

Supplementary material

Table S1. Regional evidence of ocean warming and the intrusion/ increased abundance of tropical and warm-temperate herbivores and habitat-forming organisms (coral and macrophytes) into colder temperate regions and reported ecological impacts derived from the tropicalisation of temperate marine ecosystems. + = range expansion, - = range contraction, * = tropical or subtropical origin, ^ = temperate original distribution. Herbivorous fishes are here considered in a broad sense and include macroalgal browsers, scrapers, excavators, grazers and detritivores. All these functional groups can impact macroalgal abundance, although for some nutrition is derived from detrital or other material associated with the algae [1, 2]. Note that saltmarshes and mangroves are not included in this review.

Region	Oceanography	Changes in distribution			Ecological impacts
		Herbivorous and detritivorous fishes and other herbivores	Habitat-forming macrophytes (macroalgae and seagrasses)	Corals	
Eastern Mediterranean	Regional warming [3, 4]	Rabbitfish (Siganidae) <i>Siganus luridus</i> (*, +) [5-13] <i>Siganus rivulatus</i> (*, +) [8, 11, 13-15]	Seagrass <i>Halophila stipulacea</i> (*, +) [6]	Gorgonian <i>Acabaria erythraea</i> (*, +) [16] Hermatypic coral <i>Oculina patagonica</i> (*, +) [17, 18]	> Extensive deforestation linked to rabbitfish (<i>Siganus</i> spp.) expansion, causing loss of benthic biomass and diversity [19, 20] > Shift from algal to coral dominance linked to <i>O. patagonica</i> expansion [21]
Southern Japan	Intensification of western boundary currents [22] Regional warming [23-25]	Surgeonfish (Acanthuridae) <i>Acanthurus dussumieri</i> (*, +) [26, 27] <i>Acanthurus lineatus</i> (*, +) [27] <i>Acanthurus maculiceps</i> (*, +) [27] <i>Acanthurus mata</i> [27] <i>Acanthurus nigrofuscus</i> (*, +) [26-29] <i>Acanthurus olivaceus</i> (*, +) [26] <i>Acanthurus xanthopterus</i> (*, +) [26, 27] <i>Ctenochaetus striatus</i> (*, +) [26, 27] <i>Ctenochaetus binotatus</i> (*, +) [26] <i>Naso lituratus</i> (*, +) [26, 27, 29] <i>Naso unicornis</i> (*, +) [26, 29] <i>Prionurus scalprum</i> (*, +) [27] <i>Zebrasoma flavescens</i> (*, +) [26] <i>Zebrasoma scopas</i> (*, +) [26, 29] <i>Zebrasoma velifer</i> (*, +) [26, 29] Blennies (Blenniidae) <i>Atrosalarias holomelas</i> (*, +) [27] <i>Cirripectes quagga</i> (*, +) [26] <i>Cirripectes castaneus</i> (*, +) [26] <i>Ecsenius bicolor</i> (*, +) [27] <i>Istiblennius edentulus</i> (*, +) [27] <i>Petroscirtes breviceps</i> (*, +) [26] Parrotfish (Labridae; Scarinae) <i>Calotomus japonicus</i> (*, +) [27] <i>Chlorurus microrhinos</i> (*, +) [27] <i>Chlorurus sordidus</i> (*, +) [27] <i>Scarus altipinnis</i> (*, +) [27] <i>Scarus frenatus</i> (*, +) [27] <i>Scarus ghobban</i> (*, +) [26, 27]	Kelp (Laminariales) <i>Ecklonia cava</i> (^, -) [31-33] Fucoids (Fucales) <i>Sargassum micracanthum</i> (^, -) [33, 34] <i>Sargassum okamurae</i> (^, -) [33, 34] <i>Sargassum yamamotoi</i> (^, -) [34] <i>Sargassum nipponicum</i> (^, -) [34] <i>Sargassum duplicatum</i> (*, +) [33] <i>Sargassum carpophyllum</i> (*, +) [33] <i>Sargassum ilicifolium</i> (*, +) [34]	Hermatypic coral <i>Acropora solitaryensis</i> (*, +) [35, 36] <i>Acropora hyacinthus</i> (*, +) [36] <i>Acropora muricata</i> (*, +) [36] <i>Pavona decussata</i> (*, +) [36]	> Extensive loss of kelp forest communities ('isoyake' phenomenon) linked to increased fish herbivory [31-33, 37, 38] > Collapse of abalone fishery linked to range contraction of kelp [32] > Loss of recruitment habitat for fishes linked to changes in phenology derived from shift from tropical to temperate algal species [39] > Shift from kelp to coral dominance [40]

Region	Oceanography	Changes in distribution			Ecological impacts
		Herbivorous and detritivorous fishes and other herbivores	Habitat-forming macrophytes (macroalgae and seagrasses)	Corals	
Southern Japan (cont'd)		<p><i>Scarus niger</i> (*, +) [27] <i>Scarus ovifrons</i> (*, +) [27] <i>Scarus prasioganthos</i> (*, +) [26, 27] <i>Scarus rivulatus</i> (*, +) [27] <i>Scarus rubroviolaceus</i> (*, +) [27]</p> <p>Sea chubs (Kyphosidae) <i>Kyphosus vaigiensis</i> (*, +) [27]</p> <p>Angelfish (Pomacanthidae) <i>Centropyge tibicen</i> (*, +) [26] <i>Centropyge vrolikii</i> (*, +) [26] <i>Centropyge heraldi</i> (*, +) [27]</p> <p>Damselfish (Pomacentridae) <i>Dischistodus prosopotaenia</i> (*, +) [28] <i>Pomacentrus alexanderae</i> (*, +) [28] <i>Pomacentrus bankanensis</i> (*, +) [26] <i>Pomacentrus chrysurus</i> (*, +) [27] <i>Plectroglyphidodon lacrymatus</i> (*, +) [26-28] <i>Plectroglyphidodon leucozonus</i> (*, +) [27] <i>Stegastes altus</i> (*, +) [27] <i>Stegastes fasciolatus</i> (*, +) [27]</p> <p>Rabbitfish (Siganidae) <i>Siganus fuscescens</i> (*, +) [27, 30] <i>Siganus spinus</i> (*, +) [27]</p>			
Eastern North America	<p>Intensification of western boundary currents [22]</p> <p>Regional cooling between Florida and Cape Hatteras [25]</p>	<p>Surgeonfish (Acanthuridae) Acanthuridae (species not detailed) (*, +) [41] <i>Acanthurus bahianus</i> (*, +) [42] <i>Acanthurus chirurgus</i> (*, +) [42] <i>Acanthurus coeruleus</i> (*, +) [42]</p> <p>Parrotfish (Labridae; Scarinae) Scarinae (species not detailed) (*, +) [41, 42] <i>Nicholsina usta</i> (*, +) [41] <i>Sparisoma viride</i> (*, +) [41]</p> <p>Damselfish (Pomacentridae) <i>Pomacentrus partitus</i> (*, +) [42] <i>Stegastes variabilis</i> (*, +) [42]</p> <p>Green turtles <i>Chelonia mydas</i> (*, +) [43, 44]</p> <p>Manatees <i>Trichechus manatus</i> (*, +) [45, 46]</p>	No data	<p>Hermatypic corals <i>Acropora cervicornis</i> (*, +) [47] <i>Acropora palmata</i> (*, +) [47]</p>	> Increased seagrass herbivory by parrotfishes of tropical origin, e.g. <i>Nicholsina usta</i> [48]

Region	Oceanography	Changes in distribution			Ecological impacts
		Herbivorous and detritivorous fishes and other herbivores	Habitat-forming macrophytes (macroalgae and seagrasses)	Corals	
Eastern Australia	Intensification of western boundary currents [22, 49] Regional warming [25, 50, 51]	<p>Surgeonfish (Acanthuridae) <i>Acanthurus dussumieri</i> (*, +) [52] <i>Acanthurus lineatus</i> (*, +) [52] <i>Acanthurus nigrofuscus</i> (*, +) [52] <i>Acanthurus olivaceus</i> (*, +) [52, 53] <i>Acanthurus pyroferus</i> (*, +) [54] <i>Acanthurus triostegus</i> (*, +) [52, 53, 55] <i>Acanthurus xanthopterus</i> [52] <i>Ctenochaetus binotatus</i> [52] <i>Ctenochaetus striatus</i> [52] <i>Naso unicornis</i> (*, +) [52, 53] <i>Zebrasoma flavescens</i> (*, +) [52] <i>Zebrasoma velifer</i> (*, +) [52]</p> <p>Blennies (Blenniidae) <i>Aspidontus dussumieri</i> (*, +) [54]</p> <p>Parrotfish (Labridae; Scarinae) <i>Scarus altipinnis</i> (*, +) [56] <i>Scarus chameleon</i> (*, +) [52] <i>Scarus ghobban</i> (*, +) [56]</p> <p>Angelfish (Pomacanthidae) <i>Centropyge flavicauda</i> (*, +) [52] <i>Centropyge tibicen</i> (*, +) [52-54] <i>Centropyge vrolikii</i> (*, +) [52, 53]</p> <p>Damselfish (Pomacentridae) <i>Parma oligolepis</i> (*, +) [52] <i>Plectroglyphidodon lacrymatus</i> (*, +) [52, 53] <i>Plectroglyphidodon leucozonus</i> (*, +) [52, 53, 55] <i>Pomacentrus bankanensis</i> (*, +) [52, 53] <i>Pomacentrus wardi</i> (*, +) [52, 53]</p> <p>Rabbitfish (Siganidae) <i>Siganus fuscescens</i> (*, +) [52]</p>	<p>Kelp (Laminariales) <i>Ecklonia radiata</i> (^, -) [57] (Malcolm & Vergés, unpubl. data)</p> <p>Furoids (Fucales) <i>Durvillaea potatorum</i> (^, -) [57] <i>Phyllospora comosa</i> (^, -) [57]</p> <p>Seagrass <i>Halophila minor</i> (*, +) [58]</p>	<p>Hermatypic corals <i>Acropora intermedia</i> (*, +) [59] <i>Acropora microlados</i> (*, +) [59] <i>Acropora monticulosa</i> (*, +) [59] <i>Acropora gemmifera</i> (*, +) [59]</p>	<p>> Extensive deforestation linked to expansion of the sea urchin <i>Centrostephanus rodgersii</i>, causing a shift from canopy algae to urchin barrens and inducing loss of diversity [60-62]</p> <p>> Community shift from kelp-dominated communities to turf due to fish grazing (Malcolm, Vergés et al. unpubl. data)</p>
Western Australia	Intensification of western boundary currents [22] Regional warming [25, 63-66]	<p>Surgeonfish (Acanthuridae) <i>Acanthurus nigrofuscus</i> (*, +) [67] <i>Acanthurus triostegus</i> (*, +) [67, 68] <i>Acanthurus dussumieri</i> (*, +) [69] <i>Naso unicornis</i> (*, +) [67]</p> <p>Blennies (Blenniidae) <i>Entomacrodus striatus</i> (*, +) [67] <i>Omobranchus germaini</i> (*, +) [67] <i>Petroscirtes mitratus</i> (*, +) [67]</p> <p>Batfish (Ephippidae) <i>Platax teira</i>^a (*, +) [67, 69]</p>	<p>Kelp (Laminariales) <i>Ecklonia radiata</i> (^, -) (Wernberg, unpubl. data)</p> <p>Furoids (Fucales) <i>Scytothalia dorycarpa</i> (^, -) [71, 72] <i>Sargassum</i> spp. (*, +) (Wernberg, unpubl. data)</p>	<p>Hermatypic corals <i>Goniopora norfolkensis</i> (*, +) [73]</p>	<p>> Community shift from kelp and furoid dominated canopies towards turf [65]</p>

Region	Oceanography	Changes in distribution			Ecological impacts
		Herbivorous and detritivorous fishes and other herbivores	Habitat-forming macrophytes (macroalgae and seagrasses)	Corals	
Western Australia (cont'd)		<p>Gobies (Gobiidae) <i>Amblygobius phalaena</i> (*, +) [67]</p> <p>Damselfish (Pomacentridae) <i>Plectroglyphidodon leucozonus</i> (*, +) [67, 68] <i>Stegastes obreptus</i> (*, +) [67] <i>Parma occidentalis</i> (*, +) [65]</p> <p>Parrotfish (Labridae; Scarinae) <i>Chlorurus gibbus</i> (*, +) [67] <i>Chlorurus sordidus</i> (*, +) [67] <i>Scarus ghobban</i> (*, +) [67] <i>Scarus festivus</i> (*, +) [67] <i>Scarus schlegeli</i> (*, +) [67] <i>Scarus frenatus</i> (*, +) [70] <i>Scarus prasiognathus</i> (*, +) [70] <i>Scarus psittacus</i> (*, +) [69]</p> <p>Rabbitfish (Siganiidae) <i>Siganus fuscescens</i> (*, +) [67] <i>Siganus canaliculatus</i> (*, +) [70]</p>			
Southeast Africa	<p>Intensification of western boundary currents [22]</p> <p>Intensification of the Agulhas current [74]</p> <p>Regional warming [25, 75, 76]</p>	<p>Surgeonfish (Acanthuridae) <i>Acanthurus xanthopterus</i> (*, +)[74]</p>	No data	No data	No data
Eastern South America	Intensification of western boundary currents [22, 25]	<p>Surgeonfish (Acanthuridae) <i>Acanthurus coeruleus</i> (*, +) [77] <i>Acanthurus monroviae</i> (*, +) [78]</p> <p>Leatherjackets (Pomacanthidae) <i>Aluterus scriptus</i> (*, +) [79]</p> <p>Damselfish (Pomacentridae) <i>Stegastes partitus</i> (*, +) [77]</p> <p>Parrotfish (Labridae; Scarinae) <i>Scarus trispinosus</i> (*, +) [77] <i>Scarus zelindae</i> (*, +) [80] <i>Sparisoma amplum</i> (*, +) [77]</p>	No data	No data	No data

^a Not a strict herbivore and may not digest algae, but could be important remover of large fleshy algae in the process of searching for invertebrates [81]

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