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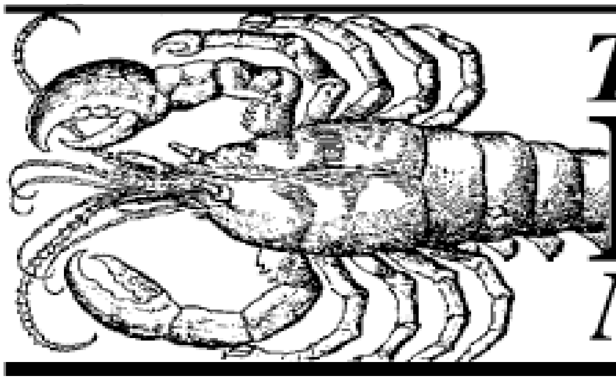

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FOCUS ON THE MARKET

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Maine lobster claws itself back from EU ban

Failed Swedish blacklisting attempt keeps ‘invasive species’ on European menus

October 15, 2016 by: Shawn Donnan in Cape Porpoise

An EU committee has rejected a Swedish attempt to have the American lobster declared an invasive species, bowing to intense lobbying from the US and restaurateurs who depend on imports to feed a growing appetite for the crustacean.

A European Commission official said on Friday that Sweden's government had been informed that the EU's Committee on Invasive Alien Species had decided at a "technical level" not to place Homarus Americanus on a new black list. Had the American lobster been declared an invasive species it would have killed $130m a year in exports from the north-eastern state of Maine into Europe.

Instead, the committee had told Sweden that it would explore other "less trade restrictive" measures, the official said.

The move appears to bring an end to a trade battle that had been threatening to descend into a transatlantic lobster war just as soaring demand from foodies around the world has driven prices to 11-year highs.

An EU scientific committee last month gave a provisional nod to an attempt by Sweden to have the American lobster listed as an invasive species after 32 American lobsters were found trespassing in its national waters since 2008.

Fredrik Nordwall, head of aquatic biodiversity at the Swedish Department for Marine and Water Management, said the small number found belied a longer-term threat. The American interlopers can carry diseases, he said. They are bigger and surlier than their European cousins and, were they to find willing local mates, they could create a new hybrid species that would over time crowd out native Europeans. American females carrying eggs fertilised by European lobsters have been among those found, Mr Nordwall said.

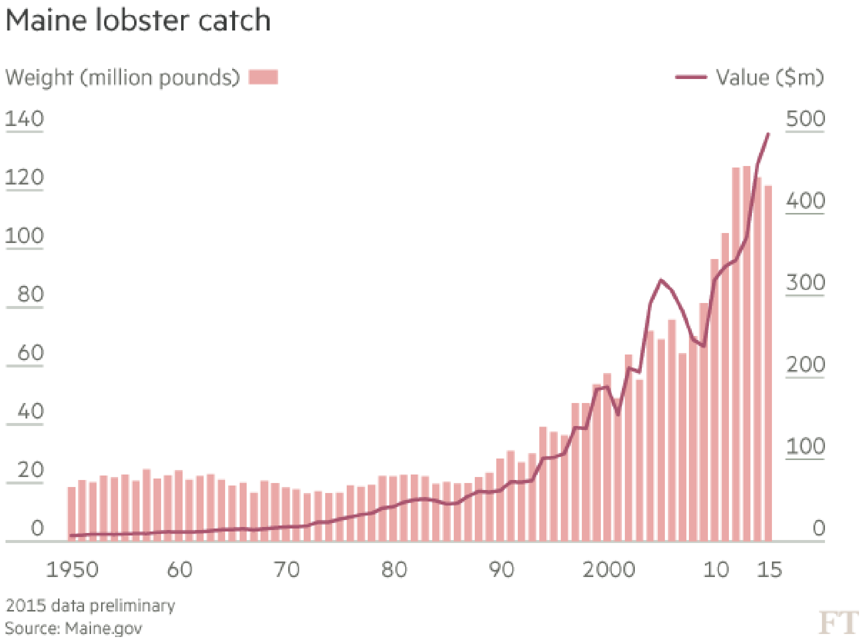
“You have to have several hundred years [into the future] in mind when you discuss this,” he said, pointing to the North American red swamp crayfish, which was imported into Europe in the 1970s and has overwhelmed Europe’s own wild populations, earning it an EU invasive species designation.

But European Commission sources said that while a scientific panel had last month found some validity to Sweden’s argument there had been no support from EU member states for a ban when the Committee on Invasive Alien Species met last week.

As a result, a "technical decision" had been taken not to pursue a listing of the American lobster, a European Commission official said. "We are now exploring other measures," the official said.

Lobster production in Maine alone is more than 50 times that of Europe’s and exports to the continent have surged as what was once a delicacy has turned into more common fare on European restaurant menus.

The threat of an EU ban had cast a pall over what has otherwise been another very good season for Maine lobstermen.



2015 data preliminary
Source: Maine.gov

Returning to the pier at Cape Porpoise, a small Maine fishing village, after a 10-hour day on the water earlier this week, Julian Zuke was full of cheer about what has been a banner season.

“The price has been great and the catch has been good,” he said.

The lobster population off Maine’s coast has exploded in recent years, with the annual catch five times what it was in the 1980s. Climate change and warmer waters have played a role in the boom.

So too has decades of overfishing that has wiped out traditional predators such as cod, according to Richard Wahle, an expert on lobster demographics at the University of Maine.

Prof. Wahle had viewed the Swedish attempt sceptically. The American lobster fishery — the country's richest — is largely disease free, he said.

Questions also remained over whether those born of mixed parentage could themselves reproduce. No juvenile American lobsters had been found in European waters, Mr Wahle pointed out, and hybrid offspring studied in labs had yet to reach sexual maturity, which takes years.

“The question essentially is: ‘Are they just mules? Or are they viable reproducers?’” he asked.

Maine’s lobster industry had also smelled a conspiracy in the Swedish push. Among their theories was that the Swedes and the EU were being manipulated by animal rights activists who freed imported American lobsters into Swedish waters to protest the fact the crustaceans are usually boiled live.

“It’s a lobster liberation thing,” said Annie Tselikis, executive director of the Maine Lobster Dealers Association.

(See https://www.ft.com/content/65576b70-91ca-11e6-a72e-b428cb934b78 for the original publication in The Financial Times)

RESEARCH NEWS

Counting the beasts – Research programmes in New Zealand lobster fisheries

From: Daryl Sykes

Research is an investment for the rock lobster industry, not a cost. The information principles that apply to current and future industry or Ministerial management decisions are "*rubbish in, rubbish out*" and on their own and through the NZ Rock Lobster Industry Council (NZ RLIC), regional rock lobster industry organisations - CRAMACs - have consistently promoted accurate and reliable data recording and reporting – in mandatory landing reports; in logbooks and in tag recapture reports – and have supported the proper analysis and use of credible data in all rock lobster fisheries planning and decision making processes.

New Zealand rock lobster fisheries research objectives are confirmed each year in a planning process involving the National Rock Lobster Management Group (NRLMG). The NRLMG regularly updates a medium-term research plan which currently gives priority to the integrity of catch and effort data; access to reliable non-commercial catch data; commercial catch monitoring; tag recapture data; periodic stock assessment; ongoing management procedure development, and model development.

Researchers also deliver puerulus settlement data from selected sites around the New Zealand coastline. The monthly levels of puerulus settlement have been followed for over 30 years at many sites within the main rock lobster fishery areas. This constitutes the longest time series of New Zealand fisheries data.

PERSONNEL AND RESOURCES

The rock lobster stock assessment contract is a collaboration between the Ministry for Primary Industries and the NZ Rock Lobster Industry Council Ltd and incorporates a selection of professional scientific and technical specialists. The core science team comprises Dr Paul Breen; Charles Edwards; Vivian Haist; Paul Starr; and Darcy Webber.

The stock assessment team is backed up by FishServe who manage the electronic logbook data base and *TagTracker* programme. The National Institute of Water and Atmospheric Research (NIWA) manages the rock lobster research catch sampling and tagging data base.

Observer catch sampling is done by Lat37 Ltd, independent fisheries technician Don Nelson, and a small team at NIWA led by David Fisher.

Rock lobster industry personnel across six management areas participate in a vessel logbook programme and directly contribute to the research contract by delivering significant quantities of stock monitoring data.

Traditionally, scientific observers have been employed to conduct intensive catch sampling onboard commercial vessels. Due to logistical constraints, such personnel usually sample a large proportion of the catch from a small proportion of fishing trips made by a small number of fishermen in each region.

Alternatively, fishermen can sample their own catch and record it in a logbook. Again, logistical constraints mean that each fisherman can usually only sample a small proportion of their catch on each day. However, the advantage of logbooks is that every day fished produces a catch sample. If that small effort is expended over the entire fleet, the net result is that a significant proportion of the catch is sampled from many fishing days over the course of the season.

This type of extensive sampling is more likely to produce data that is representative of the fishery, particularly when there are large differences between the catch characteristics of different vessels.

The latest version of the electronic logbook options (known as *BERT* and *ERNIE*) are very sophisticated units which enable the recording of information in real time and at very fine scale. Nearly two million individual records are now held on the Logbook data base.

Two significant improvements to the logbook have been the inclusion of 'zones' and high-grading information. Zones are "sub-areas" which enable the trends in the fishery to be discerned on a smaller geographical scale than the much larger statistical areas, while protecting the exact location of any "secret spots".

High-grading (which is selecting catch on dollar value rather than by size/weight/numbers) occurs in some management areas but was not routinely recorded previously by the logbook or in mandatory Ministry for Primary Industries (MPI) catch and effort returns.

Export market preferences for live lobsters tend towards the smaller grades of lobsters to 1.5 kgs in weight. Premium prices are paid for those grades and the prices tend to set the cost of the annual catching rights required by commercial fishermen. Lower valued lobsters – as measured in $/kg – are therefore routinely returned to the sea alive.

Active high-grading, such as known to occur in the CRA 8 (Southland) and CRA 9 (West Coast and Taranaki) management areas could distort the index of stock abundance derived from catch per unit effort information. Logbook data can be used by scientists to adjust catch per unit effort data derived from mandatory from MPI returns to provide a more accurate index of the stock biomass.

The general rule of thumb for rock lobster fisheries research programmes may be a cliché but is demonstrated to be very applicable to lobster fisheries – ***you cannot manage what you do not know.***

Daryl Sykes
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Abnormal reproductive morphology in two species of spiny lobster: *Jasus edwardsii* and *Jasus paulensis*.

From: Adrian Linnane, Anthony Pere, Caleb Gardner and Thibaut Thellier

Jasus edwardsii (Hutton, 1875) and *Jasus paulensis* (Heller, 1862) are commercially fished palinurid spiny lobster. *J. edwardsii* are broadly distributed throughout New Zealand and south-eastern Australia, south of about 30°S (Phillips, 2006), whereas, *J. paulensis* are confined to the isolated islands of Amsterdam and the Saint Paul Islands, as well as nearby seamounts in the southern Indian Ocean (Booth, 2006). The total catch of *J. edwardsii* across Australia and New Zealand is approximately 5500 tonnes, while annual catches of *J. paulensis* range between 300 and 400 tonnes. Both species are captured using baited traps.

The reproductive morphology in each species follows the general dioecious decapod pattern of dorsally positioned paired ovaries or testes, leading via paired oviducts to reproductive gonopores on the coxopodite at the base of the third pair of pereiopods in females and the fifth pair in males (Meglitsch, 1967). The male uses the gonopore as the sperm transfer organ to the female external sternal region, while the female gonopore is used for egg extrusion. In addition, the fifth pereiopod in females terminates in a specialized pincer used to groom the setae and manipulate the egg mass. Here we report on abnormal gonopore and pincer characteristics in both species that have been identified as part of routine catch sampling programs that support annual stock assessments.

Fig. 1 shows two specimens of *J. edwardsii* from South Australia (A) and Tasmania (B). In Fig. 1A, in addition to the normal pair of gonopores at the base of the third pair of pereiopods in a female, a pair of gonopores were observed on the coxopodites of the fourth pair of pereiopods. Fig. 1B, shows a specialized female pincer observed on a male individual.

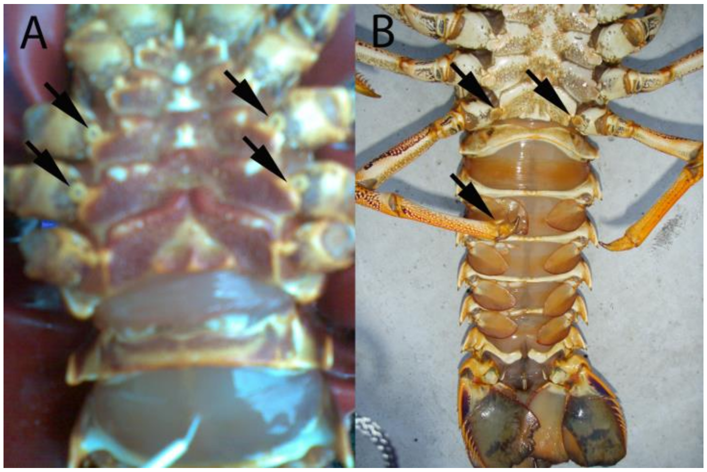

Fig. 1. Specimens of *Jasus edwardsii* exhibiting abnormal morphological reproductive characteristics. Additional pair of gonopores on the fourth pair of pereiopods (A) and specialized female pincer on a male individual (B). Gonopores and specialized pincer on the right propopodite are marked by arrows.

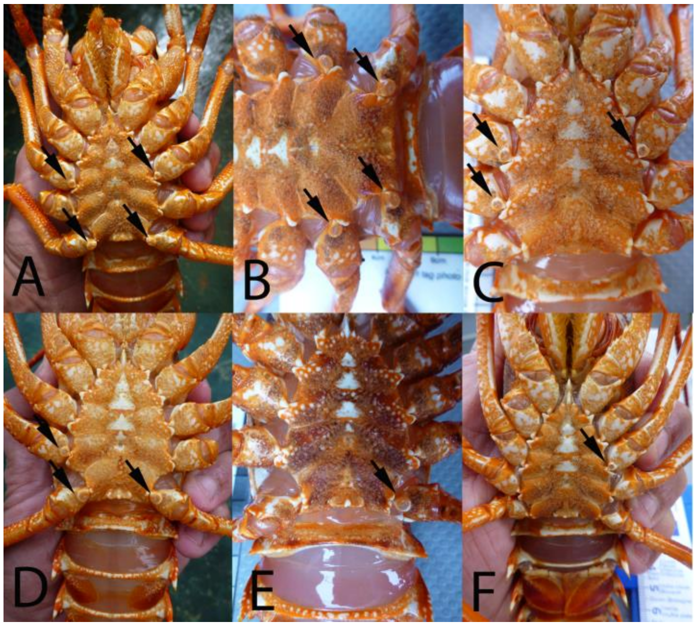

Fig. 2. Specimens of *Jasus paulensis* exhibiting abnormal morphological reproductive characteristics (A–F). Gonopores are marked by arrows.

For *J. paulensis*, exhibits include abnormal location of gonopores, with examples of general variations provided in Fig. 2. These included male individuals with an additional pair of gonopores on the coxopodites of the third (Fig. 2A) and fourth (Fig. 2B) pair of pereiopods. In addition, we observed both female (Fig. 2C) and male (Fig. 2D) individuals with an extra single gonopore on the fourth pereiopod. Finally, male (Fig. 2E) and female (Fig. 2F) individuals with just a single gonopore have been observed.

Gynandromorphy is a condition of having both female and male reproductive characteristics that occurs in bilaterally symmetrical organisms such as crustaceans. Although gynandromorphs exhibit characteristics from both sexes, they are generally unable to function as either sex and the condition is often incorrectly reported as hermaphroditism where individuals spend part of their lives as male and another part as female, or spend their entire lives as both sexes. The condition arises from a genetic abnormality in the early stages of mitosis when dividing cells fail to split sex chromosomes typically. Although cases are extremely rare, gynandromorphism has been recorded in a range of crustacean species such as crab (Micheli, 1991), shrimp (Belk, 1978) and brine shrimp (Bowen & Hanson, 1962).

It is worth noting that while observations of gynandromorphism are extremely rare in *J. edwardsii*, the condition appears to be more prevalent in the much smaller and isolated population of *J. paulensis*. Whether the higher number of cases reported here from Amsterdam and the Saint Paul Islands are genetically or environmentally driven, remains largely unknown. Overall, given that gynandromorph lobsters are rare and appear to be fully functional, the condition will have negligible impacts on a population level.

Acknowledgements
We thank the Terres Australes et Antarctiques Francaises for providing some of the *J. paulensis* images (Eva Biger) and Alan Jones for images of *J. edwardsii* from South Australia.

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Will fixed-station sampling continue to work for lobster settlement survey in the Gulf of Maine?

From: Bai Li, Jie Cao, Jui-Han Chang, Carl Wilson, and Yong Chen

The American Lobster Settlement Index (ALSI) program conducts an annual diver-based survey of newly settled lobsters and older juveniles since 1989 with 10 fixed stations in the mid-coast region of Gulf of Maine (GoM; ASMFC, 2015). It provides vital information regarding the recruitment dynamics of lobster in the GoM (ASMFC, 2015). Since most other fishery-independent surveys follow random survey designs and the performance of the fixed-station sampling design from this program has not been evaluated, it is necessary to evaluate the effectiveness of the fixed-station sampling design to identify whether the design can capture the temporal dynamics of settlers in a changing environment.

To compare the performance of fixed-station sampling design with random sampling design, we need temporally simulated "true" population of the newly settled lobster in the mid-coast region of the GoM. We developed a two-stage generalized additive model (GAM) to simulate the presence and density of the "true" population from 1989 to 2012. Both fixed- and random-station sampling designs were applied to sample the simulated population. The relative estimation error (REE) and relative bias (RB) were compared between the "true" population and the results from the two sampling designs in order to determine the discrepancy between "true" density and sampled density. Additionally, a pairwise comparison of observed lobster density of all the years (1989 - 2013) was used to calculate persistence indices to evaluate the power of fixed-station sampling in detecting temporal trends in lobster density (Warren, 1994).

The simulated "true" density of lobster supports our understanding of lobster ecology and the statistical evaluations of the model indicated the predictive performance is sufficient for simulating a reasonable distribution in this study. The results from the random-station sampling design showed better performance than the fixed-station sampling design in REE and RB. The mean of REE from the random-station sampling is smaller than the mean of REE from the fixed-station sampling (Li *et al*., 2015). The random-station sampling was unbiased but the fixed-station sampling design did not show evenly distributed RB values around zero. The fixed-station sampling design tended to underestimate the "true" density but still could capture the temporal trends in settler density (Fig. 1).

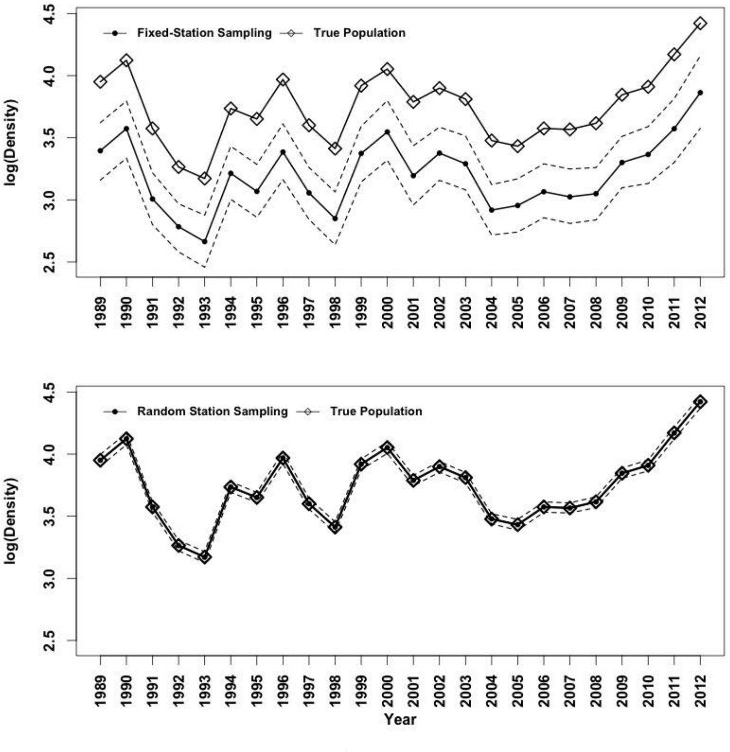

Fig. 1. Temporal trends of simulated "true" population and means of American lobster sampling designs from 1989 to 2012.

The persistence between two pairs of years was strong during most years (Fig. 2). The mean persistence value for the 24 successive pairs of years was 0.39 (SD, 0.21; Li *et al.*, 2015), and the corresponding probability that fixed-station sampling would detect the temporal trend of the lobster density in the mid-coast region of the GoM was greater than 81.4% (Li *et al.*, 2015).

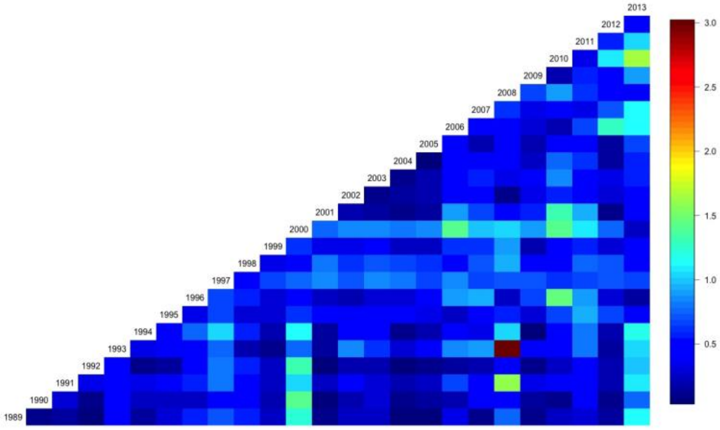

Fig. 2. American lobster degree of persistence index matrix for paired years (1989 - 2013). The smaller the index value, the greater the persistence the fixed-station sampling obtains.

In conclusion, the results from both the simulation approach of mimicking the sampling process and the analytical approach of calculating persistence index suggested that the fixed-station sampling has the ability to detect substantial changes in temporal trend of lobster density in the study area (Li *et al.*, 2015). The density index from the ALSI program can capture the temporal variability of American lobster settlers and juveniles (Li *et al.*, 2015). The simulation and analytical approaches that were developed in this study can be applied to other comparison research of sampling designs.

Acknowledgements

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Examining the response of *Homarus americanus* larvae to ocean warming and acidification

From: Jesica D. Waller, Richard A. Wahle, Spencer Greenwood and David Fields

The American lobster (*Homarus americanus*) upholds the most valuable single-species fishery in New England and Atlantic Canada. Last year Maine's lobster landings alone were worth roughly half a billion dollars and contributed to the success of countless businesses and industries across the state (ME Department of

Marine Resources). Given the commercial value of this species, it is surprising that before this work was published in September 2016 no studies had examined how ocean warming in tandem with acidification will impact American lobsters of any life stage (Waller *et al.*, 2016). Projections made by the Intergovernmental Panel on Climate Change show that as CO_2 continues to accumulate in the atmosphere, sea surface temperatures could rise by 3°C while sea surface pH could drop by 0.2 units resulting from the near doubling of CO_2 concentration expected to occur by the year 2100 (380 to 750 ppm; IPCC 2013). Planktonic larvae may be uniquely susceptible to these changes as they grow and develop in surface waters. Given the immense economic value of the American lobster fishery and the potential vulnerability of the larval stages, it is important for us to understand the response of larvae to an end-century temperature and partial pressure of CO_2 (pCO_2).

Each summer as water temperatures warm in the Gulf of Maine and Atlantic Canada, lobster larvae hatch from eggs and develop through four planktonic larval stages (Fig. 1). To examine how ocean acidification and warming might affect the larval development of *H. americanus*, we raised lobster larvae in a two-factorial experiment designed to simulate the conditions lobster larvae might experience off of the coast of central Maine today (16°C, 380 ppm) and in 2100 (19°C, 750 ppm). Over the course of the larval duration we measured survival, development time, size and oxygen consumption rate of larvae in addition to the swimming speed, feeding rate and gene expression of postlarvae from each of the four experimental treatments.

We saw that temperature played a more significant role in larval survival and development time than CO_2 concentration. Larvae raised at the end-century temperature (19°C) had significantly lower survival, faster development times and higher whole-body oxygen consumption rates compared to larvae raised at the ambient temperature (16°C), regardless of pCO_2 treatment, although we did find that larvae raised at ambient temperature in the elevated end-century CO_2 concentration (750 ppm) were longer and heavier. Our preliminary differential gene expression results showed that postlarvae raised in the ambient temperature/end-century CO_2 treatment upregulated genes related to stress response and metabolism and downregulated genes related to cuticle and chitin formation. These results need to be validated and studied further but offer insight into how rising CO_2 levels will affect gene expression and mechanisms of stress response in postlarvae although we still do not know how warming in tandem with rising CO_2 will affect gene expression. When we examined the activity of postlarvae, we found that individuals reared in the end-century temperature and pCO_2 treatment had faster swimming speeds and higher feeding rates than postlarvae from the other three treatments. Taken together these results suggest that increasing temperatures will drive larval survival and development time while rising CO_2 will have implications for larval size and gene expression. For the first time in a study of *H. americanus* we also showed that the interactive effects of warming and acidification can have significant implications for postlarval activity.

This study was the first to examine the joint effects of ocean warming and acidification on the development of American lobster larvae. We believe this work has generated valuable insights, but it is important to recognize the limitations of this type of study. We did not examine multiple *H. americanus* populations or generations, so our work does not account for the possibility of adaptation over many generations or differences between *H. americanus* subpopulations. Over the next two years our team will be conducting research to fill these gaps in our knowledge.

Acknowledgments
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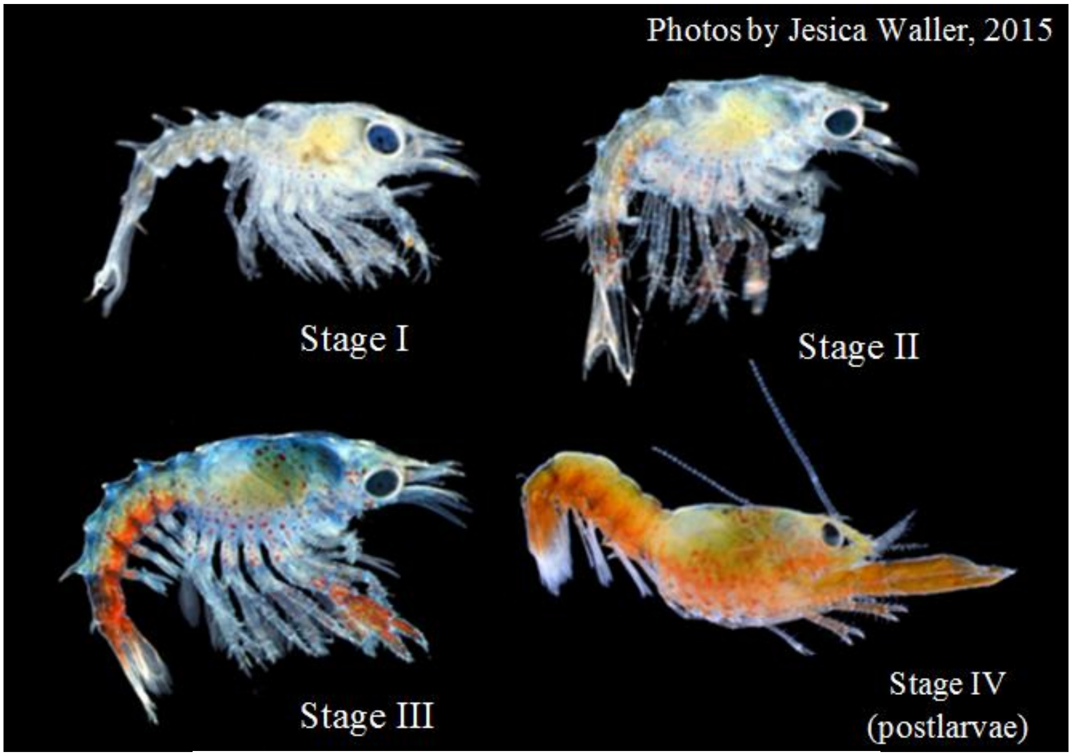

Fig. 1. Each stage of the American lobster’s larval development.

Wrecked reefs in northeastern New Zealand

From: John Booth

Whereas the reason for the emergence of 'urchin/kina barrens' in northeastern New Zealand was for a time contested, there is now consensus that these barrens are a direct result of the overharvesting of keystone predators such as snapper (*Pagrus auratus*) and red rock lobsters (*Jasus edwardsii*). Reductions in the proportions of large individuals of these predatory species - the ones capable of preying on sea urchins - have led to burgeoning kina (*Evechinus chloroticus*) populations and to the widespread loss of shallow-reef kelp forests (Ballantine, 2014). Resulting urchin barrens such as these are a world-wide phenomenon, and one surprisingly difficult to reverse (Ling *et al.*, 2014).

In the laboratory, large red rock lobsters ate all sizes of kina, but all sizes of lobster ate small kina (<50 mm diameter) in preference to larger ones (Andrew & MacDiarmid, 1991). In field experiments, a high proportion of predation of large kina was attributed to rock lobsters, predation being most intense on the smaller kina (Shears & Babcock, 2007).

The loss of the shallow-reef kelp forests throughout the main basin of the Bay of Islands has been extensive, and among the most severe in the entire country. Twenty-nine discrete locations were distinguished for which there was a series of aerial images, from the 1950s/1960s, through to 2009, in which the extent of seaweed cover could be clearly discerned (Fig. 1-3).

For most parts the reduction in kelp cover over the past six decades has been monumental: loss of kelp was obvious by the 1970s, although some kelp forests seem to have persisted until quite recently. And no evidence has been found for any kelp recovery since 2009.

All exploited coastal finfish species around New Zealand have declined dramatically in abundance since colonisation using every acceptable measure. In northern New Zealand, many predatory finfish species (as well as the red rock lobster) had by the mid-1980s declined in biomass to less than one quarter of their virgin state (Ministry for Primary Industries Plenary Report, 2015). For almost all of the sought species – including rock lobsters - the

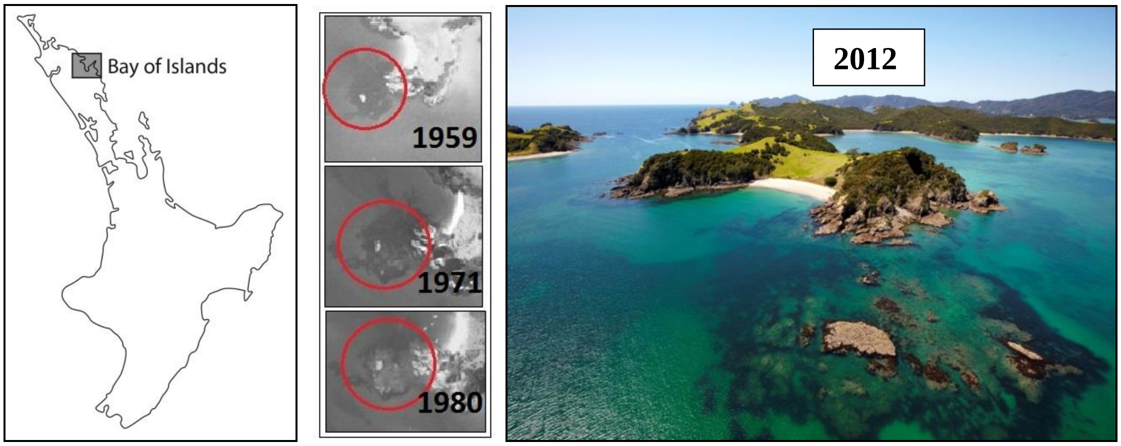

Fig. 1. Today, this reef off the northwest extremity of Bay of Island's Urupukapuka Island, displays a fringe of kelp at low tide level, and then again from about 6-m depth, with virtually all kelp between having been grazed back to the bedrock. Loss of kelp was apparent in 1971, and most was gone by 1980.

status of the Bay of Islands component is inextricably linked to that of the underlying stock.

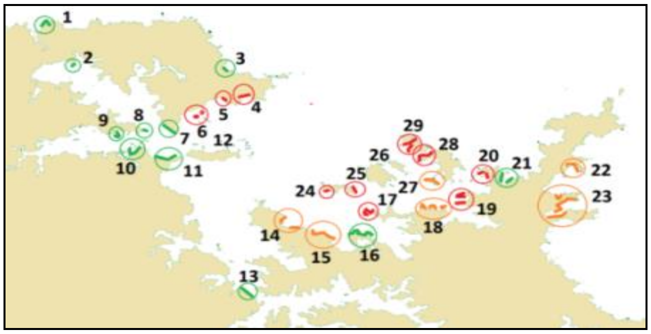

Fig. 2. Changes in Bay of Islands kelp cover between the 1950s/early 1960s and 2009. For each site there were at least four aerial images, each separated by at least a decade, and among which at least two of the early images showed extensive dark shadows associated with reef (usually kelp but possibly sometimes dark-coloured rock). The previously existing dark shadows had largely vanished by the 1970s (red), or certainly by the 2000s (orange); green indicates little apparent change in the intensity or extent of shadow (although thinning of kelp was sometimes obvious), most often seen near inlets where waters are presumably too fresh for kina.

Fig. 3. Urchin barrens (red) are now widespread in the Bay of Islands, particularly in the main basin .[5] This is the southeast of the Bay of Islands, the region known as Ipipiri, where every shore that could be clearly enough seen in aerial imagery was bereft of shallow-reef kelp (red). Open shores were often too steep to assess, or were in shadow (blue), but follow-up dives show widespread barrens there too, interspersed with some healthy kelp.

From the early/mid 1900s, commercial harvesting of finfish and shellfish in the Bay of Islands (and elsewhere in northeast New Zealand) steadily increased, to peak just ahead of introduction of the Quota Management System, in 1986, when close to 200 vessels fished out of the Bay. Since then, commercial fishing pressure has dropped to a handful of vessels, but recreational pressure has increased astronomically. It’s now clear that today’s remaining inshore fish populations are able to support only modest levels of fishing pressure; this pressure is maintained by a small commercial fleet which is emphatically trumped by that of hundreds of recreational fishers and their vessels.

Consistent with intense fishing pressure, most rock lobsters caught both commercially and recreationally in and near the Bay of Islands today are not much larger than the minimum legal size (MLS). Furthermore commercial CPUE over the past four years has averaged around 0.5 kg per pot lift, only 20% of that of the other local areas, and one of the lowest in the country (Ministry for Primary Industries Plenary Report, 2015). This points to severe regional depletion of rock lobsters.

With attempts to decrease fishing pressure – in order to allow more large-individual finfish and shellfish to survive – likely to be challenged every step of the way, the only way we can expect any recovery in the shallow-reef kelp is within the protection of no-take marine refuges. The experience at Leigh (just north of Auckland) and elsewhere in New Zealand (Ballantine, 2014) is that once fishing pressure on the predators of sea urchins is removed, the full kelp canopy returns. Yet, would you believe it, there is not a single marine reserve in the north of New Zealand.

The loss of vast areas of the shallow-water kelp community is likely to have led to a multitude of cascading consequences, most of them not yet even recognised l*et al*one understood. Kelps are highly productive, fixing carbon, fuelling the ecosystem, and providing habitat for all manner of animals and plants. Shallow forests provide areas for spawning and larval settlement, and shelter for juveniles, by reducing exposure to water movement and predation. Most rock lobster postlarvae settle out of the plankton among shallow-reef kelp, and juvenile snapper are strongly associated with it.

The urchin barrens of the Bay of Islands are a potent example of ecological overfishing: too few large rock lobsters and other keystone predators have allowed urchin populations to grow out of control. Initiated by heavy commercial harvesting, the overfishing is now also perpetuated by recreational fishers.

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Examining effects of coral reef degradation on an obligate reef-dweller

From: Enrique Lozano-Álvarez, Nelia Luviano-Aparicio and Patricia Briones-Fourzán

Habitat degradation is a decline in species-specific habitat quality related to changes in food availability, cover, or climate that leads to reduced survival and/or reproductive success in a population. Caribbean coral reefs have undergone a massive degradation as evidenced by reefs exhibiting local increases of macroalgae and loss of reef-building corals. At local scales, hard coral mortality is associated with the loss of architectural complexity and 'reef flattening' due to the breakage of coral skeletons, leading to a collapse of the 3-D reef framework (Bruno *et al*., 2009; Álvarez-Filip *et al*., 2009; Jackson *et al*., 2014). In some reefs, loss of architectural complexity associated with habitat degradation has resulted in a decline of habitat-specialist reef fishes (i.e., fishes that live exclusively in coral reefs) and an increase in habitat-generalist fishes (i.e., fishes that live in coral reefs and in other habitats) (Munday, 2004; Álvarez-Filip *et al*., 2015).

We investigated whether habitat degradation affected population density and feeding ecology (nutritional condition, diet composition, and stable isotopes $\delta^{13}C$ and $\delta^{15}N$) of *Panulirus guttatus*, an obligate coral-reef dweller (Fig. 1). *P. guttatus* are strictly nocturnal, hiding deeply in reef crevices during the daytime, and do not venture off the reef; they are also highly vulnerable to predators and strongly depend on availability of shelters for survival (Lozano-Álvarez *et al*., 2007; Robertson & Butler, 2009). Therefore, we expected to find lower levels of density and nutritional condition in lobsters on more degraded, less complex reefs than on less degraded, more complex reefs.

Fig. 1. *Panulirus guttatus* (the Caribbean spotted spiny lobster), an obligate reef-dweller.

We conducted our study in the Puerto Morelos Coral Reef National Park (Mexico). We selected two large reef patches (“Reef A”: ~11,000 m²; “Reef B”: ~14,000 m²), which visually appeared to differ widely in degree of degradation. Using a combination of line transects, belt transects, and quadrats, we obtained measures of reef complexity (rugosity index (RI), Risk 1972) and habitat assessment score (HAS) (Gratwicke & Speight, 2005), the percent cover of various benthic components (live hard coral, soft coral, dead coral, fleshy macroalgae, calcareous macroalgae, coralline algae, algal turf, sponges, other invertebrates, bare hard substrate, sand) (Loya, 1972), and estimated lobster density. We then collected lobsters from both reefs to measure three nutritional indices (weight/carapace length ratio, hepatosomatic index, and blood refractive index), their diet composition via stomach contents analyses, and their isotopic niche width. We used two separate ANCOVAs to assess the effects of lobster size (continuous covariate) and reef (categorical variable) on values of δ^{13}C and δ^{15}N.

Reef A was architecturally more complex than Reef B, as shown by its significantly higher values of RI and HAS (Fig. 2).

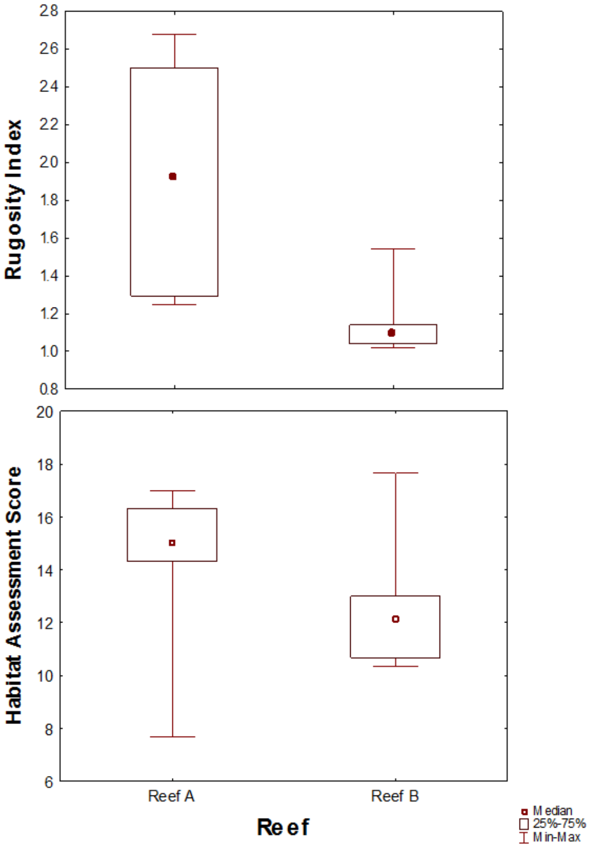

Fig. 2. Measures of habitat complexity in Reefs A and B (values averaged over 10 transects per reef). Both measures differed significantly between reefs (Mann-Whitney U-tests, rugosity index: U = 8.0, p = 0.002; habitat assessment score: U = 21.5, p = 0.034) (dot: median; box: 25%–75%, whiskers: minimum-maximum values)

The dominant benthic components on Reef A were fleshy macroalgae, soft corals, and dead coral, and those on Reef B were algal turf, calcareous macroalgae, and fleshy macroalgae (Fig. 3). However, Reef A had proportionally more cover of live hard coral, soft corals, and other sessile invertebrates (e.g., *Millepora*, *Palythoa*, anemones), whereas Reef B had proportionally more cover of algal turf, calcareous macroalgae, and bare hard substrate (Fig. 3). These results, combined with results of RI and HAS, show that Reef B was more degraded than Reef A.

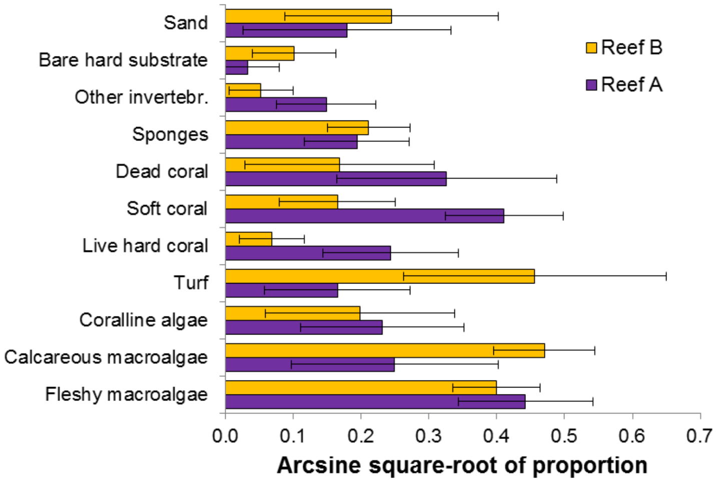

Fig. 3. Percent cover (transformed to arcsine square-root) of different benthic components over Reefs A and B, averaged across 10 transects per reef. Error bars are 95% confidence intervals.

Interestingly, though, we found no significant differences in lobster density or any of their three nutritional indices between reefs. Lobsters from both reefs fed primarily on mollusks, crustaceans, and echinoderms, but also on polychaetes, sponges, and some macroalgae. In terms of volume, mollusks were the most important component in the diet of lobsters from both reefs, but proportionally more for lobsters from Reef A (40%) than for lobsters from Reef B (30.7%). In contrast, crustaceans (mostly majoid crabs) contributed proportionally more in volume to the diet of lobsters on Reef B (26.5%) than on Reef A (6.9%). Regardless, there was a high overlap in diet of lobsters from both reefs (Horn's overlap index: 0.9).

The isotopic dispersion within the two-dimensional (δ^{13}C and δ^{15}N) space showed a clear separation of the lobster samples from the two reefs along the δ^{13}C axis, but not along the δ^{15}N axis (Fig. 4). Results of ANCOVAs showed that values of δ^{13}C were only marginally affected by lobster size ($F_{1,37}$ = 4.123, p = 0.051) but varied significantly with reef ($F_{1,37}$ = 66.643, p < 0.001), whereas values of δ^{15}N increased significantly with lobster size ($F_{1,37}$ = 9.101, p = 0.005) but did not vary significantly with reef ($F_{1,37}$ = 0.967, p = 0.332). The difference in values of δ^{13}C between reefs suggests differences in local carbon sources, i.e., the macroalgal component, and provides indirect evidence that foraging activity of individuals of *P. guttatus* is indeed constrained to the reef on which they reside. On the other hand, given that these lobsters are omnivorous and opportunistic feeders, the increase of δ^{15}N with lobster size does not necessarily reflect ontogenetic changes in diet but may rather indicate metabolic age effects not attributable to changes in diet (e.g. Overman & Parrish, 2001)

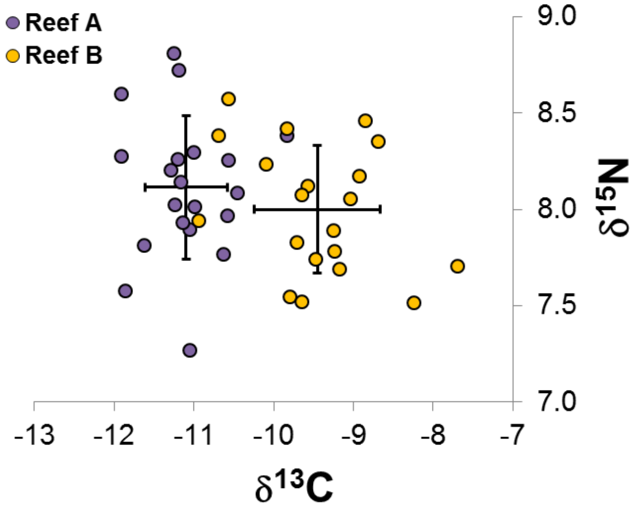

Fig. 4. Isotopic niche of *Panulirus guttatus* collected from Reef A and Reef B. Error bars are 1 standard deviation and they cross at the mean values.

Degradation of Caribbean coral reefs is an ongoing process that may further increase due to multiple stressors and is expected to affect reef specialists in particular (Bruno *et al*., 2009; Álvarez-Filip *et al*., 2015). Yet, we found no difference in density, diet, and nutritional condition of *P. guttatus* on two reefs with different levels of degradation, suggesting that the difference was not sufficiently broad so as to affect the availability of food and shelter for the local populations of these obligate reef-dwellers. Other decapods, including obligate coral-dwellers, also appear to live as well on dead corals as on live corals (e.g. Kramer *et al*., 2014;

Head *et al*., 2015). However, because degraded reefs further erode over time (Perry *et al*., 2012), food and shelter availability for *P. guttatus* may become more dependent on coral loss over the long-term. Our results provide a baseline for future studies related with habitat degradation in Puerto Morelos coral reefs.

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Modeling spatiotemporal variability of the bioclimate envelope of *Homarus americanus* in the coastal waters of the Gulf of Maine.

From: Kisei Tanaka and Yong Chen

We developed a bioclimate envelope model to evaluate the impacts of climate variability on habitat suitability of *Homarus americanus* in the inshore Gulf of Maine waters from 1978 to 2013. *H. americanus* supports one of the most economically important fisheries in the Northwest Atlantic Ocean, with 66,245 metric tons landed worth USD 617.8 million in 2015 (ACCSP, 2016). The species is most abundant in shallow coastal waters of the Gulf of Maine.

Climate change is rapidly altering environmental conditions in the Gulf of Maine, and has become a growing concern for the management of *H. americanus* fishery, as climate-induced change to the species' surrounding ecosystem is inevitable. The bottom water temperature in the Gulf of Maine has increased over the last 40 years (ASMFC, 2015, Kleisner *et al.*, 2016). Changes in water temperature could significantly impact the ecology of *H. americanus* because its population dynamics appear to be strongly regulated by bottom-up forces as relationships between the ectothermic nature of *H. americanus* and climate variables have been well documented (Butler et al. 2006; Aiken & Waddy 1986). According to the latest Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathways (RCP) 8.5 emissions scenario, the average bottom temperature in the Northeast U.S. Continental Shelf system is expected to rise more than 1°C by 2050 (IPCC, 2013; NOAA, 2015). While the projected increase in bottom temperature is likely to remain under the species' maximum physiological tolerance and may even be considered favorable, understanding the interactions between climate change and ecology of *H. americanus* has been advocated as an important step towards an ecosystem-based adaptive fisheries management (ASMFC, 2015; NMFS, 2010).

The bioclimate envelope modeling approach has recently gained wider applications in investigating climate change effects on marine species that respond to strong bottom up control (Cheung *et al.*, 2008; 2009; Pearson & Dawson, 2003; Tanaka & Chen, 2016). A bioclimate envelope model uses quantitative associations between climate variables (e.g. temperature) and relative species abundance or presence to define a species' habitat suitability and boundaries defined by physical and climate variables.

In this study, we coupled season-, sex-, and stage-specific *H. americanus* Habitat Suitability Indices (HSI) based on (1) bottom temperature, (2) bottom salinity, and (3) depth with a regional circulation model (Finite Volume Community Ocean Model) to hindcast spatiotemporal variability of the species' bioclimate envelopes from 1978 to 2013. The HSI is a numerical index that can quantify the optimal environmental conditions from 0 (least suitable habitat) to 1 (most suitable habitat) for a given species (Tanaka & Chen, 2016; Chang *et al.*, 2012; Tanaka & Chen, 2015). The model predictions indicated higher habitat suitability in inshore waters for both adult and juvenile lobsters (Fig. 1). Furthermore, a significant increasing trend in habitat suitability was observed for both sexes and stages (juvenile and adult) during the spring (April-June), while no significant trend in habitat suitability was observed in the fall (September-November) (Fig. 2).

Understanding climate-driven habitat suitability of marine species is a critical component of the ecosystem-based adaptive management of fishery resources. Our study provides a modeling framework to reconstruct climatically suitable lobster ranges that can be used to predict the biological and ecological consequences of climate change on assessment and management of this commercially important species.

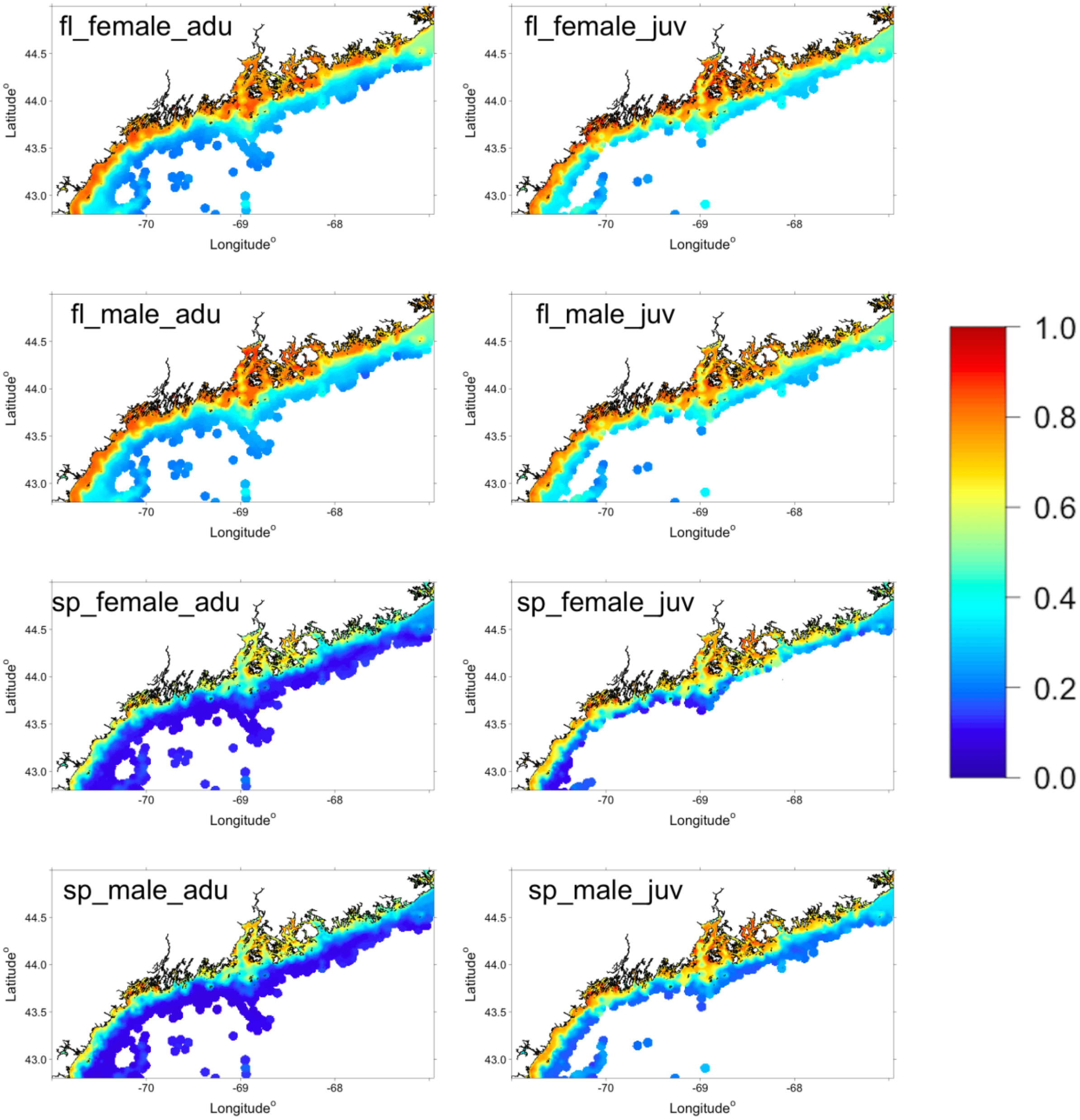

Fig. 1. Season, sex, and stage specific maps illustrating the spatial distribution of the median habitat suitability index (HSI) over 1978–2013 in the coastal waters of Maine and New Hampshire for *Homarus americanus*. fl: fall (September–November); sp: spring (April–June); adu: adult (>60 mm carapace length); juv: juvenile (<= 60 mm carapace length).

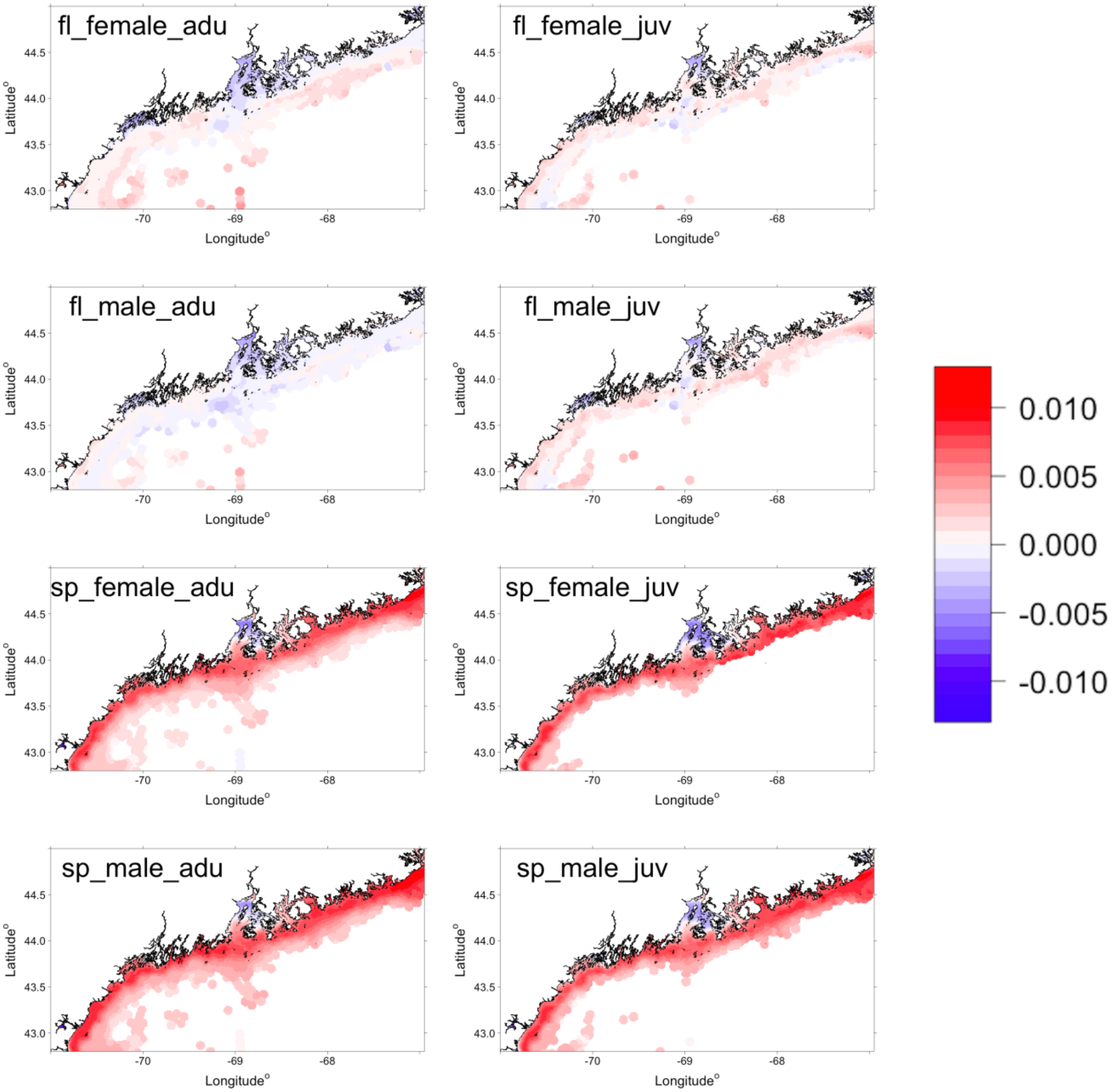

Fig. 2. Change in habitat suitability. Season, sex, and stage specific heat maps illustrating change in habitat suitability index (HSI) over 1978–2013 in the coastal waters of Maine and New Hampshire for *Homarus americanus*. fl: Fall (September–November); sp: Spring (April–June); adu: adult (>60 mm carapace length); juv: juvenile (<= 60 mm carapace length). Darker red indicates change toward higher habitat suitability at higher magnitude.

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