

Sustainable Fisheries Development and Resilient Coastal Livelihoods in Southern Yemen

Project Research Synthesis

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Key Findings

This note synthesizes the research studies carried out under IFPRI's Sustainable Fisheries Development and Resilient Coastal Livelihoods in Southern Yemen project. Key findings include:

- Fisheries development policy and assistance in Southern Yemen have faced large gaps in data and knowledge—particularly regarding fish consumption and food security implications, use of ice for chilling fish, and measurement and monitoring of artisanal fishing activities.
- Fish is a highly nutritious food, an important part of Yemeni diets, and much more affordable than meat. Improving household access to fish, especially in inland areas, is essential for improving food security and reducing malnutrition. Restoring and expanding domestic (and export) markets should be a priority of fisheries development policy.
- Ice is widely used within some links of artisanal fisheries value chains, but fishers and market retailers employ ice strategically. Consumers' willingness to pay for ice use is low compared to the high cost of ice and the demand for high-quality fish is currently very limited, making ice use unprofitable for many small fishers. Investments in energy supply and ice production to lower costs and in consumer awareness campaigns on food safety and fish quality to increase willingness to pay are crucial to maintain an uninterrupted cold chain and achieve quality-led value addition in artisanal fisheries value chains.
- A complete fishing information and monitoring system for the Gulf of Aden that captures both artisanal and commercial fishing vessels is urgently needed for sustainable fisheries development. Deep-learning-based remote sensing provides a low-cost solution for high-frequency data collection to analyze and track difficult-to-detect artisanal fishing activities and changes in local fishing fleets.

Yemen's marine ecosystems in the Gulf of Aden and the Red Sea are traditionally rich fishing grounds. Yemen has a mainland shoreline of more than 2,200 km—two-thirds of which is on the Gulf of Aden (including the easternmost part of the Arabian Sea), which stretches along six of Yemen's southern mainland governorates. The main fish and seafood species caught in the Gulf of Aden include large pelagic fish (especially yellowfin and longtail tuna), medium-sized pelagic fish (especially kawakawa, striped bonito, and different trevally species), small pelagic fish (especially sardines and different mackerel species), demersal reef fish (especially emperor and grouper), sharks, cephalopods (such as cuttlefish and octopus), and crustaceans (such as lobster and shrimp). Many of them are medium- and high-value fish.

Yemen was a major player in fish production in the Middle East and North Africa region before the current conflict erupted in 2014. Fisheries were the country's second-largest export sector (after the oil and gas sector), contributing about 3 percent of national GDP (World Bank, 2025). The most recent estimates, from 2024, suggest that Yemen's total fish production from the Gulf of Aden and the Red Sea reached 152 metric tons (mt) live weight—about 40 percent less than the country's peak production two decades earlier and 30 percent less than the pre-conflict production level a decade earlier (FAO, 2026). National fish production estimates, however, have been questioned, as no official fish stock assessment has been taken in recent decades.

The current conflict is widely thought to have had severe impacts on the fisheries sector and particularly on artisanal fisheries along the Gulf of Aden coast in Southern Yemen. Repeated attacks on ports, combined with lack of maintenance and severe underinvestment over many years, have left fishing boats and fisheries infrastructure destroyed or dysfunctional. High fuel prices and unstable electricity supply have also affected fishing and fish processing, transport, and marketing, including the production of ice needed to maintain the cold chain from catch to sale (Impact Consulting, 2022; Mercy Corps, 2023; OECD, 2026). Poor enforcement of fishing regulations, due to weak institutions and limited naval capacities, has put marine resources close to the shorelines, where local fishers with smaller boats operate, at risk from unsustainable fishing practices (Ali et al., 2024; Becker 2025; Costa et al., 2025). Poverty, food insecurity, and limited alternative employment opportunities force some artisanal fishers to prioritize short-term gains in fish resource exploitation over sustained productivity of healthy fish stocks (Teh et al., 2024; World Bank, 2025). Moreover, foreign commercial fishing fleets take advantage of Yemen's limited naval capacities by fishing illegally in its territorial waters and thus threatening artisanal fishers' livelihoods (GFW, 2020).

Despite these challenges, fisheries have been identified as a key sector to support post-conflict economic recovery and food security and to contribute to resilient coastal livelihoods in Southern Yemen (World Bank, 2022; TCC, 2023; UNDP, 2025). Fisheries are thought to still have high economic growth and export potential, especially through quality-led value addition in fish supply chains, if fish resources are managed sustainably (Impact Consulting, 2022; UNDP, 2022; Costa et al., 2025). The key role assigned to fisheries also reflects the very limited potential of the agriculture sector—which is usually the investment focus for sparking development in other low-income countries—given the arid climate and scarcity of freshwater resources. As in many other developing countries, fisheries in Yemen are dominated by artisanal fisheries, which contribute more than 90 percent to total fish production (Impact Consulting, 2022; Apex & AAMS, 2025). Fisheries sector investments are therefore expected to have sizable multiplier effects in Southern Yemen's economy and improve coastal livelihoods, especially in poor rural communities along the Gulf of Aden. Fisheries in Southern Yemen are highly decentralized, with about 60 official—mostly small—boat landing sites, more than 90 registered and active local artisanal fishers associations, and approximately 12,800 operational artisanal fishing boats (Apex & AAMS,

2025). Estimates of the number of people employed in the sector vary widely, with figures for 2024 ranging between 29,000 and 96,000 active fishers (Apex & AAMS, 2025). Additionally, fishing provides employment in upstream and downstream subsectors, including boat repair workshops, ice plants, and construction of fisheries infrastructure; fish processing and canning factories; trading, transport, and retail; and administration in fishers associations and related government agencies. Fishing also provides affordable and highly nutritious food that is an important part of Yemeni diets and crucial for reducing malnutrition. Fish is rich in high-quality protein, polyunsaturated fatty acids, and essential vitamins and trace minerals. Fish consumption is thus particularly important for children's physical and cognitive development and the reduction of nutritional deficiencies, and especially so in rural Yemeni settings, where it is difficult to obtain enough essential nutrients from a varied diet.

To contribute to enhancing the resilience of local institutions and vulnerable population groups, the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) implemented the Strengthening Resilience and Participation at Local Level (SRPL) project in selected governorates of Yemen from October 2019 to March 2026. The SRPL project was commissioned by the Federal Ministry for Economic Cooperation and Development (BMZ) of Germany as part of its global transitional development assistance (GIZ, 2022). This instrument aims to create links between short-term humanitarian assistance and long-term development cooperation; it focuses on four key areas (BMZ, 2026), including improving food and nutrition security and rebuilding basic infrastructure and services. The SRPL project's main geographic focus was the southern governorate of Hadramawt (GIZ, 2025), with development assistance to the fisheries sector its centerpiece, given the importance of artisanal fisheries for economic recovery, income generation, and food security in Yemen's coastal regions.

As part of the SRPL project, GIZ provided a grant to the International Food Policy Research Institute (IFPRI) for a research and knowledge exchange project to inform national and local governments' fisheries development policy for the Gulf of Aden region and GIZ's and other international partners' institutional, infrastructural, and technical development assistance programming. IFPRI's project, titled Sustainable Fisheries Development and Resilient Coastal Livelihoods in Southern Yemen, aimed to address critical data and knowledge gaps and share rigorous, up-to-date research-based evidence with national and local stakeholders and international partners. This target audience has been organized in the Fisheries Sub-Working Group (FSG)—a food security and livelihoods subsector working group established by the UN-led Yemen Partners Group to provide technical inputs and guidance to strategic discussions on fisheries sector development and international support. IFPRI's contract ran from November 2024 to March 2026. This note synthesizes the research studies conducted.

Research Objectives and Design

After years of conflict in Yemen, with its toll on already weak national statistics systems, enormous data and knowledge gaps have challenged development planning and assistance programming. The demand for up-to-date reliable evidence emerged rapidly after the United Nations brokered a truce agreement between the main parties to the conflict in April 2022 and commitments from international development partners were increased to support economic recovery, especially in Yemen's southern governorates. In the critical fisheries sector, incomplete data and anecdotal information were often the only available sources to inform donor investment decisions. Therefore, the main objectives of IFPRI's research were (1) to fill data and knowledge gaps to identify key leverage points in artisanal fisheries value chains to facilitate interventions that contribute to sustainable development in the sector, coastal

livelihood resilience, and food and nutrition security, and (2) to establish an evidence base for improved policymaking and future research in Southern Yemen's fisheries.

Faced with numerous data and knowledge gaps across many areas related to fisheries policy, we adopted a systematic approach to identify and select gaps of particular importance for development assistance overall and for current projects by BMZ/GIZ and other development organizations. We conducted a scoping exercise, using a systematic literature review and key informant interviews to synthesize current knowledge, understand informational needs and research priorities, and define key research issues. Based on this comprehensive review, we then implemented a series of six focused studies on specific, though interrelated, issues. This approach of multiple studies enabled us to use the methods and data most suited to each issue and so ensured high scientific rigor and in-depth analysis within the short research period. Finally, this project note synthesizes all seven studies and draws overall conclusions. The following sections summarize the methods and main research findings of each study, and the last section discusses policy implications.

Figure 1: Study area and sites



Note: The six mainland governorates along the Gulf of Aden coast and the governorate of the Socotra archipelago of Southern Yemen are shaded in green.

Our study area includes the six southern governorates that are located on Yemen's mainland along the Gulf of Aden coast, with a focus on Hadramawt Governorate and its coastal areas (Figure 1). Hadra-

mawt is a center of Yemen's fisheries: The governorate's landing sites harbored 31 percent of all operational artisanal fishing boats on the Gulf of Aden coast in 2024/25 (Apex & AAMS, 2025). These landing sites include fishing ports in two major fisheries hubs, Mukalla and Ash Shihr, and small harbors and beach landings in villages, where artisanal fisheries are essential for the local economy and many households' livelihoods. Two of our focus studies look at the role of fish in food security, household diets, and nutrition in these locations, one drawing on secondary data from across Yemen and the other on household survey data from Hadramawt. Another three focus studies investigate the use of ice in artisanal fisheries value chains based on data on fisheries value chain actors and fish consumers from our main study sites, Mukalla and Qusayir. Mukalla city is the capital of Hadramawt Governorate. The village of Qusayir—a typical node of the fisheries sector—is located about 150 km east of Mukalla, with the town of Ash Shihr about halfway in between. For one of the three focus studies on ice use, data collection in Mukalla and Qusayir was expanded to Ash Shihr. The last focus study tests remote sensing models for measuring artisanal fishing activities based on satellite imagery from Mukalla and Qusayir.

Scoping Review: Defining the Research Agenda

The scoping review (Belton et al., 2026) aimed to define the project's research agenda and comprised two research activities. We first conducted a comprehensive literature review to synthesize the current knowledge on the state of fisheries in Southern Yemen, and Hadramawt in particular, and to map out informational needs and priority areas for development policy- and program-relevant research. We then carried out elicitation interviews with experts to better understand key knowledge gaps and research priorities from different perspectives. This helped us to define specific research issues that are both central to current transitional development assistance efforts and fall within IFPRI's areas of expertise.

For the systematic literature review, we identified relevant publications in Google Scholar using the search terms "Yemen" and "fish*" together. We augmented the sample with unpublished materials made available by GIZ and other FSG members, yielding a total of 198 publications on fisheries in Yemen. We screened the documents and excluded those that did not focus on the Gulf of Aden or Hadramawt, leaving us with 45 documents for inclusion in the final review. Approximately half of these items were project reports, many of them unpublished. For the expert elicitation interviews, we followed established key informant interview protocols and devoted special attention to evidence inconsistencies, knowledge gaps, and research priorities found in the literature review. We held 14 semi-structured interviews remotely in English or Arabic with experts familiar with fisheries in Southern Yemen, who were identified by snowball sampling. They included government officials, representatives of fishers associations and private businesses, and specialists from local research institutions and international development partners.

The scoping review revealed that the scientific evidence base on the state of fisheries in Southern Yemen is quite limited (Belton et al., 2026). While a significant number of descriptive reports have been prepared in recent years, many of them are not in the public domain and most rely exclusively on qualitative fieldwork, including key informant interviews and focus group discussions, or anecdotal evidence. The main challenges to Southern Yemen's fisheries are well documented by these reports—including low productivity, high input costs, risk of overfishing, sectorwide underinvestment, and weak institutional capacities—and descriptions of their causes are generally consistent across reports. An important exception to this consistency relates to the inadequate use of ice for chilling fresh fish in some links of artisanal fisheries value chains. Hypothesized causes for inadequate ice use range from physical unavailability of ice to lack of quality-based differentiation in fish prices and irrational economic behavior of value

chain actors. In contrast to qualitative descriptions, recent quantitative evidence is extremely scarce—data is limited not only on maritime fish stocks but also on the key economic parameters of fisheries sector performance and fishing activities, fish markets and value chains, and fish consumption and consumer preferences. A notable exception is a very recent fisheries profile by Apex Consulting and Advanced Africa Management Services (Apex & AAMS, 2025). That report provides a detailed snapshot of artisanal fisheries infrastructure and fishing activities along the Gulf of Aden coast. The analysis, which is purely descriptive, is based on a comprehensive landing site survey that was conducted with support from the World Bank. However, while recent research efforts have focused on fisheries infrastructure, production, and environmental sustainability issues, there is no quantitative evidence on key economic issues, including consumer demand for fish, profitability of artisanal fishing, or the role of fisheries in food security.

The research implications of the scoping review's main findings, which emerged from the expert elicitation interviews in particular, motivated our six focus studies and outlined the methodological approaches of their analysis. Three main recommendations for research were identified:

- Analyze representative household surveys to determine fish consumption patterns and their food security and nutrition implications.
- Examine the use of ice in artisanal fisheries value chains, and conduct behavioral studies to better understand fishers' and consumers' choices based on their perceptions and economic incentives.
- Explore low-cost, high-frequency data collection methods to measure local fishing activities and changes in artisanal fishing fleets for potential inclusion in fishing monitoring and information systems.

With these recommendations in view, our six focus studies aimed to narrow the identified data and knowledge gaps. Our research focused mainly on demand-side issues, guided by the principal assumption that—because most fish landed on the Gulf of Aden coast is currently supplied to local or domestic markets as fresh fish—the food preferences, perceptions, and purchasing power of Yemeni consumers should influence fish sales, prices, and catches to a large extent, and fishers and other value chain actors should have a vested interest in understanding demand factors.

Secondary Data Analysis: Assessing Fish for Food Security in Yemen

The first focus study (Dey et al., 2026) assesses the importance of fish for food and nutrition security in Yemen and examines geographic differences within the country. We analyzed consumption of fish along with other animal-source food groups, namely meat, dairy, and eggs, as potential substitutes in household diets. We also examined the associations between fishing as a source of household livelihoods and fishing households' animal-source food consumption and food security outcomes. Our analysis is based on household data from the Data in Emergency Monitoring (DIEM) surveys of the Food and Agricultural Organization of the United Nations (FAO). These are a series of high-frequency, repeated cross-sectional surveys, designed to be statistically representative at the national and governorate levels. Roughly monthly survey rounds were conducted through relatively short, computer-aided telephone interviews using random-digit direct dialing. The data analyzed include observations from 21 survey rounds over a period of two years, from January 2023 to December 2024. Around 2,500 households from all 22 governorates were interviewed in each survey round, for a total of 52,319 household observations used in our analysis. The longitudinal nature of the data allowed us to explore temporal variation in average food consumption.

The DIEM data analysis shows that fish is an important part of Yemeni diets and is the second most commonly consumed animal-source food, after dairy (Dey et al., 2026). Nationally, fish consumption is slightly more common than meat consumption, with 9.7 percent of households reporting fish being part of their meals over the 24 hours prior to the interview (averaged over all survey rounds), compared with 9.1 percent reporting meat consumption. Although the DIEM survey was not designed to be representative at subgovernorate levels, the data strongly support an obvious consumption pattern: The share of households consuming fish is highest in coastal areas of Southern Yemen, but fish consumption is also quite common in southern inland areas—but much less common in inland areas of Northern Yemen, which include the country’s highlands. At the governorate level and across all survey rounds, the share of fish-consuming households is highest on Socotra Island, where more than half of all households consume fish daily, followed by Hadramawt and Al Maharah Governorates, both with more than 40 percent. For Southern Yemen, the DIEM data reveal only small and statistically insignificant variations in fish consumption between seasons. This result, however, refers only to the share of households consuming fish, since the survey did not ask about the quantity, species, or form (fresh or preserved) of fish consumed. It nevertheless suggests year-round availability of this highly nutritious food source in many parts of the territory. Fishing households are more likely to consume fish and therefore more likely to consume any animal-source food than are non-fishing households. They also consume fish or meat more frequently, have greater dietary diversity, and are less likely to be affected by moderate or severe food insecurity compared with non-fishing households (after accounting for other consumption factors, including household income). Together, these findings highlight the importance of fish for food security and diet quality across Yemen and point to the critical role that fishing plays in securing direct access to highly nutritious food and contributing to food-secure coastal livelihoods in the southern governorates.

Household Surveys: Investigating Fish Consumption in Hadramawt

The second focus study (Jovanovic et al., 2026a) builds on the findings from the first by closely examining household fish consumption in Hadramawt Governorate and addressing critical limitations of the DIEM survey data. For this study, we conducted a household consumption survey, with detailed survey modules on animal-source food and specifically fish consumption—including quantities, species, and forms of fish consumed—and on economic and geographic factors hypothesized to affect animal-source food consumption. The survey was designed to be representative of households in Hadramawt and, within the governorate, of four distinct geographic areas, namely inland rural, inland urban, coastal rural, and coastal urban. We collected data from 1,600 households through face-to-face interviews in 40 selected locations (that is, village or town/city, with 10 locations per area), using a quasi-random sampling approach. The sampling design ensured inclusion of households with different socioeconomic status and livelihoods, as well as different access to consumer markets and fresh fish. The survey was conducted in October 2025, which is the early period of the main fishing season (usually running from September/October to April/May) and a peak month for catches of tuna and other large pelagic species. Because of the short survey duration, the data do not capture seasonal variation in the availability of particular fish species or seasonal patterns of household food consumption.

The findings from this Hadramawt-specific survey are consistent with the findings of the national DIEM survey and provide additional detail (Jovanovic et al., 2026a). Fish, particularly fresh fish, is the most consumed animal-source food in Hadramawt, both in terms of the share of households consuming it and the quantity consumed (Tables 1 and 2). Nearly all households in our sample (95 percent) reported

fresh fish consumption in the seven days prior to the interview. The reported consumption of fresh fish by weight (including both edible and non-edible parts of fish) across the governorate averaged to 51 grams (g) per capita per day. This is within the range of the recommended intake quantity for fish and shellfish according to the most recent EAT-*Lancet* healthy reference diet, which extends up to 100 g, with an average 30 g, per capita per day for edible portions (Rockström et al., 2025). During the survey month, the most consumed fresh fish in Hadramawt was clearly kawakawa, followed by sardines, yellowfin and longtail tuna, and trevally. Total fish consumption (combining fresh and preserved fish) was, on average, more than four times higher than both total meat and total dairy consumption. Meat, egg, and dairy consumption is common in Hadramawt, with more than half of the surveyed households reporting consumption of each of these animal-source food groups over the seven days prior to the interview.

Table 1: Share of households consuming animal-source food groups and top five fish species (percent)

	Total	Coastal	Inland	t-test	Coastal rural	Coastal urban	t-test	Inland rural	Inland urban	t-test
Fish	98	99	98		100	97	***	98	98	
Fresh	95	97	94	***	99	96	**	91	96	***
Kawakawa	41	56	25	***	69	44	***	26	25	
Sardines	28	34	21	***	34	34		32	10	***
Yellowfin tuna	27	15	39	***	12	19	***	37	41	
Longtail tuna	21	8	33	***	4	12	***	26	41	***
Trevally	8	10	5	***	14	8	***	4	5	
Preserved	48	22	73	***	26	17	***	76	70	**
Meat	59	32	87	***	24	40	***	78	96	***
Eggs	52	38	65	***	34	41	**	63	68	
Dairy	59	47	71	***	47	48		75	67	**

Note: ***, **, * According to a t-test for unpaired data with unequal variances, the difference is statistically significant at the 1, 5, and 10 percent levels, respectively.

In Hadramawt, there are significant differences in consumption of fish and other animal-source foods between coastal and inland areas and, within these areas, between urban and rural areas. These differences are clearly more pronounced between coastal and inland areas than between rural and urban areas (Tables 1 and 2). Fresh fish consumption was much higher in coastal than inland areas and in coastal rural than coastal urban areas, but there was no significant difference between inland rural and inland urban areas at the time of the survey. Conversely, consumption of preserved fish (that is, mostly salted and dried fish or canned fish) was much higher in inland than coastal areas and, within both geographies, much higher in rural than urban areas. Kawakawa and sardines were the most consumed fresh fish in coastal areas, and yellowfin and longtail tuna were the most consumed fresh fish in inland areas. The consumption of these large tuna species was generally higher in urban than rural areas. Kawakawa consumption was higher in coastal rural than urban areas, and sardine consumption was higher in inland rural than urban areas. In contrast to fresh fish consumption, meat, egg, and dairy consumption was much higher in inland than coastal areas. In both geographies, meat consumption was more common among urban than rural households, while the average quantity of meat consumption was significantly higher among urban than rural households only in coastal areas.

Table 2: Average consumption quantities of animal-source food groups and top five fish species (grams per capita/day)

	Total	Coastal	Inland	t-test	Coastal rural	Coastal urban	t-test	Inland rural	Inland urban	t-test
Fresh fish	51.2	77.0	25.5	***	85.9	68.1	***	25.9	25.2	
Kawakawa	19.7	34.1	5.2	***	47.9	20.4	***	5.3	5.2	
Sardines	11.9	17.8	6.1	***	17.0	18.5		10.2	2.0	***
Yellowfin tuna	5.9	4.6	7.2	***	3.7	5.4	*	5.7	8.8	***
Longtail tuna	4.0	2.7	5.2	***	1.4	4.0	***	3.4	7.1	***
Trevally	2.6	4.6	0.7	***	6.2	3.0	***	0.4	0.9	*
Preserved fish	6.9	3.8	10.0	***	4.9	2.7	**	11.2	8.7	***
Meat	14.4	7.0	21.9	***	4.4	9.6	***	21.2	22.6	
Eggs	5.7	4.3	7.2	***	3.2	5.5	***	7.0	7.4	
Dairy	14.0	13.9	14.2		16.2	11.6	**	15.8	12.5	*

Note: ***, **, * According to a *t*-test for unpaired data with unequal variances, the mean difference is statistically significant at the 1, 5, and 10 percent levels, respectively. Consumption quantities are reported as purchased, including the edible portion (e.g., fish filet) and non-edible portion (e.g., fish head, guts, bones). The edible portion of a fish is typically 30–50 percent of its whole, uncleaned weight.

Table 3: Average market prices of animal-source food groups and top five fish species (1,000 YER per kilogram)

	Total	Coastal	Inland	t-test	Coastal rural	Coastal urban	t-test	Inland rural	Inland urban	t-test
Fresh fish	4.3	2.6	5.7	***	2.2	3.0	***	5.3	6.1	***
Kawakawa	3.2	2.4	4.7	***	2.2	2.9	***	4.3	5.1	***
Sardines	1.9	1.6	2.3	***	1.5	1.6		2.2	2.4	
Yellowfin tuna	8.0	6.7	8.4	***	5.5	7.4	***	8.6	8.2	**
Longtail tuna	5.6	3.8	5.9	***	3.6	3.9		6.2	5.8	
Trevally	4.5	2.5	7.3	***	2.3	3.1		8.2	6.7	*
Preserved fish	8.3	7.9	8.4		7.6	8.5		8.7	8.1	***
Meat	4.9	4.7	5.0	**	4.8	4.7		4.9	5.1	
Eggs	4.0	4.0	4.0		4.0	4.0		4.0	4.0	***
Dairy	4.3	4.9	3.9	***	3.9	5.6	***	4.2	3.6	***

Note: ***, **, * According to a *t*-test for unpaired data with unequal variances, the mean difference is statistically significant at the 1, 5, and 10 percent levels, respectively.

These consumption patterns for animal-source foods and fish in particular point to distinct differences in households' physical and economic access to individual food groups and fish species, which is reflected in regional price differences (Table 3).¹ At the time of the survey, fresh fish overall and each of the top five fish species consumed were much more expensive in inland than coastal areas; there were no statistically significant differences between coastal and inland prices for preserved fish and eggs; meat price differences were small; and dairy prices were lower in inland than coastal areas. Across all

¹ At the time of data collection for all project studies (October 2025–January 2026), the market exchange rate was held steady at 1,616 Yemeni rial (YER) per US dollar.

areas, sardines were the cheapest fresh fish, followed by kawakawa, while yellowfin tuna was the most expensive fresh fish, followed by longtail tuna. Sardines were also by far the cheapest animal-source food overall, and yellowfin tuna was clearly the most expensive fresh animal-source food. Sardine price differences between coastal rural and urban areas and between inland rural and urban areas were small and statistically insignificant. In coastal areas, the top five fish species consumed during the survey month were cheaper in rural than urban areas, but the price difference was statistically significant only for kawakawa and yellowfin tuna. In inland areas, kawakawa was significantly cheaper in rural than urban areas, and yellowfin tuna was significantly cheaper in urban than rural areas. Longtail tuna was also cheaper in inland urban than inland rural areas, although the price difference was statistically insignificant. Lower prices for tuna species in inland urban areas (which were still considerably higher than in coastal urban areas), together with higher average consumption quantities in inland urban areas (and lower average consumption in coastal urban areas), indicate that the main markets for these higher-value fish species are relatively far away from the landing sites, and profit margins may be higher.

Actor Interviews: Understanding Ice Use in Fisheries Value Chains

Fresh fish is highly perishable. If left at outside temperatures or stored improperly, it quickly loses taste, texture, and nutritional value and can spoil through rapid bacteria growth. Cooking cannot destroy the bacterial toxins, and consuming spoiled fish can thus cause serious food poisoning. To ensure quality and safety of fresh fish from catch to consumption, an uninterrupted cold chain across all links of the fisheries value chains is essential, especially in warm weather and with longer times between fish harvest and consumption. In Yemen, fresh fish is usually chilled and kept chilled by storing it on crushed block ice or flake ice. The findings of our scoping review, however, suggest very low rates of ice use on artisanal fishing vessels and among retailers in local, open-air fish markets, when displaying fish in market stands. The lack of ice use in these first and last links of the value chain of fresh fish for local household consumption was thought to reduce the quality of the fish sold, and thus mean forgone earnings from price premiums for fishers and retailers, as well as high rates of loss and waste for this highly nutritious animal-source food. The lack of ice use had been attributed to dysfunctional ice plants or insufficient ice-making capacity during periods of peak demand at some landing sites; insufficient carrying capacity or space on artisanal fishing vessels; or the high price of ice produced using power from diesel generators, as electricity network outages have had been common in many places. It was also hypothesized that fishers and retailers often lack economic incentives to purchase ice, as buyers insufficiently value an uninterrupted cold chain or lack awareness of proper fish safety and the potential income-earning opportunities from sales of high-quality fish.

Our third focus study (Belton & Bahurmiz, 2026) aimed to better understand local fisheries value chains and, particularly, the use of ice at different landing sites and in the different links of the value chains, while the fourth and fifth focus studies tested the hypotheses regarding the lack of economic incentives for ice use by retailers and fishers, respectively. For the third study, we conducted 40 semi-structured, face-to-face interviews with fisheries value chain actors from Mukalla, Ash Shihr, and Qusayir in November and December 2025. Interviewees included 11 ice plant operators, 7 traders or transporters, 6 fish processors, 8 retailers, and 8 fishers, with each group including actors from all three sites. Interviewees were identified through networks of existing contacts and snowballing, with support from the General Authority of Fisheries in the Arabian Sea.

The findings of this qualitative study reveal that, overall, ice is a widely used and essential input in fisheries value chains in Hadramawt (Belton & Bahurmiz, 2026). Almost all fish transported, traded, and

retailed in surveyed markets is kept on ice to maintain its freshness. Ice production capacities have expanded in recent years, but many ice plants face serious operational challenges, including unreliable electricity supply, high fuel costs, aging equipment, and volatile demand. However, lack of available ice did not appear to be a constraint to ice use in the value chains of the study sites. Traders use large quantities of ice for transporting fresh fish in insulated trucks inland and exporting it overland to other countries on the Arabian Peninsula, and would be unable to operate their businesses without it. The most common ice-to-fish ratio is 1:1, but this may be increased to 1.25:1 or more during the summer when temperatures are higher, or for longer trips. Fish purchases account for around 90 percent of traders' operating costs, but ice is the largest non-fish cost, accounting for 3–4 percent of operating costs on average, about double the average fuel costs. Traders supplying distant markets confirmed that use of ice has a significant impact on selling price, driven by fish freshness. The fish quality is determined by the buyer, including quality control supervisors at processing and export companies, or fishmongers associations at fish markets. Instances of fish being rejected by buyers due to poor quality are rare, indicating that postharvest handling by traders and transporters is effective. Fresh fish that cannot be sold to the intended buyer for quality reasons is usually sold to processors for dried fish or to fishmeal factories.

Depending on the fish species and end-product, processors may mandate the use of ice. For example, a tuna cannery that only processes yellowfin tuna, sourced from both local landing sites and fish traders, requires the use of ice for fish deliveries, unless it is sourced from very nearby, such as the closest landing site (less than 500 meters away). Processors that produce dried shark meat for domestic consumption and dried fins for export do not require suppliers to use ice but do have quality standards for fish deliveries, and sharks usually arrive at the landing center chilled, as they are mostly caught on *sanbuqs*—larger vessels that store fish on ice during long fishing trips. Other than such specialized processors, most fish processors supply a variety of markets and buyers with differentiated standards and price points, they are usually able to accept whatever grades of fish are landed on a given day, including cheaper medium grade fish which, though not of highest quality, is still palatable and can be sold at a discounted price. Inability to access sufficient high-quality fish was generally considered problematic by only a small subset of processors and exporters who target higher-end markets exclusively. In some cases, processors supply fishers with ice and deduct the ice costs from the sales price of the fish delivered. Thus, processors' fish quality (or ice use) requirements and the selling price offered influence the use of ice by fishers that cater to them.

Retailers in local fish markets use ice strategically. All markets surveyed were open air and adjacent to or within a short distance of fish landing centers, and most fish sold was sourced from fish auctions supplied by local fishers. Common practice is to display small quantities of uniced fish to shoppers—on the basis of perceived consumer preferences—and replenish the displays throughout the day with chilled fish from cool boxes with ice or freezers placed outside of customers' view (Figure 2). When left with small quantities of fish at the end of the day, retailers usually prefer to reduce the price to clear, but larger quantities of fish or larger or more valuable fish such as yellowfin tuna are retained overnight in cool boxes or freezers and sold the following morning. The price of fish sold after overnight storage depends on its quality and the supply in the market the following day, but it is usually sold at the same or slightly lower price than same-day catch. If the fish retained overnight was already cut into pieces, flesh that has become discolored due to oxidization is removed prior to sale. These practices mean that retailers experience only limited loss or waste of fish. Total daily expenses for ice are kept low, accounting for about 3 percent of retailers' daily operating costs, on average.

Figure 2: Fish market in Hadramawt



The use of ice by artisanal fishers varies by the type and size of boats, duration of fishing trips, targeted species, and buyers' requirements for fish deliveries. Yemen's artisanal fishing fleet consists primarily of two boat types: *houris* and *sanbuqs*. *Houris* are by far the most common type. They are small boats (typically 4–12 m in length) and are used for daily, inshore fishing trips lasting a few hours (usually less than 12 hours). *Sanbuqs* are larger vessels (generally 10–25 m in length) and are used for multi-day offshore trips (lasting mostly 10–20 days). All *sanbuqs* depend on ice, and almost all *sanbuqs* along Yemen's Gulf of Aden coast land their catches in Hadramawt (Apex & AAMS, 2025). Ice use on *houris* is less common and selective. For example, fishers use ice when targeting high-value demersal species, which deteriorate quickly without ice, but rarely when fishing for pelagic fish. They never use ice when targeting cuttlefish, which becomes paler and absorbs water when stored on ice, possibly causing buyers to pay a lower price. Some may use ice to preserve bait for fishing traps, but not for chilling the harvested fish itself. Generally, *houris* fishers' profits are low and they are often at risk of loss. Purchasing even small quantities of ice can diminish their profits significantly.

Overall, the findings of this qualitative study suggest that actors in all links of the fisheries value chains in our study sites adopted cost minimization—rather than profit maximization—strategies in postharvest handling of fish in view of current market conditions. Particularly fishers and market retailers, who operate on tight profit margins and are faced with limited marketing opportunities due to low demand for high-quality fresh fish and collapse of export markets, take measures to minimize physical loss and waste to the degree needed to meet the bulk of the fish demand that arises from local consumers and for medium-grade fish. However, while less risky, cost minimization strategies also imply forgone income opportunities from quality-led value addition. Profit maximization strategies based on quality-led value addition would require more and uninterrupted use of ice throughout fisheries value chains and beneficial consumer demand. Moreover, energy availability and costs and poor infrastructure are the main constraints to artisanal fisheries value chain development across all links.

Experimental Auctions: Consumers’ Willingness to Pay for Ice Use

Retailers’ economic incentive to display fish on ice for sale is determined by consumers’ willingness to pay (WTP) for fish sold on ice. The fourth focus study (Jovanovic et al., 2026b) used incentive-compatible auction methods to measure consumers’ WTP for fish displayed on ice versus fish that is not. The experimental auctions were conducted with 426 study participants in the fish markets of Mukalla and Qusayir in January 2026. The target participants were market shoppers for fresh fish for own-household consumption. We recruited participants daily on the spot and implemented the auctions during peak market hours in the mornings. The auctions took place in the open-air market halls of Mukalla and Qusayir, each at the stand of an established retailer, who was recruited during the study period. We used striped bonito—a commonly consumed, mid-price fish species that was in peak season at the time of the study—and sourced freshly caught fish of equal size and normal appearance from artisanal fishers at nearby landing sites every morning before market opening. A small, equal number of fish was displayed on the cleaned market stand in two ways: (1) placed on ice in clean and drained containers and (2) on the stand’s tile surface without ice, as fish is commonly presented to customers in these markets.

Before the start of the experiments, participants received a fixed cash amount sufficient to remove any potential liquidity constraint to participation and eliminate a potential bias of their auction bids. We carried out the auctions with one participant at a time, whom we asked to place two separate bids—one for a fish on ice and one for a fish not on ice. Then, the participant drew a slip of paper that specified a random combination of fish price and display type from an envelope. The slips had price points that varied in increments of 100 YER within a range of about 25 percent around the daily market price of striped bonito. If the participant’s bid for the display was equal or higher than the price on the drawn paper slip, the participant would purchase the fish from this display at this price. If the bid was below the drawn price, the participant was not able to purchase the fish. Immediately after the auction, we surveyed the participants’ household characteristics, factors influencing their auction bids, and general perceptions about the use of ice by retailers in fish markets.

The experimental auctions revealed that consumers’ average WTP for fish sold on ice is statistically significantly higher in our total sample (Table 4). This result is driven by significant differences in the WTP of consumers in Mukalla, while the estimated mean difference in Qusayir is statistically insignificant from zero (Jovanovic et al., 2026). Yet even in Mukalla, the estimated mean difference (166 YER) is relatively small—equivalent to about 4 percent of the market price of the fish. To put this estimate into perspective, a retailer in Mukalla would have to sell more than 30 fish on ice just to recoup the costs of a standard-size bag of ice (40–50 kg) before making any profit from offering fish on ice.

Table 4: Average willingness to pay (WTP) for fresh fish on ice and not on ice (YER per fish)

	Total	Mukalla	Qusayir
WTP for fish on ice	4,227 (1,061)	4,403 (1,220)	4,060 (855)
WTP for fish not on ice	4,149 (1,024)	4,237 (1,216)	4,065 (795)
<i>Difference</i>	78 **	166 ***	–5

Note: The total sample includes 421 participants, with 205 participants in Mukalla and 216 participants from Qusayir. Five participants, who stated zero WTP for both fish on ice and not on ice, were dropped from the sample. Standard deviations are reported in parenthesis.

***, ** According to a *t*-test for unpaired data with unequal variances, the mean difference is statistically significant at the 1 and 5 percent levels, respectively.

The survey data provide important insights that help explain the findings of our experimental auctions. Regression analysis of the association between participants' WTP and the self-reported factors influencing their auction bids showed that visual indicators of fish freshness—such as bright skin, firm flesh, and bright and bulging eyes—positively and statistically significantly influence WTP for both fish on ice and not on ice (Jovanovic et al., 2026). The estimated effects of these factors are somewhat larger for participants' WTP for fish on ice than their WTP for fish not on ice. These findings suggest that consumers in Hadramawt's fish markets pay close attention to signs of fish freshness and base their quality valuation primarily on those indicators rather than how fish is displayed, but the association of the amount that consumers are willing to pay with observed freshness is stronger when fish is sold on ice. Participants' general perceptions about the use of ice in fish markets reveal interesting insights that help explain these findings. At least 60 percent of the participants in both Mukalla and Qusayir disagreed with statements that fish sold on ice is usually less fresh, less safe, older, and has worse organoleptic characteristics than fish that is not sold on ice. However, at least 30 percent of the participants agreed with the first three statements. The responses to the four statements are very closely correlated as expected, and the response rates are similar in Mukalla and Qusayir.

Table 5: Average willingness to pay for fresh fish on ice and not on ice (YER per fish) by participants' perception about ice use

	Total	Mukalla	Qusayir
Participants who <u>agree</u> that fish sold on ice is less fresh than fish not sold on ice	32%	31%	33%
WTP for fish on ice	3,872 (1,082)	4,147 (1,325)	3,627 (735)
WTP for fish not on ice	4,258 (1,095)	4,104 (1,441)	4,394 (632)
<i>Difference</i>	-387 ***	43	-768 ***
Participants who <u>disagree</u> that fish sold on ice is less fresh than fish not sold on ice	61%	62%	61%
WTP for fish on ice	4,425 (974)	4,522 (1,131)	4,332 (786)
WTP for fish not on ice	4,132 (941)	4,315 (1,051)	3,954 (785)
<i>Difference</i>	294 ***	207 ***	378 ***

Note: The total sample includes 134 participants who agreed with the statement and 258 participants who disagreed; the Mukalla subsample includes 63 participants who agreed and 127 participants who disagreed; and the Qusayir subsample includes 71 participants who agreed and 131 participants who disagreed. Participants who stated zero willingness to pay (WTP) for both fish on ice and not on ice were dropped from the samples. Standard deviations are reported in parenthesis.

*** According to a *t*-test for unpaired data with unequal variances, the mean difference is statistically significant at the 1 percent level.

Even though, by design, the fish on ice and not on ice were equally fresh in our experiments, and participants were allowed to visually inspect the fish, further analysis indicates that participants' perceptions about common ice use practices strongly affected their WTP for fish on ice and not on ice (Table 5). In Qusayir, participants who agreed that fish sold on ice is usually less fresh than fish not sold on ice had a much lower WTP for fish on ice than for fish not on ice, and conversely, participants who disagreed with that statement had a much higher WTP for fish on ice. The estimated mean differences for both participant groups are large but cancel each other out when the groups are pooled and analyzed together. The mean differences are much larger in Qusayir than Mukalla, where only participants who disagreed with the statement showed statistically significantly higher WTP for fish on ice than not on ice. These findings suggest that consumers, particularly in small fisheries communities like in Qusayir,

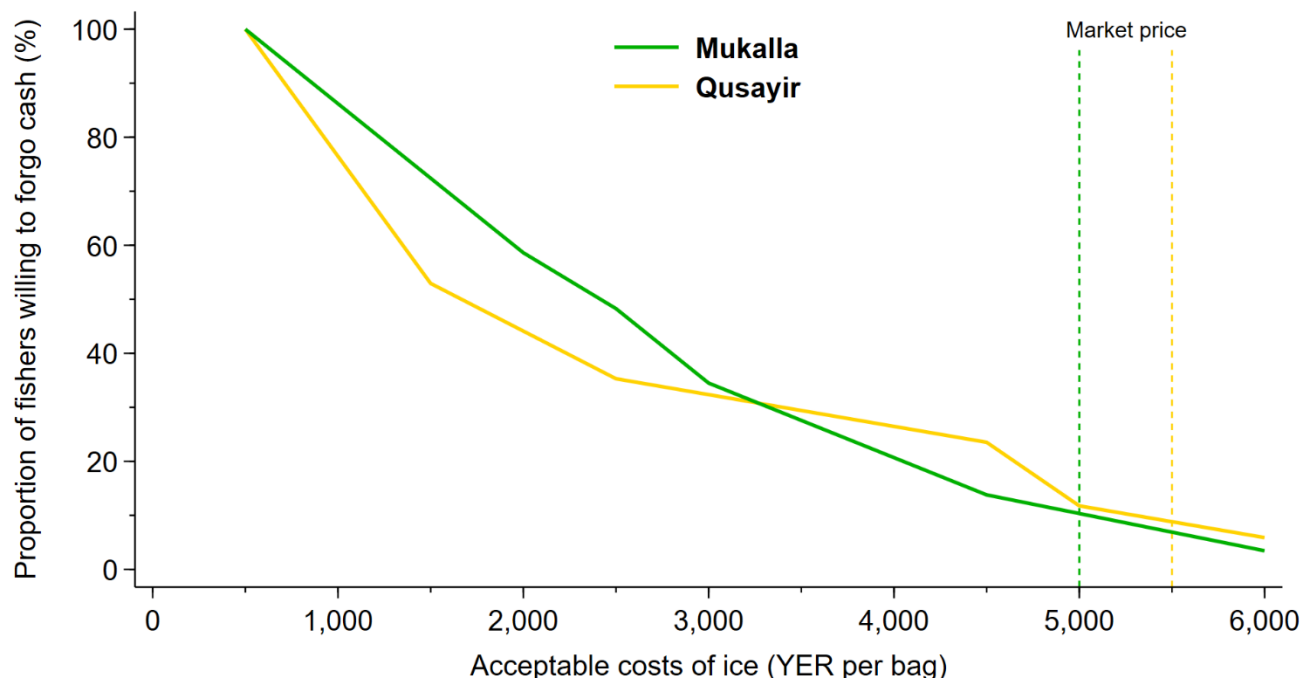
are aware of retailers' strategic use of ice, which is often limited to extending the shelf life of older fish, and therefore have strong reservations about purchasing fish sold on ice. Moreover, retailers' potential dishonesty about fish freshness or lack of operational transparency leads market shoppers to rely even more on their own observations, past experience, and second-hand information on quality signals in their purchase decisions. Conversely, consumers who have no negative perceptions about the use of ice and look for well-known signs of fish freshness are also willing to pay higher prices for chilled fish than non-chilled fish.

Choice Exercises: Artisanal Fishers' Valuation of Ice Use

The fifth focus study (Darwish et al., 2026) examined the valuation of ice use by artisanal fishers during their daily fishing trips and factors influencing their decisions. We implemented the study in Mukalla and Qusayir in January 2026 in conjunction with the consumers' WTP study. Study participants were recruited from lists of artisanal fishers associated with the local fishers associations. Using random sampling, we selected participants who operate small *houri* boats (generally less than 10 m in length) and primarily target fish species that are commonly consumed in Hadramawt (specifically smaller species of the large pelagic fish caught with lines, such as kawakawa, striped bonito, and longtail tuna). The total sample of 129 artisanal fishers included 65 from Mukalla and 64 from Qusayir. After completing a short survey on fishing assets, practices, and other operational characteristics, each fisher responded to a series of choices designed to elicit his valuation of a standard bag of ice (40–50 kg), containing enough ice for a daily fishing trip. Fishers made 13 binary choices between receiving a bag of ice or a cash amount ranging from 0 to 6,000 YER, which increased by increments of 500 YER across the choice options. For each choice, fishers' preference was recorded. The cash amount option above which a fisher switched to preferring cash over ice marked the maximum cash amount the fisher was willing to forgo in exchange for a bag of ice. The switching points of all participants represent the highest revealed values of ice—that is, acceptable ice costs—for the fishers. Last, each fisher randomly drew 1 of the 13 options and received a voucher for an ice bag (redeemable for next day's fishing trip) or the cash amount recorded on the drawn paper slip.

The participant survey confirms the findings from the qualitative value chain actor study on very low use of ice by artisanal fishers in Mukalla and Qusayir. Only 2 percent of the participating fishers reported always using ice during their fishing trips, but 53 percent indicated their general willingness to adopt the use of ice (Darwish et al., 2026). At the same time, the fishers reported that they would consider forgoing ice use for a cash payment of any positive amount considered in the choice exercises, with the minimum amount being 500 YER. This finding points to severe cash constraints and small expected profit margins as the main causes of low ice use. A bag of ice was selling at an average price of 5,000 YER in Mukalla and 5,500 YER in Qusayir at the time of data collection. The choice exercises revealed that the acceptable costs per bag of ice to fishers who stated a positive (non-zero) value amounted to 2,200 YER on average—less than half of the market prices in both locations. Only 3 percent of fishers reported that they would purchase ice at current market prices. Yet, fishers' willingness to adopt ice use is price-sensitive, as estimated ice valuation curves show (Figure 3). The proportion of fishers who were willing to forgo cash in exchange for ice in the choice exercises declined significantly with increasing costs for ice. Thus, ice price reductions could increase ice use, but for significant use increases, substantial price reductions are needed. For example, reducing the price of ice by 50 percent would induce about half of the fishers in Mukalla to use ice—an increase of about 40 percentage points over the current rate.

Figure 3: Artisanal fishers' ice valuation curves



Note: YER = Yemeni rials.

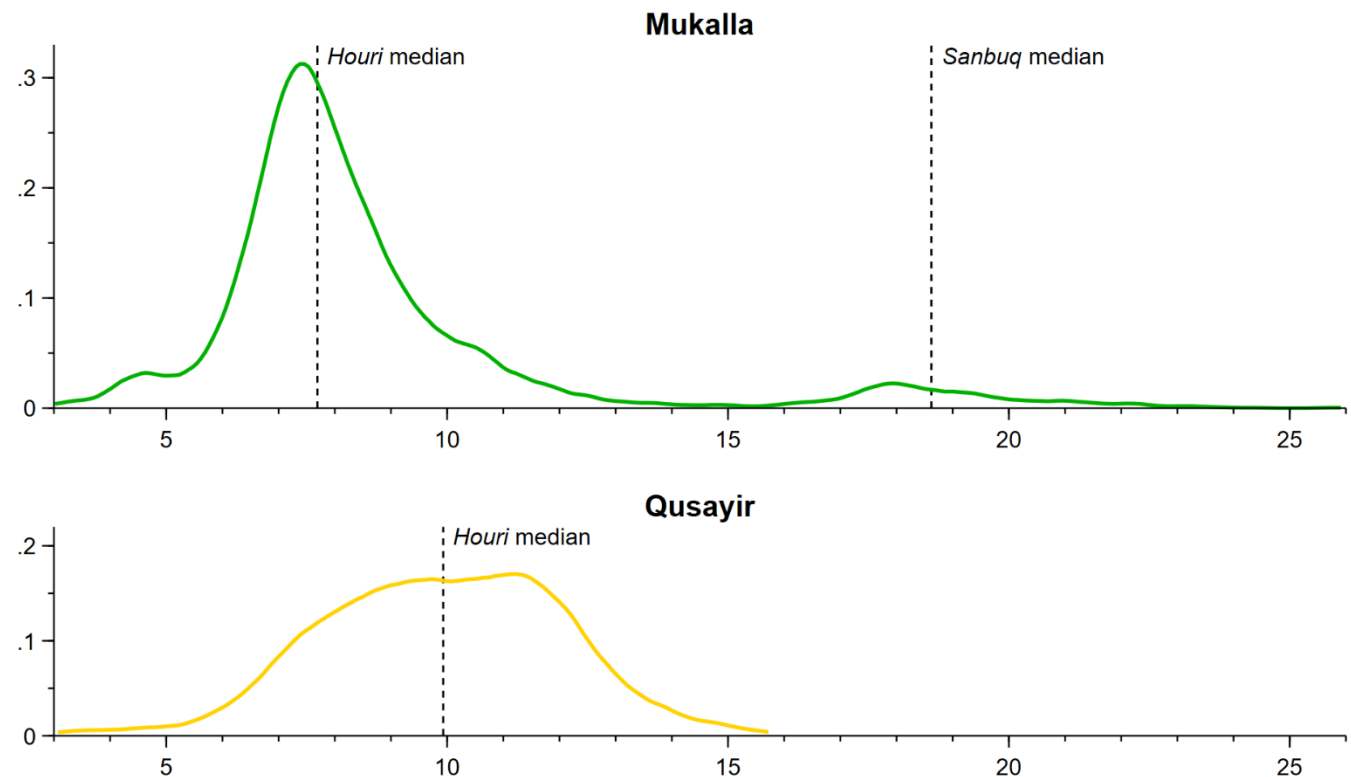
Additional analysis of the collected data shows that potential profit margins associated with the use of ice vary by fish species (Darwish et al., 2026). Estimated price premiums are modest for the most commonly targeted and locally consumed species such as kawakawa and longtail tuna. Accordingly, the economic incentives to use ice are low or even close to nil for most artisanal fishers, especially as many often operate at the edge of loss. Overall, more fishers expressed willingness to adopt the use of ice in Mukalla (65 percent) than Qusayir (41 percent). This difference is consistent with different market and infrastructural conditions in these two locations. Mukalla's fishing industry offers more diverse marketing opportunities for fresh fish, including fish processors that require high-quality fish and ice use; the city's fish consumers show higher willingness to pay for iced fish; and its ice plants sell standard ice bags at lower prices. Furthermore, regression analysis shows strong positive associations between the ownership of cool boxes and both willingness to use ice and valuation of ice use. Fishers who own a cool box are about 20 percentage points more willing to use ice than fishers who do not own a cool box, and cool box owners indicate higher acceptable ice costs than non-owners, by about 1,400 YER, on average—which is somewhat more than one-fourth of current market prices. This finding emphasizes the importance of such key productive assets for enabling cash-constrained artisanal fishers to access the benefits of ice use.

Remote Sensing Models: Measuring Artisanal Fishing Activities

The sixth focus study (Ecker et al., 2026) piloted an innovative methodology for measuring widespread artisanal fishing activities at high frequency, using machine learning and satellite imagery. We adapted deep-learning remote sensing models to detect small fishing vessels at landing sites and applied them to very high resolution (VHR) satellite imagery of selected landing sites in Hadramawt for testing and analysis purposes. Compared with traditional survey methods, the proposed methodology offers a low-cost approach for frequent collection of data on artisanal fishing boats over a large geographic area,

which makes it useful for application in national fishing monitoring and information systems. We tested three different variants of the You Look Only Once Version 11 (YOLO11) model series for small object detection and used the best performing variant to estimate the size of the operational artisanal fishing fleets of Mukalla and Qusayir, classify artisanal individual fishing vessels by boat type, determine the composition of the fleets by boat type and length class, and approximate fleets' fish-catch capacities. To validate the modeling results, we compared our estimates of boat counts and dimensions with results from the recent landing site survey by Apex Consulting and Advance Africa Management Services (Apex & AAMS, 2025). We also used the survey results as benchmarks for our vessel classification and catch capacity approximation.

Figure 4: Kernel density of estimated boat length (meters)



Note: The distribution of Mukalla's artisanal fishing fleet is based on boat length averages derived from four satellite images during the annual fishing seasons in November 2021, October 2022, May 2023, and April 2024. The boat length distribution of Qusayir's fleet is based on measurements derived from a satellite image from April 2023.

Our study results demonstrate that deep-learning remote sensing based on VHR satellite imagery can accurately detect small artisanal fishing boats (Ecker et al., 2026). The YOLO11 Oriented Bounding Boxes (OBB) model performed best, with an overall accuracy of 97 percent based on images from Mukalla. The OBB model was also the best model variant for measuring boat dimensions and identifying boat types in our study context. According to the model estimates, Mukalla's fleet averaged 800 operational boats between November 2021 and April 2024, most of which were *houris*, while *sanbuqs* accounted for 7 percent. Qusayir's fleet numbered 450 boats in April 2023, all of which were identified as *houris*. This finding is consistent with field observations, as the Qusayir's landing site lacks port structures needed for harboring *sanbuqs*. In Qusayir, 88 percent of the detected operational boats were

beached during the day, as is typical at rural beach landing sites, where small boats are generally pulled out of the water after each fishing trip, in the early morning hours. In Mukalla, around 24 percent of *houris* were found on shore, concentrated in distinct beach landing spots of the city's large port area.

The composition of Mukalla's artisanal fishing fleet by boat type and length was quite stable over the four-year observation period of this study (insufficient high-quality VHR satellite images were available for Qusayir for this pilot study). *Houris* were on average longer in Qusayir than in Mukalla, at estimated average lengths of about 10 m and 8 m, respectively (Figure 4). The range of estimated boat lengths for the Qusayir fleet was wider than that of Mukalla's fleet (although measurements may have been less accurate in Qusayir than Mukalla). The composition of the combined Mukalla and Qusayir fleets by boat type and length class was similar to the composition of Hadramawt's entire fleet, as found by the landing site survey. Fish-catch capacity estimates suggest that *houris* boats in Mukalla and Qusayir generally have sufficient hold capacity, such that capacity is not a constraint to increasing productivity of fishing trips or carrying ice for chilling fish. Consistent with this finding, most fishers interviewed in the landing site survey reported that their boats' hold capacity was sufficient for their operations (Apex & AAMS, 2025). Sufficient fish-catch capacities can also explain the observed constancy of Mukalla's fleet composition during the study period, as the limited available fish resources and other constraints on artisanal fisheries made boat upgrades economically unreasonable.

Conclusions and Policy Implications

Artisanal fisheries are crucial to support post-conflict economic recovery and food security and to contribute to resilient coastal livelihoods in Yemen's southern governorates. There is an urgent need for an effective strategy and sound policies to sustainably develop the fisheries sector in Southern Yemen for optimal long-term use of the Gulf of Aden's fish wealth to the benefit of the Yemeni people and the poor in particular. This will require striking a balance between increasing fisheries productivity and protecting natural fish resources from overuse. Artisanal fisheries must play a central role in any fisheries sector strategy, as they account for the vast majority of fish harvested from Yemeni waters and landed in Yemen. Yet strategic development planning and policymaking by the fisheries sector authorities and assistance programming of international development partners have been challenged by enormous data and knowledge gaps. With financial support from BMZ and GIZ, IFPRI's research and knowledge exchange project on Sustainable Fisheries Development and Resilient Coastal Livelihoods in Southern Yemen is a first step to address some of the key gaps.

To understand the informational needs of policymakers and other stakeholders of artisanal fisheries in Southern Yemen, we conducted a comprehensive scoping review, including expert elicitation interviews. Three research priority areas were identified. These related to the domestic and local demand for fresh fish and implications for people's food security and nutrition; the use of ice in fisheries value chains—particularly by artisanal fishers and retailers in consumer markets—to maintain fish quality and safety; and low-cost, high-frequency data collection methods to measure and track artisanal fishing activities for potential use in a national fishing monitoring and information system. We then conducted six focus studies to address these interrelated research issues, using the methods and data most pertinent to each issue. A set of policy recommendations emerges from the study findings.

Improving household access to fish and promoting fish consumption is essential for enhancing food and nutrition security in Southern Yemen. Analyses of DIEM survey data (Dey et al., 2026) and our Hadramawt household consumption survey data (Jovanovic et al., 2026a) showed that fish is

an important part of Yemeni diets. Fish is a highly nutritious food, rich in high-quality protein, polyunsaturated fatty acids, and essential vitamins and trace minerals. Fish consumption is thus particularly important for children's physical and cognitive development and reducing nutritional deficiencies—especially in rural areas, where it is often difficult to obtain enough essential nutrients from a varied diet. Fish is the second most commonly consumed animal-source food across Yemen, after dairy, and the most consumed animal-source food in several southern governorates, including Hadramawt. Fish consumption is most common in coastal areas but is also frequent in inland areas. Fishing households, who have more direct access to fish, reported more frequent consumption of all animal-source foods, greater dietary diversity, and lower risks of moderate and severe food insecurity than non-fishing households (after accounting for other consumption factors, including household income).

Fish retail markets in inland areas and fish auctions in coastal areas should be better integrated for improved consumer access to a diversity of fresh fish at different price points, and for fishers and fish traders to fully benefit from domestic market potential. Our Hadramawt household consumption survey (Jovanovic et al., 2026a) also revealed distinct differences between the species of fresh fish consumed in coastal and inland areas. Medium-size pelagic fish, particularly kawakawa, and small pelagic fish, particularly sardines, were the most consumed fish in coastal areas at the time of data collection. In inland areas, large pelagic fish, particularly yellowfin tuna, were the most consumed fish. Rural–urban differences in fish consumption were more pronounced in inland than coastal areas. Most fresh fish consumed in inland urban areas were yellowfin and longtail tuna, while sardines were most commonly consumed in inland rural areas. Yellowfin and longtail tuna consumption was also higher in coastal urban than coastal rural areas. Consumption of preserved fish was much higher in inland than coastal areas, and especially high in inland rural areas. These fish consumption patterns can be explained to a large extent by regional differences in market access and fish prices, with more affluent households, who can afford high-priced fish, living primarily in urban areas. The prices of the top five fresh fish species consumed were significantly higher in inland than coastal areas, while the price difference for preserved fish was statistically insignificant. Sardines were clearly the cheapest fish, and yellowfin tuna the most expensive. Kawakawa—a lower-medium-priced fish—was almost twice as expensive in inland areas compared with coastal areas. Rural–urban price differences within coastal and within inland areas were statistically insignificant for sardines, while kawakawa prices were lower in rural than urban areas in both geographies. Yellowfin tuna, however, was cheaper in inland urban than inland rural areas, but more expensive in coastal urban than coastal rural areas. Thus, infrastructure investments and institutional measures to better connect inland retail markets to coastal sale markets and reduce costs for fish transport and chilling are likely to lower fish prices in inland areas and improve fish access for many food-insecure households. They may also enable fishers and fish traders to better cater to a diversified consumer demand and thus better exploit domestic market potential.

Ice for chilling fish is widely used in artisanal fisheries value chains, but it is employed strategically among fishers using hours and retailers in local fish markets; reducing the high production costs of ice could increase ice use. Our fisheries value chain actor interviews (Belton & Bahurmiz, 2026) revealed that, contrary to some beliefs, ice use is common in all links of artisanal fish value chains in Hadramawt. However, because it is relatively expensive, value chain actors use ice only when needed or required and its use is seen as profitable. Traders use large amounts of ice and rely on it for transporting fresh fish to distant markets, applying an ice-to-fish ratio of 1:1 or higher, depending on outside temperatures and trip duration. Ice expenses account for the largest non-fish share of traders' total operating costs, amounting to 3–4 percent—about double their fuel costs, on average. Retailers

typically display fish to shoppers without ice, as fish sold on ice may be perceived as less fresh. Retailers display only a limited quantity of fish and replenish their market stands as needed with chilled fish from cool boxes with ice or freezers that are outside of customers' view. Fish that is not sold on the same day is stored in cool boxes or freezers overnight and sold the next morning—sometimes at a slightly lower price. Retailers spend on average about 3 percent of their daily operating budget on ice. Artisanal fishers' decision to use ice depends on operational characteristics, targeted fish species, and fish buyers' requirements. Some fish buyers, such as tuna canneries and other specialized processors of high-value fish, mandate the use of ice for fish deliveries. Multi-day fishing trips on larger *sanbuq* boats depend on ice to maintain fish freshness until offload. Fishing trips on smaller *houris* boats usually last only a few hours, and ice use among these fishers is far less common. Yet there are some notable exceptions. For example, fishers use ice when targeting high-value demersal species, though rarely when fishing for pelagic fish. For fishers using *houris*, who operate on tight profit margins and are often at risk of loss, purchasing even small quantities of ice can cut their profits significantly. Prices of ice are high largely as result of high energy prices for ice production, as well as low-efficiency and malfunctioning ice machines, variable ice demand, and additional transportation costs when ice plants are far away from landing sites. Ice plants are usually connected to the electrical grid but often rely on more expensive power from diesel generators because of electricity outages. Investments to restore and upgrade the electrical grid could reduce the costs of ice for fishers. Similarly, development assistance for installation of solar panels and solar-powered ice machines, as provided by GIZ for example, could also lower ice prices. Yet solar-operated ice plants usually have smaller production capacities and can have higher maintenance costs than traditional ice plants, which may limit their adoption and durability.

Current market conditions influence fishers' and retailers' measures to reduce loss and waste, especially the intensity of ice use for maintaining buyer-acceptable fish quality; interventions for improved postharvest handling need to be tailored to the local market conditions. Our interviews with fisheries value chain actors (Belton & Bahurmiz, 2026) also suggest that fishers and market retailers in particular adopted cost minimization—rather than profit maximization—strategies in postharvest handling, as they operate on tight profit margins and are faced with limited marketing opportunities due to low demand for high-quality fresh fish and collapse of export markets. A common approach is to minimize physical loss and waste to the degree needed to meet the bulk of the fish demand that arises from local consumers for medium-grade fish. For example, when left with large quantities of fish or larger and more valuable fish at the end of the day, retailers chill the fish overnight for sale the next day at the same or slightly lower price than same-day catch. If the fish retained overnight was already cut into pieces, flesh that has become discolored due to oxidization is removed prior to sale. Such cost minimization strategies also imply forgone income opportunities from quality-led value addition, but profit maximization strategies based on quality-led value addition are riskier. They require an uninterrupted cold chain and higher ice use intensity in each value chain link, as well as beneficial consumer demand. Moreover, market conditions can substantially vary between locations. For example, in fishing industry hubs like Mukalla, there are various fish marketing options, and buyers with diverse quality standards are usually able to accept whatever grades of fish are available on a given day, with fishmeal factories being the last resort. In more remote fisheries nodes like Qusayir, however, fishers' options to market their catch are more limited and geared primarily toward local consumption. Interventions for improved postharvest handling need to be tailored to the local market conditions to be effective and need to factor in differences in value chain actors' operational knowledge and factors influencing their economic decisions.

Consumers' willingness to pay for retailers' use of ice to maintain fish freshness is generally low, and retailers' small price premiums for fish sold on ice are at odds with high costs for ice; increasing ice use requires reducing ice costs and stimulating demand for fish on ice. Our experimental auctions (Jovanovic et al., 2026) revealed that only shoppers in Mukalla's fish market were willing to pay a statistically significantly higher price for fish that was displayed on ice compared to fish that was not, while we did not find a significant difference between the two fish displays in Qusayir's fish market. In Mukalla, the WTP for fish on ice was on average only 166 YER higher than the WTP for fish not on ice, equivalent to about 4 percent of the total price. This price premium barely exceeded the cost of ice needed to keep the fish on display chilled and required retailers to sell sizable amounts of fish just to recoup the cost of a standard bag of ice. Thus, fish retailers were economically rational in displaying fish without ice and seemed to be well aware of consumers' fish purchasing preferences. Yet maintaining an uninterrupted cold chain up to the point of sale, or even up to food preparation, is important for fish freshness and thus food quality and safety. There are several potential leverage points for interventions to increase ice use. Reducing the costs of ice would increase the economic incentives for fish retailers—and for other fisheries value chain actors—to place fish for sale on ice. Additional leverage points exist on the demand side. For example, raising consumer awareness about the benefits of ice use through public awareness campaigns on fish quality and safety is one option. Other options involve working with retailers in fish markets and supporting them to gradually introduce regular use of ice in fresh fish displays and stimulate consumer demand for fish sold on ice through customer communications. Additionally, retailers could offer buyers of fish sold on ice a free scoop of ice to keep the fish chilled on their way home. To avoid reinforcing potential negative perceptions of consumers, fish sold on ice must be at least equally fresh as fish not sold on ice.

Most consumers have positive perceptions about the use of ice for chilling fish at sale, but a considerable share of market shoppers question the quality and safety of fish sold on ice; fish retailers should reconsider their established practices of ice use. Our fish shopper surveys complementing the experimental auctions (Jovanovic et al., 2026) showed that fish prices were by far the main factor shaping consumers' purchasing decisions, but visual indicators of fish freshness and appearance of fish displays also influence their valuation of the fish offered and their purchases. At least 60 percent of the interviewed shoppers in the Mukalla and Qusayir fish markets disagreed with beliefs that generally fish sold on ice is less fresh, less safe, older, and has worse organoleptic characteristics than fish that is not sold on ice. However, around 30 percent still agreed with at least one of these statements, with slightly higher proportions in Qusayir than Mukalla. Regression analysis confirmed that market shoppers' WTP is positively associated with visual indicators of fish freshness, such as bright skin, firm flesh, and bright and bulging eyes. The estimated associations are similar for fish sold on ice and not sold on ice, but somewhat stronger for fish sold on ice. This finding suggests that shoppers pay close attention to signs of fish freshness regardless of how fish is presented, but particularly when fish is placed on ice.

Small-scale fishers using houris place low value on ice use because of its high costs and the small expected profit margins in local consumer markets; yet there is a widespread willingness to adopt ice use, if profitable. Our ice valuation exercises with artisanal fishers in Mukalla and Qusayir (Darwish et al., 2026) revealed that fishers on small *houris* boats who undertook daily fishing trips of a few hours and targeted species for local consumption placed a low value on ice use for chilling fish during their trips. Fishers' average acceptable costs for a bag of ice were less than half of the current market prices in both locations. However, their willingness to use ice significantly increases

with declining costs for ice, with somewhat more favorable perceived value–cost ratios in Mukalla. Reducing the price of ice by 50 percent, for example, would lead to half of the fishers in Mukalla using ice—an increase of about of 40 percentage points over the current rate. Thus, artisanal fishers in Hadramawt are economically rational in forgoing ice use under current market conditions and are responsive to price signals. Reducing the cost of ice (and other production costs) is essential for implementing the cold chain in Yemen’s artisanal fisheries immediately at harvest, to improve fish quality and safety in later value chain links.

Interventions providing productive assets such as cool boxes can facilitate ice use adoption among ordinary artisanal fishers; specialization may be a viable strategy for some fishers. Regression analysis based on survey data collected along with the ice valuation exercises (Darwish et al., 2026) showed strong positive associations between both fishers’ willingness to use ice and valuation of ice use and the ownership of cool boxes. Additional survey data analysis revealed that potential gains from ice use vary substantially by fish species and fisheries infrastructure at landing sites. Fishers are more willing to use ice when targeting higher-value fish and when ice plants are located near landing sites, meaning there are no transportation costs for ice delivery. Thus, development assistance programs that distribute cool boxes to artisanal fishers and invest in rehabilitation and upgrading of fish landing sites—such as done by BMZ and GIZ and other international organizations—likely contribute to more widespread ice use.

Restoring and expanding domestic and export markets should be a main pillar of any fisheries development strategy. Overall, our studies suggest that suboptimal ice use and lack of superior fish quality in the artisanal fisheries sector is driven by limited demand and lack of adequate remuneration. Widespread poverty and low household purchasing power in coastal communities mean that local fish markets are often too thin and lack enough high-grade fish buyers to create the economic incentives fishers and retailers need to widely establish an uninterrupted cold chain and cater to high-price market segments. Since the onset of the recent conflict, supply routes to many parts of inland Yemen and export to Gulf countries have been interrupted frequently or even closed for extended periods of time, which has impacted fish production in terms of both quantity and quality. To rebuild and further develop the fisheries sector in Southern Yemen and support coastal livelihoods, greater attention should be given to fish demand and marketing issues, and efforts to restore and expand domestic and export fish markets should be prioritized.

Fishing information and monitoring systems are fundamental to effectively and sustainably develop the fisheries sector in Southern Yemen and other developing countries; satellite imagery-based machine learning models offer a low-cost option to track and analyze artisanal fishing activities and complement existing instruments for monitoring commercial fishing activities. Our pilot study showed that VHR satellite imagery-based deep-learning models can accurately detect artisanal fishing boats on Yemen’s Gulf of Aden coast. Artisanal fisheries account for the largest share of total fish production in Yemen and many other developing countries, but unlike the activities of large commercial fishing vessels using transponder-based systems, artisanal fishing activities can only be measured and monitored by observation. The remote sensing methodology proposed offers a practical approach to complement existing transponder-, survey-, and coarser satellite-imagery-based instruments for measuring and analyzing all fishing activities at high frequency. A comprehensive and up-to-date fishing information and monitoring system is urgently needed to assess the current state of fishing and understand fishing trends and dynamics associated with fish stock growth and health, climate change, and the impacts of economic and political crises. Better data on the size and composition of

local artisanal fishing fleets and their activity patterns are fundamental inputs to develop effective strategies and formulate policies for sustainable development of the fisheries sector in Southern Yemen.

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REFERENCES

Ali, A., Donnat, H., Fadhl, S., Mahmood, A., Srivastav, S., and White, E.P. 2024. Empowering Yemen's fisheries: A strategy for reform through public-private partnerships. Final Report YEM-23120. London: International Growth Centre, London School of Economics.

Apex (Apex Consulting) and AAMS (Advance Africa Management Services). 2025. Fisheries profile for the Gulf of Aden coast, Republic of Yemen. Unpublished report submitted to the World Bank.

Becker, J.K. 2025. Fisheries: A key lever for change in Yemen. Sector Network Rural Development Africa. Accessed May 30, 2026. <https://www.snrd-africa.net/fisheries-a-key-lever-for-change-in-yemen/>

Belton, B., and Bahurmiz, O. 2026. Ice use in the fisheries value chain in Hadramawt: Findings from a qualitative survey. MENA Project Note 30. Washington, DC: International Food Policy Research Institute. <https://hdl.handle.net/10568/181710>

Belton, B., Abdelhadi, A., Dey, D., Jovanovic, N., Kurdi, S., and Ecker, O. 2026. The state of fisheries in Hadramawt: Insights from a scoping review. MENA Project Note 29. Washington, DC: International Food Policy Research Institute. <https://hdl.handle.net/10568/179858>

BMZ (Federal Ministry for Economic Development, Germany). 2026. Transitional development assistance: Overcoming crises, strengthening resilience, creating new prospects. Accessed May 30, 2026. <https://www.bmz.de/en/issues/transitional-development-assistance>

- Costa, C., Donnat, H., Fadhl, S., Mahmood, A., and Wright, L.W. 2025. Yemen fisheries and climate change. Policy Brief YEM-24282. London: International Growth Centre, London School of Economics.
- Darwish, M., Bahurmiz, O., Kurdi, S., and Ecker, O. 2026. Ice valuation among artisanal fishers in Hadramawt: Findings from a field-based choice study. MENA Project Note 32. Washington, DC: International Food Policy Research Institute. <https://hdl.handle.net/10568/183197>
- Dey, D., Belton, B., Kurdi, S., and Ecker, O. 2026. Fish for food security in Yemen: Insights from the Data in Emergencies survey. MENA Project Note 28. Washington, DC: International Food Policy Research Institute. <https://hdl.handle.net/10568/179637>
- Ecker, O., Guo, Z., Li, H., and Di, L. 2026. Measuring artisanal fisheries using remote sensing: A deep-learning model piloted in Hadramawt. MENA Project Note 31. Washington, DC: International Food Policy Research Institute. <https://hdl.handle.net/10568/182787>
- FAO (Food and Agriculture Organization of the United Nations). 2026. Fisheries and aquaculture: Global production by production source. Accessed March 22, 2026. https://www.fao.org/fishery/statistics-query/en/global_production
- GFW (Global Fish Watch). 2020. Fisheries intelligence report GFW-TMT-NWIO-02-2020. https://drive.google.com/file/d/1-eB3OI-9Y68JNY9_q6bxbCwMcYiMDsV0/view. Accessed March 22, 2026.
- GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH). 2022. Transitional assistance in Yemen: Strengthening resilience and supporting vulnerable households. <https://www.giz.de/de/downloads/giz-2022-en-transitional-assistance-in-yemen.pdf>
- GIZ. 2025. Strengthening resilience and promoting rural households in Yemen. https://www.snrd-africa.net/wp-content/uploads/2025/06/SRPL_Strengthening-resilience-and-promoting-rural-households-in-Yemen.pdf
- Impact Consulting. 2022. Yemen fisheries assessment report. Unpublished report submitted to the United Nations Development Programme.
- Jovanovic, N., Darwish, M., Belton, B., and Ecker, O. 2026a. Fish consumption in Hadramawt: Insights from household survey data. MENA Project Note 33. Washington, DC: International Food Policy Research Institute. <https://hdl.handle.net/10568/183518>
- Jovanovic, N., Darwish, M., Bahurmiz, O., and Ecker, O. 2026b. Implications of ice use on consumers' willingness to pay for fresh fish: Findings from experimental auctions in Hadramawt fish markets. MENA Project Note 34. Washington, DC: International Food Policy Research Institute. <https://hdl.handle.net/10568/184951>
- Mercy Corps. 2023. Yemen market assessment: Fisheries and livestock. Unpublished report submitted to the United Nations Development Programme.
- OECD (Organisation for Economic Co-operation and Development). 2026. Promoting economic resilience in Yemen. Paris: OECD Publishing. <https://doi.org/10.1787/81ed2898-en>
- Rockström, J., Thilsted, S.H., Willett, W.C., Gordon, L.J., Herrero, M., Hicks, C.C., ..., and DeClerck, F. 2025. The EAT–Lancet Commission on healthy, sustainable, and just food systems. *The Lancet*, 406 (10512), 1625–1700. [https://doi.org/10.1016/S0140-6736\(25\)01201-2](https://doi.org/10.1016/S0140-6736(25)01201-2)
- TCC (Technical Coordination Committee; Yemen Ministry of Agriculture, Irrigation, and Fisheries). 2023. National Agriculture and Fisheries Strategy and Implementation Plan (NAFSIP) 2024-2030. Draft version, July 2023. Aden: Ministry of Agriculture, Irrigation, and Fisheries. <https://faolex.fao.org/docs/pdf/yem224350E.pdf>
- Teh, L.S., Teh, L.C., Giron-Nava, A., and Sumaila, U.R. 2024. Poverty line income and fisheries subsidies in developing country fishing communities. *npj Ocean Sustainability*, 3 (1), 14. <https://doi.org/10.1038/s44183-024-00049-7>
- World Bank. 2022. Program on Sustainable Fishery Development in Red Sea and Gulf of Aden (SFISH). Project Appraisal Document PAD255754. Washington, DC: World Bank.
- World Bank. 2022. Program on Sustainable Fishery Development in Red Sea and Gulf of Aden (SFISH). Project Appraisal Document PAD255754. Washington, DC: World Bank.

World Bank. 2025. Sustainable fisheries for Yemen's resilience. Accessed March 22, 2026.
<https://www.worldbank.org/en/news/feature/2025/11/20/sustainable-fisheries-for-yemen-s-resilience>

UNDP (United Nations Development Programme). 2025. Yemen fisheries market systems analysis report.
<https://www.undp.org/yemen/publications/yemen-fisheries-market-systems-analysis-report>

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