Reducing bycatch of marine megafauna through interfishery conservation resource transfers

Peckham, SH\textsuperscript{1,2}, CJ Donlan\textsuperscript{3,4}, LB Crowder\textsuperscript{5}, R Cudney-Bueno\textsuperscript{6,7}, C Wilcox\textsuperscript{8}

\textsuperscript{1}ProPeninsula 740 13th Street Suite 502
San Diego CA 92101 USA

\textsuperscript{2}Department of Ecology and Evolutionary Biology,
University of California at Santa Cruz, Santa Cruz CA 95060 USA

\textsuperscript{3}Department of Ecology and Evolutionary Biology,
Cornell University, Corson Hall, Ithaca, NY 14853, USA

\textsuperscript{4}Advanced Conservation Strategies, P.O. Box 1201,
Midway, UT, 84049 USA

\textsuperscript{5}Center for Marine Conservation, Nicholas School of the Environment and Earth Sciences, Duke
University, Beaufort, NC 28516 USA

\textsuperscript{6}Conservation and Science Program, The David and Lucile Packard Foundation, 300
Second Street, Los Altos, CA USA

\textsuperscript{7}Institute of Marine Sciences
University of California at Santa Cruz, Santa Cruz, CA 95060 USA.

\textsuperscript{8}CSIRO Marine and Atmospheric Research, Hobart 7001, TAS, Australia

*Previous affiliation
ABSTRACT
Fisheries bycatch is a leading threat to marine megafauna worldwide. Changes in fishing gear and techniques have resulted in substantial reductions in bycatch in some industrial fleets. Ubiquitous small-scale fisheries can cause severe, population-level mortality of marine megafauna, but scarce resources generally limit mitigation of their bycatch. Large disparities in regulation, revenue, geography, and bycatch rates between industrial and small-scale fleets can offer powerful leverage for cost-effectively reducing bycatch through interfishery conservation resource transfers (ICRTs). High-revenue, low-bycatch industrial fleets that have exhausted avoidance and mitigation strategies could offset their residual bycatch by transferring capital to fund and audit measurable mitigation in high-bycatch, small-scale fleets. There is a range of regulatory, reputational, and economic incentives for both small-scale and industrial fleets to participate in ICRTs. With offsets increasingly considered as a management option we examine the conditions and precautions under which ICRTs could function. We use bycatch of the endangered Pacific loggerhead sea turtle (Caretta caretta) in both the Hawaiian long-line fleet and Mexican small-scale fleets as a case study to illustrate the conservation potential of ICRTs.
Despite increasing awareness, regulation, and explicit international treaties focused on abatement, fisheries bycatch remains a leading threat to marine megafauna worldwide, including seabirds, sea turtles, sharks, and marine mammals (Hykle 2002; Lewison et al. 2004a). Given the important roles that migratory megafauna can play in the structure and function of ecosystems (Jackson et al. 2001; Springer et al. 2003; Myers et al. 2007), mitigating bycatch is a pressing conservation concern. As a result of widespread population declines of seabirds and sea turtles, fisheries are under increasing pressure to reduce their bycatch and internalize the associated costs, a process that has often resulted in costly economic and socio-political tensions (Crowder & Murawski 1998; Curtis & Hicks 2000; Hall et al. 2000). In certain cases, changes in fishing gear and practices have resulted in substantial reductions in bycatch (Gilman et al. 2005; Gilman et al. 2007). But in many more cases bycatch remains high, and even fleets that use current best practices experience residual bycatch (Donlan & Wilcox 2008; Lewison et al. 2004b, Wilcox and Donlan 2009). The technological and economic challenges of bycatch reduction are exacerbated by the difficulties of ocean governance (Dutton & Squires 2008).

The oceanwide migrations of marine megafauna populations expose them to bycatch mortality between multiple nations and fisheries ranging from artisanal to industrial in scale. Recent studies have revealed substantial marine megafauna mortality from small-scale fisheries (Jahncke et al. 2001; D'Agrosa et al. 2003; Alfaro-Shigueto et al. 2007; Peckham et al. 2007; Pinnegar & Englehard 2008). These artisanal fisheries include subsistence and commercial activities and are characterized by small vessels with low capitalization and mechanization. Ubiquitous worldwide, they employ over 99% of the world’s 51 million fishers (Berkes et al. 2001). Nevertheless, bycatch in small-scale fisheries has been assumed to be low because their assessment and management have been generally poor relative to industrial fisheries. Advances in bycatch management have been
largely limited to industrial-scale operations, despite high bycatch rates in small-scale fisheries (Lewison & Crowder 2007; Peckham et al. 2007). To fully mitigate bycatch, we will have to address globally ubiquitous small-scale fisheries as well as industrial fisheries.

Here, we suggest a novel, integrated approach to bycatch management that links high revenue, regulated, industrial-scale fisheries with small-scale fisheries for which mitigation is currently resource limited. The many mortality sources that marine megafauna face during their lifetimes present diverse opportunities for conservation. Large disparities in regulation, revenue, geography, and bycatch rates that exist between industrial and small-scale fleets could offer powerful leverage for reducing global bycatch of megafauna populations through interfishery conservation resource transfers (ICRTs). ICRTs are consistent with the *avoid, mitigate, and offset* sustainable-use hierarchy of the Convention on Biological Diversity (Donlan & Wilcox 2008; Slootweg et al. 2006). Net conservation gains could be achieved by facilitating high-revenue, low-bycatch industrial fleets that have exhausted bycatch avoidance and mitigation strategies to offset their residual bycatch by funding measurable mitigation programs in high bycatch, small-scale fisheries. We use bycatch of the endangered Pacific loggerhead sea turtle (*Caretta caretta*) in both the U.S. Hawaiian long-line fishing fleet and small-scale fishing fleets in Mexico as a case study to illustrate the potential of ICRTs.

**Interfishery Conservation Resource Transfers: North Pacific Loggerhead Turtles**

Nesting exclusively in Japan, North Pacific loggerheads have declined precipitously (50-90%) in recent decades to fewer than 1500 nesting females yr\(^{-1}\) (Kamezaki et al. 2003; Kamezaki et al. *In Press*). Juveniles migrate across the Pacific Ocean and spend several decades foraging in the central and eastern Pacific (Fig. 1; Bolten & Witherington 2003). In the central Pacific, juvenile
loggerheads experience bycatch mortality due to industrial Hawaiian and international long-line fisheries, along with illegal fishing activities (Lewison et al. 2004b; Polovina et al. 2006). Further east, juveniles from the same nesting population suffer extremely high bycatch mortality along the coast of Mexico’s Baja California peninsula from at least two small-scale fishing fleets (Peckham et al. 2008).

The disparities in revenue, fishing effort, and bycatch rates between the Hawaiian long-line fleet and these small-scale fleets present powerful conservation leverage (Table 1). In 2005, loggerhead bycatch per unit effort was more than two orders of magnitude higher in the small-scale Mexican long-line fleet compared to the Hawaiian industrial fleet. The differences in loggerhead bycatch between the industrial and small-scale fleets are due largely to an overlap between the Mexican fleets and a high-density loggerhead foraging area (Peckham et al 2007), as well as successful mitigation measures recently implemented by the Hawaiian fleet (Gilman et al. 2007).

An ICRT would entail a low bycatch, industrial fleet transferring capital to help fund and audit bycatch reduction programs in a high bycatch, small-scale fleet. In our case study, the Hawaiian fleet, in order to minimize its residual bycatch, could finance bycatch mitigation programs by the small-scale fleets in Mexico including locally proven bycatch reduction strategies such as gear conversions and rent for fishing rights in high-density turtle foraging areas.

If the financing were performance-based, measurable, and audited, then the Hawaiian fleet could cost-effectively offset their residual bycatch by ensuring that any loggerhead interactions beyond the 46 they are currently permitted annually are offset by avoiding mortality for at least one individual of a similar reproductive value in Mexican waters (Wallace et al. 2008, i.e., offsetting a juvenile with another juvenile). Thus a discounting model needed for trading between life history stages, such as eggs for juveniles or adults, would be unnecessary (Wilcox & Donlan 2007). In fact,
surplus turtles would likely result at least in the beginning of such a program: tens to hundreds of
turtles could be saved in Mexican fisheries each year for each of the turtles impacted by the
Hawaiian fishery.

Ongoing research and educational outreach have identified critical loggerhead foraging
areas and proven methods to reduce sea turtle bycatch in Baja California Sur, Mexico (Hall et al.
2007; Peckham et al. 2007; Rodgers 2008). But comprehensive bycatch reduction is currently
limited largely due to a lack of long-term financing for implementation of these mitigation
measures. Funding from an ICRT could provide resources necessary for small-scale fishers to
systematically implement proven conservation measures at Baja California Sur.

The potential for ICRTs is not limited to our case study (Wilcox and Donlan 2009). In cases
where species of concern span international borders and are impacted by multiple economic
activities, ICRTs provide a market mechanism that allows species to be managed at the population
level, without the challenge of coordinating international agreements between governments. While
international coordination of the conservation of highly migratory species may be preferable to
ICRTs, progress in international ocean governance is slow and problematic (Dutton & Squires
2008). Experience with management of commercially harvested species has shown that
intergovernmental mechanisms are difficult to run successfully and are often ineffective (Barrett
2003; Willock & Lack 2006). ICRTs may thus provide a tool for addressing pressing conservation
issues until further progress can be made in international ocean governance.

**Aligning incentives with performance-based funding**

There are an increasing number of regulatory, reputational, and economic incentives for industrial
fishing fleets to participate in bycatch offset programs structured through ICRTs (Donlan & Wilcox
2008; ten Kate et al. 2004). Those incentives will differ depending on the fishing fleet and its regulatory laws. The Hawaii long-line fleet has been heavily regulated with respect to bycatch since 2003, when the fishery was closed for two years under the US Endangered Species Act (ESA). In 2005, the fishery reopened with mandatory mitigation measures including 100% observer coverage for the portion of the fleet targeting swordfish and a fleet-wide bycatch limit of 17 loggerhead interactions per year (Gilman et al. 2007; the catch limit was raised to 46 loggerheads in 2008; NMFS 2008). Those regulations compel the Hawaiian fleet to reduce sea turtle bycatch in order to avoid closures and revenue loss. In 2006, the fishery was closed just three months into the ten-month season when the sea turtle bycatch limit was reached. Thus, the Hawaiian long-line fleet has clear economic and reputational incentives to embrace offsets for the fleet’s bycatch above the turtle interaction limit.

In addition to the regulatory incentives in the Hawaii fishery, there is precedent for industrial fisheries to pursue bycatch offsets motivated by reputational concerns alone (Dutton & Squires 2008). The California drift-gillnetters association contributed funds for leatherback turtle (Dermochelys coriacea) nesting beach protection in Mexico (C. Fahy, pers. comm.). The US-based shrimp industry in the Gulf of Mexico provided political and financial support for the Kemp’s ridley (Lepidochelys kempii) recovery program (Eckert et al. 1994). The Western Pacific Regional Fishery Management Council, which is mandated to minimize bycatch, is currently financing a number of leatherback and loggerhead nesting beach programs (Pilcher 2006) and previously financed loggerhead bycatch reduction programs at Baja California Sur (Hall et al. 2007; Peckham et al. 2007).

To date these voluntary offset programs have not been incorporated into fisheries regulatory policy when agencies evaluate the impacts of a fishery, leaving fisheries managers with the sole
option of closures when fisheries violate mandated requirements. However, while closures often appear to be a reasonable regulatory strategy, they may have unanticipated negative consequences. For example, evidence suggests that unregulated fleets increase their effort when the well-regulated Hawaiian fleet (that employs best practices to avoid sea turtle bycatch) is closed after reaching its annual bycatch limit, potentially resulting in greater turtle mortality (Sarmiento 2006). Regulated offset programs operating under a measurable and science-driven framework could alleviate such trade leakage, align incentives, reward responsible fishing practices, and ultimately result in net conservation gains (Donlan & Wilcox 2008).

Governments would have incentives for participating in ICRTs to reduce bycatch. In our case study, the Mexican government is likely to implement bycatch reduction measures for loggerheads in the near future (D. Maldonado-Diaz, pers. comm.). Mexico has implemented strong conservation measures for other endangered marine species such as the grey whale and the critically endangered vaquita porpoise. For the vaquita alone, millions of dollars have been invested in the last several years to facilitate fishing gear changes and livelihood alternatives for fishers (CEC 2008, CONANP 2008). In general governments may be in a position to support ICRTs because they would facilitate cost-effective progress toward mandated species recovery goals.

For small-scale fishers, the economic incentives of ICRTs may prove particularly important as well. In addition to bycatch reduction, resources could be directed to improving fisheries efficiency through technology changes and improved local management and governance. Many fishers recognize ongoing declines in their revenue and may welcome the opportunity to transition to more profitable fisheries or to alternative livelihoods. The current socio-political context of the Mexican fishing communities raises the probability of an ICRT bycatch program producing conservation gains for sea turtles. Reputational incentives in terms of fishers’ sense of pride and
honor in their work have been documented as important behavioral drivers for Mexican small-scale fishers as they have come to understand the global impacts of their local bycatch (Hall et al. 2007). As a result, outreach and incentive programs have already reduced loggerhead bycatch in the region (Rodgers 2008; Peckham et al. 2008).

While existing sea turtle offset programs are well intended and some are producing results, they are clearly not performance-based in that they lack detailed, independent audit programs. Consistent with increasing recognition of the need for performance-based conservation actions (Ferraro & Kiss 2002), ICRTs could offer directly quantifiable conservation gains. Systematic observation of the bycatch rates of recipient fleets would enable performance-based evaluation of the efficacy of ICRTs. In our case study, small-scale fleets could be observed to measure changes in bycatch rates as a result of ICRT-funded actions relative to historical bycatch rates (Peckham et al. 2008). Further support for mitigation actions by the recipient fleets would depend on these independent evaluations of performance.

**Risks & Global Opportunities**

Biodiversity offsets via ICRTs are not without risks. For them to be effective the ecosystem-wide effects of the offset in both donor and recipient fleets would have to be continuously evaluated and the program adapted as necessary (Doak et al. 2007; Wilcox & Donlan 2007; Finkelstein et al. 2008). As is the case with the Hawaiian long-line fleet, donor fleets would have to demonstrate significant avoidance and mitigation efforts prior to engaging in ICRTs (Donlan and Wilcox 2008; Gilman et al. 2007). Likewise, solving bycatch issues in a recipient fishery would take much more than the simple transfer of funds, potentially requiring new gear developments, outreach programs, or even development of alternative income sources. Both donor and recipient fleets would require
independent, transparent verification of real bycatch reduction; however, such monitoring and
verification is essential for any conservation investments to be effective (Ferraro & Pattanayak
2006). ICRTs would need to be audited, including transparent accounting of biological and
economic resources, and those costs should be internalized. Frameworks and methods are now
emerging through collaborations between industries and non-governmental organizations to meet
the challenges of viable biodiversity offsets (ten Kate et al. 2004).

While there is no explicit provision for the proposed Hawaii-Mexico ICRT under the ESA,
there is legal precedent for similar frameworks. Under the ESA the creation and trading of species
credits is over a decade old (habitat conservation plans and safe harbor agreements; Fox et al.
2005). These conservation banking efforts are supported by the US Fish and Wildlife as an effective
means to mitigate biodiversity impacts from development. Similarly, wetland habitat has been
traded for over two decades. Due to concerns over wetland loss, the US Clean Water Act prohibits
the discharge or fill of material into wetlands without a permit from the Army Corps of Engineers.
Once pending impacts are demonstrated to be unavoidable and steps are taken to minimize them,
the Corps can grant a discharge permit with the condition that the residual impact be mitigated by
the creation or restoration of wetlands (Shabman et al 2002).

These markets are not without challenges. Some have harshly criticized how wetland
banking has been implemented, while others are optimistic regarding revised approaches of both
With respect to sea turtles and bycatch, NOAA/NMFS currently authorizes limited interactions,
effectively setting an annual take (NMFS 2008). Such authorizations could be explicitly linked to
conservation gains through ICRTs.

Evidence suggests that one requisite of success for emerging pollution or biodiversity
markets is that the geographic reach of the market must be confined to the biophysical characteristics of the asset being traded. For example, while carbon can be successfully traded on a global basis, North Pacific loggerhead turtle ICRTs should be restricted to the range of the population; bycatch reductions in Atlantic, Indian or South Pacific Ocean loggerhead populations would not be relevant for North Pacific loggerhead ICRTs.

Social equity is an important factor in other emerging market-based environmental strategies including payment for ecosystem services and carbon emissions trading. Addressing social equity in ICRTs could build on ongoing progress of these emerging markets (Wunder 2006; Laurance 2008). Among other specifics, ICRTs would have to avoid the pitfalls and concerns surrounding fishery buy-out programs (Holland et al. 1999; Clark et al. 2005). ICRTs would have to be structured to produce and implement solutions that result in changes in fishing behavior that also sustain fishers, fisheries, and their ecosystems. They would also have to align long-term incentives and responsibly transfer value from donor to recipient fleets with particular attention to local socio-political contexts. Planning and implementation of ICRTs could for example build on both the successes and shortcomings of past voluntary sea turtle offset programs occurring around the world, including long-line fisheries and low-income communities that are compensated to monitor and protect nesting beaches (Kinch 2006; Pilcher 2006).

Opportunities for more effective bycatch management using ICRTs are global. Many industrial and small-scale fishing fleets interact with the same populations of sea turtles and other shared megafauna, and the large disparities in revenues and bycatch are not unique to our Hawaii-Mexico example. For example, small-scale fleets in the East China Sea and other regions of the North Pacific are suspected to have high loggerhead bycatch rates (Hatase et al. 2002; Ishihara 2007; Peckham et al. 2008). ICRTs have the potential to finance efficient conservation gains within
countries and between industries. For instance, Spanish industrial longliners adopting bycatch best practices for their Mediterranean operations could negotiate ICRTs with Spanish small-scale fleets known to cause high turtle mortality (Carreras et al. 2004; Tomas et al. 2008).

Less regulated industrial fisheries also stand to gain from ICRTs, as they are under intensifying international pressure to address the externalities of their fishing. As supply decreases and competition increases, industrial fleets will need to demonstrate that they are fishing sustainably in order to maintain their market shares. For instance, there are increasing efforts to shift consumer choice to more sustainable alternatives via certifications like those available through the Marine Stewardship Council. If certification schemes incorporate a policy of avoidance, minimization and offsetting into their evaluation criteria for fisheries, ICRTs and other tools may be useful in cost-effectively meeting certification requirements. A seabird-, sea turtle-, or marine mammal-neutral fishery could gain market access advantages in US and European markets, among others.

Under current levels of small-scale fisheries bycatch, many marine megafauna populations may be unable to recover regardless of conservation gains elsewhere in their ranges. In some cases bycatch mitigation has been proven to be feasible in these fisheries but is currently severely limited. ICRTs could enable industrial fisheries to finance bycatch reduction in small-scale fisheries and provide resources for innovation otherwise prohibitively expensive under a mutually beneficial framework. Opportunities may also exist for other megafauna populations including marine mammals, shark, and seabirds (Donlan & Wilcox 2008; Wilcox and Donlan 2009). By linking revenues and incentive structures of industrial fisheries with small-scale fisheries, ICRTs offer an opportunity that could result in important conservation gains for threatened, bycatch-prone marine species compared to current practices.
Table 1. Three fishing fleets that experience Pacific loggerhead bycatch, and differences in their gross revenue, mortality rates, bycatch per unit effort (BPUE), and loggerhead mortality rate in 2005. Revenue values and bycatch rates obtained from the following sources: 1 (WPRFMC 2006), 2 (pers. comm. D. Maldonado-Diaz), 3 (Peckham et al. 2008), 4 (Gilman et al. 2007), 5 (NMFS 2004).

Figure 1. Developmental migration of the North Pacific loggerhead. With nesting occurring exclusively in the Japanese archipelago, hatchlings are entrained into the North Pacific gyre where they spend 3-4 decades foraging their way to maturity, upon which they return to Japanese waters to mate and nest. Juveniles are exposed to fisheries bycatch in two regions of the North Pacific Basin where they aggregate, to the north of the Hawaiian archipelago and off of Mexico’s Baja California peninsula.

Cover Photo. Small-scale fishers can catch disproportionately high numbers of endangered megafauna such as loggerhead turtles. Large disparities in regulation, revenue and bycatch rates between industrial and small-scale fleets can offer powerful leverage for reducing bycatch through interfishery conservation resource transfers. Copyright SH Peckham.

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