

Recorded captures of American lobster (*Homarus americanus*) in Swedish waters and an observation of predation on the European lobster (*Homarus gammarus*)

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Abstract: The intentional or unintentional release of American lobsters (*Homarus americanus*), imported through the European seafood trade, has resulted in findings of *H. americanus* in European waters. A total of 36 specimens was recorded within a smaller area, halfway along the Swedish west coast, between 2008 and 2016. The lobsters were caught by both recreational and professional fishermen and delivered to the Institute of Marine Research in Lysekil, where species identification, measurements, and genetic sampling were performed. Twenty-five of these lobsters were caught inside the sill of the Gullmar Fjord, most of them close to Lysekil harbor, where escapes from an illegal holding is suspected. Six females had eggs, which in two cases were hybrids. While there is no evidence to suggest that a population has been established in the Gullmar Fjord or elsewhere in Swedish waters, serious concerns must be raised regarding the possible consequences for the native species. An American lobster has for the first time been filmed eating a killed European lobster (*Homarus gammarus*) in Swedish waters.

Résumé : Les lâchers intentionnels ou non intentionnels de homards américains (*Homarus americanus*), importés dans le cadre du commerce européen des fruits de mer, se sont soldés par la découverte de *H. americanus* en eaux européennes. Au total, 36 spécimens ont été signalés dans une région plus restreinte, dans la partie centrale de la côte ouest de la Suède, entre 2008 et 2016. Ces homards ont été capturés par des pêcheurs tant sportifs que professionnels et livrés à l'Institut de recherche sur la mer à Lysekil, où l'identification de l'espèce, des mesures et un échantillonnage génétique ont été réalisés. Vingt-cinq de ces homards ont été capturés à l'intérieur du seuil du fjord de Gullmar, la plupart près du port de Lysekil, d'où les homards sont soupçonnés de s'être échappés d'un lieu de rétention illégal. Six femelles portaient des œufs qui, dans deux cas, étaient des hybrides. S'il n'y a aucun indice de l'établissement d'une population dans le fjord de Gullmar, ni ailleurs en eaux suédoises, les conséquences possibles pour l'espèce indigène sont très préoccupantes. Un homard américain a, pour la première fois, été filmé dans des eaux suédoises en train de manger un homard européen tué (*Homarus gammarus*). [Traduit par la Rédaction]

Introduction

In recent years, several specimens of the American lobster (*Homarus americanus*) have been caught along the Swedish west coast. Since both the recreational and commercial lobster fisheries are very important in Sweden, the consequences the new species might have for the native species *Homarus gammarus* are of great concern. An information campaign along the Swedish west coast, initiated in 2008, on how to identify and report on findings of the American lobster resulted in an increased awareness among the public and lobster fishermen and hopefully also among fishmongers that keep live lobsters. This paper presents all reported captures in Swedish waters up to 2016 and in particular the unique concentration of findings of *H. americanus* inside the sill of the 120 m deep Gullmar Fjord. The presence of and concerns regarding American lobsters in European waters have earlier been discussed by, for example, Stebbing et al. (2012) and Jørstad et al. (2011).

Methods

The lobsters were caught by both recreational and professional fishermen using lobster pots or Norway lobster pots, and one

lobster was caught by a trawler and one by a diver. The fishermen were given a reward for each reported and delivered lobster. The delivery was normally on the day of the catch. Specimens were frozen after first being photographed, measured, sexed, weighed, and visually identified (all our data and calculations can be found in the online supplementary materials¹). All the lobsters received had typical morphological characteristics of the American lobster that often or always differ from the European lobster (e.g., subrostral spines, red spines on chelipeds, carapace with some yellowish spots, brownish uropods and telson). Primary visual identification was later confirmed genetically. Four specimens were not sent for genetic identification because they were kept by the fishermen. Muscle and egg samples for genetic analyses were preserved in 96% ethanol and sent to the Institute of Marine Research in Bergen, Norway. Details of the genetic method used are given in Jørstad et al. (2007). An underwater video (see supplementary materials¹) showing an American lobster eating a European lobster was taken during scuba diving (8 October 2016 at 1300 h) using a GoPro camera Hero 4 Black Edition. In our information campaign

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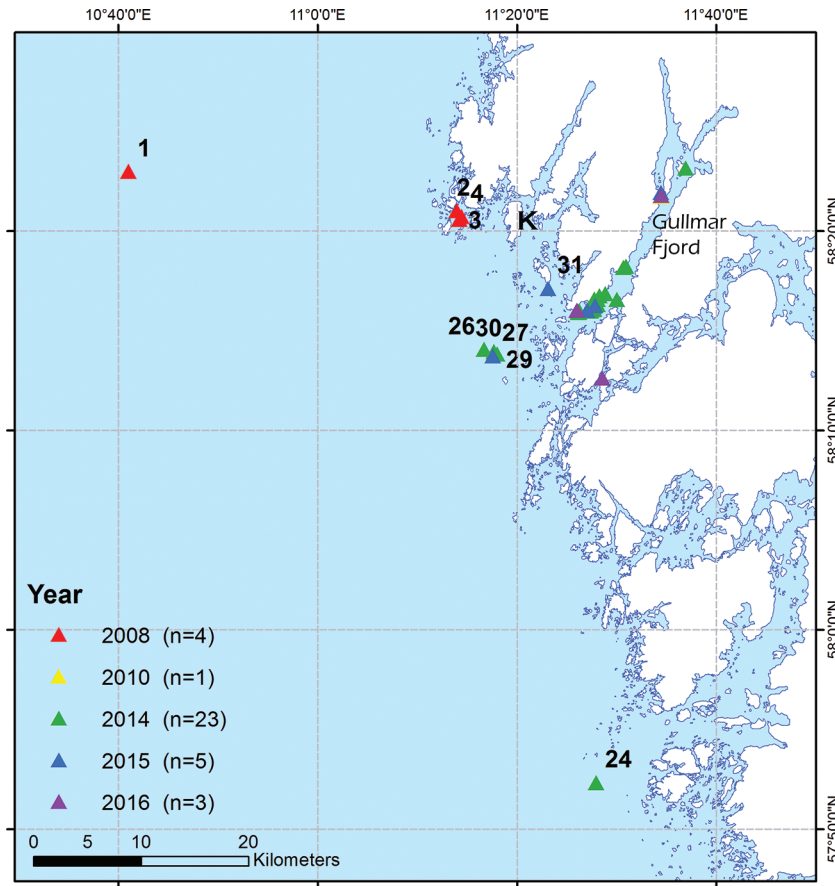
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Fig. 1. Locations where 36 American lobsters (*Homarus americanus*) were caught between 2008 and 2016 inside and outside the Gullmar Fjord on the Swedish west coast (ICES). K = Kävra lobster reserve.

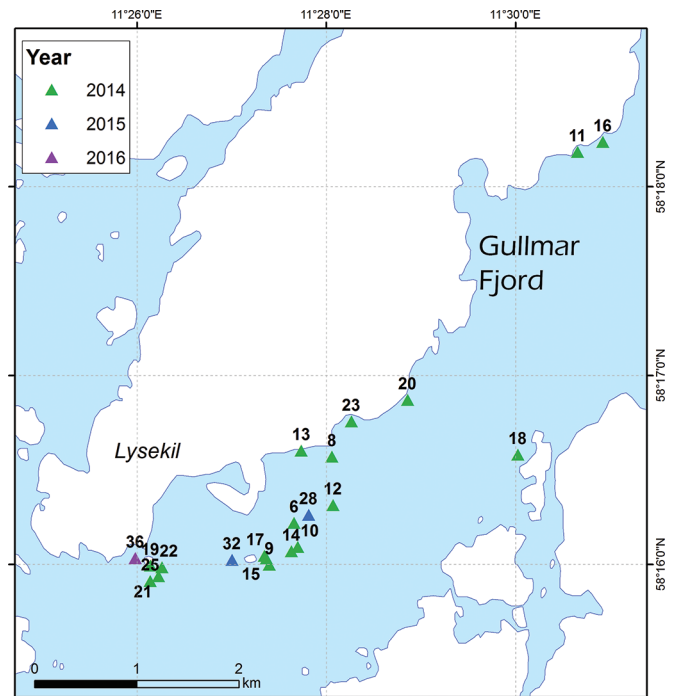


for fishermen, we set up posters in, for example, harbours and shops selling lobster equipment and lobster bait from the Norwegian border to the city of Halmstad in the south, and we distributed around 70 000 cards (with photograph of an American lobster, phone numbers, and a reward for reporting catches) in shops and supermarkets within 15 km from the coastline along the Swedish west coast. We estimate that we covered at least 95% (280 km) of the coastline where lobsters are fished. We also appeared numerous times in media to inform the public of our information campaign.

Results

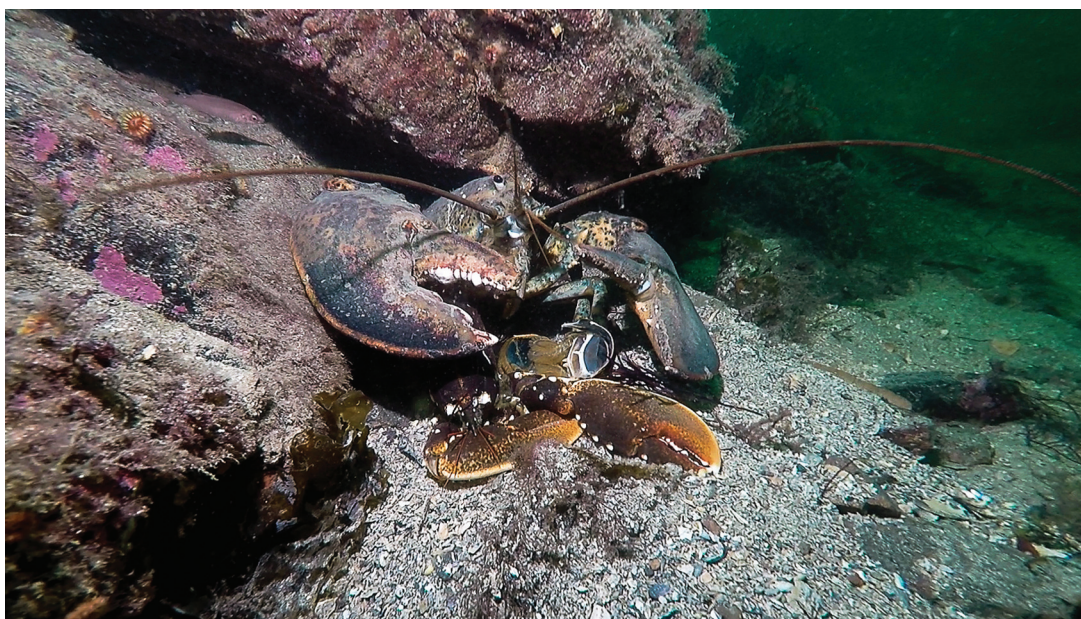
Figure 1 shows the position of each finding (2008–2016). The first lobster (1) was caught by a trawler at 160 m depth in the Skagerrak in May 2008. Later the same year, during the lobster fishing season, three more lobsters (2–4) were reported outside a fish auction in the village of Smögen. Another one was found in 2010 off the Bornö Islands far inside the Gullmar Fjord, and three more specimens were found in the same area in 2014, 2015, and 2016 (the 2016 position mark hides the findings in 2010 and 2015 in Fig. 1). After 2010 no lobsters were reported until 2014 when 23 lobsters were caught (18 just close to Lysekil harbour; Fig. 2). The southernmost finding (24) was caught 47 km from Lysekil (Fig. 1). In 2015 and 2016, only five and three lobsters, respectively, were reported in total. Four of these lobsters (26–30) were caught offshore >10 km from Lysekil harbour. No. 31 was caught 2 km south of the Kävra lobster reserve (see Fig. 1). Pot depths were between 9 and 38 m. The carapace lengths were between 80 and 121 mm (mean 101 mm), and there were 58% males and 42% females (six females

Fig. 2. Locations of American lobsters (*Homarus americanus*) close to Lysekil harbour in the Gullmar Fjord (ICES).



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Fig. 3. An American lobster (*Homarus americanus*) eating a European lobster (*Homarus gammarus*) in the Gullmar Fjord. [Photo: Gert Oxby, Divers & Scientist West Coast Sweden.]



with eggs, of which two had hybrid eggs). The masses were between 520 and 1480 g (mean 877 g).

The male *H. americanus* (No. 36; Figs. 2 and 3) eating a *H. gammarus* was video-filmed by Gert Oxby during scuba diving at a depth of 19 m off Släggö Island, 100 m from Lysekil harbour (8 October 2016 at 1300 h, temperature = 15 °C; see online supplementary materials¹). To our knowledge this feeding behaviour has never before been observed. The video shows that this was not an empty exoskeleton but a dead individual (confirmed by the diver). The video shows clearly that the carapace itself was cut in two at its lower end (not between the carapace and the abdomen, which can be seen on the video), the muscles were still present in the carapace and appeared fresh (also observed by the diver), indicating that the death was recent. The muscles in the front part of the abdomen were absent. During a dive the following day, neither the remains of the dead lobster nor the predator could be found. Catching lobsters during scuba diving is not allowed without special permission. However, the lobster had preliminarily been identified as an American lobster from the video, and it was therefore caught with permission by a diver approximately 40 m away from the video location 18 days later and brought to the laboratory. Its carapace was 115 mm and its mass was 1400 g. From dive photographs and photographs taken in the laboratory, especially of the crusher claw (the tip was broken and the “teeth” worn down), we could conclude that we had caught the individual appearing in the video.

Discussion

The catches of American lobster in Scandinavian waters have been reported in Jørstad et al. (2011). However, since that time more lobsters have been caught, especially in Swedish waters. The lobster catches in Norwegian waters were more spread out along the coastline compared with the Swedish catches. Stebbing et al. (2012) reported catches from Scottish waters down to the English Channel. In contrast, all the American lobsters in Swedish waters were caught within a smaller area, halfway along the Swedish west coast and especially within the Gullmar Fjord. Although we regard our information campaign as rather successful, some catches might not have been reported due to some fishermen being unaware of the campaign, especially during its first years. However,

both recreational and professional fishermen have indeed been very positive to the campaign. For comparison with catch locations of American lobster, the European lobster is distributed and fished along the entire Swedish west coast, between the Norwegian border and the Sound (between Sweden and Denmark) in the south. Lobsters are not found in the Baltic Sea where the salinity is low (<10‰).

The lobsters reported just outside the auction hall in Smögen in 2008 may have come from an escape event from an illegal holding in the sea in the same area (two specimens had rubber bands around the claws). The large numbers found in 2014 close to Lysekil harbour most probably came from illegal holdings inside the harbour area (three specimens had rubber bands). Fishing for lobster is not allowed in the harbour area. We will not speculate as to who is responsible for these events. We have no idea how many lobsters in total have escaped into the sea and thus do not know what proportion of them has been caught. There is a high fishing pressure on lobster in the Gullmar Fjord, where in 2014, V. Øresland recorded 1977 pots (unpublished report in 2017 to the Swedish Agency for Marine and Water Management). The number of reported American lobsters decreased during 2015 and 2016. This may be due partly to the previous year’s fishing and to the fact that the lobsters are spreading offshore and along the coast, as indicated by the findings, where they get harder to catch. The offshore spread is not surprising, since the American lobster is known to migrate long distances (see e.g., Campbell 1986 (specifically <http://geo.ices.dk/>) and Maine DMR 2015 (specifically <http://www.maine.gov/dmr/commercial-fishing/index.html>). In contrast, the European lobster appears to be much more stationary (Øresland and Ulmestrand 2013) and is, at least in Swedish waters, seldom caught below 40 m. The lobster fishing in Swedish waters normally occurs at depths between 10 and 35 m. Therefore, American lobsters that migrate to deeper waters are less likely to be fished. In addition, our ongoing information campaign has hopefully made fishmongers that keep live lobsters more aware of the problems associated with illegal holdings in the sea, and this may be the reason why no new large escape events have been detected since 2014.

The mass data (520–1480 g) reported here (see supplementary materials¹) show that the specimens are above normal import size (generally between 500 and 530 g). That indicates that the larger

reported *H. americanus* had been in the sea before the escape event in 2014 and that minor escape events have occurred before 2014. We did get one lobster in 2010 in the Gullmar Fjord. However, we cannot rule out the possibility that some of the lobsters that escaped in 2014 were above normal import size. Lobsters that are above the normal import size are usually delivered as special orders and in very small quantities and are therefore less likely to be kept in illegal holding tanks in the sea (Christer Wrisemo, ABC Food, personal communication). Fishermen are not allowed to keep *H. gammarus* females carrying eggs (berried). Consequently, European females with hybrid eggs will not be reported by the fishermen. However, if a fisherman reports an *H. americanus* female with eggs while still at sea, permission to land and deliver the lobster to the laboratory is given directly. Of particular note is the finding of American lobster close to the Kåvra lobster reserve, which may be the oldest in Europe (established in 1989). Lobsters have been tagged for many years in this area (Øresland and Ulmestrand 2013), and now one can also study very large lobsters that occur in high concentrations, and any interaction between the two species would therefore be of great concern.

Whether or not American lobsters will establish permanent subpopulations in Swedish waters is still open to speculation. Larvae of *H. gammarus* in the Kåvra lobster reserve were found at a mean depth of around 16 m, below the sharp halocline. The larvae were retained locally due to a combination of larval depth and a persistent retention of water masses below the halocline (Øresland and Ulmestrand 2013). If such larval depth distribution below the halocline is true also for *H. americanus* in the Gullmar Fjord, the establishment of subpopulations would be facilitated. The number of findings within a short period, typical lobster habitats, a sill, and deep water circulation below a strong halocline make the Gullmar Fjord a possible candidate for a permanent subpopulation. However, the considerable lobster fishing in the fjord and migration offshore are two important factors that would act against the establishment of a permanent population in the fjord. The findings of hybrid eggs are of great concern, but we have up to now no data on bottom-living hybrid lobsters, and we have no data on hybrid eggs among *H. gammarus* females (it is forbidden to catch berried females).

We are convinced that the *H. americanus* found eating a *H. gammarus* also killed its prey and that the *H. gammarus* did not die while moulting. This is based on the diver observations of remaining

muscles inside the abdomen and that the carapace appeared fresh, that the lobster was cut in two through the carapace, and that its exoskeleton looked normal and healthy. We believe the actual killing process is quick and therefore extremely difficult to capture on video during diving. *Homarus americanus* can grow much larger than *H. gammarus*, which would naturally be an advantage in a predatory situation, as in this case. This observation should lead us to ask also how common cannibalism is (within both species) and especially within lobster reserves where large lobsters are numerous.

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