A Data Collaborative Case Study

Global Fishing Watch

Pooling Data and Expertise to Combat Illegal Fishing

Michelle Winowatan, Andrew Young, and Stefaan G. Verhulst

January 2020

GOVLAB

Photo by Ivan Bjelajac on Unsplash

A Data Collaborative Case Study

Global Fishing Watch

Pooling Data and Expertise to Combat Illegal Fishing

Summary: Global Fishing Watch, originally set up through a collaboration between Oceana, SkyTruth and Google, is an independent nonprofit organization dedicated to advancing responsible stewardship of our oceans through increased transparency in fishing activity and scientific research. Using big data processing and machine learning, Global Fishing Watch visualizes, tracks, and shares data about global fishing activity in near-real time and for free via their public map. To date, the platform tracks approximately 65,000 commercial fishing vessels globally. These insights have been used in a number of academic publications, ocean advocacy efforts, and law enforcement activities.

Data Collaborative Model: Based on the typology of data collaborative practice areas, Global Fishing Watch is an example of the **data pooling** model of data collaboration, specifically a **public data pool**. Public data pools co-mingle data assets from multiple data holders—including governments and companies—and make those shared assets available on the web. This approach enabled the data stewards and stakeholders involved in Global Fishing Watch to bring together multiple data streams from both public- and private-sector entities in a single location. This single point of access provides the public and relevant authorities with user-friendly access to actionable, previously fragmented data that can drive efforts to address compliance in fisheries and illegal fishing around the world.

Data Stewardship Approach: Global Fishing Watch also provides a clear illustration of the importance of data stewards. For instance, representatives from Google Earth Outreach, one of the data holders, played an important stewardship role in seeking to connect and coordinate with SkyTruth and Oceana, two important nonprofit environmental actors who were working separately prior to this initiative. The brokering of this partnership helped to bring relevant data assets from the public and private sectors to bear in support of institutional efforts to address the stubborn challenge of illegal fishing.

GOVLAB

OPERATIONAL VARIABLES

Global Fishing Watch Data Collaborative Operational Variables.
Detailed description of each variable can be found here.

Setting the Scene

Illegal, unreported, and unregulated (IUU) fishing (for brevity illegal fishing) is a transnational problem that comes with significant economic, environmental, and human costs. It includes "fishing without a license, fishing in a closed area, fishing with prohibited gear, fishing over a quota, or the fishing of prohibited species."[1] It occurs both on international waters and within national jurisdictions in violation of national or international laws.[2] Illegal fishing accounts for up to USD 23.5 billion worth of seafood annually, or roughly one-fifth of annual world seafood trade which is valued at USD 150 billion per year.[3] In other words, 1 in 5 of wild-caught ocean fish come from illegal fishing.[4]

Further, illegal fishing often provides a window for human rights abuse in the form of labor exploitation. A report by the Environmental Justice Foundation documents multiple cases of slavery, debt bondage, abject living condition, violence, and homicide aboard fishing vessels carrying flags of 11 countries.[5] In addition, fishing conducted in no-fishing zones and overfishing causes damage to the marine ecosystem,[6] which can create food and economic insecurity.[7]

Monitoring transnational fishing activity is an immense task. The ocean is a vast territory distributed across many national jurisdictions; each country implements its own set of fishery regulations and operates in discrete systems. Large vessels with capacities exceeding 100 gross tons or about 24 meters in length must broadcast their locations using the Automatic

[1] "FAQ: Illegal, Unreported, and Unregulated Fishing." n.d. Pew. Accessed September 5, 2019. http://bit.ly/1vZ7CUv.

[2] "What Is IUU Fishing?" n.d. Food and Agriculture Organization. Accessed September 5, 2019. http://www.fao.org/iuu-fishing/background/what-is-iuu-fishing/en/.

[3] "Illegal Catch Finding Its Way Into Fish-Meal, Other Fish Products." n.d. Accessed September 5, 2019. https://pew.org/2Ms8Lns.

[4] David J. Agnew, et al. 2009. "Estimating the Worldwide Extent of Illegal Fishing." PLOS ONE 4 (2): e4570. https://doi.org/10.1371/journal.pone.0004570.

[5] "Full Scale of Human Rights Abuse in the Fishing Industry Revealed." 2019. Text/html. Environmental Justice Foundation. September 5, 2019. https://ejfoundation.org/news-media/2019/full-scale-of-human-rights-abuse-in-the-fishing-industry-revealed-in-new-ejf-report.

[6] Seyed Mostafa Aghilinejhad, et al. 2018. "What Are the Drivers of the Occurrence of Illegal Fishing and Conservation Barriers of Sturgeons in the Caspian Sea?" Aquatic Conservation: Marine and Freshwater Ecosystems 28 (3): 690–701. https://doi.org/10.1002/aqc.2897; David Harasti, et al. 2019. "Illegal Recreational Fishing Causes a Decline in a Fishery Targeted Species (Snapper: Chrysophrys Auratus) within a Remote No-Take Marine Protected Area." PLOS ONE 14 (1): e0209926. https://doi.org/10.1371/journal.pone.0209926.

[7] "Overfishing." n.d. World Wildlife Fund. Accessed September 5, 2019. https://www.worldwildlife.org/threats/overfishing.

Identification System (AIS) to prevent collisions.[8] AIS uses a public radio broadcast system, therefore anyone with a radio receiver in the vicinity can access this information. Smaller vessels, however, are not required to use AIS but are typically regulated by their national government to broadcast their location using the nationally owned Vessels Monitoring System (VMS). This data is similar to AIS, but it is owned by the government and not publicly accessible.[9]

Furthermore, these national governments also have different capacity in enforcing their fisheries' regulations, which creates gaps in ocean patrolling capability. These dispersed and fragmented systems make it highly challenging for researchers, NGO actors, or national governments to obtain information that could inform policies to tackle transnational illegal fishing.

Establishing the Data Collaborative

Global Fishing Watch is an NGO founded by Oceana, SkyTruth and Google Earth Outreach. Oceana is an international nonprofit organization that focuses on ocean conservation. SkyTruth is a nonprofit that uses satellite imagery and remote sensing data to protect the environment. Google Earth Outreach is a division of Google that uses their maps database for various research and public interest activities.[10] SkyTruth and Oceana had been working with Google Earth Outreach separately, in the intersection of remote sensing and environmental conservation leveraging Google Earth Outreach satellite imagery datasets.[11] Acknowledging an opportunity for amplifying impact through collaboration, a Senior Program Manager for Google Ocean & Earth Outreach connected the two organizations. Together, these actors decided to collaboratively leverage Google Earth Outreach's datasets and pool their expertise and capacity through Global Fishing Watch, aiming to advance "ocean sustainability and stewardship through increasing transparency."[12]

"[SkyTruth] saw the opportunity to apply the data to [combating illegal fishing]. Oceana saw the opportunity to drive direct advocacy in the countries where they operate. And Google saw the way that provides lots of big data tools to a technologically savvy organization like SkyTruth and have good things happen. [...] And so we all threw a little bit of resources in a pot and decided to go try to make a prototype."

Paul Woods, CTO, Global Fishing Watch

[8] Kimbra Cutlip. 2017. "AIS for Safety and Tracking: A Brief History." Global Fishing Watch. March 31, 2017. https://globalfishingwatch.org/data/ais-for-safety-and-tracking-a-brief-history/.

[9] "Indonesia's Vessel Monitoring System." n.d. Global Fishing Watch. Accessed September 5, 2019. https://globalfishingwatch.org/initiatives/indonesia-vms/.

[10] "Transparency in Commercial Fishing," Global Fishing Watch, accessed September 5, 2019, https://globalfishingwatch.org/about-us/.

[11] Paul Woods, The GovLab's Interview with Paul Woods, Chief Technology Officer, Global Fishing Watch, August 28, 2019.

[12] "Transparency in Commercial Fishing." n.d. Global Fishing Watch. Accessed September 5, 2019. https://globalfishingwatch.org/about-us/.

To that end, Global Fishing Watch uses Google's satellite imagery datasets and combines it with previously siloed public and closed government data and algorithms to track fishing vessel activity. Global Fishing Watch purchases the license to AIS data from ORBCOMM and Spire, companies that offer various industrial internet of things products.[13] However, AIS data is limited in that only vessels exceeding 100 gross tons are required to carry AIS.[14] Most fishing vessels are smaller than that, though many such vessels use AIS voluntarily or are required to by local regulations. Vessels can also choose to switch AIS off completely, not broadcast their locations, or log false coordinates to conceal illegal activities. To get around these gaps, the Global Fishing Watch also collaborates with several national governments to open their VMS data The government of Indonesia became the first country to share its VMS to Global Fishing Watch, followed by Peru and Panama. Chile, Namibia and Costa Rica have also made public commitments to share their vessel tracking data via the Global Fishing Watch.[15]

Using these inputs, Global Fishing Watch currently visualizes the activity of about 65,000 commercial fishing vessels going back to 2012.[16] About half of the vessels tracked by Global Fishing Watch are categorized as large vessels (>24 meters) and several tens of thousands are medium vessels (12–24 meters).[17] This data is put online with a three-day time lag, for two reasons.[18] First, the cost of getting a real-time license is higher.[19] Second, real-time data might present some liability on Global Fishing Watch's part should the data be used maliciously.[20]

Global Fishing Watch restricts access to its data using a three-part classification scheme.[21] The first element involves access to the maps in a public and free manner. Anyone can register on their website and observe the map, without any review process. Second is access to raw map data, which is also free but more restricted. Researchers need to disclose the purpose of their projects and attribute Global Fishing Watch to get access. The third involves access to raw vessels tracks, which is highly restricted due to the licensing agreement that Global Fishing Watch has with its private data providers, ORBCOMM and Spire. Researchers who want access to the raw vessels tracks need to go through a sub-licensing process that can involve a fee or a grant agreement.

---

[13] Global Fishing Watch, "Spire Partnership Nearly Doubles Data in Global Fishing Watch," Global Fishing Watch, November 1, 2017, https://globalfishingwatch.org/press-release/spire-partnership-nearly-doubles-data-in-global-fishing-watch-media-kit/; Sarah Bladen, "Datasets and Code: Anonymized AIS Data and Other Data," Global Fishing Watch, accessed January 6, 2020, https://globalfishingwatch.org/datasets-and-code/ais-and-other-data/.

[14] "Indonesia's Vessel Monitoring System." *supra* note 10.

[15] "Vessel Monitoring Systems in the Fishing Industry." n.d. Global Fishing Watch. Accessed September 5, 2019. https://globalfishingwatch.org/vms-transparency/.

[16] Paul Woods and Sarah Bladen, "Final Draft of Global Fishing Watch Case Study - Request for Comments," December 10, 2019.

[17] Paul Woods, *supra* note 11.

[18] Ephrat Livni, *supra* note 10.

[19] Paul Woods, *supra* note 11.

[20] *Ibid.*

[21] *Ibid.*

Outcome and Impact

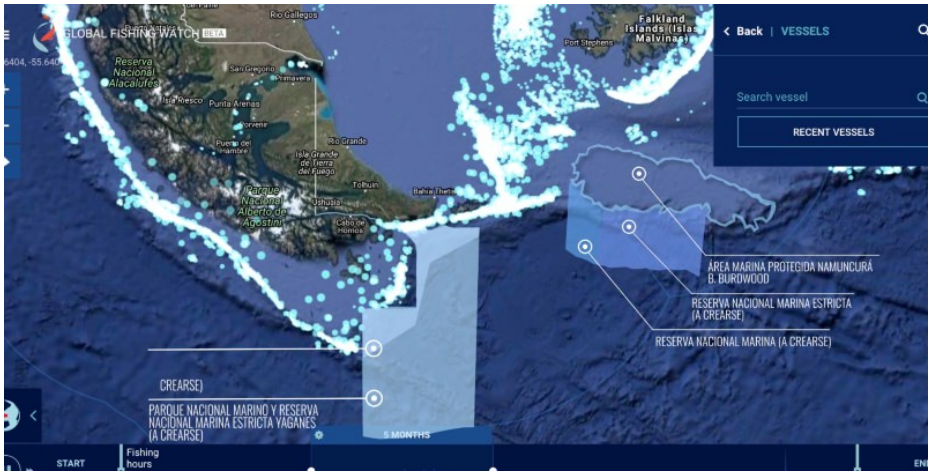
Intended Impact

Global Fishing Watch's goal is to support fisheries management, research, and advocacy endeavors surrounding ocean conservation by making previously siloed datasets accessible through their platform.[22] It uses data and analysis to inform policymakers in making ocean conservation policies.[23]

Outcomes to Date

Global Fishing Watch's data and map are used in multiple ways that align with its broad mission. The initiative enables new insights into illegal fishing and marine protected areas and also drives an array of enforcement and protection activities.

Marine Protection: Global Fishing Watch's maps played a role in the establishment of Argentina's first two Marine Protected Areas (MPAs).[24] Previously, the plan to set two areas of Argentinian ocean as protected was met by opposition from the fishing industry who argued that the law would negatively affect the industry. Two Argentinian marine activists used maps data from Global Fishing Watch as evidence there was little fishing activity in the proposed MPAs so the fishing industry would not be negatively affected. Informed by this evidence, the Argentinian Congress passed a law that established the two MPAs in December 2018.



Global Fishing Watch maps used by the activists to show how little fishing occurred within the proposed site of the new Marine Protected Areas. Image taken from Global Fishing Watch.

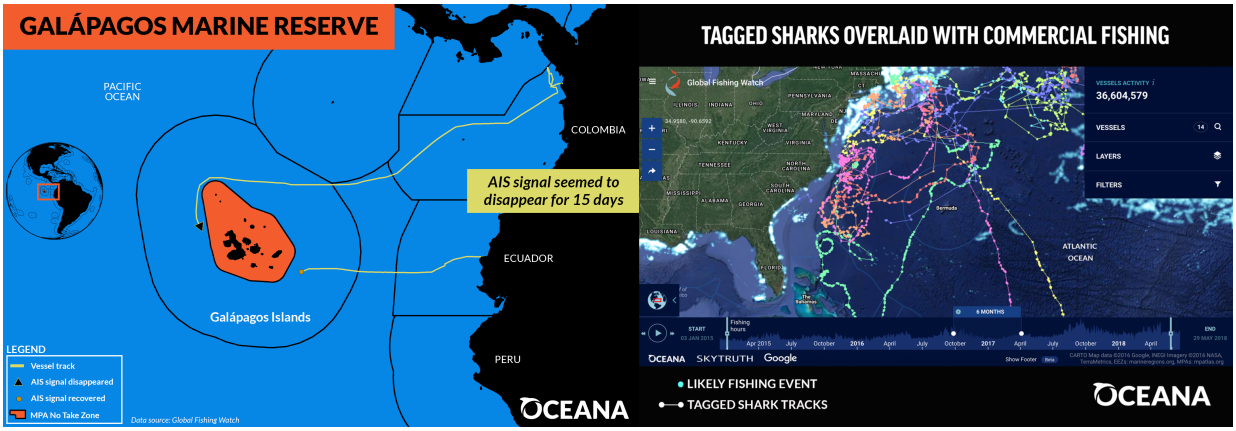
[22] "Transparency in Commercial Fishing." *Supra* note 12.

[23] *Ibid.*

[24] Camellia Williams. 2018. "Global Fishing Watch Data Key to MPA Victory in Argentina." Global Fishing Watch. December 13, 2018. https://globalfishingwatch.org/news-views/global-fishing-watch-data-key-to-mpa-victory-in-argentina/.

Enforcement: Global Fishing Watch data and analysis also helped Indonesia in seizing a notorious illegal fishing vessel MV NIKA on July 12, 2019.[25] MV NIKA had been a suspect of illegal fishing for years. It had changed its name and flag multiple times to conceal illegal activities. It was once impounded by the Russian authority for illegal crab fishing. INTERPOL officially put it on its wanted list in June 2019. A Global Fishing Watch analyst in Indonesia had been tracking and predicting the course of this vessel since February 2019. The analyst provided this information to the Indonesian IUU fishing task force, which led to the decision to intercept the vessel and bring its crew into custody. Upon capture, authorities found fish processing facilities on board upon capture, despite being registered as a general cargo board.

Advocacy: One of Global Fishing Watch's founding partners, Oceana, uses this data for its ocean advocacy programs.[26] For instance, it has used the data to study the impacts of commercial fishing activities on sharks and bring government attention on possible illegal activities by vessels that switched off their AIS around MPAs.



Global Fishing Watch's maps used by Oceana in their advocacy efforts.

Research: Finally, dozens of published research articles use Global Fishing Watch's offerings.[27] One recent paper used vessel tracks data to study the spatial overlaps of sharks movement and fishing fleets.[28] A separate paper uses vessel data to look at the impact of trawling activities inside MPAs on marine conservation.[29] Yet another identifies global hot spots of transshipment (the moving of catch from vessels to vessels) to cover the origin of the catch and other illegal practices.[30]

---

[25] Sarah Bladen. 2019. "The Capture of the MV NIKA: A Case of Illicit Fishing and a Showcase for How to Beat It - Global Fishing Watch." Global Fishing Watch. July 23, 2019. https://globalfishingwatch.org/vms-transparency/the-capture-of-the-mv-nika-a-case-of-illicit-fishing-and-a-showcase-for-how-to-beat-it/.

[26] Megan Jordan. 2018. "How Oceana Used Global Fishing Watch Data to Promote Transparency at Sea during 2018." Global Fishing Watch. December 18, 2018. https://globalfishingwatch.org/data/how-oceana-used-global-fishing-watch-data-to-promote-transparency-at-sea-during-2018/.

[27] "Publications on the Commercial Fishing Industry." n.d. Global Fishing Watch. Accessed September 5, 2019. https://globalfishingwatch.org/publications/.

[28] Nuno Queiroz et al., "Global Spatial Risk Assessment of Sharks under the Footprint of Fisheries," Nature 572, no. 7770 (August 2019): 461–66, https://doi.org/10.1038/s41586-019-1444-4.

[29] Manuel Dureuil et al., "Elevated Trawling inside Protected Areas Undermines Conservation Outcomes in a Global Fishing Hot Spot," Science 362, no. 6421 (December 21, 2018): 1403–7, https://doi.org/10.1126/science.aau0561.

[30] Kristina Boerder, Nathan A. Miller, and Boris Worm. "Global Hot Spots of Transshipment of Fish Catch at Sea." Science Advances 4, no. 7 (July 1, 2018): eaat7159. https://doi.org/10.1126/sciadv.aat7159.

Risks and Mitigation Strategy

Vessels Security Issue. Global Fishing Watch intends its data to help track and monitor fishing activities and to make sure they are conducted in compliance with the law. However, the opening of this data might also result in a number of security issues. Many national governments, such as the United States, have strict laws that prohibit the public disclosure of VMS data as it is deemed to contain sensitive law enforcement data.[31] Although there has been no evidence of misuse of Global Fishing Watch's data, the organization is cautious about the unknown security risks that might arise from their good intention. To mitigate these risks, Global Fishing Watch created a three-day time lag in their public map.[32]

Lessons Learned – Enablers

Combination of various complementary capacities by Google Earth Outreach, SkyTruth, and Oceana. The combination of digital infrastructure, map analytics expertise, and advocacy capacity possessed by the three founders of the nonprofit optimized the value brought forward by this partnership. The digital infrastructure provided by Google through its Earth Outreach platform enables a nonprofit to use otherwise costly technology to create public value.[33] The analytics expertise possessed by SkyTruth is another important piece in the collaboration that enables the further use and analysis of the data.[34] Finally, Oceana, as an ocean advocacy organization, plays an important role in ensuring the insights obtained from Global Fishing Watch are relayed to key decision makers for improving ocean conservation.[35]

The importance of data stewards. Earth Outreach's role in facilitating engagement between relevant actors was instrumental in the establishment of this initiative. SkyTruth and Oceana had been working separately on similar issues until Google made the linkage between the two organizations and helped establish Global Fishing Watch.

Google Earth Outreach Human and Technical Infrastructure. By providing cloud infrastructure and satellite imagery datasets through its cloud credit grant mechanism,[36] Google helped eliminate the cost of building the technical infrastructure from scratch, which would have required a significant investment of resources. These infrastructures helped these nonprofit actors advance their mission, while increasing the use of Google's cloud platform. To date, Earth Outreach has supported a number of nonprofit partners working on a diverse range of issues including health, education, and environment.[37]

---

[31] "National Vessel Monitoring System Privacy Impact Assessment Statement." 2009. National Oceanic and Atmospheric Administration (NOAA). https://www.cio.noaa.gov/itmanagement/pdfs/PIA_VMS_041609.pdf.

[32] Paul Woods. *Supra* note 16.

[33] "Google Earth Outreach." n.d. Google Earth Outreach. Accessed September 5, 2019. https://www.google.com/earth/outreach/.

[34] "About." n.d. The SkyTruth Story (blog). Accessed September 5, 2019. https://skytruth.org/about/.

[35] Megan Jordan, *supra* note 26.

[36] Paul Woods, *supra* note 11.

[37] "Special Projects," Google Earth Outreach, accessed December 9, 2019, https://www.google.com/earth/outreach/special-projects/.

Access to government data. In addition to including AIS data, Global Fishing Watch also obtains data from several national governments, which share their closed VMS data with Global Fishing Watch. So far, only three national governments are sharing their VMS data, but their leadership has set examples of how national authorities can benefit from sharing VMS data, and other nations are starting to follow their lead.

Lessons Learned – Challenges

Incomplete data. Global Fishing Watch mainly relies on AIS data, which has several limitations. As mentioned previously, AIS is only required for large vessels, which account for a small portion of fishing vessels. Furthermore, AIS can be manipulated. Vessels can choose to switch off their devices or manually input wrong locations to shield illegal activities. As such, Global Fishing Watch calls for collaboration with more national governments willing to share their VMS data. Greater access to VMS data would bolster their ability to monitor the activity of smaller vessels.

VMS data is typically restricted by national governments for many reasons including protecting national security and industry trade secrets.[38] When the government of Indonesia decided to disclose its VMS data, it opened up the possibility for sharing to other countries. To date, three countries (Indonesia, Peru, and Panama) share their VMS data freely through the Global Fishing Watch platform. While these early movers might inspire greater collaboration from other countries, regulatory hurdles and competitive disincentives might slow progress toward more access to VMS data.

Alongside AIS and VMS data, the map platform includes night-light vessel detections using Visible Infrared Imaging Radiometer Suite (VIIRS)—a satellite sensor that can identify lights at night.[39]

Data lag. The data provided through Global Fishing Watch platform has a three-day lag for risk mitigation purposes. The lag also bars observers from responding to illegal activity in real-time. Global Fishing Watch plans to reduce the time lag to 24 hours, to improve the accuracy of observation while still mitigating risks associated with real-time data availability.[40]

Engaging governments. In cases where Global Fishing Watch engages with governments, the challenge lies in harmonizing its capacity with its intended objective. For instance, VMS data collected by governments is often not up-to-date and can contain errors.[41] Before Global Fishing Watch created their platform and made their data accessible to researchers, it used to take researchers months to clean up the data before they can begin their analysis. Furthermore, addressing illegal fishing requires complex coordination among multiple agencies, such as the designated ministry, national law enforcement, and INTERPOL. Oftentimes, inter- and intra-

[38] *Ibid.*

[39] Global Fishing Watch, "Understanding VIIRS Data" (Global Fishing Watch, n.d.), https://globalfishingwatch.org/wp-content/uploads/Understanding-VIIRS-Data.pdf.

[40] Paul Woods, *supra* note 11.

[41] *Ibid.*

agency communications do not flow as smoothly as needed, creating a hurdle in ensuring a quick response to an issue at hand.

Building capacity to use the data. After creating access to the data, the challenge lies in putting the data to good use, which requires the capacity to use data analytics tools. Global Fishing Watch publishes the data using tools such as Google Big Query and Earth Engine, which are not easy to use for those without a data science background. Responding to this challenge, Global Fishing Watch is developing tools that would enable those with less data science expertise to utilize its offerings. [42]

Next Steps

Started as a collaborative project between Oceana, SkyTruth, and Google, Global Fishing Watch demonstrates the value of cross-sector collaboration and responsible stewardship of both public- and private-sector data assets. Today, Google Earth Outreach has supported a number of public-oriented projects related to public health, education, and agriculture, with nonprofit partners operating all around the world. SkyTruth and Oceana continue to collaborate through Global Fishing Watch, which is now a nonprofit organization, operating independently.[43]

Building on its achievements and continuing to improve its platform in several ways. First, Global Fishing Watch wants to improve the quality of its data by reducing the amount of time lag to 24 hours, from 72. Second, it plans to integrate its maps data with other satellite imagery datasets that depict salinity, temperature, and other earth imagery data to enable cross-topic analysis. This data could enable the study of topics such as the correlation between fishing activity and the activity of certain marine species. Global Fishing Watch is also investigating adding satellite radar data and emerging commercial systems, such as radio frequency detections. Third, to improve the usability of its data, Global Fishing Watch is building analytics tools that would make data analysis more accessible to those who do not have an extensive knowledge in coding or programming. To this end, it recently hired personnel specifically tasked to build these tools.[44]

Global Fishing Watch is also working toward establishing collaboration with 20 countries publicly sharing their VMS data within the next five years. In another indication of the value of data collaboration, these government data providers will in turn receive analytics support from Global Fishing Watch, enabling a joint, multi-faceted approach to strengthening compliance and stamping out illegal fishing.[45]

---

[42] *Ibid.*

[43] "Oceans," Google Earth Outreach, accessed December 9, 2019, https://www.google.com/earth/outreach/special-projects/oceans/.

[44] *Ibid.*

[45] "Vessel Monitoring Systems in the Fishing Industry," *supra* note 14.

SOURCES

The SkyTruth Story. “About.” Accessed September 5, 2019. https://skytruth.org/about/.

Aghilinejhad, Seyed Mostafa, Saeid Gorgin, Daan van Uhm, Ramtin Joolaie, Rasoul Ghorbani, Seyed Yousef Paighambari, Jahangir Mohammadi, and Ali Jalali. “What Are the Drivers of the Occurrence of Illegal Fishing and Conservation Barriers of Sturgeons in the Caspian Sea?” *Aquatic Conservation: Marine and Freshwater Ecosystems* 28, no. 3 (2018): 690–701. https://doi.org/10.1002/aqc.2897.

Agnew, David J., John Pearce, Ganapathiraju Pramod, Tom Peatman, Reg Watson, John R. Beddington, and Tony J. Pitcher. “Estimating the Worldwide Extent of Illegal Fishing.” *PLOS ONE* 4, no. 2 (February 25, 2009): e4570. https://doi.org/10.1371/journal.pone.0004570.

Bladen, Sarah. “Datasets and Code: Anonymized AIS Data and Other Data.” Global Fishing Watch. Accessed January 6, 2020. https://globalfishingwatch.org/datasets-and-code/ais-and-other-data/.

———. “The Capture of the MV NIKA: A Case of Illicit Fishing and a Showcase for How to Beat It - Global Fishing Watch.” Global Fishing Watch, July 23, 2019. https://globalfishingwatch.org/vms-transparency/the-capture-of-the-mv-nika-a-case-of-illicit-fishing-and-a-showcase-for-how-to-beat-it/.

Boerder, Kristina, Nathan A. Miller, and Boris Worm. “Global Hot Spots of Transshipment of Fish Catch at Sea.” *Science Advances* 4, no. 7 (July 1, 2018): eaat7159. https://doi.org/10.1126/sciadv.aat7159.

Cutlip, Kimbra. “AIS for Safety and Tracking: A Brief History.” Global Fishing Watch, March 31, 2017. https://globalfishingwatch.org/data/ais-for-safety-and-tracking-a-brief-history/.

Dennis, Brady. “How Google Is Helping to Crack down on Illegal Fishing — from Space - The Washington Post.” The Washington Post, September 15, 2016. https://www.washingtonpost.com/news/energy-environment/wp/2016/09/15/from-space-a-new-effort-to-crack-down-on-illegal-fishing-across-the-globe/.

DeSombre, Elizabeth R. “The Security Implications of Fisheries.” *International Affairs* 95, no. 5 (September 1, 2019): 1019–35. https://doi.org/10.1093/ia/iiz140.

Dolgin, Elie. “Massive NIH–Industry Project Opens Portals to Target Validation.” *Nature Reviews Drug Discovery* 18 (February 27, 2019): 240–42. https://doi.org/10.1038/d41573-019-00033-8.

Dureuil, Manuel, Kristina Boerder, Kirsti A. Burnett, Rainer Froese, and Boris Worm. “Elevated Trawling inside Protected Areas Undermines Conservation Outcomes in a Global Fishing Hot Spot.” *Science* 362, no. 6421 (December 21, 2018): 1403–7. https://doi.org/10.1126/science.aau0561.

Pew. “FAQ: Illegal, Unreported, and Unregulated Fishing.” Accessed September 5, 2019. http://bit.ly/1vZ7CUv.

Environmental Justice Foundation. “Full Scale of Human Rights Abuse in the Fishing Industry Revealed.” Text/html, September 5, 2019. https://ejfoundation.org/news-media/2019/full-scale-of-human-rights-abuse-in-the-fishing-industry-revealed-in-new-ejf-report.

Global Fishing Watch. “Spire Partnership Nearly Doubles Data in Global Fishing Watch.” Global Fishing Watch, November 1, 2017. https://globalfishingwatch.org/press-release/spire-partnership-nearly-doubles-data-in-global-fishing-watch-media-kit/.

———. “Understanding VIIRS Data.” Global Fishing Watch, n.d. https://globalfishingwatch.org/wp-content/uploads/Understanding-VIIRS-Data.pdf.

Google Earth Outreach. “Google Earth Outreach.” Accessed September 5, 2019. https://www.google.com/earth/outreach/.

Harasti, David, Tom R. Davis, Alan Jordan, Luke Erskine, and Natalie Moltschaniwskyj. “Illegal Recreational Fishing Causes a Decline in a Fishery Targeted Species (Snapper: Chrysophrys Auratus) within a Remote No-Take Marine Protected Area.” *PLOS ONE* 14, no. 1 (January 8, 2019): e0209926. https://doi.org/10.1371/journal.pone.0209926.

“Illegal Catch Finding Its Way Into Fish-Meal, Other Fish Products.” Accessed September 5, 2019. https://pew.org/2Ms8Lns.

Global Fishing Watch. “Indonesia’s Vessel Monitoring System.” Accessed September 5, 2019. https://globalfishingwatch.org/initiatives/indonesia-vms/.

Jordan, Megan. “How Oceana Used Global Fishing Watch Data to Promote Transparency at Sea during 2018.” Global Fishing Watch, December 18, 2018. https://globalfishingwatch.org/data/how-oceana-used-global-fishing-watch-data-to-promote-transparency-at-sea-during-2018/.

"National Vessel Monitoring System Privacy Impact Assessment Statement." National Oceanic and Atmospheric Administration (NOAA), April 2009. https://www.cio.noaa.gov/itmanagement/pdfs/PIA_VMS_041609.pdf.

"NIH's Francis Collins on Obama, Congress, and His One Regret." Accessed September 9, 2019. https://www.statnews.com/2016/12/16/nih-francis-collins-interview/.

Google Earth Outreach. "Oceans." Accessed December 9, 2019. https://www.google.com/earth/outreach/special-projects/oceans/.

World Wildlife Fund. "Overfishing." Accessed September 5, 2019. https://www.worldwildlife.org/threats/overfishing.

Global Fishing Watch. "Publications on the Commercial Fishing Industry." Accessed September 5, 2019. https://globalfishingwatch.org/publications/.

Queiroz, Nuno, Nicolas E. Humphries, Ana Couto, Marisa Vedor, Ivo da Costa, Ana M. M. Sequeira, Gonzalo Mucientes, et al. "Global Spatial Risk Assessment of Sharks under the Footprint of Fisheries." *Nature* 572, no. 7770 (August 2019): 461–66. https://doi.org/10.1038/s41586-019-1444-4.

Google Earth Outreach. "Special Projects." Accessed December 9, 2019. https://www.google.com/earth/outreach/special-projects/.

Global Fishing Watch. "Transparency in Commercial Fishing." Accessed September 5, 2019. https://globalfishingwatch.org/about-us/.

Verhulst, Stefaan G. "The Three Goals and Five Functions of Data Stewards." Medium, September 19, 2018. https://medium.com/data-stewards-network/the-three-goals-and-five-functions-of-data-stewards-60242449f378.

Global Fishing Watch. "Vessel Monitoring Systems in the Fishing Industry." Accessed September 5, 2019. https://globalfishingwatch.org/vms-transparency/.

Food and Agriculture Organization. "What Is IUU Fishing?" Accessed September 5, 2019. http://www.fao.org/iuu-fishing/background/what-is-iuu-fishing/en/.

Williams, Camellia. "Global Fishing Watch Data Key to MPA Victory in Argentina." Global Fishing Watch, December 13, 2018. https://globalfishingwatch.org/news-views/global-fishing-watch-data-key-to-mpa-victory-in-argentina/.

Woods, Paul. The GovLab's Interview with Paul Woods, Chief Technology Officer, Global Fishing Watch, August 28, 2019.

Woods, Paul, and Sarah Bladen. "Final Draft of Global Fishing Watch Case Study - Request for Comments," December 10, 2019.