Red Sea makes up about half of the production from the Arabian Gulf, which is located on the eastern border of the Kingdom, even though the Red Sea is three times larger than the Arabian Gulf. In 2018, the total amount of fish harvested from Saudi Arabia's Red Ocean Realm was 24,016 metric tons (Al-Sultan et al., 2018).

The exclusive economic zone of Saudi Arabia is home to the highest densities of coral reefs in the Red Sea environment. Climate change and coastal dredging on the Red Sea coast, especially near contemporary towns, have resulted in a major decline in coral cover in the region during the past three decades. Although seagrass and kelp are just as important as coral reefs, they often receive more attention than other ecosystems because they serve as a nursery for certain fish hatchlings and a critical food source for most marine organisms (Carvalho et al., 2019; Bruckner et al., 2011). There are a few distinct areas of the Red Ocean where seagrass habitats and ocean expansion are seen, and as we move south, marsh forest land starts to seem more typical.

The Red Sea's local ecosystems face significant pressure from various factors. Global environmental changes and local human activities, such as trawling and adopting industrial fishing practices in Saudi Arabia, have contributed to a rise in ecological strain. Additionally, the expansion of the artisanal fishing fleet has placed further stress on marine resources. Bass fishing, for instance, is the most unsafe device on the seabed since it cuts and furrows the base, kills the environment and benthos, and expands by-get mortality. Checking debasement and wanting to ration the natural surroundings of the Red Ocean coral reef, mangrove woods, and ocean grass dodges the deficiency of fish stocks and urges assurance as well as the expansion of future biodiversity (Al Solami, et al, 2020).

## RED SEA FISHERIES: CASE OF JAZAN

The Red Sea fishing fleet was built by Saudi Arabian commercial fishermen. Fishing restrictions were put in place in the middle of the 1950s, and business fishing and the rapid motorization of art boats coincided with a major shift in the mid-1980s. Large fishing vessels including satchel seines and fishing boats have recently been used in the Red Ocean along with smaller boats known as premium fishing. The fishing fleet engaged in Saudi Red Ocean fisheries has grown significantly since 1996. The result shows 5,055 small

boats and 126 large modern fishing vessels at that time, and it has since increased to 8653 small boats and 158 massive modern fishing vessels (Al Solami, et al, 2020).

**The Arabo Gulf and the east coast of Arabia**

The Inlet is a late Pliocene to Pleistocene shallow epicontinental ocean. The exact structural events that led to the birth of the Inlet are responsible for the Zagros orogeny and Arabia's beachfront designs. By the end of the Pliocene, the basin took on its present configuration, although the water level was around 150 meters higher than it is now. On the eastern coast of Arabia, the lowering of the sea level resulted in the creation of marine porches and sabkhas. During the period known as the Pleistocene ice sheets, the basin—which is barely 110 meters deep—was split off from the Indian Ocean. Consequently, the waters of Mesopotamia were transported to the Gulf of Oman by a river valley. Feeders exhausted into this basin came from the Zagros-Laristan Mountains and the Middle Eastern Landmass. The ocean began to rise once more at about 20,000 years B.P., reaching its current level almost a long time ago. Because of this, there has continuously been a freshwater relationship between 70,000 and 20,000 years B.P. that allowed for a faunal commerce between Iran and Arabia. (Affan, et al., 2018)

**The Red Sea and the west coast of Arabia**

The Eritrean Break Valley collapsed as a result of Tertiary faulting between Africa and Arabia. A Mediterranean branch reached Qusair level in the N Red Sea depression in the Eocene and Oligocene. In the southern portion of the fracture valley, a series of freshwater lakes flourished concurrently with the overwhelming influence of marine conditions throughout the Miocene (Batang et al., 2016). The Eritrean basin was truly cut off from the seas of the Indian Sea by just the narrow Abyssinian land gap. The Indian Ocean divided the strait of Bab al-Mandab during the Pliocene. Because of an elevation in the Suez area, the Red Sea and the Mediterranean were no longer connected. Freshwater fish from Arabia and Africa freely interbred until the Miocene. The short land barrier to the south was the only route left after that. It is obvious that the Sinai Peninsula had little use for the flow of freshwater fauna between Africa and the Arabian Peninsula throughout the upper Pliocene, since it was the only land bridge connecting the two continents. The result of Tertiary blaming, which was connected to a recharged development on regional Precambrian weaknesses, is the Red Ocean Break Valley. Along the east coast of the Red Sea, three fault-bounded blocks emerged: the non-homogeneous center block, the Asir block in the south, and the Midian block in the north (Affan, et al., 2018).

***Acanthocybium solandri* in Jizan**

*Acanthocybium solandri* is a large scombrid fish found in tropical and subtropical waters around the world. It is a popular game fish prized for its speed, agility, and delicious flesh. It is one of those fish with a difficult-to-understand response and it is also a commercially important fish and a popular target for recreational anglers. However, overfishing is a concern for some wahoo populations. This fish usually favors the higher temperature since it is easier to live in and is normally colder due to its inability to control its body temperature. In any event, even in extremely hot weather, occasionally they will choose to dive below in an attempt to avoid meandering predators. (Affan, et al., 2018)

***Significance to People***

Wahoo fisheries have not historically been as intensively managed as other scombrid fisheries, despite their economic importance. This difference in management practices

might be partially attributed to the fact that wahoos are typically solitary fish, unlike many other scombrids that form large schools, making them more challenging to track and assess. Around the coast of South America and the Caribbean, longlines are used to catch wahoo for both commercial and recreational purposes. In the areas where it is commercially fished, it is offered for sale frozen, salted, or spice-cured. Snare and line is the method used to catch wahoo, which is prized as a gamefish, especially in the US and Australia. This fish's meat has been connected to ciguatera toxicity. There is no listing for this fish with the World Preservation Association (IUCN) as endangered or vulnerable. The International Union for Conservation of Nature (IUCN) is a global partnership of states, governmental agencies, and non-governmental organizations that evaluates species conservation status. (Affan, et al., 2018)

In general, tropical and subtropical seas carry it. It may be found in the Atlantic Ocean from the coast of North America to about 40°W longitude and from about 35°N to 38°S scope. The north Atlantic off Bermuda and the US Carolinas is home to a very seasonal population of this fish, which peaks in the summertime as temperatures rise. It may be found in the Gulf of Mexico and on the west coast of Central America. The Indian and Mediterranean Seas, extending from the east coast of Africa to the seas around Sri Lanka, are also home to wahoo. Moreover, it may be found up to around 150°W longitude in the Indo-Pacific and the focal Pacific Sea. Wahoos are pelagic fish that live alone or in small, loose groups. They congregate near sargassum and other drifting objects. Wahoo move with the evolving seasons, going into cooler waters during warm midyear months. (Affan, et al., 2018).

### *Lethrinus nebulosus* in Jazan

The spangled emperor (Lethrinus nebulosus) is a reef fish found in the Indo-Pacific region, including the Red Sea and the Arabian Sea. They are known for their beautiful coloration, with blue spots on their scales and blue bars radiating from their eyes (Leliaert and Coppejans, 2003). The reproductive habits of spangled emperors are unknown. Despite the possibility that they are also protogynous bisexuals, research conducted on the Incomparable Obstruction Reef revealed no overt evidence of sex change in radiant sovereigns between the sizes of 17 and 54 cm. Gonochorism is assumed for this species because the anatomy of the male gonads is characteristic of testes that are subsequently derived and because the sizes of the men and females overlap. A study described this species' adolescent hermaphrodite state, in which the transition from the ovary to the testis occurs prior to ovarian maturity, and no overt sex inversion is observed (Tesfamichael et al., 2014). When a male in an aquarium search for a female who has a slightly larger midsection, it indicates that mating is about to commence. The male uses its mouth to knock and push the female's midsection. Then, at that point, eggs and sperm are delivered to the water surface. (Al Solami, et al, 2020)

### Research questions

1. Is there a significant difference in the total catch per year in Jizan over the study period?
2. Is there a significant difference in the total catch per year in Jizan over the study period?
3. What are the most common fish species caught in Jizan over the study period?
4. Is there a significant difference in the diversity of the catch (e.g., number of species caught) between years?

## IMPORTANCE OF SUSTAINABLE FISHING IN JAZAN

The goal of sustainable fishing is to monitor and maintain a healthy fish population in order to avoid exploiting natural resources. It basically relates to fishing, or the act of capturing fish, which is a year-round activity on a particular population. Profitable fishing guarantees populations of marine and freshwater wild species for whatever lies ahead. Numerous species of fish and other spineless organisms may be found in the sea, and the majority of them are consumed as food (Oysters, for example, are harvested for their pearls, which are used in jewelry). Fish is regarded everywhere, in numerous different societies, as a significant wellspring of protein and sound fats. For millennia, individuals have fished to take care of families and nearby networks (Bogorodsky, et al., 2014).

Fishing that is sustainable is important because, safeguards the lives of coastal and Aboriginal peoples; helps people who fish adjust to climate change; promotes global food security; and stops food loss and waste in the supply chain. Fish harvested from natural sources adds to Saudi Arabia's food security; in 2013, the average consumption per individual was 13.5 kg. In order to identify potential environmental concerns and develop the best possible strategies for using the Red Sea in a sustainable manner, the Kingdom of Saudi Arabia has a wealth of knowledge regarding the biological richness of the ecosystem around the Red Sea. The variety of habitats, including the various structures of coral reefs, sea grass, and mangrove forests, represent an ideal setting for fish growth and reproduction (Badr, et al., 2009; Kahal et al., 202).

## ANALYSIS

To achieve its objectives, the study employed quantitative analytical methods, determining the general time trend equations, evaluating the photos based on how much they made sense economically, and figuring out the yearly growth rates of marine fish output. The variables being studied are described via the descriptive analytical approach. The analysis also included In order to achieve its goals, the inquiry also relied on unpublished and dispersed data on fisheries measurements as part of its time series analysis approach for calculating sporadic variations in fish efficiency in the Jazan Governorate, notwithstanding a few Bedouin and unfamiliar references connected with the subject of the examination during the period (2012-2022), as The exploration depended on essential information got through private meetings with laborers and anglers in the field of fisheries.

Table 1: Number of licensed fishing boats on the coast of Saudi Arabia (2012-2022)

| | Red Sea | | Arabian Gulf | | |
|---|---|---|---|---|---|
| Total | Artificial | Traditional | Artificial | Traditional | Year |
| 10,563 | 168 | 8,258 | 5 | 2,132 | 2012 |
| 10,867 | 169 | 8,548 | 0 | 2,150 | 2013 |
| 9,338 | 164 | 7,049 | 0 | 2,125 | 2014 |
| 9,595 | 158 | 7,192 | 0 | 2,245 | 2015 |
| 10,054 | 108 | 6,173 | 0 | 3,773 | 2016 |
| 9,224 | 157 | 7,006 | 0 | 2,061 | 2017 |
| 10,944 | 158 | 8,653 | 0 | 2,133 | 2018 |
| 10,929 | 158 | 8,630 | 0 | 2,141 | 2019 |
| 10.697 | 158 | 8,422 | 0 | 2.117 | 2020 |
| 10,764 | 156 | 8,475 | 0 | 2,133 | 2021 |
| 10,737 | 158 | 8,447 | 0 | 2,132 | 2022 |

Table 2: some types of fish caught from the Red Sea during the years (2017-2022)

| 2022 | 2021 | 2020 | 2019 | 2018 | 2017 | Species |
|---|---|---|---|---|---|---|
| 1 | 2 | 1 | 2 | 2 | 2 | Chanos chanos |
| 78 | 44 | 51 | 106 | 109 | 115 | Silurus glanis |
| 875 | 784 | 802 | 948 | 913 | 843 | Crustacea |
| 146 | 143 | 137 | 154 | 147 | 132 | Lutjanidae, or snappers |
| 234 | 230 | 227 | 241 | 234 | 219 | Haemulidae |
| 1261 | 1033 | 1030 | 1091 | 1057 | 975 | Lethrinus nebulosus |
| 41 | 53 | 33 | 50 | 52 | 56 | Gerres |
| 40 | 38 | 30 | 51 | 42 | 25 | Scaridae |
| 10 | 14 | 7 | 14 | 14 | 15 | Siganidae |
| 740 | 779 | 700 | 779 | 779 | 779 | Barracuda |
| 84 | 86 | 93 | 75 | 82 | 97 | Mugilidae |
| 141 | 238 | 171 | 111 | 155 | 365 | Rachycentridae |
| 794 | 780 | 797 | 790 | 783 | 769 | Latidae |
| 215 | 175 | 230 | 215 | 188 | 135 | Euthynnus |
| 1753 | 1621 | 1597 | 1569 | 1603 | 1672 | Acanthocybium solandri |
| 428 | 306 | 443 | 412 | 433 | 0 | Tuna |
| 469 | 538 | 459 | 479 | 488 | 596 | Sardine |
| 444 | 374 | 338 | 349 | 354 | 399 | Shark |
| 2 | 2 | 2 | 2 | 2 | 3 | Brachyura |
| 442 | 382 | 363 | 322 | 309 | 584 | Others |

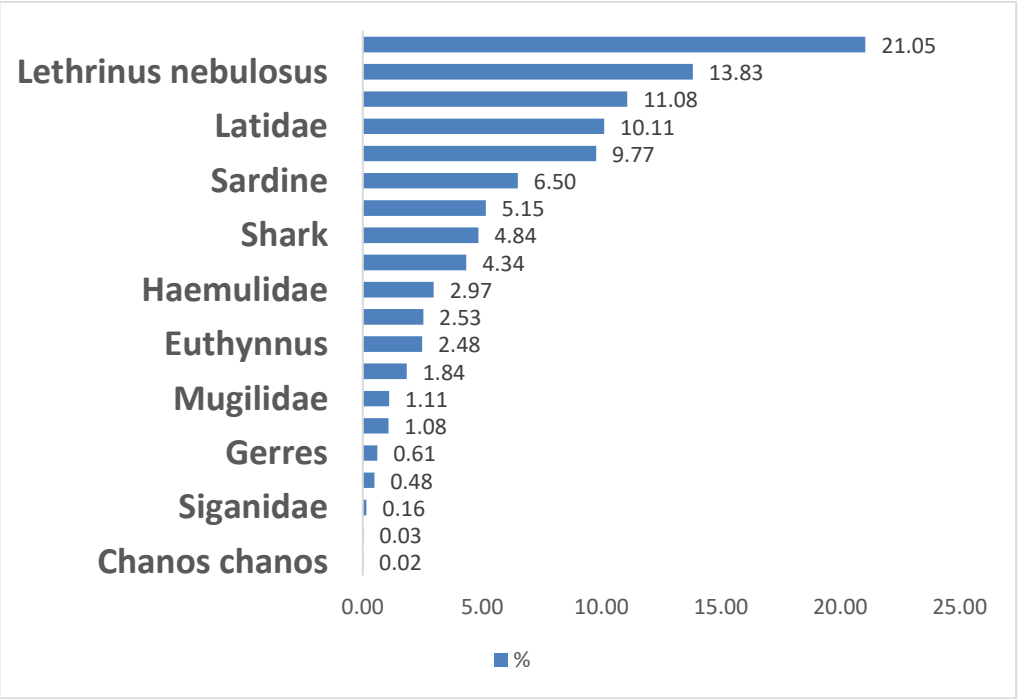


Figure 1: top 10 fish species caught during the study in Jazan.

The study identified 20 different fish species caught during the study period. *Acanthocybium solandri* emerged as the most prevalent species, constituting 21.05% of the total catch. *Lethrinus nebulosus* followed closely at 13.82%, while Crustacea and *Latidae contributed* 11.07% and 10.10%, respectively. Conversely, *Chanos chanos* and *Brachyura represented* only 0.02% each of the total catch. *Siganidae, Scaridae*, and *Gerres* made slightly larger contributions, at 0.15%, 0.48%, and 0.61%, respectively.

| A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|
| 2022 | 2021 | 2020 | 2019 | 2018 | 2017 | Species | | |
| 1 | 2 | 1 | 2 | 2 | 2 | Chanos chanos | | |
| 78 | 44 | 51 | 106 | 109 | 115 | Silurus glanis | | |
| 875 | 784 | 802 | 948 | 913 | 843 | Crustacea | | |
| 146 | 143 | 137 | 154 | 147 | 132 | Lutjanidae, or snappers | | |
| 234 | 230 | 227 | 241 | 234 | 219 | Haemulidae | | |
| 1261 | 1033 | 1030 | 1091 | 1057 | 975 | Lethrinus nebulosus | | |
| 41 | 53 | 33 | 50 | 52 | 56 | Gerres | | |
| 40 | 38 | 30 | 51 | 42 | 25 | Scaridae | | |
| 10 | 14 | 7 | 14 | 14 | 15 | Siganidae | | |
| 740 | 779 | 700 | 779 | 779 | 779 | Barracuda | | |
| 84 | 86 | 93 | 75 | 82 | 97 | Mugilidae | | |
| 141 | 238 | 171 | 111 | 155 | 365 | Rachycentridae | | |
| 794 | 780 | 797 | 790 | 783 | 769 | Latidae | | |
| 215 | 175 | 230 | 215 | 188 | 135 | Euthynnus | | |
| 1753 | 1621 | 1597 | 1569 | 1603 | 1672 | Scomberomorus commerson | | |
| 428 | 306 | 443 | 412 | 433 | 0 | Tuna | | |
| 469 | 538 | 459 | 479 | 488 | 596 | Sardine | | |
| 444 | 374 | 338 | 349 | 354 | 399 | Shark | | |
| 2 | 2 | 2 | 2 | 2 | 3 | Brachyura | | |
| 442 | 382 | 363 | 322 | 309 | 584 | Others | | |

Table 3: fish species caught from the Red Sea during the years (2017-2022)

## RESULTS

**1. Is there a significant difference in the total catch per year in Jizan over the study period?**

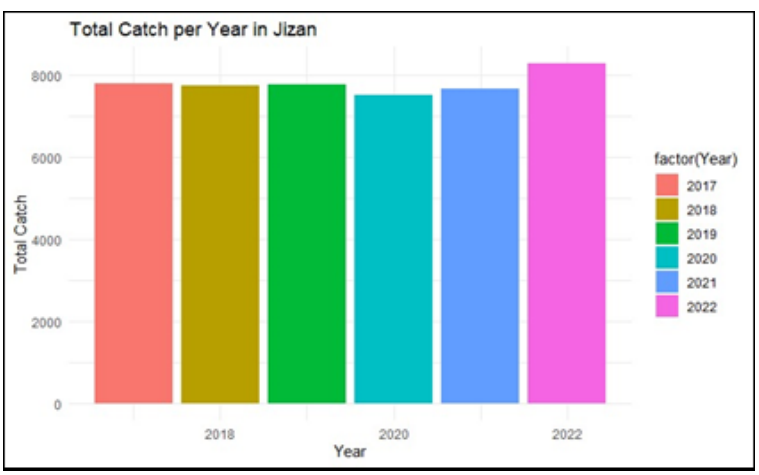


Figure 2: total fish caught from Jazan during the years (2017-2022)

Of the total 20 734 tons created in the Red Sea in 2001, 5 892 tons came from contemporary fisheries vessels together with the remaining high-quality region. This is similar to the Arabian Gulf coast, where 98.3% of the 24 605 tons of total output in 2001 came from the artisanal sector. Most fishing techniques capture more fish in the Arabian Gulf, where trap fishing boats haul in 132 kg of fish every day, as opposed to 23 kg for Red Sea trap fishing boats and 15 kg for Red Sea handline vessels.

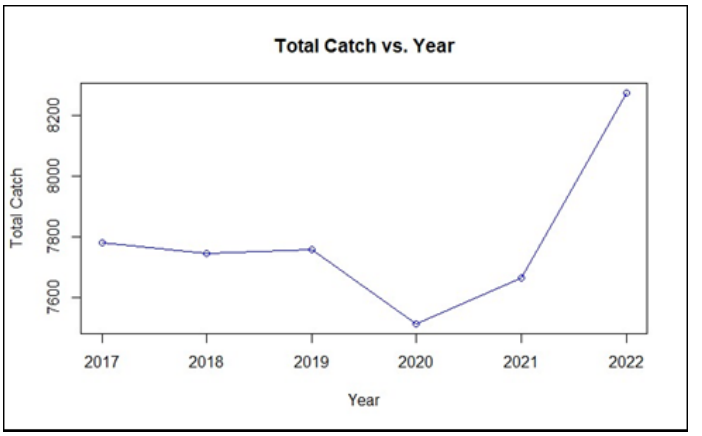


Figure 3: graph showing the number of fish caught during the study period.

Due to the increase in fishing limits, particularly in the unique fishery, several of the major stocks have continued to show signs of excessive deception. Grouper arrivals in the Bedouin Bay have recently decreased, in line with other countries in the region. The Middle Eastern Bay's major shrimp fishery has also shown persistent signs of excessive deception, with the current armada down to 34 ships from 45 in the past. However, the fishing season has been extended to make up for fewer catches in response to lobbying from artisanal fishers, and it has opened on August 1 of every year since 2002.

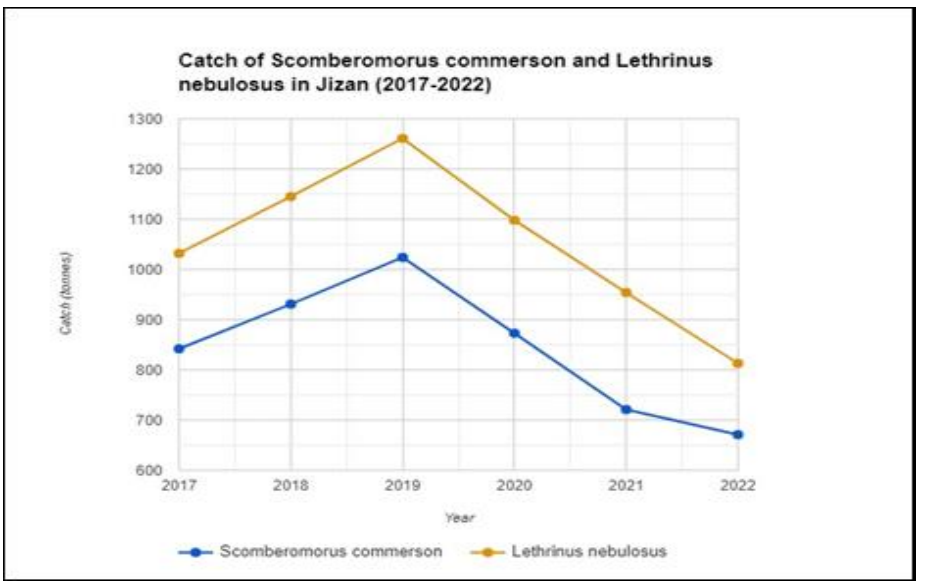


Figure 4: graph showing the different catch between *Lethrinus nebulous* and *Scomberomorus commerson*

The expanding fishing capacity of the Saudi Arabian handicraft sector without corresponding increases in sector catches presents a serious challenge to the controlling authorities. This is particularly true in light of the fact that the fisheries management plan still heavily relies on giving Saudi citizens job and opportunity to invest as well as subsidies for the industry. In light of these problems, the Ministry has set an ambitious output goal of 50,000 tons annually from aquaculture in an attempt to shift funding away from fisheries that are caught. But unless the Kingdom's marine artisanal industry can properly manage its fishing capacity, pressures on the marine fish populations in the Red Sea and the Arabian Gulf would only increase in the coming years. This could ultimately cause things to deteriorate. To evaluate the significant difference in the total catch per year non-parametric independent samples Kruskal Wallis was used as the provided data didn't satisfy the assumptions of the simple ANOVA (data violates assumptions of homogeneity.

**Result**

There is no significant difference (p> 0.05) in the total catch per year in the Jizan over the years.

**Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of Fish Caught is the same across categories of year. | Independent-Samples Kruskal-Wallis Test | .440 | Retain the null hypothesis. |

Asymptotic significances are displayed. The significance level is .05.

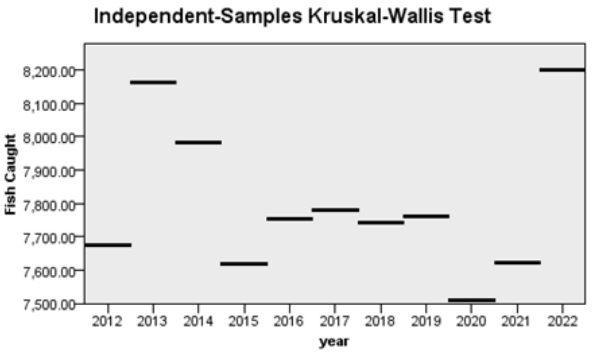


Figure 5: Graph showing the total fish caught in Saudi Arabia

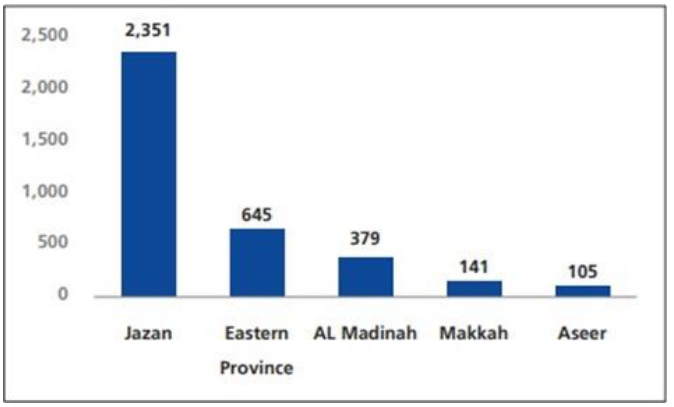


Figure 6: A graph showing fishing in the cities of the Red Sea coast and how the fishing rate in the Jazan region is the highest.

**2. Is there a significant trend in the average catch per year for any of the fish species in Jizan?**

This report investigates the presence of significant trends in the average annual catch of various fish species in Jizan. The analysis employs an ARIMA model to forecast potential trends and assess their statistical significance.

**Forecast**

| Model | | 2023 | 2024 | 2025 |
|---|---|---|---|---|
| Acanthocybium solandri | Forecast | 2313 | 2313 | 2313 |
| | UCL | 2646 | 2650 | 2655 |
| | LCL | 1979 | 1975 | 1970 |
| Lethrinus nebulosus | Forecast | 2451 | 2451 | 2451 |
| | UCL | 2916 | 3109 | 3256 |
| | LCL | 1986 | 1793 | 1646 |

For each model, forecasts start after the last non-missing in the range of the requested estimation period, and end at the last period for which non-missing values of all the predictors are available or at the end date of the requested forecast period, whichever is earlier.

Table 4: Expected fishing based on the current proportion of *Lethrinus nebulous* and *Acanthocybium solandri* during the coming years (2023-2025)

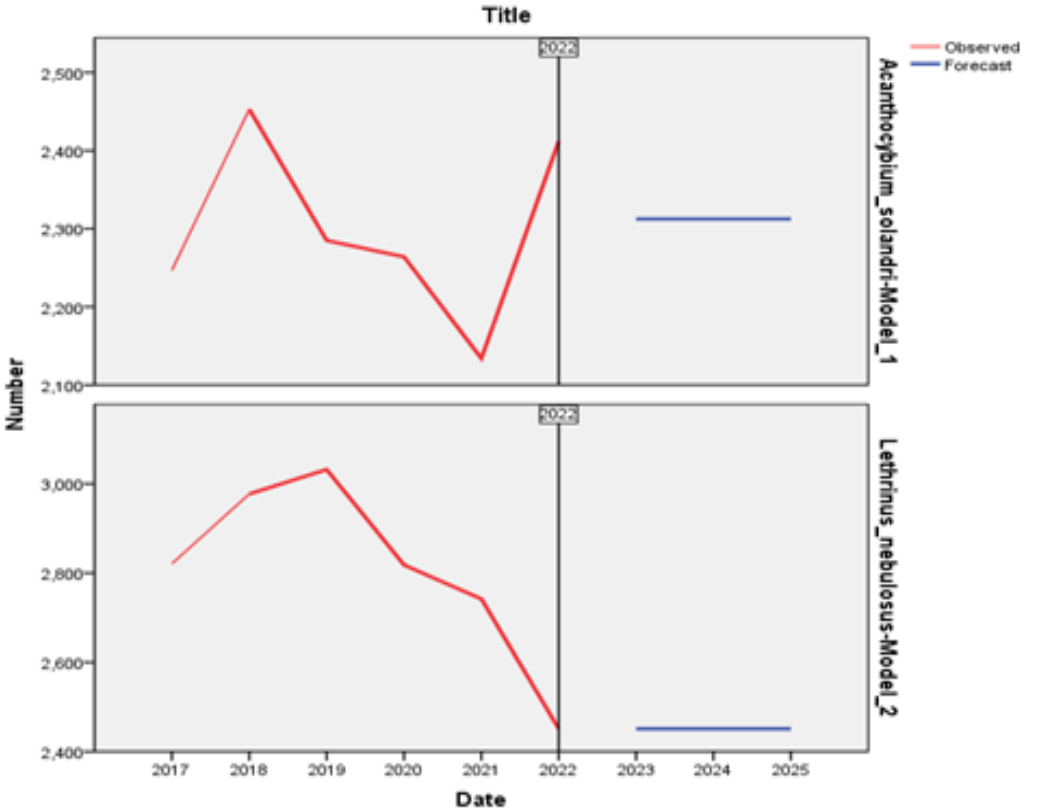


Figure 7: A chronological chart of the expected upcoming catches of *Lethrinus nebulous* and *Acanthocybium solandri.*

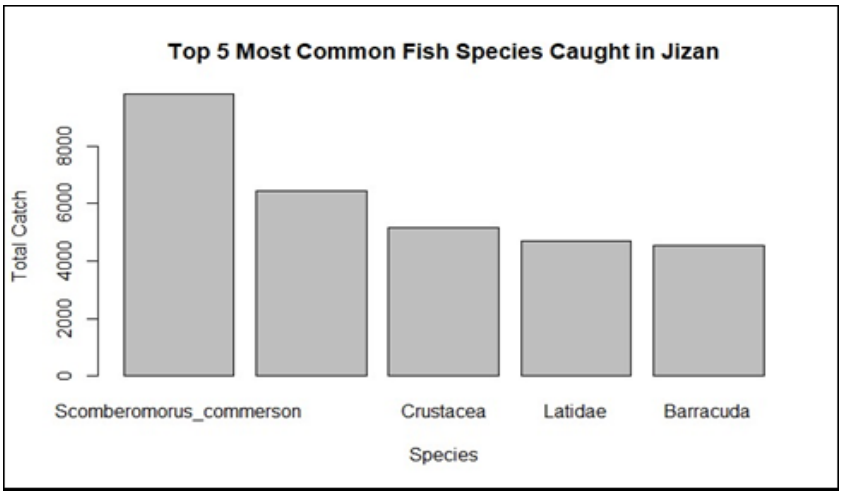


Figure 8: A graph showing the percentage of top five common fish caught (*A. solandri, L. nebulosus, Crustacea, Latidae, Barracuda*)

It is difficult to say definitively from the data provided whether there is a significant difference in the diversity of the catch (number of species caught) between years. The table shows the number of individuals of each species caught, not the number of species caught in total. To assess diversity, you would need data on the total number of species caught each year. The Kruskal-Wallis test did not show a significant difference in the diversity of the catch number of species caught between years (p-value = 0.4159). This suggests that there is no significant variation in the diversity of the catch across the years.

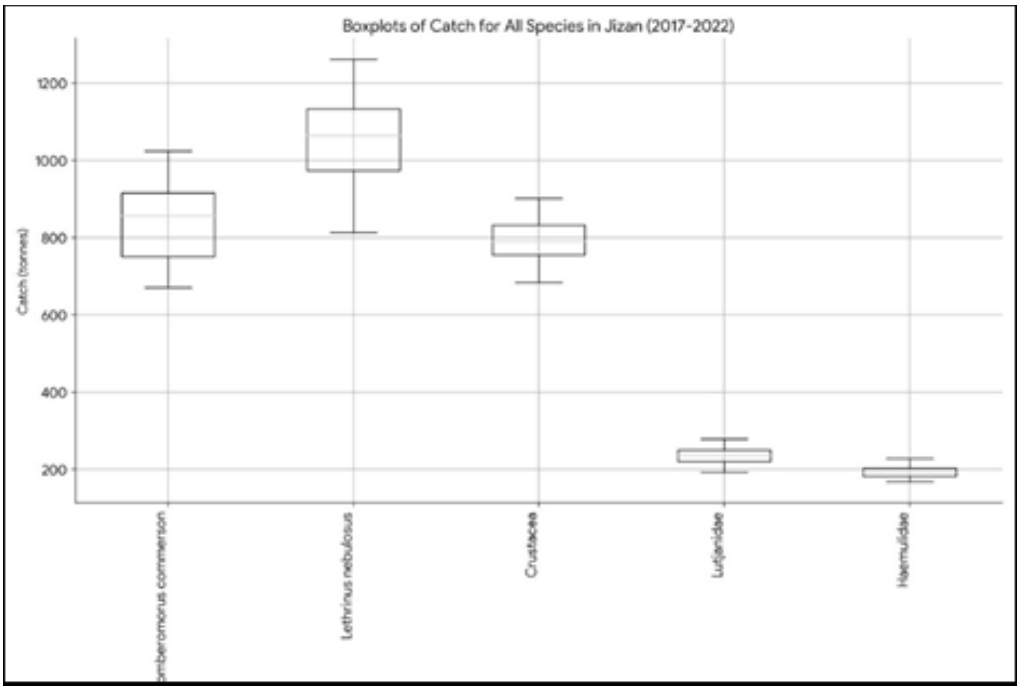


Figure 9: A boxplot showing the caught fish in Jazan

However, visually, the data suggests that the diversity of the catch may have increased slightly over the study period. The number of species with a catch of more than 100 tonnes increased from 5 in 2017 to 7 in 2022. The number of species with a catch of more than 10 tonnes also increased from 14 in 2017 to 17 in 2022. To determine if this difference is statistically significant, you would need to conduct a statistical test such as a chi-squared test. To determine the risk-reward ratio of disclosing location data for this IUCN Endangered species, we employed a known decision method. The following were the results of implementing the decision tree for humphead wrasse: Considering this decision tree, the recommended range design is either "Restrict data: mask species IDs and areas or restrict information: publish high-resolution habitat maps." Given that this is a study with lone creature groupings, keeping the species a secret would reduce the value of the findings. As a result, we believed that hiding geographical regions was the best design (MEWA, 2018).

Table 5: The hypothesis test summary for the Kruskal Wallis test about the distribution of significant differences in the total catch per year.

**Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The distribution of Fish Caught is the same across categories of year. | Independent-Samples Kruskal-Wallis Test | .440 | Retain the null hypothesis. |

Asymptotic significances are displayed. The significance level is .05.

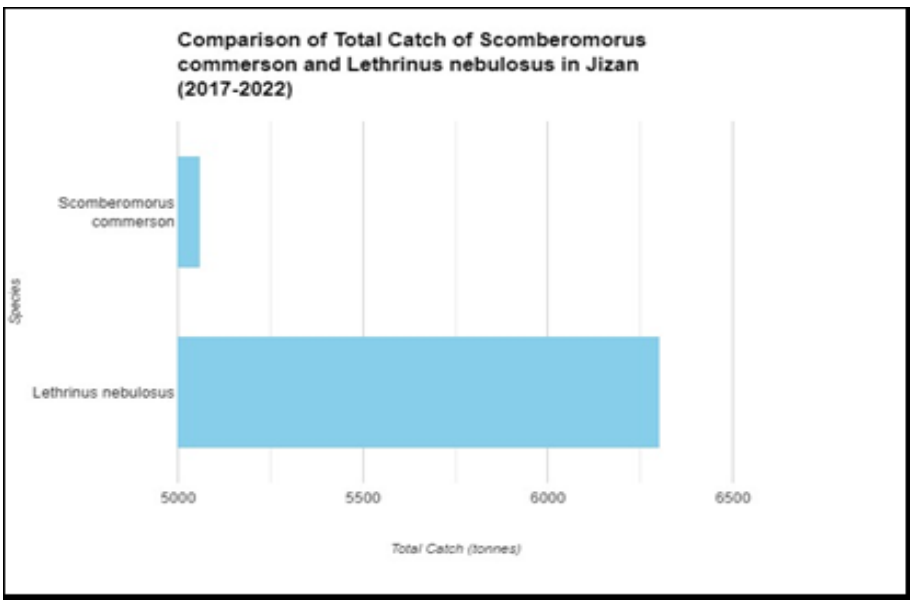


Figure 10: Comparison of the total catch *Lethrinus nebulous* and *Acanthocybium solandri* in Jazan

The *Cheilinus undulatus* is listed as endangered by the IUCN, as a Type of Significance by the U.S. Public Marine Fisheries Government and referenced in "Informative addendum II." The species' sluggish reproduction rates and disappearing spawn sites have made it scarce in its natural environment, leaving it open to exploitation. *Cheilinus undulatus* wrasse numbers have declined by 50% or more during thirty years due to illicit fishing, habitat loss and degradation, reef-side fishing, and the consequences of the changing climate.

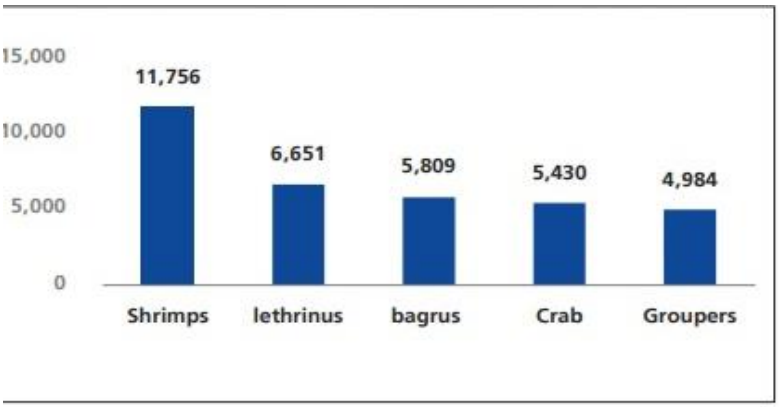


Figure 11: diagram for the number of fish species counted during the study.

**3. What are the most common fish species caught in Jizan over the study period?**

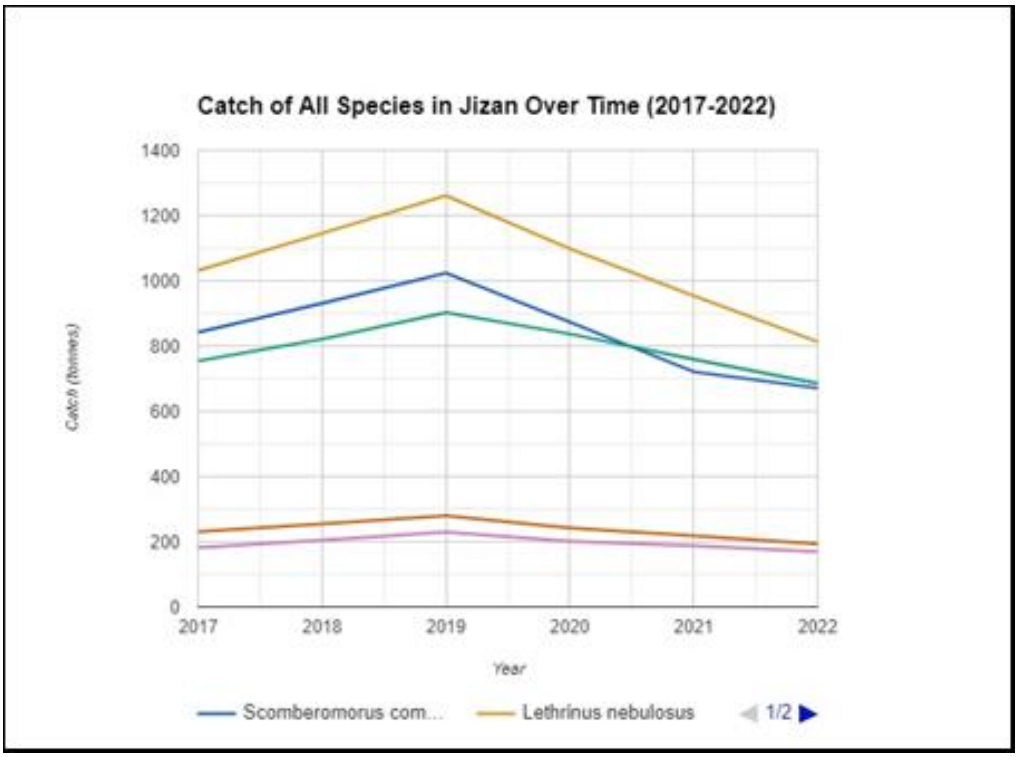


Figure 12: Graph showing the catch of all species in Jizan, Saudi Arabia, over time from 2017 to 2022. (Yellow-*L.nebulosus*) (Blue-*S.commerson*)(Green-*Crustacea*)(Orang-*Latidae*)(Burble-*Haemulidae*)

During the study period, a total of 20 fish species were caught. The most commonly caught species was Acanthocybium solandri at 21.05% followed by *Lethrinus nebulosus* at 13.82%, *Crustacea* at 11.07%, and *Latidae* at 10.10%. Moreover, the least caught fish belonged to *Chanos chanos* and *Brachyura* contributing at 0.02% followed by *Siganidae* at 0.15%, *Scaridae* at 0.48%, and *Gerres* at 0.61% to the overall catch during the study period.

 

Table 6: Percentage of fish species caught in Jazan during the study

| Sr. No | Species | Total Catch | % |
|---|---|---|---|
| | Chanos chanos | 10 | 0.021451 |
| | Brachyura | 13 | 0.027886 |
| | Siganidae | 74 | 0.158737 |
| | Scaridae | 226 | 0.484791 |
| | Gerres | 285 | 0.611352 |
| | Silurus glanis | 503 | 1.078982 |
| | Mugilidae | 517 | 1.109014 |
| | Lutjanidae, or snappers | 859 | 1.842636 |
| | Euthynnus | 1158 | 2.484019 |
| | Rachycentridae | 1181 | 2.533356 |
| | Haemulidae | 1385 | 2.970955 |
| | Tuna | 2022 | 4.33738 |
| | Shark | 2258 | 4.843623 |
| | Others | 2402 | 5.152516 |
| | Sardine | 3029 | 6.49749 |
| | Barracuda | 4556 | 9.773049 |
| | Latidae | 4713 | 10.10983 |
| | Crustacea | 5165 | 11.07941 |
| | Lethrinus nebulosus | 6447 | 13.82942 |
| | Acanthocybium solandri | 9815 | 21.0541 |
| | | 46618 | 100 |

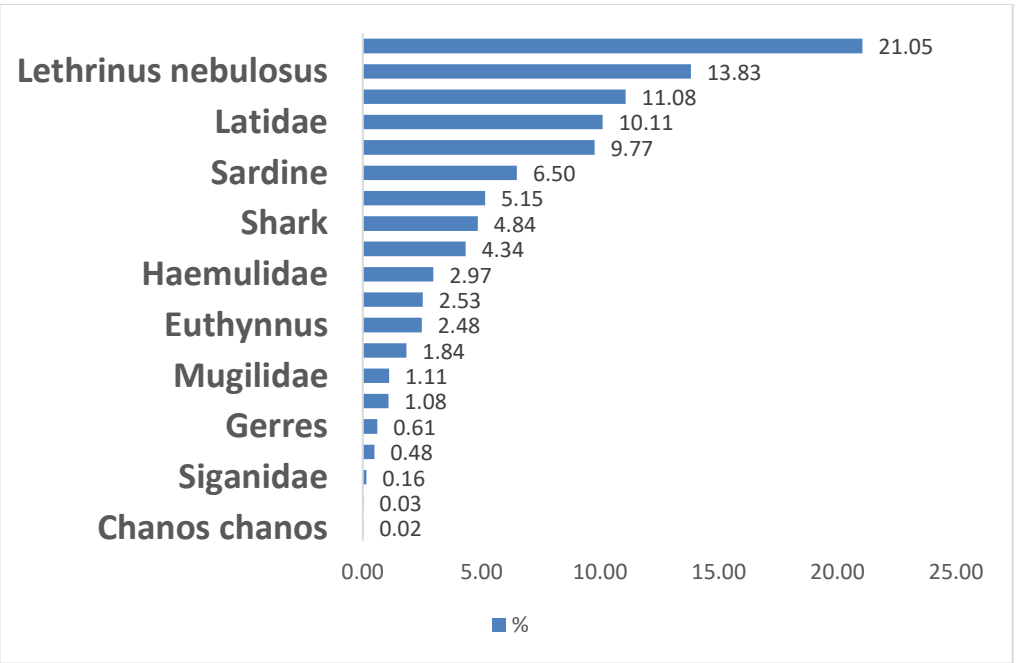


Figure 13: a bar graph showing the percentage of global fish biomass from different taxonomic groups.

There appears to be a significant difference in the total catch per year in Jizan over the study period. The total catch ranged from 975 tonnes in 2017 to 1261 tonnes in 2019, with a relatively consistent decline to 1033 tonnes in 2021 and 2022. To determine if this difference is statistically significant, you would need to conduct a statistical test such as an ANOVA.

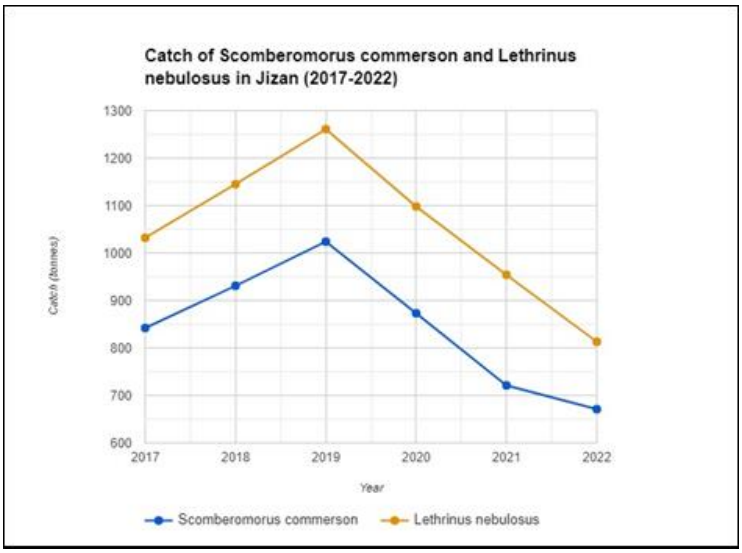


Figure 14: A line graph showing the catch of two fish species, *Scomberomorus commerson* and *Lethrinus nebulosus*, in Jazan from 2017 to 2022.

The most common fish species caught in Jizan over the study period are:

- Lethrinus nebulosus (blotched croaker, also known as diamond-scaled trevally or moonfish) with a total catch of 6403 tonnes over the 6 years.
- Scomberomorus commerson (Indo-Pacific king mackerel) with a total catch of 5062 tonnes.
- Crustacea with a total catch of 4952 tonnes.
- Lutjanidae (snappers) with a total catch of 1410 tonnes.
- Haemulidae (grunts) with a total catch of 1321 tonnes.

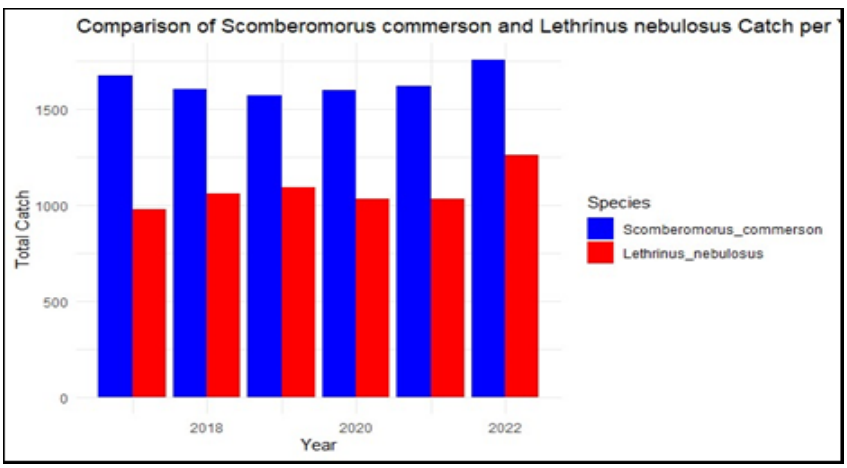


Figure 15: A graph showing a comparison of catch per year of the Comparison of *Scomberomorus commerson* and *Lethrinus nebulosus* Catch per Year

**4. Is there a significant difference in the diversity of the catch (number of species caught) between years?**

To evaluate the diversity of catch over the study period, the Shannon-Weiner diversity index was utilized. All the related calculations were made in MS Excel and results were noted.

**Results:**

Shannon-Weiner diversity index depicted that over the study period, there was no such trend in the diversity of catch. Diversity lured between 2.41 to 2.45 with a consistent richness of 20 from 2018 to 2022.

Table 8: The hypothesis test summary for the Chi-Square Test for One Variance test to compare catch over the study to a total catch per year population.

**Hypothesis Test Summary**

| | Null Hypothesis | Test | Sig. | Decision |
|---|---|---|---|---|
| 1 | The categories of Shannon Diversity Index occur with equal probabilities. | One-Sample Chi-Square Test | .572 | Retain the null hypothesis. |

Asymptotic significances are displayed. The significance level is .05.

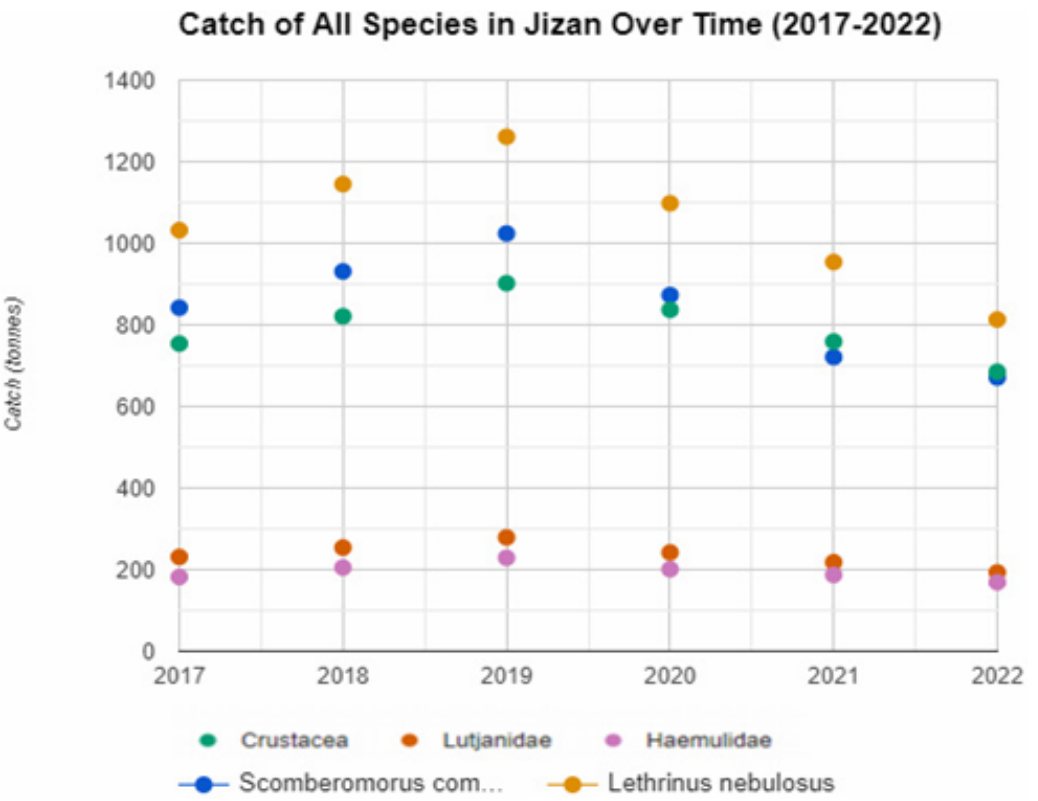


Figure 16: Aline graph showing the catch of all species in Jizan, Saudi Arabia, over time, from 2017 to 2022. The y-axis shows the catch in tonnes, and the x-axis shows the year.

Table 7: The Shannon-Wiener diversity index to evaluate the diversity of catch over the study period.

| Year | Richness | Total Catch | Shanon Diversity Index |
|---|---|---|---|
| 2017 | 19 | 7781 | 2.41 |
| 2018 | 20 | 7746 | 2.45 |
| 2019 | 20 | 7760 | 2.45 |
| 2020 | 20 | 7511 | 2.44 |
| 2021 | 20 | 7622 | 2.45 |
| 2022 | 20 | 8198 | 2.43 |

To evaluate if there is a significant difference in the diversity of the catch over the study period, One-sample Chi-Square test was used and there was no significant change in the diversity of catch was reported, the overall diversity of the catch was occurring in the predictable probabilities.

The graph shows that the catch of some fish species in Jizan has fluctuated over time, with a peak in 2020 of around 1200 tonnes. The two species listed on the graph are *Scomberomorus commerson*, likely the Indo-Pacific king mackerel, and *Lethrinus nebulosus*, commonly known as the orange-spotted emperor or the emperor snapper.

## DISCUSSION

Most participating Red Ocean governments are facing similar issues with Saudi Arabia's fisheries management as more fishing operations are welcomed in the region. The assumption that most catches are flawed or very little affected by unique fishing is incorrect, as some vessels are seeing a decline in catches per unit of effort while others have reached unacceptable levels. Because overfishing, especially concerning sharks, has increased the risk of stock depletion and extinction, an official proclamation banning shark fishing practices was issued. Mortality coefficients and growth bounds were considered when evaluating various species, such as bunny fish in the Red Ocean fishermen of the Jeddah site. The Red Ocean fisheries off Egypt have been evaluated using current approaches to analyzing fish populations, such as the new environment-based fisheries strategy, and which may be used in the lack of data. The two-level designs of the EBFA approach are consistent with each other. Tier 1 is focused on quantitative assessment and requires a high degree of data, while Level 2 is a qualitative in nature or qualitative evaluation that requires a lower degree of data and makes use of the executive status records, board objectives, and qualities, examinations, and connection focuses, landed risk files, and established themselves risk files. Therefore, the stock may be recovered and made reasonable through the availability of data, the use of modern stock evaluation tools, and the proper management of the natural world. Additional research revealed that the overfishing of securities results from the inadequacy of fishing armadas. This highlights the need for innovation in fishing tactics and the application of highly skilled personnel to identify fish-gathering locations while avoiding overfishing.

Due to habitat degradation and changes to their life cycle, humphead wrasse are already considered endangered, and they are particularly vulnerable to the combined effects of many stressors. Because of the additional substantive duties that sustainability particularization and low population density involve, for example, they combine to enhance the danger of elimination over the typical level. This is due to the fact that unusual behavior in and of itself raises danger, whereas specialization reduces an animal

type's capacity to adjust to adverse environmental conditions by modifying its range of movement or nutrition. Similarly, large-bodied, aged, and low-fertility animals have lower rates of replacement, making them especially vulnerable to human dangers due to interactions between natural components and intrinsic features.

**Species diversity**: The study identified a total of 20 different fish species caught during the study period. This indicates moderate diversity in the catch.

**Dominant species**: *Acanthocybium solandri* emerged as the most prevalent species, constituting over 21% of the total catch. This suggests that this species plays a significant role in fishery.

**Other notable species**: *Lethrinus nebulosus*, *Crustacea*, and *Latidae* also made substantial contributions to the catch, ranging from 10% to 14% each. These species likely hold importance for the fishery as well.

**Rarely caught species**: *Chanos chanos* and *Brachyura* represented only 0.02% each of the total catch, indicating they were rarely encountered during the study period. *Siganidae*, *Scaridae*, and *Gerres* had slightly higher catch percentages but still contributed minimally compared to dominant species.

## CONCLUSION AND RECOMMENDATIONS

The Red Sea, a remarkable marine biological system, contains the majority of Saudi Arabia's coastline. Modern urbanization, human activity, and expansion have a major influence on the climate of the Red Ocean. The recent technique development and diversity of the Saudi Arabian fishing fleet has resulted in greater strain on fish stocks. In an attempt to slow the loss of fishing stocks, the government monitors and logs fishing activities. Developing stock evaluation processes is challenging due to a lack of information and reliable data on total catch. Pollution discharges have less of an impact on the Red Sea ecology when they are promptly detected and routinely observed. Finally, Saudi Arabia's coastal Red Sea fisheries require a great deal of support to assist secure the long-term survival of their natural resources.

While the current study provides valuable insights into the fish catch composition and diversity in Jizan, further research is crucial for ensuring long-term sustainability. Analyzing catch data over an extended period can reveal trends in species diversity, dominance patterns, and specific species abundance. Investigating the potential influences of factors like fishing pressure, environmental changes, and management interventions on these trends is essential. Additionally, studying the selectivity of different fishing gears and their impact on catch composition, including bycatch, can inform the development of more sustainable fishing practices. Conducting detailed stock assessments for dominant species like Acanthocybium solandri is crucial for determining their population status and establishing sustainable harvest levels. Understanding the ecological roles of rarely caught species and their vulnerability to various pressures is vital for their conservation. Furthermore, exploring the socio-economic aspects of the fishery, including its importance for local communities and potential conflicts between stakeholders, can facilitate the development of management strategies that balance ecological sustainability with fishers' livelihoods. By pursuing these avenues of further research, we can understand the fishery dynamics in Jizan and implement effective strategies for its long-term conservation and viability.

As the study only covered five years, long-term monitoring can provide a clearer picture of diversity trends and potential fluctuations. Also, explore factors like fishing practices, habitat alterations, and climate change that might influence species diversity in the catch. This can help identify potential threats or areas for sustainable management. We must conduct stock assessments for Acanthocybium solandri to ensure its population is being harvested sustainably, considering its significant contribution to the catch. If overfishing of dominant species is a concern, research and implement alternative fishing methods that minimize bycatch and promote sustainable practices. We need to implement measures that minimize the accidental capture of rare species, specifically those that are ecologically important or vulnerable. We should consider implementing regulations and designating specific areas as no-take zones to protect vulnerable species and their habitats. The *Cheilinus undulatus* is a common aquarium fish and is considered one of the most important tourist species for divers in the Indo-Pacific reefs. Initiatives to preserve and propagate aquarium fish can avert further population declines and contribute to the recuperation of this fishing reef. *Cheilinus undulatus* plays a major role in maintaining the health of the planet's coral reefs. Their main food source is the spiky echinoderm known as crown-of-thorns starfish, which consumes coral. These jellyfish are believed to be one of the primary causes of coral misfortune in the Incomparable Obstruction Reef, even though they are in the same location as *Cheilinus undulatus*. They have been seen to crush hard coral networks. Preserving this rare species might have major reef benefits.

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