Biol Invasions
DOI 10.1007/s10530-014-0778-y

LETTER TO THE EDITOR

'Double trouble': the expansion of the Suez Canal and marine bioinvasions in the Mediterranean Sea

Bella S. Galil · Ferdinando Boero · Marnie L. Campbell · James T. Carlton · Elizabeth Cook · Simonetta Fraschetti · Stephan Gollasch · Chad L. Hewitt · Anders Jelmert · Enrique Macpherson · Agnese Marchini · Cynthia McKenzie · Dan Minchin · Anna Occhipinti-Ambrogi · Henn Ojaveer · Sergej Olenin · Stefano Piraino · Gregory M. Ruiz

Received: 22 August 2014 / Accepted: 2 September 2014

"Egypt to build new Suez canal… 'This giant project will be the creation of a new Suez canal parallel to the current channel' said Mohab Mamish, the chairman of the Suez Canal Authority, in a televised speech." (http://www.theguardian.com/world/2014/aug/05/egypt-build-new-suez-canal, viewed August 13, 2014).

This is ominous news. Expected to double the capacity of the Suez Canal, the expansion is sure to have a diverse range of effects, at local and regional scales, on both the biological diversity and the ecosystem goods and services of the Mediterranean Sea.

Of nearly 700 multicellular non-indigenous species (NIS) currently recognized from the Mediterranean Sea, fully half were introduced through the Suez Canal since 1869 (Galil et al. 2014). This is one of the most potent mechanisms and corridors for invasions by marine species known in the world. Further, molecular methods demonstrate high levels of gene flow between the Red Sea and the Mediterranean populations

B. S. Galil (✉)
National Institute of Oceanography, Israel Oceanographic and Limnological Research, Haifa, Israel
e-mail: bella@ocean.org.il

F. Boero · S. Fraschetti · S. Piraino
Department of Biological and Environmental Science and Technologies, University of Salento, Lecce, Italy
e-mail: ferdinando.boero@unisalento.it

S. Fraschetti
e-mail: simona.fraschetti@unisalento.it

S. Piraino
e-mail: stefano.piraino@unisalento.it

M. L. Campbell · C. L. Hewitt
School of Science, University of Waikato, Hamilton, New Zealand
e-mail: mcampbel@waikato.ac.nz

C. L. Hewitt
e-mail: chewitt@waikato.ac.nz

J. T. Carlton
Maritime Studies Program, Williams College-Mystic Seaport, Mystic, CT, USA
e-mail: James.T.Carlton@williams.edu

E. Cook
Scottish Marine Institute, Oban, Argyll, UK
e-mail: Elizabeth.Cook@sams.ac.uk

S. Gollasch
GoConsult, Grosse Brunnenstrasse, Hamburg, Germany
e-mail: sgollasch@aol.com

A. Jelmert
Flødevigen Marine Research Station, Institute of Marine Research, His, Norway
e-mail: anders.jelmert@imr.no

E. Macpherson
Centro de Estudios Avanzados de Blanes (CSIC), Blanes, Girona, Spain
e-mail: macpherson@ceab.csic.es

Published online: 28 September 2014

(Golani and Ritte 1999; Hassan et al. 2003; Bariche and Bernardi 2009).

Most of the NIS introduced via the Suez Canal have established thriving populations along the Levant, from Libya to Greece, and several spread in the Western Mediterranean. The individual and cumulative impacts of these NIS adversely affect the conservation status of particular species and critical habitats, as well as the structure and function of ecosystems and the availability of natural resources. Some species are noxious, poisonous, or venomous and pose clear threats to human health.

Significant and often sudden decline of native species, including local population extirpations, have occurred and are occurring concurrent with proliferation of Canal-introduced NIS. Among many examples, the introduced goldband goatfish, *Upeneus moluccensis* has replaced the native red mullet, *Mullus barbatus*, in the Levantine fisheries; introduced prawns, though considered a boon by local fishers, have displaced the native prawn, *Melicertus kerathurus*, which supported a commercial fishery throughout the 1950s and the introduced Spiny oyster, *Spondylus spinosus*, has completely outcompeted the native congener *S. gaederopus* off the Israeli coast within a decade of its first record (Galil 2007). Local population losses and niche contraction of native species may not induce immediate extirpation, but they augur reduction of genetic diversity, loss of functions, processes, and habitat structure, increase the risk of decline and extinction, and lead to increased biotic homogenization.

From an unfortunately long list of examples of NIS that have led to profound environmental, economic, and human-health issues, we cite a few. A scyphozoan jellyfish, *Rhopilema nomadica*, has since the early 1980s formed huge swarms each summer along the Levantine coast, which adversely affect tourism, fisheries and coastal installations. The annual swarming stops coastal trawling and purse-seine fish catch due to net clogging and inability to sort yield. Jellyfish-blocked water intake pipes interfere with the operation of desalination plants and power plants (www.bbc.co.uk/news/world-middle-east-14038729). Based on evidence elsewhere, the impacts of a 180 km long swarm of large planktivores on the local food web must be considerable (Boero 2013). Last, *Rhopilema*'s stings result in envenomation effects that may last weeks and even months (Benmeir et al. 1990). Its swarms have been recorded as far away as Tunisia (Daly Yahia et al. 2013). The recent spread of a pufferfish, *Lagocephalus sceleratus*, throughout the Levant and westwards to Italy and Tunisia, poses severe health hazards: its internal organs contain tetrodotoxin, a strong paralytic neurotoxin, inducing symptoms ranging from vomiting to respiratory arrest, seizures, coma and death. Between 2005 and 2008, 13 persons were treated for poisoning in Israel alone (Bentur et al. 2008). Two herbivorous rabbit fish, *Siganus luridus* and *S. rivulatus*, are responsible for an extraordinary shift in the Levantine rocky infralittoral from well-developed native algal assemblages to 'barrens' with a dramatic decline in biogenic habitat complexity, biodiversity and biomass (Sala et al. 2011).

Although effects of many NIS have not been evaluated to date, some significant ecological and social consequences are known and the potential reach

A. Marchini · A. Occhipinti-Ambrogi
Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy
e-mail: agnese.marchini@unipv.it

A. Occhipinti-Ambrogi
e-mail: occhipin@unipv.it

C. McKenzie
Northwest Atlantic Fisheries Centre, St. John's, NL, Canada
e-mail: Cynthia.Mckenzie@dfo-mpo.gc.ca

D. Minchin
Marine Organism Investigations, 3 Marina Village, Ballina, Killaloe, Co Clare, Ireland
e-mail: moiireland@yahoo.ie

H. Ojaveer
Estonian Marine Institute, University of Tartu, Pärnu, Estonia
e-mail: henn.ojaveer@ut.ee

S. Olenin
Coastal Research and Planning Institute, Klaipeda University, Klaipeda, Lithuania
e-mail: sergej@corpi.ku.lt

G. M. Ruiz
Smithsonian Environmental Research Center, Edgewater, MD, USA
e-mail: ruizg@si.edu

and magnitude of the cumulative impacts are enormous. The effects of past invasions are continuing to increase, as the ranges of NIS continue to expand through the Mediterranean basin and beyond, since impact is partly a function of occupied area (Parker et al. 1999).

The United Nations Division for Ocean Affairs and the Law of the Sea (DOALOS) calls for "…the management of human activities, based on the best understanding of the ecological interactions and processes, so as to ensure that ecosystems' structures and functions are sustained for the benefit of present and future generations." (http://www.un.org/Depts/los/ecosystemapproaches/ecosystem_approaches.htm). Signatories to the Convention on Biological Diversity (CBD) are required to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" (Article 8 h) and "In the case of imminent or grave danger or damage, originating under its jurisdiction or control, to biological diversity within the area under jurisdiction of other States or in areas beyond the limits of national jurisdiction, notify immediately the potentially affected States of such danger or damage, as well as initiate action to prevent or minimize such danger or damage; (Article 14d) (www.cbd.int/convention, viewed August 13, 2014).

Moreover, the 18th Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols, United Nations Environment Programme (i.e. the 'Barcelona Convention'), aimed "…to preserve a healthy Mediterranean that was productive and biologically diverse" and to that effect discussed definitions of 'Good Environmental Status' (GES) and targets, including 'Invasive non-indigenous species introductions are minimized' and 'Introduction and spread of NIS linked to human activities are minimized, in particular for potential IAS' (UNEP (DEPI)/MED IG.21/9, Annex 1, operational objective 2.1, 16 December 2013).

Yet, despite these well-meaning international conventions, and a century worth of scientific publications documenting the spread and impact of NIS introduced through the Suez Canal to the Mediterranean Sea—not to mention a vast literature that speaks to the staggering economic, cultural, and environmental impacts of marine NIS around the world—we are faced with a seeming *fait accompli*.

While global trade and shipping are vital to society, the existing international agreements also recognize the urgent need for sustainable practices that minimize unwanted impacts and long term consequences. It is not too late for the signatories to the 'Barcelona Convention' and the CBD to honor their obligations and urge a regionally-supervised, far-reaching 'environmental impact assessment' (including innovative risk management options) that would curtail, if not prevent, an entirely new twenty first century wave of invasions through a next-generation Suez Canal.

References

Bariche M, Bernardi G (2009) Lack of a genetic bottleneck in a recent Lessepsian bioinvader, the blue-barred parrotfish, *Scarus ghobban*. Mol Phylogenet Evol 53:592–595

Benmeir P, Rosenberg L, Sagi A, Vardi D, Eldad A (1990) Jellyfish envenomation: a summer epidemic. Burns 16:471–472

Bentur Y, Ashkar J, Lurie Y, Levy Y, Azzam Z, Litmanovich M, Gurevych B, Golani D, Eisenman A (2008) Lessepsian migration and tetrodotoxin poisoning due to *Lagocephalus sceleratus* in the eastern Mediterranean. Toxicon 52:964–968

Boero F (2013) Review of jellyfish blooms in the Mediterranean and Black Sea. In: Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 92. Rome, FAO 2013. p 53

Daly Yahia MN, Daly Yahia-Kefi O, Maïte Gueroun SK, Aissi M, Deidun A, Fuentes V, Piraino S (2013) The invasive tropical scyphozoan *Rhopilema nomadica* Galil, 1990 reaches the Tunisian coast of the Mediterranean Sea. BioInvasions Rec 2:319–323

Galil BS (2007) Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. Mar Pollut Bull 55:314–322

Galil BS, Marchini A, Occhipinti-Ambrogi A, Minchin D, Narščius A, Ojaveer H, Olenin S (2014) International arrivals: widespread bioinvasions in European seas. Ethol Ecol Evol 26(2–3):152–171

Golani D, Ritte U (1999) Genetic relationships in goatfishes (Mullidae: Perciformes) of the Red Sea and the Mediterranean, with remarks on Suez Canal migrants. Sci Mar 63:129–135

Hassan M, Harmelin-Vivien M, Bonhomme F (2003) Lessepsian invasion without bottleneck: example of two rabbitfish species (*Siganus rivulatus* and Biology). J Exp Mar Biol Ecol 291:219–232

Parker IM, Simberloff D, Lonsdale WM, Goodell K, Wonham M, Kareiva PM, Williamson MH, Von Holle B, Moyle PB,

Byers JE, Goldwasser L (1999) Impact: toward a framework for understanding the ecological effects of invaders. Biol Invasions 1:3–19

Sala E, Kizilkaya Z, Yildirim D, Ballesteros E (2011) Alien marine fishes deplete algal biomass in the eastern Mediterranean. PLoS One 6(2):e17356