

Agriculture Practice

Precision fisheries: Navigating a sea of troubles with advanced analytics

Advanced analytics may help struggling fisheries thrive while simultaneously protecting endangered ocean resources.

by Philip Christiani, Julien Claes, Elin Sandnes, and Antoine Stevens



At restaurants and dinner tables around the world, seafood is often the entrée of choice. Fish, crustacean, and mollusk consumption account for about 17 percent of the world's total animal protein intake, with much of this coming from the ocean. Fish and shellfish are especially important in low-income areas where total protein intake is low and diets are less diversified.

Fishing companies—businesses that catch fish or other seafood in the wild—will play a major role in sustaining food security and supporting fishing communities. But in their quest to capture enough fish to satisfy soaring demand, they are exerting unprecedented pressure on marine and freshwater ecosystems. It now takes five times the effort (in kilowatt-hours) to catch the same amount of fish as it did in 1950, because the targeted species are now in scarce supply.¹ This shortage not only jeopardizes commercial prospects for fishing companies but also greatly threatens the ability of endangered ocean species to reproduce and maintain their numbers.

Balancing fishery interests with environmental concerns is not easy, but advanced analytics (AA)—the use of sophisticated methods to collect, process, and interpret big data—might represent an untapped solution to this problem. While fishing companies, regulators, and environmentalists now apply these tools, their use is typically limited to small-scale pilots. But we may have reached the point where advanced analytics will take off within the fishing sector. In addition to the development of new technologies that support analytics in this field, both policy makers and fishing-company leaders have an increased sense of urgency because of dwindling fish stocks. Further, people entering the fishing industry or participating in regulatory development are more tech savvy than their predecessors, giving them a greater understanding of advanced analytics and other digital tools. Even

fishermen from emerging markets can access information on these technologies—and their benefits—through a simple smartphone search.

The growth of advanced analytics could promote the development of precision fishing—the use of advanced tools and technologies to optimize fishing operations and management. If large-scale fishing companies around the world move to this model, they could decrease their annual operating costs by about \$11 billion, and customers would benefit from lower prices for fish and seafood. Precision-fishing techniques can also contribute to improved management of ocean resources, which could increase industry profits by as much as \$53 billion by 2050 while simultaneously raising the total fish biomass to at least twice the current level.²

This article attempts to paint a picture of the current situation in the fishing industry, focusing on the challenges that are making it more urgent to adapt advanced analytics and associated tools. It also discusses several of the most popular use cases that have emerged for advanced analytics, as well as others that show great potential. Finally, the article provides a practical guide to next steps for all industry stakeholders.

Trouble as deep as the ocean: The current environmental challenge

The appetite for tuna, salmon, shrimp, and other ocean creatures is nothing new. Demand has increased an average of 3.2 percent annually between 1961 and 2016—more than twice the 1.6 percent rate of population growth over the same period and higher than the 2.8 percent rise in consumption of terrestrial mammals.³ Overall, the world's fish consumption is predicted to increase by 20 percent from 2016 to 2030, driven by global population growth, the expansion of the middle

¹ Yannick Rousseau et al., "Evolution of global marine fishing fleets and the response of fished resources," *Proceedings of the National Academy of Sciences of the United States of America*, 2019, Volume 116, Number 25, pp. 12,238–43, [pnas.org](https://www.pnas.org).

² Christopher Costello et al., "Global fishery prospects under contrasting management regimes," *Proceedings of the National Academy of Sciences of the United States of America*, 2016, Volume 113, Number 18, pp. 5,125–9, [pnas.org](https://www.pnas.org).

³ *The State of World Fisheries and Aquaculture 2018: Meeting the sustainable development goals*, Food and Agriculture Organization of the United Nations, 2018, [fao.org](https://www.fao.org).

class, and greater urbanization (giving more people more access to seafood, as well as the electricity and refrigeration needed to store it). Consumers also increasingly prefer healthy food choices, and many view fish as a good alternative to red meat.

As boats across the world search for a good haul, wild-fish capture has been slowly declining. Since the mid-1990s, the amount of wild fish processed has fallen by about 0.6 percent on an annual basis, while the amount coming from aquaculture rose by 5.7 percent (Exhibit 1). (Aquaculture production comprises entities that breed, rear, and harvest all types of fish as well as other organisms that live in water.) The value of fish coming from aquaculture now tops \$250 billion annually, compared with about \$170 billion for wild catches.

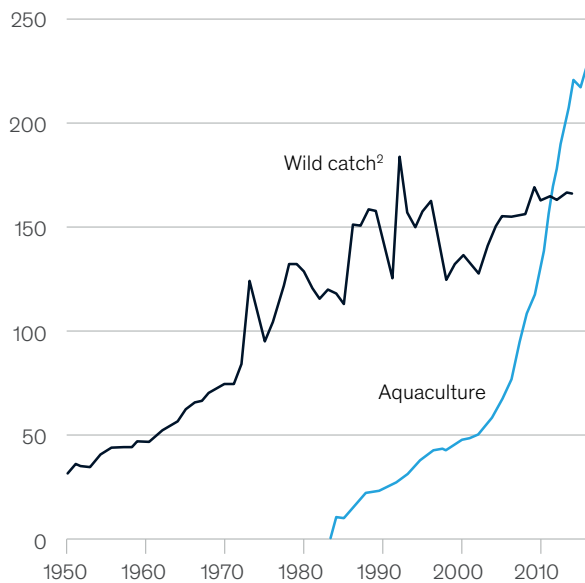
To cope with the decreased catch in their traditional fishing grounds, commercial fishing companies have considerably expanded their footprint on the oceans. In addition to targeting new species, they have increased their fishing efforts in tropical zones and extended their operations from coastal regions to the high seas, raising the total area fished from 60 percent to 90 percent of the world's oceans.⁴

Thanks to technological improvements, fishing companies have also penetrated further depths to target deepwater animals such as grenadiers and blue lings. Fishing these species is rarely sustainable because many have slow reproduction rates, which limits spawning and population growth. In the past, targeting such fish has often resulted in ecological

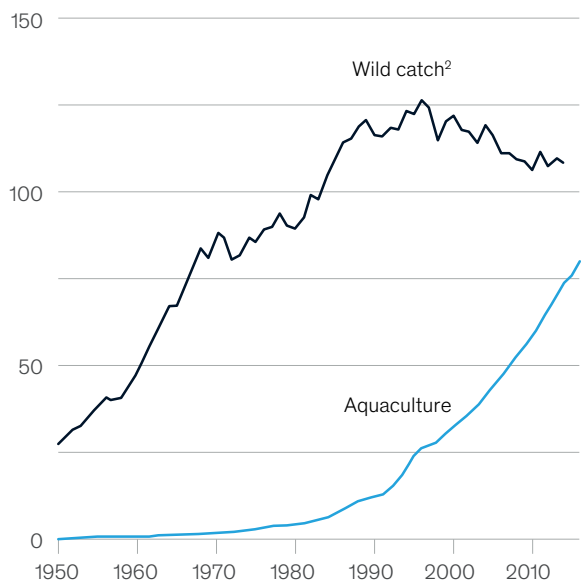
Exhibit 1

Wild catch is a decreasing part of global fish consumption.

Global fish value, \$ billion



Global fish production, million metric tons¹



¹Metric tons: 1 metric ton = 2,205 pounds.

²Excludes aquatic mammals; alligators, caiman, and crocodiles; seaweeds; and other aquatic plants.

Source: Food and Agriculture Organization of the United Nations; Sea Around Us

⁴David Tickler et al., "Far from home: Distance patterns of global fishing fleets," *Science Advances*, 2018, Volume 4, Number 8, advances.sciencemag.org.

disasters. In the 1980s, for instance, the deep-sea orange roughly almost suffered extinction through overfishing until researchers discovered that it was slow growing and exceptionally late to mature.

As fishing companies expand their reach, they are putting extreme pressure on the ocean environment. About half the world's fish stocks are now classified as collapsed, rebuilding, or overexploited, and wild-catch rates are falling in most regions (Exhibit 2). This phenomenon is particularly apparent with large fish at the top of the food chain, including sharks, tuna, and billfish.⁵ The loss of these apex predators has cascading effects that disrupt the equilibrium of ocean ecosystems.⁶ Take the decline of some shark populations, which has been known to trigger sudden and undesirable population changes in species living in the same habitat. The number of shellfish or herbivores might collapse, for instance, or a large algae bloom could develop.

Other perils also loom. By 2025, oceans could contain 250 million metric tons of plastic—one per every three tons of fish—unless companies and other stakeholders institute some mitigation measures.⁷ The accumulation of plastic debris may reduce the fish-survival rate, lowering stocks. Climate change, and its accompanying acidification, warming, and deoxygenation processes, is already affecting the oceans and will have profound implications for marine ecosystems, including reduced biodiversity and shifts in habitat. According to some scenarios, these shifts could decrease fishing revenues by 35 percent by 2050.⁸

Recognizing the growing threat to fish stocks, some countries and regions have acted to improve resource management, with mixed results.⁹

For instance, the United States has increased the proportion of stocks fished at biologically sustainable levels from 53 percent to 74 percent from 2005 through 2016, an increase that may be partly attributed to the Magnuson-Stevens Fishery Conservation and Management Act.¹⁰ Similarly, around 69 percent of stocks managed by the Australian Fisheries Management Authority were sustainably fished in 2015. But these regional gains are negated by overfishing in other markets, illegal fishing, and excessive waste.

Turning the tide with fishery analytics: Recent technological advances

Since regulations alone cannot eliminate overfishing, fisheries need other solutions to stay on a sustainable trajectory while minimizing their environmental impact. For most issues, including catch reporting, trade-information sharing, subsidies, tariff policies, and regulation enforcement, greater national and international collaboration will help. But fisheries and the public could also benefit from the increased use of advanced analytics (Exhibit 3). These algorithms have become popular across industries over the past few years as technological improvements have increased data availability, facilitated the deployment of information, and expanded data-ingestion capabilities.

Many industry stakeholders have already incorporated advanced analytics into all components of the value chain. Here's a look at some of the most important recent developments relevant to fisheries.

Data acquisition through sensing platforms

Sensors for collecting data have become more

⁵ Jonathan L. Payne et al., "Ecological selectivity of the emerging mass extinction in the oceans," *Science*, 2016, Volume 353, Number 6,305, pp. 1,284–6, science.sciencemag.org.

⁶ James A. Estes et al., "Trophic downgrading of planet Earth," *Science*, 2011, Volume 333, Number 6,040, pp. 301–6, science.sciencemag.org.

⁷ Jenna R. Jambeck et al., "Plastic waste inputs from land into the ocean," *Science*, 2015, Volume 347, Number 6,223, pp. 768–71, science.sciencemag.org.

⁸ Vicky W. Y. Lam et al., "Projected change in global fisheries revenues under climate change," *Scientific Reports*, 2016, Volume 6, Number 3,2607, nature.com.

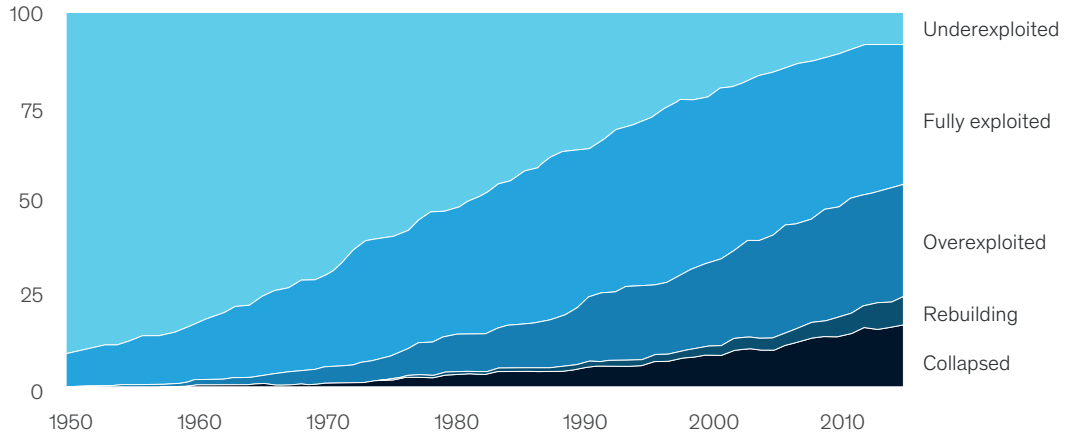
⁹ Daniel Ricard et al., "Examining the knowledge base and status of commercially exploited marine species with the RAM Legacy Stock Assessment Database," *Fish and Fisheries*, 2012, Volume 13, Number 4, pp. 380–98, onlinelibrary.wiley.com; Rainer Froese et al., "Status and rebuilding of European fisheries," *Marine Policy*, 2018, Volume 93, pp. 159–70, sciencedirect.com.

¹⁰ *The State of World Fisheries and Aquaculture 2018: Meeting the sustainable development goals*, Food and Agriculture Organization of the United Nations, 2018, fao.org.

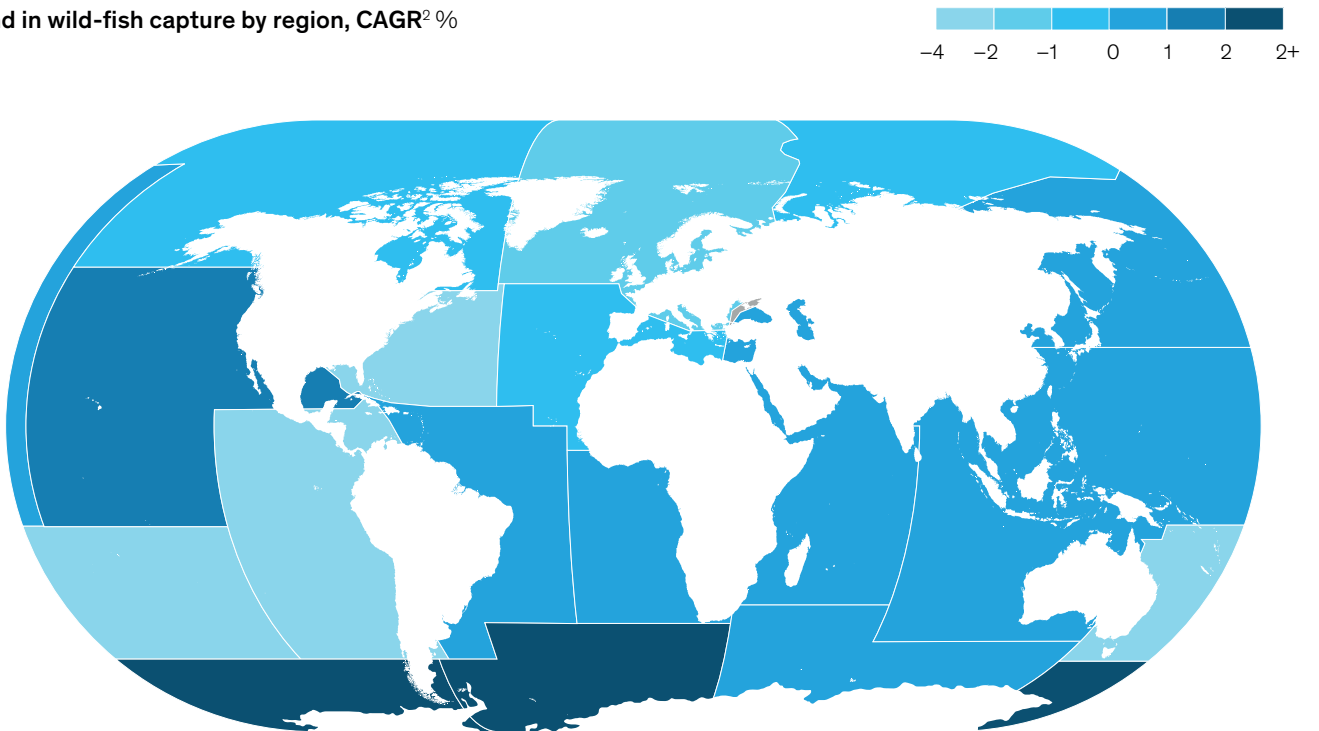
Exhibit 2

Nearly half the world's fish stocks are overexploited, rebuilding, or collapsed.

Status of global wild-fish stock,¹ %



Trend in wild-fish capture by region, CAGR² %

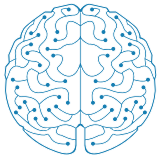


¹Stock status is evaluated by looking at the trends displayed by the lines separating the categories, rather than the vertical % values, due to the imprecise/changing definitions of the categories. Rebuilding stocks are stocks recovering from collapsed status.

²Compound annual growth rate of marine capture, 1994–2014. Anchoveta, fished along the coast of Peru and Chile and one of the biggest single-species fisheries, is excluded from the analysis because of its highly variable stocks related to El Niño conditions and past collapse events due to overfishing.

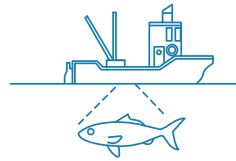
Source: Sea Around Us, 2014

Both fisheries and seafood consumers can benefit from advanced analytics.



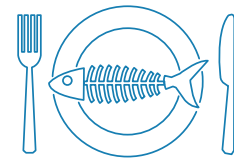
Advanced analytics is
now more viable because of ...

- Increased data availability through sensors, satellite imagery, cameras, drones, and other technologies
- Better tools for deploying and communicating information, such as smartphones and the Internet of Things
- Improved data-ingestion capabilities resulting from machine learning, artificial intelligence, better data storage, increased computational power, and other technological advances



... driving improvements
for fisheries with ...

- Better decision-making tools to achieve complex and sometimes conflicting goals, such as profitability and sustainability
- New tools that address biological variability, capture uncertainty, and manage revenue volatility and risks
- Better methods for reporting to public authorities



... and creating benefits
for seafood consumers with ...

- Increased sustainability of the world's fish stocks, which will improve global food security and maintain the economic and social benefits of fisheries
- More efficient monitoring, control, and surveillance instruments, which will reduce illegal fishing (as well as the poor labor conditions and human-rights abuses often found at companies that engage in such practices)

common, compact, and less expensive over the past few years. At the same time, the variety of platforms on which these devices can be deployed has considerably expanded, allowing them to capture data more rapidly and over greater distances. Sensing platforms that are particularly important within the fishing industry include the following:

- **Satellite.** Optical and radar sensors on satellites can offer a holistic view of the environment at unprecedented spatial and temporal resolution, making them particularly valuable for monitoring purposes. Optical sensors measure the light reflected by the earth's surface across a wide range of the electromagnetic spectrum. Important oceanic parameters can be derived from such data, including sea temperature and turbidity. Radar sensors emit microwave radiation and measure the portion that is scattered back to the instrument. They can provide data about ocean topography, winds, sea ice, and the

movement of vessels. Unlike optical sensors, radar systems can collect information even during poor weather and lighting conditions, including times when the sky is dark or cloudy.

- **Drones.** Equipped with cameras or other sensing devices, drones are increasingly used to explore the ocean. Some are even capable of navigating underwater. Compared with oceanographic vessels, drones are cheaper and more flexible. When sent in groups, they can also provide a more exhaustive sampling of the environment.¹¹ Although drones cover a smaller area than satellites, they can provide more detailed images, allowing them to detect smaller objects or phenomena.
- **Onboard or underwater devices.** Data related to fishing operations and catch are typically recorded by fishermen or observers. Common parameters include those related to vessel

¹¹ Jules S. Jaffe et al., "A swarm of autonomous miniature underwater robot drifters for exploring submesoscale ocean dynamics," *Nature Communications*, 2017, Volume 8, Number 14,189, nature.com.

location, gear types, and catch, including species, volume, biophysical characteristics, and discards. Onboard sensors can automate and facilitate this laborious process while simultaneously generating more exhaustive and reliable data. The data are then integrated into platforms known as electronic monitoring systems (EMSs). Several fishing-management authorities also require large fishing vessels to be equipped with vessel-monitoring systems (VMS), a technology that the European Union established in the early 2000s to support the monitoring, control, and surveillance of fishing vessels in its waters. VMS can collect information on a vessel's position, speed, and heading. Vessel operators can also send valuable information to authorities through their VMS, such as estimated catch and the start and end times for their fishing operations. Another onboard utility, the automatic identification system (AIS), was designed to complement radar systems and decrease the likelihood of marine collisions. Like VMS, it can be used to track the activity of fishing vessels. Other sensors, such as cameras and fuel-monitoring systems, can also be placed on board or next to underwater nets for real-time tracking.

Public organizations such as the National Oceanic and Atmospheric Administration and the Copernicus Marine Environment Monitoring Service have increased the effective usage of data obtained from satellite sensors by freely publishing them. Many start-ups and other companies also offer various products related to sensing platforms, including output from satellite sensors and data-collection systems designed for commercial fisheries.

Improved data-transmission technologies

The growth of the Internet of Things (IoT), land- and satellite-based mobile networks, and smartphones makes it much easier for fisheries to transmit data from vessels for analysis. For instance, vessels can use IoT to monitor and transmit data on fuel consumption in real time. The resulting data are then sent ashore through wireless mobile networks, including 3G and 4G, when close to shore. At further distances, vessels rely on satellite networks for transmission.

More insightful data analysis

Computational power has increased substantially, making it easier to process and analyze information using sophisticated algorithms. Across industries, some of the most important advances relate to the rise of artificial intelligence and machine learning, which can identify hidden relationships in large amounts of data. In particular, image-recognition and object-detection tools, powered by deep learning, have made a significant leap forward during the past decade. For instance, onboard cameras, assisted by image-recognition software, can provide fishermen with important information on the content of their catch in real time, including species, volume, and fish size.

Charting the course: Common use cases for AA within fisheries

Fishing-industry stakeholders are already transforming their operational and business processes by incorporating AA into all parts of the value chain, including fishery management, detection and capture, processing, reporting, and surveillance and control (Exhibit 4). They typically use multiple AA tools and sensors in combination, and a few even apply them from end to end within the value chain (see sidebar, "How are fisheries exploring new technology? An interview with Matts Johansen, CEO of Aker BioMarine Antarctic"). We have found that in some of the most important use cases involving AA and fishing, the following actions have been taken.

Monitoring illegal, unreported, and unregulated fishing

Authorities leverage AA to combat illegal, unregulated, and unreported fishing using geolocation data from AIS and VMS. AA can predict whether fishing vessels are actively engaged in fishing by looking at their AIS speed and course profile. For example, a vessel that slows down to one to three knots and frequently changes direction would likely be fishing. If geolocation data are not available, AA can also determine the position of vessels through image-recognition algorithms and satellite imagery (both radar and optical) that allow authorities to monitor the fishing fleet directly from

space and detect any suspicious activity under their purview, such as fishing in restricted zones or the offloading of fish cargo from one vessel to a refrigerated transport vessel—a practice that is sometimes used to conceal a catch from authorities.

Some industry organizations also use sensor data to monitor fishing activity, with the goal of increasing sustainability, such as Global Fishing Watch, a not-for-profit organization that aims to increase transparency by offering free data about the activity of the global fishing fleet based on AIS, VMS, and satellite imagery.¹²

Improving the detection of fish

Most fisheries have scarce data about their target catch. They might assess stock yearly, rather than making more frequent observations, and their analyses focus on information about landed catches and data recorded by observers. Tools that incorporate advanced analytics can provide a more dynamic, reliable, and nuanced view of the fluctuating ocean environment.

Consider patterns related to fish aggregation and migration, which change in response to temperature, wave height, the presence of sea ice, and other ocean conditions. Fisheries can monitor these changes through satellite imagery obtained from sensors. Complemented with information from other sources, such as the location of fishing vessels and catch data, advanced analytics can help determine the distribution and migratory patterns of a target species over time and space with greater accuracy and frequency.

Some researchers have already applied advanced analytics to get better information on the distribution

of fish. One team developed high-resolution predictive models by combining various ocean data, including sea-surface temperature, wind speed, and chlorophyll levels associated with plankton, with information obtained from fisheries and tagging sensors. The models provide daily recommendations about where to fish and how to avoid bycatch, increasing efficiency.¹³ With a more detailed and dynamic vision of fish stocks, fishing companies can decrease the amount of time, effort, and fuel required for each catch. Likewise, authorities can use the data to improve resource management.

Reporting to authorities and central managers

As noted earlier, fishermen and independent observers typically monitor and report fishing activities themselves. The results are then sent to relevant authorities or central managers within their company. EMS can automate and facilitate this time-consuming process to generate more exhaustive and reliable data based on sensor input. These systems typically consist of cameras connected to a GPS receiver and other vessel-tracking devices, such as engine-monitoring sensors that send data on fuel consumption in near real time. As fishing companies evolve toward a more data-rich environment, advanced analytics will become more and more relevant. Eventually, fishing companies will be able to combine data in ways that deliver new insights about key operational-performance drivers, such as fuel consumption and fish-catching rates.

Traceability

The supply chain in the seafood industry is complex, opaque, and lacking in international harmonization because the stakeholders involved often closely guard their information.¹⁴ The lack of clarity makes it easier for vessels to skirt regulations and fish

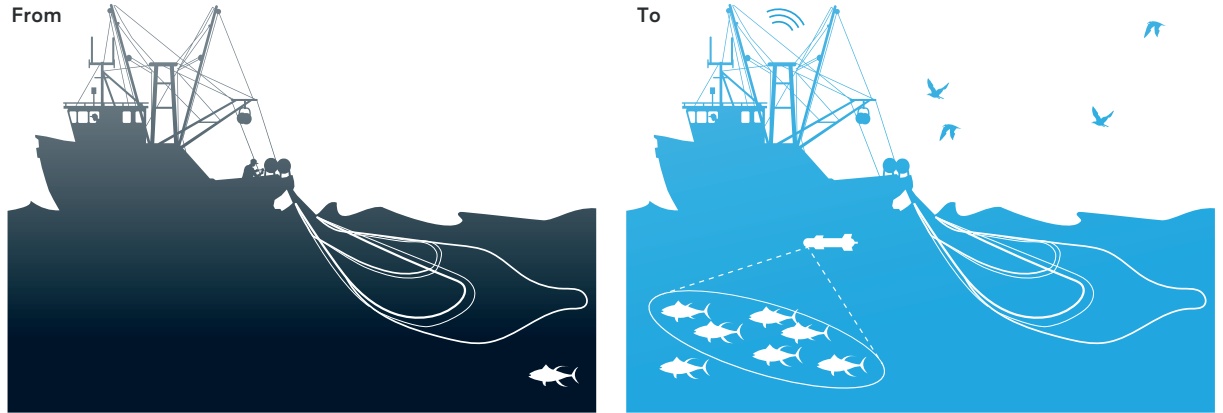
¹² More than 65,000 fishing vessels are tracked each day by Global Fishing Watch—an increasing number each year, with countries such as Indonesia, Panama, and Peru making their proprietary vessel-monitoring-systems data available on the Global Fishing Watch platform. While this represents only a fraction of all motorized fishing boats (estimated at 2.9 million units), it accounts for more than half of the fishing efforts 100 miles maximum from the shore.

¹³ Elliott L. Hazen et al., "A dynamic ocean management tool to reduce bycatch and support sustainable fisheries," *Science Advances*, 2018, Volume 4, Number 5, advances.sciencemag.org.

Exhibit 4

The adoption of analytics in fisheries requires a shift to data-informed, tech-enabled processes.

Key operational processes



Fisheries management	Data-scarce vision of fisheries based on landed catches and observer data	A data-rich environment that provides more reliable assessments
	Static management with yearly stock assessment	Dynamic management in which fishing stock is continually assessed
Detection and capture	Detection driven by intuition, experience, and short-range or immediate observations	Detection supported by high-resolution models and daily forecasts over the entire fishing territory
	Navigation according to experience	Internet of Things sensors that monitor navigation parameters, helping to define the most optimal routes and energy-efficient navigation strategies
	Low visibility on net contents	Automatic and continuous detection of catch parameters, such as fish size
Processing	Manual catch sorting	Automatic scanning and control of seafood-product quality through cameras and intelligent sorting systems
Reporting	Recording of captured species and their biological parameters via logbooks	Reporting assisted by onboard camera and artificial-intelligence recognition software
Surveillance and control	Surveillance based on partial and uncertain information about fishing activities	Real-time vision of fishing activities that assist with the design of efficient surveillance plans
	Lack of transparency because of the multiple stakeholders involved	Decentralized and reliable information-management system requiring little human intervention
	Few certification bodies to guarantee sustainability and conduct regular reassessments	New sources of data that identify violations in almost real time

illegally. It also frustrates consumers, who are increasingly asking for more information about the source and freshness of the food on their plates.

To improve transparency, some researchers are investigating distributed-ledger technologies that track and store information on transactions, including data on the movement of goods along the supply chain, in a secure, distributed database. Although distributed-ledger technologies are not classified as advanced-analytics tools, they are an important enabler. The information in a distributed-ledger-technology database, including insights from advanced analytics, is available to all approved users in real time.

Researchers are also investigating other technologies for tracking seafood, such as radiofrequency-identification tags and quick response codes, both of which transmit product information when scanned. With tagging, fishing companies may find it easier to receive permission to place labels on their products certifying that they are approved by the Marine Stewardship Council and other organizations that guarantee a product has been sustainably sourced, monitored along the supply chain, and correctly labeled. Consumers may increasingly look for such labels, giving an advantage to those that fish responsibly.

Sailing through the storm: Next steps for the fishing industry

Although commercial fishing companies are exploring advanced analytics through pilots and other activities, their decisions about where, when, and how to fish are still largely based on intuition and experience. Similarly, most regulators are not taking full advantage of advanced analytics. They have collected and analyzed some data, but their information is often incomplete and prone to inaccuracies, especially in emerging markets.

With all industry stakeholders concerned about fishing stocks, it is now time to take a more

aggressive approach to advanced analytics. As noted earlier, recent technological advances will facilitate this push, since costs for data storage and processing are decreasing each year. Their greater affordability means that most fishing companies and other stakeholders can now afford to implement more advanced-analytics tools in the near future. Likewise, talent recruitment will become less difficult for fisheries since the supply of data scientists, engineers, and technicians is growing. Fisheries will still face more challenges in acquiring talent than well-known tech companies or other industries that have traditionally promoted advanced analytics, but the recruitment pool will be larger.

Fishing companies

To guide their advanced-analytics journey, fishing companies must create a road map focusing on challenges they hope to address, such as those related to fishing efficiency, capture volatility, and fleet monitoring. To identify quick wins, companies should first assess their data stores to see what information is readily available. Most will find that they already have much relevant information on hand, including vessel-specific data on daily catch (both volume and species), GPS position, and fuel consumption.

Simple yet powerful use cases could be built around such data. Rather than using this information for purely descriptive purposes—for instance, noting the average catch for each vessel during past months—fishing companies could adopt a forward-looking analytical approach. One analysis might involve using geospatial modeling to map fishing activity and catch rate over the course of the season, allowing fisheries to track the fleet more closely and gain a better understanding of performance drivers. Increased fishing efficiency would also reduce fuel consumption and running costs. In addition to such simple analyses, fishing companies could use geospatial modeling to predict the location of targeted fish according to various environmental conditions. Such tools could inform not only fishing operations but also downstream commercial activities, including seafood pricing and labeling.

¹⁴ *Advancing traceability in the seafood industry: Assessing challenges and opportunities*, FishWise, February 2018, fishwise.org.

Fishing companies will also find many other use cases for advanced analytics. For example, they could generate even greater fuel savings by examining data from IoT sensors that provide information on vessel behavior, including fuel consumption and navigation conditions. Their analyses could help them generate real-time recommendations about the most energy-efficient routes and maneuvers. Similarly, fishing companies could examine data from onboard sensors to determine if any equipment is experiencing the sorts of problems that typically occur before a breakdown. With this information, they could detect potential failures ahead of time, thereby preventing costly repairs and long downtimes. In an analysis of large fishing companies worldwide, we estimated

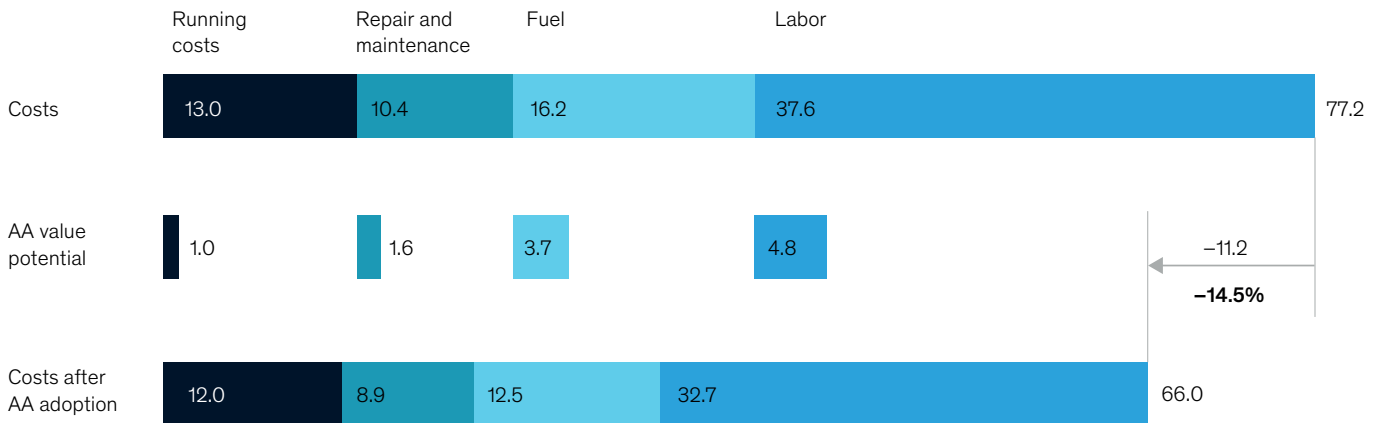
that using advanced analytics could produce more than \$11 billion in savings by reducing running costs, as well as expenses for fuel, labor, and repair and maintenance (Exhibit 5).

While these potential gains are impressive, fishing companies will not achieve them by simply implementing advanced-analytics initiatives. Instead, they must undertake an end-to-end digital transformation throughout all their functions.¹⁵ Such transformations require employees to have the right skill sets, as well as appropriate tools, processes, and interfaces (for instance, dashboards where they can readily access data). In addition, organizations should provide training and support to help employees see the value of advanced analytics,

Exhibit 5

Advanced analytics could produce more than \$11 billion in cost savings for large-scale fishing companies worldwide.

Operational variable costs and reduction potential from advanced analytics (AA),¹ \$ billion



Note: Figures may not sum, because of rounding

¹We estimated global fishing costs by multiplying the observed-cost breakdown of the large-scale EU fishing fleet in 2017, expressed in % of value of landings, with the global value of landings of large-scale fishing companies in 2014 given by the Sea Around Us project. Then, for each use case, we applied the estimated reduction in costs to the associated cost component, assuming that all large-scale fishing companies would adopt AA. Increased costs associated with AA were not evaluated.

Source: Scientific, Technical and Economic Committee for Fisheries (STECF): *The 2019 annual economic report on the EU fishing fleet*, Publications Office of the European Union; Sea Around Us; ACRE by McKinsey; McKinsey analysis

¹⁵ "Driving impact at scale from automation and AI," February 2019, McKinsey.com.

Organizations should provide training and support to help employees see the value of advanced analytics.

especially if they appear reluctant to change their ways. Without this support, employees may view advanced analytics as an imposition—a mind-set that is likely to impede progress.

Government and fishery-management agencies

With fish stocks dwindling and environmental challenges mounting, governments and fishery-management agencies could consider investing in data-collection technologies and research programs that can provide a comprehensive, near real-time vision of both ocean resources and fishing activities. By leveraging the data, they can adopt new measures and regulations more quickly and also rapidly respond to external pressures such as climate change. Fishing quotas could also become more dynamic. Rather than setting a quota annually, at the beginning of the fishing season, authorities could make adjustments throughout the year based on real-time information about the amount and type of catch that vessels are collecting.

The current exchange of information between fishermen and authorities is not optimal.¹⁶

A collaborative problem-solving approach—potentially happening at the global or regional

level—is needed to develop a clear road map defining data standards and mutual goals, such as those for bycatch reduction. These efforts would build trust among stakeholders and benefit all.

Food companies

By improving both the monitoring of fishing activities and the reporting of associated catches, advanced analytics can increase transparency about the seafood supply chain from ocean capture to the dinner table. Food companies can share this information with consumers, who have a growing interest in the quality, traceability, and sustainability of food products. In addition to their own health, they are concerned about environmental impact. If advanced analytics reveals that most of a company's catch comes from endangered species or overfished areas, the company can shift to other options to increase sustainability (either moving its own fishing fleets or changing suppliers). Certain technologies, including distributed-ledger technologies and radiofrequency-identification tags, can help companies share their insights about catch origin more efficiently and might merit additional investment.

¹⁶ Darcy Bradley et al., "Opportunities to improve fisheries management through innovative technology and advanced data systems," *Fish and Fisheries*, 2019, Volume 20, Number 3, pp. 564–83, onlinelibrary.wiley.com.

How are fisheries exploring new technology? An interview with Matts Johansen, CEO of Aker BioMarine Antarctic

Aker BioMarine Antarctic is the world's leading commercial supplier of krill—small crustaceans found in all the world's oceans. Focusing on Antarctic waters, the company harvests, produces, and sells many krill-based products, including ingredients for nutraceutical, aquaculture, and animal-feed applications. With an emphasis on sustainability, Aker BioMarine has recently investigated drones, machine learning, and other technologies to improve operations. McKinsey's Julien Claes and Elin Sandnes recently spoke with CEO Matts Johansen about the need for innovative technologies within fisheries.

McKinsey: What are the main challenges that fisheries face today?

Matts Johansen: Fisheries must advance their R&D, innovation, and technology if they want to get more value from the oceans. This is particularly essential to cope with climate change. Addressing that will require a twofold strategy. First, fishing operations must reduce their own footprint. But they also have to understand the impact from climate change on the fish stocks and the oceans. There's also a talent issue. We need to get more scientists and biologists into the fishing industry.

McKinsey: Can you tell us about some of your recent machine-learning innovations?

Matts Johansen: We have captains who have been fishing krill for many years and have developed an elaborate process to find it during the season: they record the temperature of the water, they look at the historical catch from preceding years, they look at the currents.

We're building a machine-learning model that will do the same thing, but it will be more refined. We are only testing it now; we're not yet using it to make decisions. So far, the model produces pretty good correlations.

The model will learn as it gets more and more experience. We now spend about 10 percent of our time searching for krill. With this model, we expect that to be close to zero.

McKinsey: Your products are typically high end, with potentially 20 to 30 times the value of classical seafood. Do you think that fishing companies that focus on lower-value products could also use new technologies to decrease their carbon footprint?

Matts Johansen: Definitely. We have to look for sustainable solutions throughout our entire value chain. There is a lot we can do by looking at the vessels and the technology that can be utilized to reduce the carbon footprint. Recently, we built the first-ever krill-harvesting vessel from scratch that is designed to be energy efficient and equipped with a host of environmentally friendly technologies. The engineers and the crew put their heads together to build a vessel that is 30 percent more environmentally efficient compared to today's trawlers.

McKinsey: What is needed to create technologies that encourage sustainability?

Matts Johansen: Data is an important element for getting more knowledge. Fisheries sometimes don't have a good set of data to build models like ours. But I think they will get the data they need over the next few years. It will be driven by economy—the need to save fuel costs and drive efficiency—things like that. Once more and more fisheries start to create and build databases like ours and share them, as we do, that will increase the available data.

Right now, fishing companies use old-school methods to assess biomass of different species. You go out there with a net and catch in a grid in a certain area and see how much you get in the net. It's very costly and takes a lot of resources. If we are able to build robust and proven data models, you get the information you need in real time. And then you can adjust regulations based on this information.

McKinsey: Some companies see a potential advantage to sharing data with competitors, as you do, to get a more holistic view of specific fishing territories. Do you think such cooperation could help fisheries improve resource management?

Matts Johansen: I think actually openly sharing data among industry, regulatory, and science stakeholders is key to improving management. It also depends on what leading companies do. It's easier to share and be open if you're the leader, since you have more resources and you're always going to be one step ahead. If you're a challenger and you're looking for new ways to compete with the establishment, sharing is much harder.

McKinsey: You mentioned that finding the right talent could be one of the barriers to adopting new fishing technologies. Do you see other potential barriers?

Matts Johansen: I'm all for big leaps in technology development, but that usually happens in big companies that have resources. I think larger organizations might help drive adoption of new technology. Having owners that take the long view and are willing to invest early in technology might also enable change.

You also need the right mix of talent. Take our organization as an example. We have a mix of hardcore fishermen who have been fishing their whole lives, and people with double PhDs that really understand the products. In addition, we have people who were formerly in the business sector. It's key to develop organizations like that.

McKinsey: Do you develop new technologies in-house or purchase them?

Matts Johansen: We do both. For krill harvesting, there are no off-the-shelf solutions. We frequently work with partners to develop new technologies, especially for machine learning. We also worked with a partner on drone solutions.

McKinsey: Do you feel positive about the future of fisheries and the impact of technology?

Matts Johansen: Yes. I think that we will be able to develop solutions that build a more sustainable food system in which we use the ocean in a better way than what we're doing today.

Modern farmers already rely on sophisticated weather forecasts, sensors, and geospatial tools to optimize their harvest and manage land more sustainably. Now it's time for fishing companies and other stakeholders to start their own digital and analytical journey. Getting fuller nets and larger fish is one goal, but a more important objective relates to sustainability. As fish stocks drop and fishing companies expand their reach,

advanced analytics may be one of the best tools for protecting endangered species and other ocean resources. While data and algorithms may seem a better fit for boardrooms than boats, some fisheries have already achieved major gains by applying them. It's now time for more widespread adoption before the environmental consequences of overfishing accelerate.

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