airspace, could protect daily animal movements such as for foraging. However, many air users cover large distances, taking them beyond their reserves (*14*). This complicates efforts to protect them and must be taken into account when designing reserves.

Conservation measures must also consider the sociocultural aspects of human-wildlife conflict. For example, the spring bird hunt in Malta has negative demographic effects on bird species that are migrating to breed. However, it is considered a traditional practice and in a recent referendum, the Maltese population narrowly voted to continue with the practice. This case shows how difficult it is to translate some traditions into current conservation practices. Similarly, military practices may also have negative impacts in areas sensitive for wildlife (e.g., flying through rocky canyons where vultures and many other species fly). These sociocultural conflicts with flying species occur throughout the world and require integrative conservation approaches that go beyond reserves.

There are thus three main levels at which to deal with airspace conflict: identification of pristine airspaces with high aerial wildlife densities where valuable air reserves can be created; identification of airspaces where humans and wildlife are already in severe conflict and where more dramatic measures must be taken to reduce collisions; and a suite of standard measures, such as anti–bird collision light systems, that should be implemented in places when bird strike probabilities are appreciable. Such a combination of strategies will provide a better perspective for airspace conservation. ■

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SUSTAINABILITY

Secure sustainable seafood from developing countries

Require improvements as conditions for market access

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POLICY

Demand for sustainably certified wild-caught fish and crustaceans is increasingly shaping global seafood markets. Retailers such as Walmart in the United States, Sainsbury's in the United Kingdom, and Carrefour in France, and processors such as Canadian-based High Liner Foods, have promised to source all fresh, frozen, farmed, and wild seafood from sustainable sources by 2015 (*1*, *2*). Credible arbiters of certifications, such as the Marine Stewardship Council (MSC), require detailed environmental and traceability standards. Although these standards have been met in many commercial fisheries throughout the developed world (*3*), developing country fisheries (DCFs) represent only 7% of ~220 total MSC-certified fisheries (*4*, *5*). With the United Nations Food and Agriculture Organization reporting that developing countries account for ~50% of seafood entering international trade, this presents a fundamental challenge for marketers of sustainable seafood (see the photo).

Progress toward sustainability means overcoming difficulties DCFs face in complying with MSC-like standards (*6*–*8*). With a limited amount of certified wild-caught seafood available, some firms include seafood sourced from fishery improvement projects (FIPs) (*9*), in which fishers are rewarded with market access conditional on the fishery making progress toward sustainability. Rapid spread of FIPs, which often operate without transparent and independent assessment, raises questions about their effectiveness as a tool to foster environmental, economic, and social improvement.

ACCESS, THEN IMPROVEMENTS. FIPs are varied in their scale and scope, developed and funded by nongovernmental organizations (NGOs) and the private sector. At their core, they are partnerships with the supply chain seeking to source seafood for developed country markets to supplement the stock of MSC-certified products (*6*) (fig. S1). Although FIPs are not formally part of the MSC or any other certification process, they provide fisheries, especially those that might perform poorly during pre-assessment stages of formal certification, an opportunity to be rewarded with access to markets (and potentially higher ex-vessel prices) (*10*). The costs of engaging a fishery in a FIP or MSC process appear similar (*11*, *12*) and depend on the size and complexity of the fishery, but the distribution over time can vary because of the larger upfront costs associated with MSC certification.

According to the FishSource data library

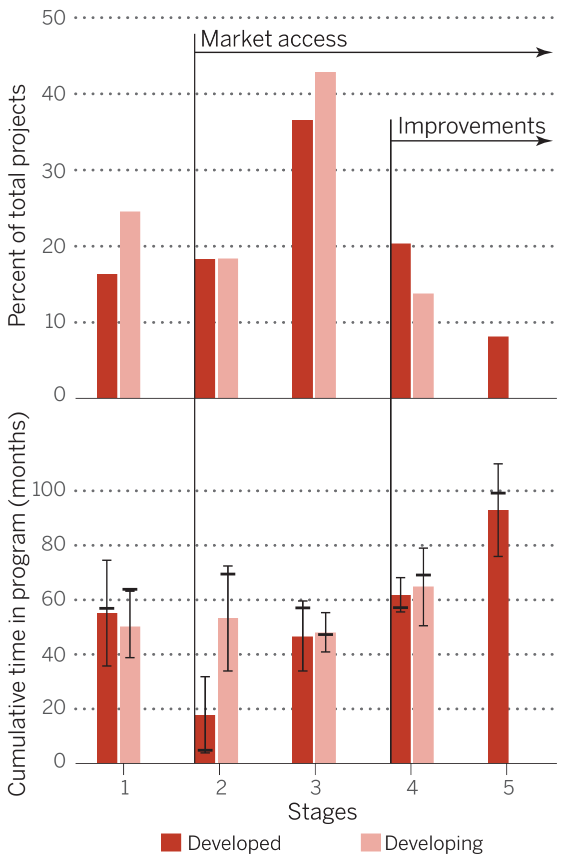
The municipal port in Bitung, North Sulawesi. Indonesia.

PHOTO: SIMON R. BUSH/WAGENINGEN UNIVERSITY (see supplementary materials), there are >130 fisheries in FIPs worldwide, with DCFs accounting for nearly half (fig. S1). In the next 2 years, hundreds more FIPs are expected (*13*). The National Fish and Wildlife Foundation's Fishery Improvement Partnership Fund estimates that "more than 400 FIPs are needed to meet buyer demand for sustainable seafood worldwide" (*14*).

The Sustainable Fisheries Partnership (SFP) (*15*) process for a FIP includes five stages (fig. S2). After an initial scoping stage, stage 2 involves stakeholder meetings to develop work plans. At this stage, participating fishers and processors gain access to major markets. In stage 3, work plans are made publicly available and suppliers engage with fishery regulators to reform practices. Stage 4 is when changes in fisheries policies, practices, or both happen (e.g., regular vessel inspections or port data collection). The fifth stage involves demonstrating improvements in the water on measurable indicators like biomass or fishing mortality. An optional sixth stage is entry to the MSC certification process.

We find that nearly two-thirds of DCFs in FIPs (table S1) have obtained market access but are not yet delivering fisheries improvements (see the graph, top). On average, DCFs have spent more time (50 months, SEM = 3.1) than fisheries in developed countries (41 months, SEM = 4.9) in the first 3 FIP stages (see the graph, bottom). There seems to be a set of DCFs that are not moving past stages 1 and 2, given that their median cumulative time in a FIP is ~20 months longer than for those DCFs that move on to stage 3 (table S2). In addition, the median time spent by DCFs that are in stages 1 and 2 is ~10 months longer than the median time for developed country fisheries in stage 3. Although not all FIPs may be driven by a desire for greater access to export markets (*16*), for those that are, it is unclear whether retail partners' conditions—progressive improvements in exchange for continued market access—are effective. For both developed and developing countries, fewer than one-fourth of fisheries in FIPs have reached stage 4 or beyond, at which they are delivering policy or conservation gains.

Improvements after market access



Fisheries stagnate in early stages of FIPs. (**Top**) Developed and developing country fisheries according to FIP stage (*n* = 111). Market access occurs in stage 2 and regulatory and ecological improvements after stage 3. (**Bottom**) Cumulative time since the fishery was established as a FIP and current stage for developed and developing countries. The vertical bars represent mean time, the horizontal lines are medians, and error bars represent ±2 SEM. Data are from (*15*).

RACE TO THE BOTTOM. What factors and practices enable improved fishery management and ecosystem conservation in developing countries? MSC certification is an obvious yardstick to measure FIP success and is the basis for the SFP's FishSource scoring metric. In response to demands from major seafood buyers, MSC has reinforced its position in the "FIP market" by developing a benchmarking and tracking tool that FIPs can voluntarily use to report progress against the MSC framework (*2*). Legitimized by these metrics as fisheries on a path to sustainability, FIPs are creating de facto sustainability claims recognized by retailers and others in the supply chain, effectively competing with MSC and other third-party certifications. This competition could lead to a race to the bottom in standards for sustainability unless FIPs' conditional access to markets is closely adhered to by retailers.

DCFs present particular challenges for FIPs. These fisheries are important components of local economies and culture, upon which fisher and nonfisher livelihoods depend (*17*). FIPs can have uncertain effects on fishing communities when they result in increased pressure on local and regional marine stocks (*18*) and push fisheries toward export rather than local markets. Although developing countries as a whole derive improvements in food security from seafood trade (*19*), the distribution of benefits and costs of increased seafood trade and effects on local food security for individual developing countries remain unclear.

Characteristics of fishing communities also affect the ability to change fishery governance and management systems, both of which determine outcomes of a FIP. Most DCFs in the FishSource database are characterized by weak fisheries management and use input restrictions (e.g., time or area closures and/or gear restrictions) that only indirectly affect total catch and often do not control fishing effort (table S3). Only 5 of the 66 DCFs in FIPs specify a cap on total catch. Even with reforms, a FIP may not lead to control of total output in this environment. Market access may create economic returns for fishers, leading to expanded fishing effort and larger harvests (or greater incentives to land catches outside the FIP) to meet growing demand.

Most FIPs in DCFs are focused on single species (table S3). If FIPs create incentives to target single stocks, they could lead to a concentration of fishing capacity by those fishers with access to capital and high-value markets rather than support communities built on multispecies fisheries (*5*, *17*). FIPs may not address the issues of spillover to other fisheries and natural resources (e.g., bycatch and effort creep) [see, e.g., (*9*)].

More positively, FIPs can provide a means to protect marine life in weak institutional environments where local and national governments have not taken ac-

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tion. For example, FIPs can improve data collection and monitoring to address illegal, unreported, and unregulated (IUU) fishing. The blue swimming crab FIPs in Vietnam, Indonesia, and the Philippines have accomplished various forms of catch data collection that did not exist before FIP formation (*15*). Traceability along the supply chain, as being developed by the Brazilian Lobster FIP (*15*), can play an important role discouraging IUU fishing (*20*, *21*). FIPs in the Ecuador mahi mahi fishery resulted in policies that reduced sea turtle bycatch (*22*).

Finally, retailers and NGOs involved in a FIP must maintain their partnerships and support for an extended period of time. Yet success of FIPs may be challenged if financial support is vulnerable to market pressures (e.g., changing demand for seafood and donations to NGOs).

> ***"Strict adherence by retailers to conditionality of market access on continued improvements ... is needed ..."***

ADHERE TO CONDITIONAL ACCESS. Advocates of fishery management reform and ocean conservation should view FIPs as an opportunity to capitalize on ongoing stakeholder engagement to enact durable reforms, but in ways that take into account characteristics of the social-ecological system. Achieving successful and durable outcomes, however, is not assured.

Consideration of basic exclusionary rights for fish stocks (e.g., individual quotas, territorial user rights, fishing cooperatives) may be necessary to ensure that fishing activity is effectively measured and disclosed in the interest of substantiating fishery improvements. Exclusion is a particularly sensitive subject in poor fishing communities that rely on fishery resources for their livelihood. Yet, without controlled access, the race to secure sustainable wild-caught seafood could stimulate a race to fish.

Strict adherence by retailers to conditionality of market access on continued improvements, transparently monitored by independent third parties, is needed, albeit at additional cost. FIPs might encourage better and more durable protection by withholding market access until after fishery management systems are in place or by withdrawing market access if targets are not met in a timely manner. This could also provide assurances to the consumer that "sustainable" seafood is accurately described in the marketplace.

Retailers will continue to seek and develop sources of sustainable seafood to make good on their declarations. But FIPs may do little for environmental, economic, and social sustainability without investments in understanding the social-ecological systems in which they operate. For example, how effective are market-based incentives for motivating and maintaining engagement of fishing communities? How are costs and benefits of FIPs—in the short and long run—distributed through supply chains and fishing communities? How do fishery and community characteristics affect the durability of value chain-driven improvements? How can greater regulation and surveillance of FIPs in DCFs be balanced with the higher cost they would entail? Are there local community characteristics that correlate with beneficial impacts of current FIPs that can help guide where and how new FIPs should be created? ■

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SUPPLEMENTARY MATERIALS

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IMMUNOLOGY

Early life Aire

The development of particular T cells at a specific time prevents autoimmunity

By **Atsushi Tanaka** *and* **Shimon Sakaguchi**

The immune system protects us from invading microbes but does not react with the constituents of our body. When this immunological unresponsiveness to self is broken, autoimmune diseases such as type I diabetes and rheumatoid arthritis may develop. To establish and maintain this self-tolerance, lymphocytes—in particular, T cells—are subjected to two essential processes during their development in the thymus: the elimination (negative selection) of self-reactive T cells, and the generation of regulatory T (T_{reg}) cells. The latter are specialized for suppressing peripheral activation and expansion of those self-reactive T cells that have escaped elimination in the thymus. On page 589 of this issue, Yang *et al.* (*1*) show that a specific population of T_{reg} cells produced particularly early in life are highly efficient in preventing autoimmune disease and sustaining stable self-tolerance.

Genetic anomalies of T_{reg} cell development cause severe autoimmune diseases including type 1 diabetes in humans, indicating that they are indispensable for immune self-tolerance and homeostasis (*2*). As another genetic anomaly, mutations of the *autoimmune regulator* (*Aire*) gene, which is expressed in medullary thymic epithelial cells, produce autoimmune diseases collectively called autoimmune polyendocrinopathy–candidiasis–ectodermal dystrophy (or autoimmune polyglandular syndrome 1), although it is a matter of debate whether *Aire* mutations cause autoimmunity through effects on negative selection, T_{reg} cell generation, or both (*3*). Yang *et al.* show a new link between T_{reg} cell development and the function of Aire during perinatal life.

Medullary thymic epithelial cells present peripheral tissue antigens to developing T cells. These antigens include those that are targeted in autoimmune disease, such as insulin (*4*). Aire, which is a nuclear factor that controls transcription, is involved in the expression of a variety of peripheral tissue antigens by medullary thymic epithelial cells. Several studies have suggested that these Aire-expressing cells are engaged