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Risks of Introductions of Marine Fishes: Reply to Briggs

Walter R. Courtenay, Jr., Courtenay is professor emeritus of zoology, Florida Atlantic University, Boca Raton, residing in Gainesville, Florida. He can be contacted at courtenayw@yahoo.com.

Bruce B. Collette, Collette is senior scientist, National Systematics Laboratory, National Marine Fisheries Service, Smithsonian Institution, Washington, DC.

Timothy E. Essington, Essington is associate professor, College of Aquatic and Fisheries Sciences, University of Washington, Seattle.

Ray Hilborn, Hilborn is a professor at the College of Aquatic and Fisheries Science, University of Washington, Seattle, and Fellow of the Royal Society of Canada.

James W. Orr, Orr is a fisheries research biologist for the Alaska Fisheries Science Center of NOAA's National Marine Fisheries Service, Seattle, Washington.

Daniel Pauly, Pauly is director of the Fisheries Centre, University of British Columbia, Vancouver, Canada.

John E. Randall, and Randall is senior ichthyologist emeritus, Bernice P. Bishop Museum, Honolulu, Hawaii.

William F. Smith-Vaniz. Smith-Vaniz is a research associate at the Florida Museum of Natural History, University of Florida, Gainesville.

ABSTRACT: This is a rebuttal to a publication by John C. Briggs in the April 2008 issue of *Fisheries* in which he suggested introducing fishes and invertebrates from the North Pacific into the North Atlantic to increase diversity toward improving fisheries in the latter. We argue otherwise for reasons that Briggs downplayed or never considered. Using examples of introductions within the Pacific and the Atlantic, and movements of species from the Pacific to the Atlantic, we provide a record of failures and damage or dangers to native species from the few introductions that became successful. We argue that a lack of diversity of fishes and invertebrates in the North Atlantic versus that of the North Pacific is not the problem to be corrected by introductions as Briggs suggested. A record of overfishing and management policies is the problem in the North Atlantic. Introductions from the North Pacific to the North Atlantic are not worth the costs or the environmental risks involved.

Riesgos de la introducción de peces marinos: una réplica a Briggs

RESUMEN: Esta es una réplica al artículo de John C. Briggs, publicado en el número de abril de 2008 de la revista *Fisheries*, en el cual él sugirió introducir peces e invertebrados del Pacífico norte al Atlántico norte con el fin de incrementar la diversidad y mejorar las pesquerías en esta última región. Aquí argumentamos lo contrario por razones que Briggs nunca consideró. Mediante ejemplos de introducciones realizadas dentro del Pacífico y el Atlántico, y de movimientos de especies de un océano al otro, en esta contribución se muestra un registro de casos fallidos o de peligros para especies nativas a partir de las pocas introducciones que se volvieron exitosas. Se argumenta que la poca diversidad de peces e invertebrados en el Atlántico norte versus aquella del Pacífico norte no es un problema que deba corregirse mediante introducción de especies, como lo sugiere Briggs. En el Atlántico norte, la sobrepesca histórica y las políticas de manejo son realmente el problema. Llevar a cabo introducciones del Pacífico norte al Atlántico norte no compensa los costos o los riesgos ambientales que esto implica.

INTRODUCTION

Impetus for this article was a provocative paper by John C. Briggs (2008) advocating transplantations of North Pacific fishes into the North Atlantic for "proactive management" and toward a stock enhancement program. Briggs's proposal was stated to have potential benefit by supplementing diversity, supposedly contributing to stabilization of the ecosystem, increasing biomass, and possibly preventing a future decline of commercial and recreational fishery stocks. He argued that because the North Atlantic has an impoverished fauna compared to that of the North Pacific, benefits from introductions of North Pacific fish and invertebrate species into the North Atlantic outweigh risks, and "the chances of a disastrous results would appear to be exceedingly slim." We found many faults with the premises that Briggs suggested and provide reasons why, using examples of failures and some serious mistakes made with introductions of marine species.

We disagree with most of Briggs's (2008) assumptions regarding introductions and, more importantly, believe he has downplayed or dismissed some serious and perhaps irreversible dangers inherent in marine or other introductions generally. More importantly, the proactive management strategy he proposed does nothing to address underlying causes for the collapse of fish stocks worldwide or specifically in the North Atlantic (Pauly et al. 1998; Pauly and Maclean 2003) that are primarily due to overfishing. We believe it sends the wrong message that this problem can be corrected by introductions that would likely fail, and would require huge expenditures of funds for pre-introduction research and implementation of transplantations on a massive scale. Even assuming the introductions Briggs proposed might achieve the goals he targeted, he ignored what might be long-term ecological effects to the native biota of the North Atlantic.

Briggs (2007, 2008) stated that relatively few introduced marine fishes and invertebrates become pests or are detrimental to native biological communities, and that potential benefits from such introductions might justify the risks. Indeed, the following sentence given in recent popular media indicates that Briggs's management suggestion is being seriously considered: "At the very least, the reader is left wondering if this is an idea whose time has come" (Rodger 2008). What that statement seems to imply is that Briggs (2007, 2008) and Rodger (2008) are unfamiliar with the large, growing body of literature concluding that introductions of nonnative species can result in often unpredicted negative effects to receiving communities and to the biota therein over time.

The premise of Briggs's (2008) argument is flawed in many ways. Intrinsic vulnerability to fishing of different species is largely a function of their adult size and age at first maturity (Cheung et al. 2005), not their taxonomic or biogeographical affinities. The notion that greater taxonomic diversity among fishes in the North Pacific has contributed to greater productivity of the fisheries of that region compared to the relatively low diversity in the North Atlantic is only an assumption on his part, for which he cited no supporting references. That idea ignores the wealth of information and data that have demonstrated that declines of fishery stocks in the North Atlantic are due to widespread overfishing (Christensen et al. 2003) and not to a lack of species diversity.

Relentless technological innovations that rapidly increased fishing capacity and efficiency, ineffective management of shared stocks (species whose ranges span international borders), and the tendency to ignore scientific advice in favor of higher catch quotas have led to this decline (Pauly et al. 2002; Pauly and MacLean 2003). These are the factors that have caused extraordinary high and unsustainable exploitation rates, resulting in stock collapses. Hilborn (2007) showed that the primary determinant of stock recovery is whether they continue to be fished at unsustainable levels. This was avoided to some degree in the North Pacific because management regimes there succeeded in limiting fishing pressure before major collapses occurred. It has been the differential success of management agencies in regulating fishing efforts that underlie the contrasts between North Atlantic and North Pacific, and not the underlying biology of the ecosystems.

It is naïve and probably dangerous to suggest a biological-based "fix" via introductions to a problem that is of a social and political nature. Moreover, the idea that ecosystems with a more diverse fish fauna are more resilient to overfishing is tenuous at best and, in our opinion is unsupported by convincing research. Assuming that transplanted North Pacific fish species became successfully established in the North Atlantic, why would they be less susceptible to overfishing than resident North Atlantic fish species they are intended to supplement or perhaps replace?

We are alarmed that his proposal might be taken seriously, including his view (Briggs 2007) that few marine species introductions have had negative effects on native species, a topic that will be addressed separately by others (J. T. Carlton, Williams College, pers. comm.).

Briggs (2007, 2008) is correct that marine introductions have not so far and might not cause species extinctions, but that is a "straw-man" argument that ignores or downplays cases of serious and perhaps irreversible negative impacts to native biota in novel waters. Extinctions are not the major concern regarding introductions of marine or other non-native species. Rearrangements and perhaps irreversible serious disturbances to receiving communities as a result of introductions that might or might not result in extinctions should be of major concern. Moreover, how should such rearranged systems be managed effectively to produce the results he is seeking?

Briggs (2008) also argued that the historical exchange (ca 3.5 million years ago) of faunas during the so-called Great Trans-Arctic Biotic Interchange resulted in no significant loss of biodiversity, but he seems to ignore the fact that human sociological adjustments to local faunal mixing of the dimension he proposes would take place on a far shorter time scale.

The literature contains many examples of freshwater fish introductions that have had and continue to cause serious problems (Courtenay et al. 1985; Courtenay and Robins 1989; Minckley and Douglas 1991; Kottelat and Freyhof 2007), but herein we focus on introductions involving marine species with a strong admonishment that they not be undertaken.

A BRIEF SUMMARY OF MARINE FISH INTRODUCTIONS FROM THE PACIFIC TO THE ATLANTIC

To our knowledge, the only successful (= totally self-sustaining) fish introduction from the Pacific/Indian Ocean into the Atlantic to date have been that of two species of lionfishes, *Pterois volitans* and *P. miles* (Whitfield et al. 2002; Ruiz-Carus et al. 2006, Whitfield et al. 2007; Hamner et al. 2007; Albins and Hixon 2008). Both species are of subtropical to tropical origin but, unexpectedly, were found established in cooler, deeper waters along the eastern Atlantic coast of the United States (Whitfield et al. 2007). Since becoming established, lionfishes have rapidly extended their ranges widely into northern and central areas of the Caribbean, including shallow, warm waters where they are now common. Lionfishes have become demonstrably invasive, with significant negative impacts to native fishes in the Bahamas (Albins and Hixon 2008).

THE HAWAIIAN EXPERIENCE WITH MARINE INTRODUCTIONS

The indigenous biota of few places on Earth has suffered more from the impact of humans than the Hawaiian Islands, beginning with arrival of the first Polynesians in about 500 AD. More recently, marine organisms have been transported to the islands from fouling on ship's hulls and from release of ballast water.

Lack of concern regarding negative impacts of introductions to the marine environment of the Hawaiian Islands is evident from intentional importations of marine algae, crustaceans, mollusks, and fishes. Thirty-three species of marine fishes have been introduced to the islands (Brock 1952; Maciolek 1984; Randall 1987; Eldredge 1994; Randall 2007). In addition, there are several reports of exotic marine fishes being found in Hawaiian waters as results of releases by aquarists, akin to similar reports of Indo/Pacific fishes introduced to waters of southeastern Florida (Semmens et al. 2004).

Intentional introduction of marine fishes, with approval of the state of Hawaii, were toward objectives of some becoming baitfish for tuna or as food fishes believed to be of greater value than native species, the latter activity intended for proactive management. The Hawaiian Islands have only two native species of groupers (Serranidae)—the rare giant grouper (*Epinephelus lanceolatus*) and an endemic deep-water species, the Hawaiian grouper (*E. quernus*). Hawaii also lacked native snappers of the genus *Lutjanus* (Lutjanidae).

Six species of groupers and three snappers were introduced from French Polynesia to the Hawaiian Islands from 1956 to 1958. Three species are clearly established, two now in alarming numbers. One is the bluestriped snapper (*Lutjanus kasmira*) and the other, the peacock grouper (*Cephalopholis argus*).

The bluestriped snapper has undergone a population explosion throughout the entire Hawaiian Archipelago, likely by leaving predators and competitors behind, but also because of a lack of fishing pressure (Randall 2007; Dierking 2008). Although good-eating, it reaches a total length of only 32 cm. Thus, it has not been widely accepted as a food fish in spite of a relatively low market price. It is unpopular with anglers, not only because of its low value, but also because it ranges to depths greater than 150 m where it is caught by anglers whose intended catches were for valuable deeper water, native lutjanid species of the genera *Etelis* and *Pristipomoides*. The bluestriped snapper is suspected of causing a reduction in populations of some local goatfishes of the genera *Mulloidichthys* and *Parupeneus* via competition for food resources, and as a predator on young of the valuable crustacean *Ranina ranina*, locally known as the Kona crab. One can only worry what further reductions or, at worst, possible extinctions of the Hawaiian marine fauna might eventually result in the future from introduction of this snapper.

Of even greater concern are impacts of the introduced peacock grouper. Its population has been slow to build within the islands, beginning with a major increase on the west coast of the island of Hawaii in recent years. It reaches 60 cm in total length and is esteemed as a food fish in areas where ciguatera fish poisoning does not occur. Nevertheless, in the Hawaiian Islands, about one out of every five caught can cause ciguatera. As a result, few people will risk eating this grouper. Lacking natural predators, its population continues to increase and is building westward in the Hawaiian chain. Studies of its food habits revealed fishes comprise 77.5–95.7% of its prey (Randall and Brock 1960; Helfrich et al. 1968; Harmelin-Vivien and Bouchon 1976; Randall 1980).

Native Hawaiian reef fishes have evolved over many centuries without abundant resident fish predators in their environment. However, long-term projections indicate introductions might lead to population reductions and, at worst, extinctions. Earle (2005) summarized the current view of this introduction with his article titled "Have We Created a Monster?"

SOME PAST AND RECENT INTRODUCTIONS IN THE ATLANTIC

Smith-Vaniz et al. (1999) reported attempted intentional fish introductions to Bermuda from sources in southeastern Florida during the summer of 1924, approved by the legislature of Bermuda, supposedly to supplement and enhance commercial species already present. They documented the lack of establishment or infrequent subsequent capture of all of these attempted introductions. Smith-Vaniz et al. (1999) noted that because the fish fauna of Bermuda originated from Caribbean sources, the intended introduced species might have occurred there naturally had conditions been suitable for them. They also remarked that such additional introductions were misguided attempts to add to the established, natural fish fauna of Bermuda. Introduced lionfishes, however, have been found in Bermudian waters in recent years, likely the result of Gulf Stream gyres that brought them there (Whitfield et al. 2002), but without substantiated evidence of their establishment to date.

WHAT ARE THE ASSUMPTIONS OF SUCCESS VERSUS RISKS?

Baltz (1991) summarized the 120 marine and coastal introductions around the world known at that time, finding that the majority were unintentional releases into coastal estuaries that "profoundly affected the community structure." Most intentional introductions did not establish populations or did not achieve their objectives. The few that became established all had negative effects, including harm to valuable fisheries, introductions of parasites, and perhaps future endangerment of native species. Historically, most intentional attempts at introductions have been to add North Atlantic species to the North Pacific and, with the exception of anadromous species (striped bass, *Morone saxatilis*, and American shad, *Alosa sapidissima*), nearly all failed (Baltz 1991). Introductions have continued, although for most, the source of the introduction and whether or not populations became established remain unknown (Streftaris et al. 2005).

Only the former Soviet Union has attempted to transplant fishes from the North Pacific to the Atlantic. Of 42 attempts, 15 were in waters connected with the open ocean and of these, only 3 became established. Two species, one anadromous and the other secondarily marine, showed evidence of spawning but only persisted as small populations. After repeated introductions in the Barents Sea, the third species, pink salmon (*Oncorhyncus gorbuscha*), survived as a naturally reproducing population that now supports a small fishery but requires periodic replenishment from the North Pacific (Petryashov et al. 2002).

No introductions of North Pacific marine fishes to other open ocean waters have been successful. One example Briggs (2008) mentioned of a "successful" marine introduction was considered by Matishov et al. (2004) to be the "greatest intended large-scale change in the Barents Sea coastal ecosystem." Instead, this clearly illustrates the dangerous unknowns of marine introductions. The red king crab (*Paralithodes camtschaticus*), an endemic North Pacific crustacean, was experimentally introduced to the Barents Sea by the Soviet Union on a small scale in the 1930s in an attempt to provide a target for a local fishery. After very limited success, it was later systematically introduced on a larger scale from 1961 to 1969 (Zelenina et al. 2008). Few crabs were found until the late 1970s, when a reproductive population became established and the crabs began to expand rapidly. By the early 2000s, the stock had established to the point of supporting a substantial fishery and continues to expand south along the coast of Norway, invading new coastal areas. Following patterns of established introductions, the species is likely going through an explosive expansive phase (Matishov et al. 2004). Ironically, because the crab easily entangles in gillnets, it is now considered a "bycatch nuisance" in the fishery and has precipitated calls for its eradication by gillnet anglers (Petryashov et al. 2002).

Due to its recent expansion, little is yet known regarding effects of the crab on the Barents Sea ecosystem (Kuzmin and Sundet 2000). What is known is that the red king crab is a polyphage, feeding on any edible material it can capture by crushing and shredding it with powerful claws. It has been observed feeding on scallops. As the crabs become larger and more abundant, the commercially important scallop *Chlamys islandica* may become threatened with destruction (Jørgensen and Primicerio 2007). The crabs are also known to feed on fishes and fish roe, especially capelin (*Mallotus villosus;* Petryashov et al. 2002). Although capelin are highly fecund, possible disruption of capelin reproduction and future contribution to the food chain may have damaging effects on populations of higher-level predators

Common cod (*Gadus morhua*) has been overfished and stressed. An added stressor may be the provision of a fertile ground for parasites. The red king crab also serves as a carrier for a marine leach, *Johanssonia arctica*, an intermediate host of the blood parasite, *Trypanosoma murmanensis*, which has been implicated in the death of juvenile cod and known to have debilitating effects on adult cod and other fishes (Hemmingsen et al. 2005).

Briggs (2008) seems unaware of the role that the International Council for the Exploration of the Sea (ICES) played regarding introductions of marine species. Sindermann (1992) reported on an aquaculture meeting sponsored by ICES, held in Puerto Rico during the 1980s, on a proposal (due to rising interest in introductions and transfers of marine species for culture purposes) for introductions of marine species. Sindermann and others entitled that session the "International Decade of Indiscriminate Ocean Transfers" (acronym = IDIOT). Little enthusiasm followed that meeting, although the ICES working group on introduced species drafted assessments that led to several guidelines for contemplated marine introductions (Sindermann 1992). Those assessments need further refinement and implementation, especially in view of Briggs's recent (2008) proposal.

Finally, what Briggs (2008) suggested by increasing biodiversity via introductions from the North Pacific to the North Atlantic to improve fisheries ignores increasing evidence that such introductions can create more problems than they might solve. Although some few introduced species have potential to become invasive and increase biodiversity, they "often have a destabilizing effect on natural community abundance patterns and ecosystem services, especially if they become dominant" (Palumbi et al. 2008).

SUMMARY

From the preceding, it should be evident that introductions made with the best of intentions can become biological "time bombs" and can have unpredicted effects on native biota, depending on the species introduced.

We cannot be certain if introduced North Pacific fishes or invertebrates, as Briggs (2008) proposed, might or might not become established in the North Atlantic or become invasive. However, this will not resolve the problem of overfishing and delayed management policies. What is needed is far greater focus by fishery managers, fishers, and the public on the human-associated causes of the problem, and what efforts will be needed, perhaps mandated, to reverse the existing situation (Pauly et al. 2002). Where is the documentation that introductions have benefited human society versus their disruption and damage to aquatic ecosystems? Such issues have never been adequately addressed in the past prior to implementation of introductions. What succeeded or failed via introductions are more important questions. The past record of marine introductions has not been positive. Are intentional introductions of fishes or other marine species truly required anywhere and, if so, why? Are the unknown dangers worth the risks? We think not.

Information, not assumptions without proof of benefits, and full evaluation of potential risks should be major guidelines for fishery managers (Pauly et al. 2002; Simberloff et al. 2005; Hansen and Jones 2008), and biogeographers as well. The bottom line is, do we have enough knowledge and, especially forethought, to properly manage our marine or other fishery resources without recommending intentional introductions that could exacerbate our previously created problems?

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