

SOCIAL SCIENCES

Seeing slavery in seafood supply chains

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The seafood supply chain is often long and fragmented, and slavery is a tenacious problem. The vast majority of workers are engaged in the early stages of production and often employed through subcontracts or brokers. We hypothesized that food companies could identify risks and implement improvements by adding a labor safety dimension to their tracking and traceability systems. We designed a five-point framework—the Labor Safe Screen—and tested it for 118 products. The framework combines the use of technology in existing platforms with the collection of industry data and authoritative human rights data. Eighteen food companies used three or more components of the framework and systematically documented their supply chains, engaged suppliers, and cross-checked results. The companies were able to identify areas where working conditions met minimum principles, were unknown, or were inadequate. Three companies also incorporated direct worker feedback to focus resources and improve working conditions. We conclude that food companies can effectively and efficiently assess and reduce risks of forced labor in seafood supply chains—not to claim “no slavery” but to greatly improve their awareness of the labor conditions in the making of the products they trade and to identify feasible targets for further diligence and remedies.

INTRODUCTION

In the global seafood industry, flows of raw materials from fishing vessels and aquaculture farms are tracked over long distances with incredible accuracy, but the hands pulling fish from the net disappear from sight. Most consumers are unfamiliar with where and how the largely imported seafood they eat is caught or the sector’s impacts on local livelihoods and fishing communities (1). Benefits have shifted with technological innovation to the centralized and capital-intensive operations of global companies, and the ethics of work have also shifted (2). At least 260 million people depend on seafood work (3) (some estimates are 800 million), and the sector is possibly the world’s largest employer. Sixty-five percent to 70% of seafood for export markets is produced in developing countries (4) where labor costs are relatively low. For the rural poor, increasing work opportunities in distant water fleets, aquaculture areas, and processing hubs (2) offset decreasing local opportunities for seafood work, but this may require migration and dependence on labor brokers (5, 6). Seafood is made with a significant incidence of forced labor, child labor, or forced child labor in the seafood hub countries of Indonesia, Thailand, Vietnam, the Philippines, and Peru (7). In 2016, widespread forced labor in seafood work was reported in 47 countries (8), with incidents reported in additional countries, including New Zealand, Ireland, the United States, and Taiwan.

Forced labor is defined by the International Labour Organization (ILO) as “work or service exacted from any person under the menace of penalty and for which the person has not offered himself voluntarily” (9). Recent legislative changes have made food companies liable for the working conditions behind the goods they sell; for example, the UK Modern Slavery Act (2015) and revised trade enforcement procedures in the United States (2016) (10). Large companies doing business in California are obliged to disclose their efforts to address forced labor in supply chains, if any (11), and there are similar rules

in the UK and France. A blueprint is provided for businesses to follow in the UN Guiding Principles for Business and Human Rights, particularly its protect, respect, and remedy framework that stems from the Protocol to Prevent, Suppress, and Punish Trafficking in Persons (Palermo Protocol). The Work in Fishing Convention 188 (12) came into force in 2017 and provides explicit guidance for safe labor in fishing operations. Every member country to the ILO is bound by Convention 29 on Forced Labor and seven related conventions, and companies can appeal to regulators in their operating areas to step up labor enforcement. They can also join regional programs like the ILO project to protect migrant workers in Thailand’s fishing sector.

Public data regarding forced labor in seafood production are also available; for example, the Sweat and Toil smartphone application published by the U.S. Department of Labor contains relevant, country-level data, including a “list of goods produced by child labor or forced labor,” a “list of products produced by forced or indentured child labor,” and “findings on the worst forms of child labor” (7). The ILO, United Nations Office on Drugs and Crime (UNODC), Action for the Cooperation to Prevent Human Trafficking (UN-ACT), Nexus Institute, and Human Rights Watch have published findings on forced labor risk in seafood.

While the normative framework and tracking of country-level findings are largely in place, companies lack mechanisms to collect the human-scale data needed for identifying and remediating forced labor risks inside their supply chain. The challenges are numerous. First, the nature of fishing work is fundamentally different from other labor-intensive industries, and these differences can mask workers’ voluntary or involuntary status. Fishing vessels operate remotely and are physically isolated. Working hours are determined by ocean conditions and the around-the-clock duties needed to keep the vessel operating safely. Payment for work most frequently is a share of the catch value (13) based on seniority. A senior crew member earning thousands of dollars on a trip may work alongside a new crew member earning a minimum wage equivalent or less if trip costs or broker fees are deducted (14). Labor agencies supply a mix of professional crew from seafaring nations such as the Philippines, Chile, or Ukraine,

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and less-skilled and lower-cost crew from countries such as Myanmar, China, Indonesia, Vietnam, Cambodia (15), and Nepal. Less-skilled crew who are working in a foreign language environment without legal standing in the vessel's flag state are vulnerable to involuntary and unpaid work (5, 6, 16), particularly where a distant labor agent is the direct employer rather than the vessel owner (17). Forced labor should not be presumed from vulnerable conditions alone, however, because fishing wages provide dignified livelihoods and an escape from poverty for millions of fishers and crew.

Second, the traceability of seafood origins is still poorly implemented in some areas, and peer-reviewed research about hired workers is scarce (18, 19). At the beginning of our study, fishing boat slavery had already appeared in the U.S. media (20), and executives stated a preference for addressing risks in the supply chain internally with facility audits. We agreed that food companies with a strong relationship to a few suppliers could complete onsite assessments but pointed to ILO findings that forced labor conditions are generally hidden; for example, the owners and supervisors of boats, farms and plants may not know the actual wage details for the workers in their facilities, where labor is contracted to a broker (6) or that some are indentured and paying ongoing fees.

Third, a data gap separates the industry and human rights sphere. Slavery in seafood was described as a tenacious and prevalent problem in Southeast Asia and international fishing fleets, based on our 12 interviews with human trafficking experts at the beginning of the study period in 2013. By contrast, slavery in seafood was described as an isolated and aberrant problem in eight interviews with senior seafood executives in the United Kingdom, United States, Australia, and Thailand in 2013. The human trafficking experts had gathered significant evidence of forced labor in seafood. However, their organizations had only limited relationships with the seafood industry at that time, limiting their access to data and avenues to effect change. The seafood companies gathered evidence to comply with legal and customs requirements and had limited access to worker data, human rights findings, and avenues to effect change. The data available suggest that the working conditions that allow for forced labor are nuanced, and risk identification requires firsthand worker perspectives (21–23). Any interpretation of forced labor conditions is influenced by language and trust, and any preconceived notions about what a victim of forced labor looks like and how a victim behaves can aggravate consequences for human beings (24, 25). To collect worker data effectively, both the industry and human rights spheres needed new relationships and methods.

We considered that companies could collect and combine previously incompatible data sources like working conditions in the supply chain, even worker aspirations (26). Food companies have buying leverage and use digital technology to manage production across the supply chain, for example; within agreed time and temperature con-

trols for food safety (18). The same technology provides a powerful mechanism to implement responsibility and control for ethics in the supply chain (26). Opening the “black box” of worker knowledge and behavior could incorporate a broader representation of seafood sustainability that can better represent social goals (1). Here, we combined the strengths of existing policy, technology, and data platforms and developed a five-point framework for data sharing among multiple parties, such as the exporters and processors providing the majority of the product and human rights authorities with standing in the social context of production. We screened a wide variety of seafood products with long and fragmented supply chains, and here, we report on the process and our findings.

RESULTS

We screened 118 seafood products between 2014 and 2017 with 18 participating food companies. We produced accurate pictures of working conditions across each supply chain. To do it, we developed a five-point framework—the Labor Safe Screen (LSS)—which features triangulation of data from suppliers, human rights authorities, and workers for a progressively finer resolution of working conditions, moving from the product's country-level origins upstream into the workplace (Fig. 1). We combined data-driven and human-focused methods to produce an evidence-based and intersectoral systems approach to illuminate blind spots in production. This shifted the basis of screening from attempting to prove or to disprove specific forced labor cases toward the establishment of system fundamentals for human rights due diligence. Our research produced general findings also on transparency and working conditions in farmed shrimp, surimi, and Pacific tuna seafood segments of the sector.

In the five-point LSS framework, four components were used for risk identification: (i) product screening for country-level origins and standing on forced labor in seafood, (ii) a template to map the supply chain, (iii) an algorithm to estimate risk in fishing operations, and (iv) surveys to collect proof of protective conditions in the workplace. The fifth component is a set of principles for minimum protective conditions in the workplace and supporting templates for a code of conduct, universal contract, grievance mechanism, and disclosure of efforts. Companies used this component to incorporate findings from the earlier components and correct work conditions.

The majority of the participating food companies carry hundreds of seafood products, and they sought to learn which products were of concern to human rights authorities. We developed a tiered approach for screening a large number of products, with quantitative, scoring for persistent risks moving upstream into the supply chain and the workplace (Fig. 2). Companies using this approach screened all products at tier 1 (LSS component 1) and fewer products at tier 2 (LSS components 2 and 3) and tier 3 (LSS components 4 and 5).

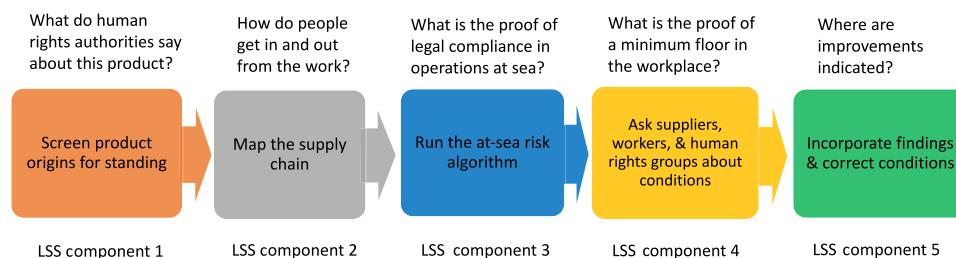


Fig. 1. LSS components and flow.

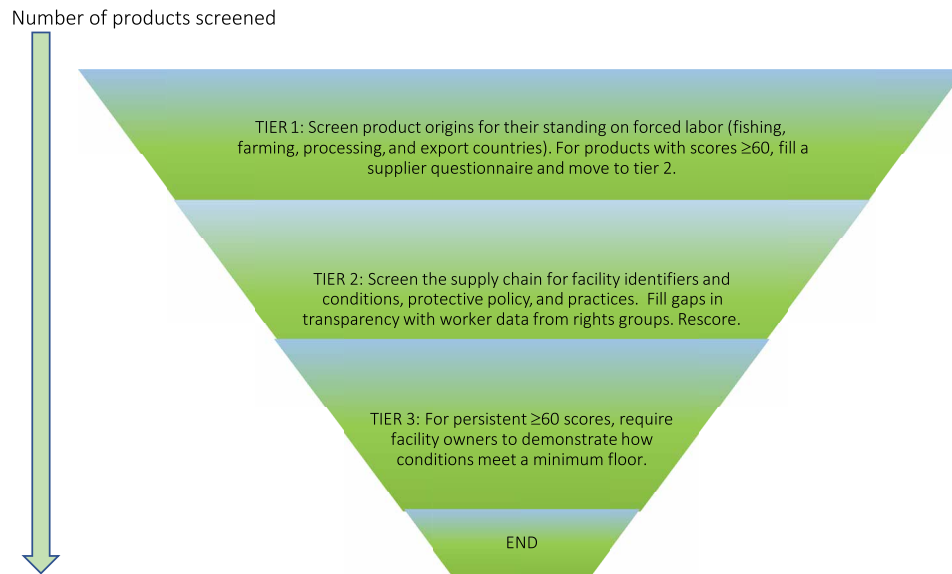


Fig. 2. Tiered approach for screening a large number of products.

To extend the coverage of our framework, we developed a process for continuously monitoring products—a decision tree with rule sets that can be populated with accessible data. The decision tree is an automated version of LSS components 1 and 4 and was embedded in food traceability software used by large U.S. grocers and seafood companies worldwide. The software owner, Trace Register LLC of Seattle, receives and communicates supplier data to its users for food safety and other types of compliance. Automation enables companies to learn which of their products are associated with country-level risks and to demonstrate, or begin steps toward, due diligence in human rights and disclosure to their customers.

Screen product origins against risks documented by human rights authorities

The first component in the five-point LSS framework is product screening for the country origins and standing as determined by human rights authorities and assignment of a numeric score. The majority of human rights data on forced labor in seafood production exist at the country level, and we drew from the list of goods produced by child labor or forced labor, the list of products produced by forced or indentured child labor, findings on the worst forms of child labor (7), the Trafficking in Persons Report (8), and the Global Slavery Index to assign product country-level scores. We considered the status of a country's commitments to the ILO forced labor conventions 29, 98, and 182; the Palermo Protocol; and the Port State Measures Agreement as an indicator of prevention.

For some products, not all country-level origins were visible. Wild-caught seafood products, for example, had inputs from the flag states of the fishing vessel and refrigerated cargo vessels, from the countries of landing, primary and secondary processing, export, and sometimes re-export. Aquaculture products had inputs from all of these and the countries supplying fry, feeds, and farms. We found that few companies tracked product origins systematically or the fishing vessel and farm origins. We recommended establishing a line of command upstream and preparing a complete list of vessels and farms. To assist, we prepared supply chain diagrams.

Supply chain mapping

The second component in the five-point framework is a template for mapping a seafood supply chain (diagrammed for Indonesian shrimp in Fig. 3). This provides a simplified view of the complex flows of raw materials and people, starting with the trade details. We found that mapping the human rights data onto supply chain diagrams increased the resolution of the known risks of forced labor. For example, in Pacific tuna supply lines, forced labor conditions have been reported in the waters of Papua New Guinea, onboard vessels operated by fleets from the Philippines (27) and Korea (28), and also in the waters of the Solomon Islands by the Taiwan tuna fleet (29). Sex trafficking has been reported of women and children in service of the fleets landing tuna in the Marshall Islands (30) and Kiribati (31). Trafficking of Cambodian fishers who were recruited by an established labor agency has been reported (21, 25). Supplemental context was provided by media reports, which allege cases in the Korean and Taiwanese fleets fishing tuna in Fijian waters (32, 33), on Thai fishing and cargo vessels (reefers) transporting tuna from the Pacific to Singapore and Thailand for processing and export (34), and on tuna reefers operating in Papua New Guinea waters and vessels fishing in Indonesian waters (35, 36). Figure S1 provides results for Pacific yellowfin tuna exports from Singapore, Papua New Guinea, Marshall Islands, Vietnam, Fiji, and the Philippines.

Similarly, we prepared farmed shrimp chain diagrams for five leading export countries (table S1). In the farmed shrimp supply chain, fishmeal for shrimp feed and fry from shrimp hatcheries are transported to shrimp farms, and then saleable-size shrimp are transported to auctions, peeling, secondary processing facilities, and export facilities that are sometimes in another country (re-export). For example, a consignment of shrimp farmed in Ecuador may be processed in Vietnam or China, before landing in the United States (37, 38). Others, such as Bangladesh shrimp, may be exported in unprocessed form after multiple trades across a string of wholesalers, erasing farm origins without adding value (39). Companies were particularly concerned with risks in feed supply chains. Feed supply chains are complex to assess for risks. In Thailand,

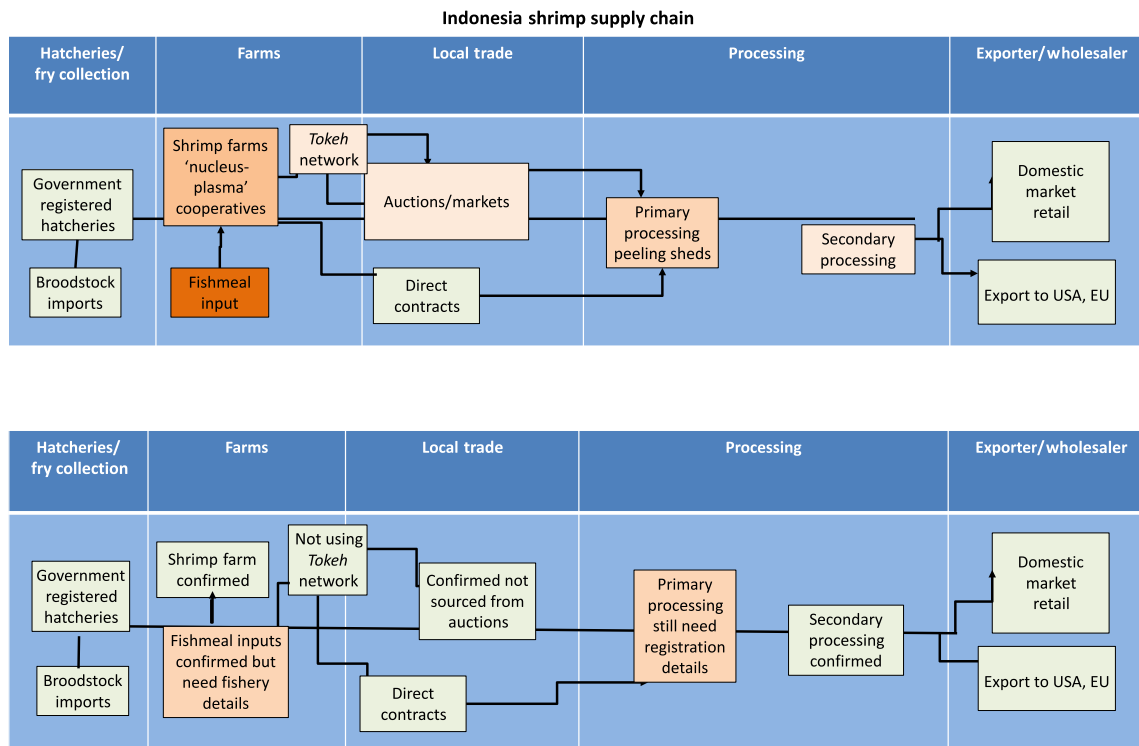


Fig. 3. Seafood supply chain diagram. The major nodes in the supply chain are shown in the top diagram. The bottom diagram shows updates as the identity of facilities was confirmed.

ILO research indicated that 17 to 26% of workers on vessels fishing for feed products were subject to forced labor (40). Furthermore, outside of International Fishmeal and Fish Oil Organisation (IFFO)-certified facilities (41), transparency of working conditions to the feed level was weak to nonexistent.

Seeing risks at sea where transparency and legal compliance of vessels are uncertain

The third component in the five-point LSS framework is an algorithm to identify risks in the at-sea portion of the supply chain, which is often the least visible and least documented. The risk factors for the at-sea portion were identified and verified through an extensive, iterative process including input from fishing and human rights experts and workers to develop the risk assessment parameterization (Table 1). The algorithm was successfully deployed to estimate the transfers of people and raw materials at sea and around ports with available (albeit imperfect) data coverage. Companies who gathered vessel data to run the predictive algorithm for the at-sea portion of the supply chain consequently identified areas of exposure to illegal, unreported, and unregulated fishing (IUU) and trafficking in persons (TIP).

A low aggregated risk score indicates good controls and an evident line of command for transfers and documentation. A high-risk score on any factor indicates a need for further diligence. In one dataset, the regulatory oversight for identity documents (seafarers book, national work permit) was low to nil, documentation of crew transfers at sea was unavailable but known to occur through supply vessels, the flag history of the supply vessel was unknown, and the refrigerated cargo vessels had a history with multiple flag changes in the previous 5 years, potentially indicating evasion from enforcement.

Seeing the working conditions in the supply chain and the workplace

The fourth component of the five-point framework involved online surveys to collect supply chain data from the suppliers of the product. The food companies received summary reports and learned where their suppliers have a reasonable knowledge of the workforce, contracting, proportion of foreign workers, and brokers, and where knowledge is limited or missing; for example, points in the supply chain where supplies from multiple origins are combined and resold. We provided the companies with questions to follow-up with suppliers privately.

Increasing transparency inside the complete supply chain is an important attribute of risk reduction for distant buyers because they cannot address an upstream hazard (whether it threatens labor or food safety) without accurate production data and a line of command. In one instance, a shrimp exporter located in Samut Sakhon (Thailand) reported that less than 10% of the workers at his facility were migrants. This was in direct contrast to published ILO data, indicating that migrant workers make up 90% of the workforce in the same area (6). Triangulating supplier and human rights data allowed us to raise an important set of questions [had the exporter accounted for full-time employees only (for example, office staff) and omitted subcontracted workers?], illustrating the importance of data triangulation at each level of the supply chain. In another instance, the working conditions reported by a surimi processor about its boats, refrigerated storage, seafood processing factory, and assistance to factory workers were consistent with reports by a local migrant rights organization.

Seeing conditions from the workers' perspective

The most accurate way to characterize working conditions in a supply chain is by incorporating worker feedback. In Thailand, we undertook

Table 1. At-sea LSS risk assessment parameterization to assess transparency and legal compliance of vessels.

Risk factor 1: Vessel ownership and home port	Risk factor 2: Vessel registration and flag	Risk factor 3: Sea-going crew
Where there is a joint venture fishing operation, who has the responsibility for labor management of the at-sea crew?	What is the registration status of the CV?	What identity documents are carried by the crew at sea on the catching vessels?
What is the ownership of the CV [catching vessel(s)]?	What is the registration status of reefer vessels that are greater than 100 GRT ?	For at-sea crew transfers, what documentation is maintained on the vessels?
What is the ownership of the reefer vessel(s)?	What is the registration status of reefer vessels that are less than 100 GRT ?	What are the procedures that are routinely used to pay the crew for their sea duty?
What is the ownership of the supply vessel(s) for the CV?	What is the history of flags for the CV?	Are the tasks/duties of the crew individuals at sea documented, and to what standards?
What is the Home Port (incl. fishing/private dock) for the CV?	What is the history of flags for the reefer(s)?	How are the sea-going crew recruited?
What is the Home Port (incl. fishing/private dock) for the reefer(s)?	What is the history of flags for the supply vessel(s)?	To what extent are the labor practices associated with the at-sea crew documentation above confirmed by a process of certification?
What is the home port (incl. fishing/private dock) for the supply vessel(s)?		
To what extent are the labor practices associated with the vessel ownership and home port identity above confirmed by a process of verification?		
Risk factor 4: Vessel resupply, transshipping	Risk factor 5: Governance framework	Risk factor 6: Monitoring, control, and surveillance framework
What is the size of the catching vessel?	What is the level of compliance with the international labor standards for fishing operations?	What is the history of the catching vessel in relation to regional, national, and industry labor or fishing standards?
What is the frequency of at-sea transfer of crew to the catching vessel?	What is the level of compliance with the Thai national labor standards for fishing operations?	What is the history of the reefer or supply vessel in relation to regional, national, and industry labor or fishing standards?
What is the destination of the vessel-to-vessel crew transfers?	What is the level of compliance with minimum voluntary (for example, codes of practice) labor standards for fishing operations?	In what ocean area are the fish caught?
What is the size of the reefer or supply vessel involved in crew transfers?	To what extent are the labor practices compliant with the standards described above confirmed by a process of verification or certification?	To what extent are the oversight of labor practices and source areas described above confirmed by a process of verification?
To what extent are the labor practices associated with the at-sea transshipping of crew described above confirmed by a process of verification?		

a research partnership with the Labour Rights Promotion Network (LPN) for firsthand perspectives on work in surimi, squid, tuna, and other supply chains. In Hawaii, we undertook a research partnership with the Hawaii Seafood Council, Hawaii Longline Association, and an independent social scientist (Amy Gough) for firsthand perspectives to employ in remediation.

Thailand's fishing industry relies almost exclusively on migrant workers (40). LPN interviewed 197 fishing crew and processing plant workers in the Samut Sakhon vicinity for this study in 2015 (summarized in table S2). Nearly every plant worker had come from Myanmar (82 of 84 people). They were paid the equivalent of Thai minimum wage, but many still owed brokers for travel costs of 1000 to 16,000 baht (\$32 to \$507) and a 5500 baht fee to apply for a factory job (\$174). Half of the respondents had worked previously on fishing boats and said they had moved up to the largely better working conditions onshore in the processing sector. Of 113 men working on

Thai fishing boats, 111 had no contract and were paid by labor agents on an irregular basis. Debt bondage was commonplace through a system of advances and fees by the brokers. For example, seafood workers said they were charged 10,000 baht (\$317) for a cap, toothpaste, toothbrush, and boots, as well as for travel expenses and document fees, plus 4000 to 5000 baht per month for food (\$127 to \$158 per month at 32 baht per USD). Respondents from boats supplying surimi factories said their wages had increased. They lacked first aid training and equipment and reported fainting from inhaling the gases released from fermenting fish in the hold. Death of some fellow crew members from the unsafe conditions had been observed. Overall, the seafood workers said they generally lacked safety and occupational training and mechanisms to claim payments in the amounts initially agreed. Basic work costs were often deducted from their pay. They wanted assistance with their employers to improve their legal status, to obtain a contract and vocational training, and to file a

complaint when needed. Positive changes and improvements were occurring in Thailand, they said, and helping to empower workers and raise awareness of their rights. Given a choice, 132 of 197 respondents said they would stay with their current employer (67%).

In Hawaii, we used the worker data in the development of a new universal crew contract and labor code of conduct for the longline fleet. The interview set included the working conditions described by crew members from all language groups and home countries in the fleet, including Kiribati, Vietnam, Indonesia, Philippines, Fiji, and Papua New Guinea, and broker details and terms. The seafarers' ministry, Filipino and Kiribati Consuls, the local Indonesia committee, and other community organizations also contributed perspectives from crew members. Concerns about livelihood security dominated worker data collected in interviews. Seeing the conditions from the workers' perspective in Thailand and Hawaii caused us to reconsider our approach in 2015/2016. We shifted the basis of screening from attempting to prove or to disprove forced labor conditions in supply chains toward establishing system fundamentals for human rights due diligence.

Focus for improvements

The fifth component of the five-point LSS framework is a set of tools to incorporate findings and correct conditions. We developed principles for minimum protective conditions in the seafood workplace (Fig. 4) and templates for human rights due diligence [a code of conduct, universal contract, grievance mechanism, and a disclosure statement (table S3)]. These tools have been used in the Hawaii commitment to decent work in fishing and in a mandatory disclosure statement for fishing companies in the Marine Stewardship Council program for sustainable fisheries (a third application is proprietary). At present, 125 fishing vessel owners in Hawaii are required to demonstrate that all crew have a double-signed universal contract written in their language. The United Fishing Agency auction at Honolulu's Pier 38 maintains the fleet's file of letters of assurance from vessel owners,

captains, and labor brokers of compliance to the fleet's code of conduct for decent work in fishing. The code specifies minimum conditions to protect workers from forced labor that derive from the principles, which are generally applicable to seafood workplaces. We prepared the principles through dialogue with fleet representatives and authorities at the U.S. Department of Labor's Bureau of International Labor Affairs.

Summary of results

Overall, the 18 food companies in our study used three or more components of the five-point LSS framework and systematically documented their supply chains, engaged suppliers, and cross-checked results. They experienced successes and challenges in trying to collect and verify data in their supply chains, which we have illustrated with examples and details (based on public data and excluding proprietary data). Human rights due diligence was a new concept to the seafood sector in the study period. The methods that worked well were supply chain mapping (component 2) and using supplier and human rights data together (component 4). These were indispensable for seeing previously unknown and at-risk conditions in the supply chain, for example, where brokers are predominant. It was challenging to collect data on working conditions from suppliers with online surveys (component 4). Respondents wanted to comply with their buyers' requests but were concerned about losing business. The surveys were revised in 2016/2017 in part to de-risk the experience for suppliers and in part to improve the surveys in ways human rights authorities recognize to be legitimate. In the digital program, we found that suppliers did not maintain the labor code of conduct, universal contract, and grievance mechanisms the survey asked for but were familiar with local labor laws and social certification programs. We added an open question to collect all labor diligence efforts and avoid duplication and prescription. In Hawaii, we learned that remediation takes time and community engagement. The chain of custody documents (component 5) were revised in multiple rounds of stakeholder input and field testing



Fig. 4. Field-tested principles for minimum conditions to protect workers from forced labor.

to make sense to industrial fishing and seafood employers and to include specific references to the normative framework, for example, the C188 Work in Fishing Convention.

Slavery in seafood supply chains is an incendiary topic, and our intermediate goal was to resolve the finest possible scale of drivers and impacts from trade data and the factual accounts of workers and employers, and their representatives. We observed the drivers of working conditions in 118 supply chains, as well as the large-scale drivers of weak enforcement of labor and fisheries regulations and weak tracking of seafood product origins by companies and customs agencies worldwide. Forced labor in seafood coexists with overfishing, illegal fishing, corruption, and sex trafficking to service fishing fleets—a widespread problem documented by the U.S. Department of State. In the Pacific tuna hub of the Marshall Islands, for example, local girls and foreign women are recruited by foreign business owners to engage in prostitution with crew members of foreign fishing and transshipping vessels that dock in Majuro (30). In other parts of the western Pacific, seafood workers have benefited from regulatory changes that confront drivers of forced labor, for example, surimi workers in our study said that they benefited from better enforcement in Thailand and Indonesia on vessels with previously strong ties to illegal fishing.

We are contributing interdisciplinary methods that we hope future researchers will use in service of decent work and labor safety in seafood. We learned that seafood companies want their vendors to have systems to identify risks and make improvements and to disclose their efforts. Companies said they wanted each entity in the supply chain producing the good before it reaches them to be responsible for protective working conditions in their operations. They wanted an onramp for the sector, and some wanted a seat at the table for the overall direction of the effort in the sector to ensure that it meets best practice, and particularly that it meets the highest-order legal tests from customs officials. Human rights authorities did not want the work done by companies to be token. They expected companies to use knowledge and resources in the human rights sphere, to act on the findings from workers, and to make their efforts available for verification. The company executives and human rights experts who contributed to our study expected certification programs for seafood sustainability to incorporate human rights due diligence.

INTERPRETATION

Over a period of 5 years, our team developed a framework with five components to efficiently and effectively assess and manage the risk of forced labor in seafood supply chains. The framework was tested in the commercial sector and demonstrated utility for food companies importing seafood from around the world. By combining and analyzing existing public human rights and supply chain data through the new lenses provided by these tools, screening allowed companies to see deeper within their own sources of supply, and forced labor risk could be identified. Data drawn directly from workers provide an essential line of sight into actual working conditions, and more worker data are clearly needed to complete the picture and ensure that management programs are effective. We have shown that adding labor screening to existing digital platforms is an efficient way to learn about working conditions at scale, and that integrating the worker voice into these platforms produces a more accurate picture of working conditions across the supply chain (for example, data collected from programs like Verifik8 and Ulula). This type of risk

assessment helps companies target diligence and improvement resources to the most at-risk aspects of their supply chain.

Through the course of this study, we identified four aspects of labor management that generally reduce the risks of forced labor. First is making a commitment to the principle of no forced labor. Properly, it means providing workers with a protective and actionable contract because enforceable agreements are a prerequisite for access to effective remedy, which, in turn, is necessary for brand accountability (42). Second is adoption of the employer-pays model. It means that the vessel owner or facility owner explicitly pays all costs of work and prohibits brokers from taking ongoing fees. The seafood company Thai Union adopted an employer-pays policy in 2016 (43). Third is contract consistency. The contract terms for work on the vessel must match the terms signed onto (for migrant workers, with the labor broker in the home country). The Seafood Task Force, an industry-led coalition, has audited labor documentation on Thai fishing vessels for consistency to improve product traceability and labor transparency (44). Fourth is free agent status. It means that contracted workers have the freedom to leave work (defined in the contract) and freedom to negotiate work terms, either individually or as a group. When foreign crew members wish to change vessels in the Hawaii longline fleet, they are assisted with placement and contracting changes by the vessel owners and the U.S. Department of Homeland Security.

In conclusion, it is clear that food companies can deploy a combination of available procedures and data to effectively and efficiently assess and manage the risk of forced labor in their seafood supply chains. This capability gives the sector an opportunity to increase and expand protections to all seafood workers, including migrant people working in subcontracted conditions and commercial fishers working without a contract—who may represent a significant fraction of the estimated 28 million fishers in the industrial sector (3). The evaluation of risk in a supply chain produces no guarantee that products are free from labor risks, which can rarely be supported (45, 46), but, set in a supportive implementation context such as that of the LSS, it provides a specific focus on the most urgent points for next steps. Ideally, robust risk assessment and remediation should be part of a multipronged strategy for sustainable seafood, which is socially responsible (47) and includes a strategy to hear directly from workers at the forefront, and therefore to engage frontline organizations.

MATERIALS AND METHODS

Overview

We developed a five-point framework to screen seafood products for the working conditions in the making of a product. In component 1, a seafood product was first considered from all possible countries of origin, and a numerical score was assigned. Next, the supply chain was diagrammed with trade data and data on producer demographics (component 2). For fishing operations, an at-sea risk score was generated with available data (component 3). We collected proprietary data from the suppliers to participating companies and worker data from human rights authorities (component 4) and subsequently triangulated all data available. Some companies in our study incorporated our findings and corrected conditions with assistance from workplace principles and templates we developed for their use for remediation (component 5).

Overall, this interdisciplinary study combined manual and automated approaches to gather information from the public domain,

directed survey, and semistructured interviews. The approach to risk evaluation was the product of interdisciplinary methods used in a collaborative process to engage with a broad range of experts and experience in the food industry, human rights, fisheries science and risk, food safety and traceability, labor and counter-TIP agencies, and mentors from the apparel, mining, and electronics sectors to determine the type and location of potential labor risk in supply chains. Primary data collected through interviews with anti-human trafficking experts (25 interviews) and industry executives (26 interviews) also contributed to the development and testing of the five-point framework. The five-point framework was presented at GOAL, Boston Seafood, and SeaWeb trade shows and conferences in the seafood sector in 2014–2017, and the participating companies were self-selected.

LSS components 1 and 2

We began screening by looking at all possible countries of origin for the seafood product in component 1 and by developing a numerical score. For example, Indonesia shrimp products scored 55 and fish products scored 65 because Indonesia has ratified the Palermo Protocol and ILO C29, C98, and C182, and Indonesian fish is on the list of seafood goods made with significant forced labor (7) and shrimp is not. We set a score of 60 or greater as an arbitrary threshold for recommending further investigation.

Product supply chains were conceptualized graphically in LSS component 2 and populated with published evidence on seafood production and working conditions. A unique diagram was prepared for each export product and included all levels of production and the majority of raw material inputs: fishing area, fishing countries, vessels and gear, or alternatively feed source fisheries, hatcheries, and farms for aquaculture, landing and local trade, processing, export, and retail. Proprietary data from supplier surveys complemented public domain data/knowledge (by using LSS component 4, see below).

LSS component 3

At-sea workplaces—vessels and ports—are notoriously difficult for surveillance of labor risk (19). To address this, we developed an algorithm for LSS component 3 using a likelihood and consequence structure, with a set of utility function relationships derived empirically from the literature and proprietary data/knowledge. We derived risk parameters from a set of empirical relationships known or predicted by existing reports of labor risks onboard vessels and around ports. This risk assessment framework was coded into an expert system algorithm, which uses 34 data entry questions to produce 0 to 100 scores in a likelihood and consequence model of risk assignment. The data are weighted by verification in the algorithm: If a response is validated with high-quality public data, it is weighted 100%, or 50% where it is not. The data entry questions elucidate the history of a product in relation to each risk parameter, and the algorithm assigns a performance level relative to a utility function derived from the available literature and datasets. The risk factors include a range of factors that have been linked to IUU and labor violations, including vessel history of flag states, vessel ownership and history of compliance with international seafaring rules, and the destinations and the frequency of at-sea transfers of raw materials and crew (Table 1). Risks can be estimated with vessel data provided by the supply chain or independent accounts and databases. Outputs were provided as kite graphs, which were internally consistent and easily interpreted to identify points of risk that are susceptible to corrective action.

LSS component 4

We collected supply chain data on product, facility, and producer characteristics in online surveys from the suppliers to participating companies (www.smartsurvey.co.uk/s/LSS_Supply_Chain_Questionnaire and www.smartsurvey.co.uk/s/Farmed_Shrimp_Questionnaire/). The online surveys were produced collaboratively with assistance from a seafood supply chain expert and from a senior executive at Thai Union, a major Thai seafood company, in 2014. Data were collected from suppliers with Thai language support in 2014–2016. We additionally produced and piloted surveys to test for proof of minimum protective conditions from forced labor in specific supply chains. We collected and used data from the surveys as a basis for scoring the risk in products and to move upstream in the chain from exporters and processors to first receivers.

LSS component 5

Three companies in our study incorporated findings from risk identification and corrected conditions. We developed workplace principles and templates for their use in an iterative and multistakeholder process, which involved trialing and revision for general applicability through peer review with industry and human rights experts and regulatory authorities. For example, the disclosure statement for fishery clients to the Marine Stewardship Council program was vetted and revised line by line in a stakeholder workshop in November 2017 and public consultation in early 2018 (48). A generic disclosure statement is provided in table S3.

Continuous monitoring

We adapted a version of the LSS and embedded it in the seafood traceability program by Trace Register LLC of Seattle. The “Labor Safe Digital Certificate” gives companies an option to deploy continuous monitoring, achieved by automating information inputs and scoring all products first at the country level (component 1) and second at the supplier and facility levels (component 4). This provides the user with knowledge of which products come from high-risk origins in near real time, based on available public data and digital information already collected in the program. The total aggregated score combines product risk and facility risk. The facility owner can improve the score by demonstrating, or beginning steps for, human rights due diligence and by disclosing their efforts to their customers.

With this proof of concept, we won the grand prize in the Partnership for Freedom challenge in 2016 to rethink supply chains with technological solutions that identify and address labor trafficking in global supply chains for goods and services. The program was piloted in 2017, partially satisfying our hypothesis that food companies can identify risks by adding a labor safety dimension to their tracking and traceability systems.

SUPPLEMENTARY MATERIALS

Supplementary material for this article is available at <http://advances.sciencemag.org/cgi/content/full/4/7/e1701833/DC1>

Supplementary Methods

Table S1. Summary of country-level labor risks in farmed shrimp.

Table S2. Findings from semistructured interviews with Thai seafood workers ($n = 197$).

Table S3. Disclosure template for seafood suppliers to prepare a human rights statement.

Fig. S1. Pacific yellowfin tuna supply chains for six Asia-Pacific nations supplying the U.S. market.

Fig. S2. Supply chains for shrimp from five major exporting countries and for fishmeal.

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G.P. co-developed the at-sea risk algorithm, developed research plans to screen Thai seafood, and edited the manuscript. D.C.T. produced the program's supply chain reports and diagrams and online surveys for suppliers, provided technical and Thai language support to Thai seafood suppliers engaged in screening, and edited the manuscript. P.T. conducted 197 interviews with workers and S.S. characterized working conditions at sea and onshore working conditions in the Thai seafood sector. **Competing interests:** The authors declare that they have no competing interests. **Data and materials availability:** All data needed to evaluate the conclusions in the paper are present in the paper and/or the Supplementary Materials. K.N.'s intellectual property has been released into the public domain for others to use, customize, and improve upon. Additional data related to this paper may be requested from the first author.

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