SCIENTIFIC ADVICE ON CAUSES OF LOBSTER DAMAGE IN LOBSTER FISHING AREA (LFA) 33 AND LFA 34

Context

DFO Maritimes Science Branch was asked by Fisheries and Aquaculture Management (FAM) Branch to "identify the likely cause and/or timing of damage to lobsters in a portion of southwest Nova Scotia and possibly extending to the eastern Nova Scotia area". A response was requested by May 31, 2008.

Background

During the fall lobster season in LFA 33 and 34 (Fig. 1), fishers reported a significant increase in the number of lobsters with damaged body parts, predominantly from the Voglers Cove (LFA 33) to the Cape Sable Island (LFA 34) areas. Lobster fishers contend this is damage from scallop dragging in the Cape Sable area prior to lobster season. However, it is possible a severe storm in the area may also be responsible for some or all of the damage. There is considerable interest in this issue on the part of industry, as the interaction between the scallop fishery and the lobster fishery in this area is controversial and long standing. Should scallop drag activity be identified as the sole or main source of the damage, the existing authorized scallop fishery in the area could be severely curtailed or require major management adjustments in season and/or areas authorized.

Analysis

Approach for Evaluation of Damage

Population Ecology Division (PED) was first notified about the elevated occurrence of damaged lobsters by fishermen in the Cape Sable Island area on 13 December 2007. From that point onward, effort was made by port technicians to evaluate the damage. Data on the type, intensity and spatial extent of damage was available from port samples, discussions and interviews with fishermen and two at-sea samples. Interviews were conducted in February 2008 with lobster fishermen who were port representatives or who Science had worked with in the past. The questions are listed in Table 1. A total of 29 interviews were conducted: 15 in LFA 33 and 14 in LFA 34.

Description of Damage

Images of some damaged lobsters (Fig. 2) were obtained from a fisherman in the Cape Sable Island area, a PED port sampler in LFA 34, and the FSRS who were contracted to conduct port samples in LFA 33. The damage in the images consisted mainly of crushing wounds (Fig. 2a) and puncture like wounds to the carapace and tail (Fig. 2b-f). Some wounds appeared relatively recent (Fig. 2b, c, d) while others appeared to be older. As indicated below, the timing of the damage cannot be estimated with precision. In addition to the types of wounds in Fig. 2, fishermen who were interviewed (Table 1, Question 2) mentioned broken and crushed carapaces, tails and claws, broken rostra, missing legs and claws. Several fishermen indicated that some wound healing was evident.

Spatial Extent and Intensity of Lobster Damage

To fully assess the spatial extent and intensity of lobster damage would require an extensive at-sea sampling program. No such program is in place in the Maritimes Region for a variety of reasons. PED does conduct some at-sea sampling on an ad-hoc basis, but a port-sampling program is used to monitor lobster size-frequency of the commercial catch. A combination of site and phone interviews by port-technicians and two sea-samples in the Sable Island area were used to evaluate the extent and intensity of the damage.

Spatial extent

Damaged lobsters were observed throughout LFA 33 based on the response to Question 1 of the interviews (Fig. 3). In addition, there were reports of lobsters being washed ashore in LFA 33 in the area of the La Have Islands and to the south. In LFA 34, interviews indicated there were no observations of damaged lobsters north of Pubnico Point. These data are dependent on the interviewees being aware of any reports of damaged lobsters in the ports they represent. In LFA 34, damaged lobsters were not restricted to the nearshore as evidenced by positions of at-sea observations (Fig. 3).

Intensity

In LFA 33, the response to Question 3 (“How many of these have you seen per day on average?”) was wide ranging. Responses were 2-3%, 2-4, 1-2, not many, a few, 5%, 15%, 15-20, 8-10, 20-30% and up to 40%. In summary, damaged lobsters generally comprised less than 10% of the catch per day, but in some areas the rate was higher. In LFA 34, those fishermen who saw damaged lobsters indicated they saw 5-10 per crate; 25-30, 50-60 lb per day, 10-15, 8-10, 10% of the catch. As for LFA 33, it appears damaged lobsters usually made up < 10% of the daily catch in LFA 34, but some areas may have experienced a higher rate.

Depths

Interviews indicated the damaged lobsters were found over a wide range of depths from 5-40 fathoms. Based on ad-hoc discussions with more than ten fishermen in LFA 34, D. Frotten (port sampler) relayed reports of damaged lobsters as deep as 90-110 fathoms north of Browns Bank. Within LFA 33, fishermen who fished primarily in protected areas often had not seen damaged lobsters themselves, but they knew that fishermen with traps in more exposed areas were seeing damaged lobsters.

Seasonal Trend in Occurrence

Question 6 (“Any changes in number seen per day since the beginning of the season“) should have inquired about rate rather than number. As posed, the answers may be confounded with the fact that total catches decline as the season progresses due both to removals and decreased catchability. The answers indicated there was a decline in the numbers of damaged lobsters from the start of the season in some areas. In LFA 33, most fishermen indicated the numbers were constant over the season so far, with a few mentioning a decline since the start of the season. In LFA 34, most fishermen who saw damaged lobsters indicated there were fewer now (February) than at the start of the season.

Comparison with Previous Years

Virtually all fishermen interviewed in affected areas indicated the rate of occurrence of damaged lobsters was unusual and high compared to previous years. Comments included ”worst ever”, “many more this year”, “never seen before”, “never before in 32 years” and “never seen so much damage”.

Perception of Cause and other Comments

One cause mentioned by fishermen interviewed throughout the area was damage caused by Tropical Storm Noel. Each of the 15 fishermen interviewed in LFA 33 put this forward and several LFA 34 fishermen mentioned this as a potential cause. The second cause mentioned by fishermen was damage from contact with scallop fishing gear. This was put forward as the primary cause in all interviews of fishermen from the Cape Sable Island area, and other fishermen in LFA 34 suggested it as a possible cause. A few fishermen raised the possibility that the survey for scallops conducted in SFA 29 may have caused the damage.

Fishermen in the Cape Sable Island area indicated there had been bad storms before, but they had never seen this much damage to lobsters.

Timing of the Damage

Estimation of when the damage occurred is complicated by a number of factors. These include imprecision in characterizing the freshness of the wounds, uncertainty around the rate of healing, and the effect of temperature and uncertainly in the timing of molting of individual damaged lobsters. The temperature effect on healing is further complicated by the fact that lobsters may experience a range of temperatures as they undertake migrations from shallow to deep as bottom temperatures cool in the fall and early winter.

Images and a few actual specimens with damage were examined by the Atlantic Veterinary College's Lobster Science Centre (AVCLSC) in December 2007. Dr. Lavallée (AVCLSC) indicated that none of the damage seemed disease-related. As far as when the damage occurred, this could not be estimated with precision. From email correspondence of 19 December 2007 to J. Tremblay:

> *"…it is very difficult to precisely determine the time when the trauma/damage occurred. Our experience here at the AVCLSC, based on various field and lab studies is that initial melanisation of the lesion/wound (formation of the thin layer of black pigments) can occurred as early as 10-15 days post-trauma (at 15 °C) to up to 50 days (at temperature going from 18 to 10 °C over 55 days). We suspect that at colder water temperatures, this healing process would take longer."*

This would indicate that if no melanization was present, the damage occurred within the previous 2-8 weeks as long as temperatures were above 10°C. Bottom temperatures vary with time and location in LFAs 33 and 34 but are generally above 10°C from August to October. Looking at the western portion of LFA 33 (Shelburne County), and a portion of LFA 34 that includes the waters around Cape Sable Island (Fig. 4), temperatures between 5 and 40 m are on average 10-12°C in August, 12-13°C in Sept, 11°C in Oct, 8°C in Nov. and 5°C in Dec. Temperatures from 5-40 m tend to be a little higher in LFA 34 than the western portion of LFA 33 (Fig. 4).

If melanization was present, the damage could have occurred more than 8 weeks earlier.

Potential Causes of the Damage – Scallop Dragging

Damage to lobsters by scallop dragging cannot be ruled out, but scallop dragging cannot explain the distribution of damaged lobsters observed during the LFA 33 and LFA 34 fisheries in December 2007. Damaged lobsters were found from Cape Sable Island to Sambro. Maps of recorded scallop dragging effort show little scallop fishing to the west of Port Mouton (Fig. 5). Although there is some uncertainty as to whether all scallop fishing effort east of Baccaro Point

is captured in PED databases, there is no doubt that scallop dragging effort diminishes substantially from Cape Sable Island to Sambro. Damaged lobsters were not reported north and west of Pubnico Point, yet scallop dragging is continuous along the coast of southwest Nova Scotia and into the Bay of Fundy (Fig. 5).

The SFA 29 scallop survey (1-14 October 2007) can be ruled out as an important contributor to the observed lobster damage because it was restricted to the SFA 29 area, and because it involves much less dragging than the commercial fishery in the same area. During the survey, 120 tows of 8 minutes duration were completed for a total of 16 hours of dragging. This is a small fraction of the approximately 8000 hours of commercial dragging (Fig. 6).

Scallop dragging has occurred for the last 4 years in the Cape Sable Island area where damaged lobsters were found. There is no evidence from fishing logs or vessel monitoring systems (VMS) that compared to previous years 2007 scallop fishing effort was different in spatial distribution or in intensity (Fig. 6). Scallop fishing effort in SFA 29 west of $65^0$30' was actually substantially lower in 2007 than in 2006.

The last scallop fishing in SFA 29 west of $65^0$30' occurred on 21 July 2007. Given temperatures of greater than 10°C from August until October, it is expected that by the time the LFA 34 fishery began, melanization would have occurred in all lobsters damaged by the scallop fishery. Since some wounds did not have melanization, it is very unlikely that these were damaged by the scallop fishery.

As far as the type of damage observed, DFO Science cannot be definitive as to whether it is more typical of damage caused by scallop draggers or by other factors. A better characterization of these types of damages would be required to do so. Scallop drags do catch lobsters and there is incidental damage. Based on reports from on-board observers of the fleets fishing in SFA 29, injured or dead lobsters usually comprise 14-18% of the lobsters caught by scallop drags. In some years the rate can be as high as 30%. Extrapolated to both fleets, the observer reports suggest that injured or dead lobsters brought up in the scallop drags have comprised less than 2500 lobsters per year from 2002-2006 (Smith et al. 2007). Any damage to lobsters by scallop drags that might occur on the bottom is not known. Knowledge of the timing of the damage and the timing of the molt of lobsters in the areas would allow better evaluation of whether scallop dragging played a role in the damage observed off Cape Sable Island.

Potential Causes of the Damage - Tropical Storm Noel

There are several lines of evidence that indicate that Tropical Storm Noel was responsible for the damaged lobsters. These are the path of the storm, its strength and the type of damage to lobsters that was associated with another major storm (Hurricane Juan).

Tropical Storm Noel was a strong storm that entered Nova Scotia coastal waters on 4 November 2007 (Fig. 7). It was notable by its large size. From Environment Canada's Post-Tropical Storm Noel Final Information Statement issued by the Canadian Hurricane Centre at 6:00 PM AST Sunday 04 November 2007 (http://www.atl.ec.gc.ca/weather/hurricane/bulletins/20071104215828.Noel.txt.en):

> *"Once Noel cleared the Bahamas it intensified quickly to a category one hurricane late Thursday November 1. Subsequently hurricane Noel continued moving northeast with maximum sustained winds of near 140 km/h. Almost immediately after becoming a hurricane Noel began transitioning to a post-tropical storm. During this transition it became a very large and powerful post-tropical storm. The storm centre reached the southwest coast of Nova Scotia in*

> *the early morning hours of Sunday November 4 still carrying maximum sustained winds of 140 km/h. By Sunday afternoon the storm was over Labrador and fully extratropical in nature."*

The storm centre passed over Cape Sable Island or just to the west (Fig. 7). Note that winds will be strongest to the right of the storm centre in the northern hemisphere.

Storm Track and Strength of Storm Noel

One way of evaluating the strength of Storm Noel is by examining the measured and predicted wave heights. One of the wave buoy sites is Chebucto Head. Wave heights are routinely predicted by DFO for the Northwest Atlantic including the entire Scotian Shelf using wind data from Environment Canada as the driving fields to determine their generation and development (see http://www.mar.dfo-mpo.gc.ca/science/ocean/icemodel/forecast.html). The high precision of the model for predicting wave heights is evidenced by the prediction wave heights for the buoy at Chebucto Head compared to the measured wave heights (Fig. 8).

The distribution of wave heights along the shore as Noel progressed (Figs. 9-11) shows that Digby County and most of Yarmouth County did not experience wave heights as high as Shelburne, Queens, Lunenburg and Halifax Counties. The area of highest wave heights included Cape Sable Island, the south shore and the shore east of Halifax.

The wave heights generated by Storm Noel were very high compared to most storms that hit this area of Nova Scotia. This is illustrated by comparing wave heights during Noel with those generated by Hurricane Juan (Fig. 12). Halifax was one of the main areas affected by Juan and wave buoy measurements on Sept. 30 2003 show the strong signal. At the wave buoy off Chebucto Head during Juan, significant wave heights (the average of the upper third of the distribution of wave heights observed over a specified period) reached 8 m and maximum wave heights reached 20 m. Wave heights measured at the same buoy were higher during Noel. Significant wave height reached 10 m, while the maximum wave height measure was an impressive 27 m (Fig. 12). These wave heights translate into considerable disturbance on bottom. According to linear wave theory, wave heights of 10-12 m result in near bottom speeds of 1.8-2.2 m sec^{-1} even at 40 m depth (Fig. 13). Lobsters might be expected to be rolled along the bottom at these speeds.

Lobster Damage in Spring 2008 Fisheries

Because of the track of the storm it was thought there could be some damaged lobsters in LFAs 32 and 31 that opened in April 2008. Seven interviews were completed in May 2008 with port representatives from Chezzetcook to Port Felix (approx 25 km W of Canso). The interviews indicated elevated numbers of damaged lobsters in LFA 32 from Chezzetcook to the Owls Head area (approx. 75 km east of Halifax); with no unusual levels of damaged lobsters further to the east.

Lobster Damage from Hurricane Juan

After Hurricane Juan, there were anecdotal reports of increased numbers of damaged lobsters from fishermen in affected ports (e.g., Sambro, Eastern Passage and ports to the east). They also appear to have experienced lower catch rates after Juan (e.g., Claytor 2004), suggesting lobster mortality. The Fishermen and Scientists Research Society (FSRS) obtained some images of lobsters thought to have been damaged by Juan in the two ports within 40 km east of Halifax Harbour (Petpeswick and Three Fathom Harbours) (Fig. 14). These lobsters had similar types of damage to those found in November-December 2007. Note that these images were taken in the spring fishery, 7-8 months after Hurricane Juan.

Additional information needed to evaluate the effect of storm events on lobster populations is the timing of molting in relation to the storm, and the location of migrating lobsters.

Conclusions

Damaged lobsters were observed at much higher levels than usual in the catch of the fall lobster fisheries in LFAs 33 and 34. Damaged lobsters were reported throughout LFA 33, but only in the southern portion of LFA 34 (south of Pubnico Point). The damaged lobsters usually comprised less than 10% of the daily catch from late November until January. The most plausible explanation for the widespread distribution of damaged lobsters is Tropical Storm Noel, which passed over coastal Nova Scotia on 4 November 2007. The track of the storm and the area of highest wave heights are coincident with the distribution of damaged lobsters. While scallop dragging cannot be ruled out as a contributing factor in some areas, the distribution of scallop dragging effort does not match the distribution of damaged lobsters.

The storm produced wave heights higher than those measured during Hurricane Juan in the area where Juan came ashore. The observed damage to lobsters in the fall fisheries of 2007-08 was similar to damage seen after Hurricane Juan in two lobster fishing areas. While damage to lobsters from scallop gear cannot be ruled out as a contributing factor to the observed lobster damage in the Cape Sable Island area, there is no evidence that scallop dragging in SFA 29 west of 65^0 30 was different in spatial extent or intensity in 2007 compared to previous years of scallop dragging in the area. In most of LFA 33, scallop dragging can be ruled out as a contributing factor. This is also the case in the western portion of LFA 32, where the spring fisheries also experienced elevated levels of damaged lobsters, presumably related to Storm Noel.

Storms may be significant sources of lobster mortality in some years. Evaluating storm-related mortality would require several streams of information. These would include better characterization of the types of damage, underwater images of the bottom and potentially damaged or dead lobsters shortly after the storm, higher resolution maps of the distribution and intensity of damage, and high resolution tracking of the catch in the affected areas. Also required is a better understanding of the rate of wound healing and the factors that affect it, including temperature and the molt stage when the damage occurs.

Contributors

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Conducted interviews	S. Nolan	Population Ecology Division, Science Branch, BIO
Commercial samples/ad hoc interviews/images of damaged lobsters	D. Frotten	Population Ecology Division, Science Branch, BIO
Images of damaged lobsters	C. MacDonald and J. Graves	Fishermen and Scientists Research Society (FSRS)
Images of damaged lobsters	M. Newell	Cape Island lobster fisherman
Data on scallop fishery	S. Smith and M. Lundy	Population Ecology Division, Science Branch, BIO
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Reviewer	P. Comeau	Population Ecology Division, Science Branch, BIO
Reviewer	H. Vandermeulen	Population Ecology Division, Science Branch, BIO
Reviewer	M. Showell	Centre for Science Advice - Maritimes Region, BIO

Approved by

Mike Sinclair Regional Director, Science
Date Approved: 27 May 2008

Sources of information

Claytor, R.R. 2004. Stock indicators for LFA 33 with respect to management changes implemented in 2000. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/71.

Smith, S.J., S. Rowe, M.J. Lundy, J. Tremblay, and C. Frail. Scallop Fishing Area 29: Stock status and update for 2007. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/029.

Appendices

Table 1. Damaged lobster interview questionnaire.

Interview date_____

Fisherman_____

Port_____

1. Have you seen any damaged lobsters this year?

2. Can you describe damage

3. How many of these have you seen per day on average?

4. Have you seen them in any particular part of your fishing ground (more exposed or less exposed areas?)

5. Particular depths?

6. Any changes in number seen per day since the beginning of the season?

7. How do the numbers seen this year compare to previous years?

8. Have other fishermen in your area mentioned seeing damaged lobsters?

9. Can you associate the damage to anything that has happened in the last year?

10. Other comments?

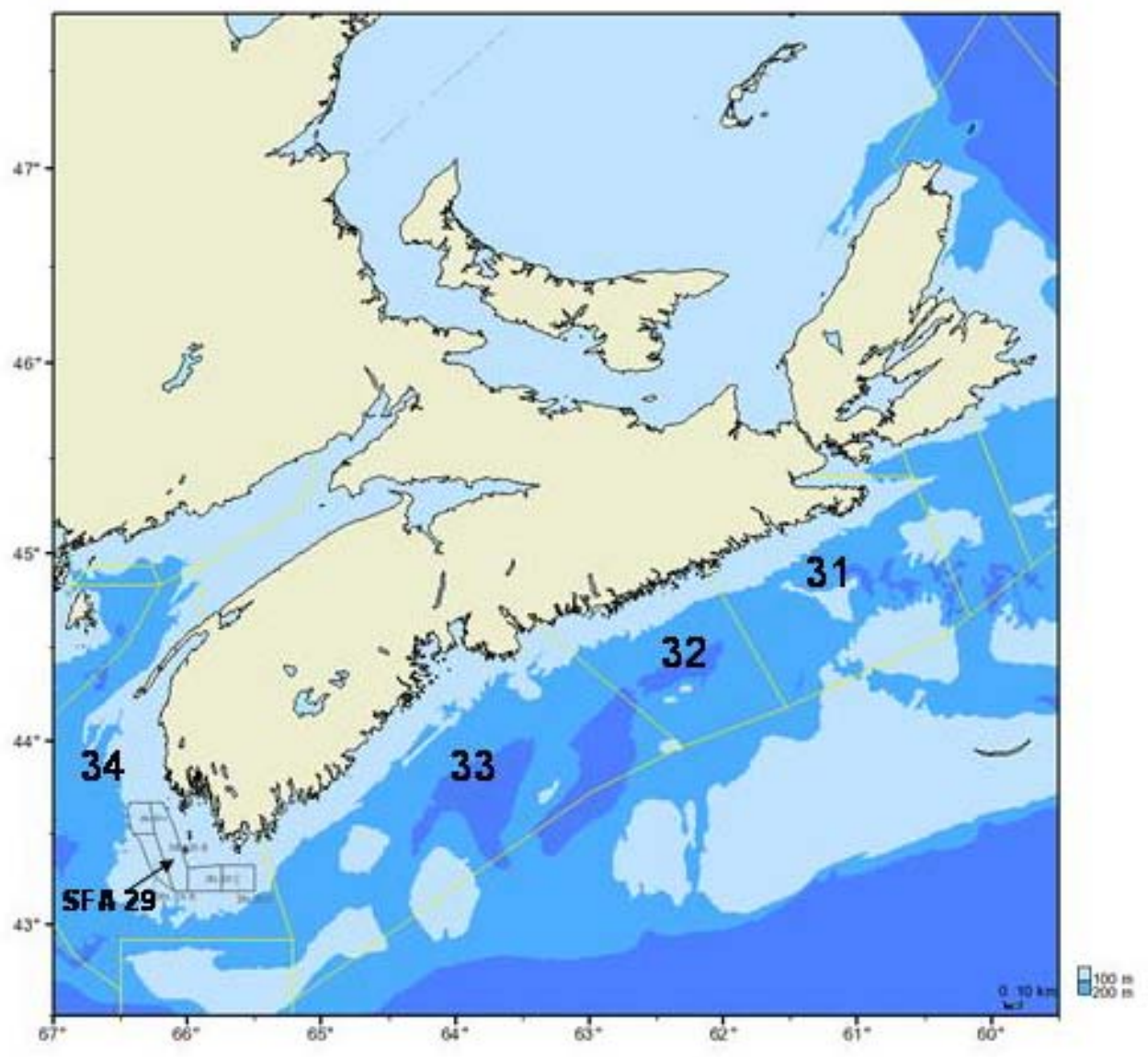


Fig. 1. Map showing Lobster Fishing Areas (LFAs) 34 to 31 and Scallop Fishing Area (SFA) 29 (West of longitude 65^{0}30').

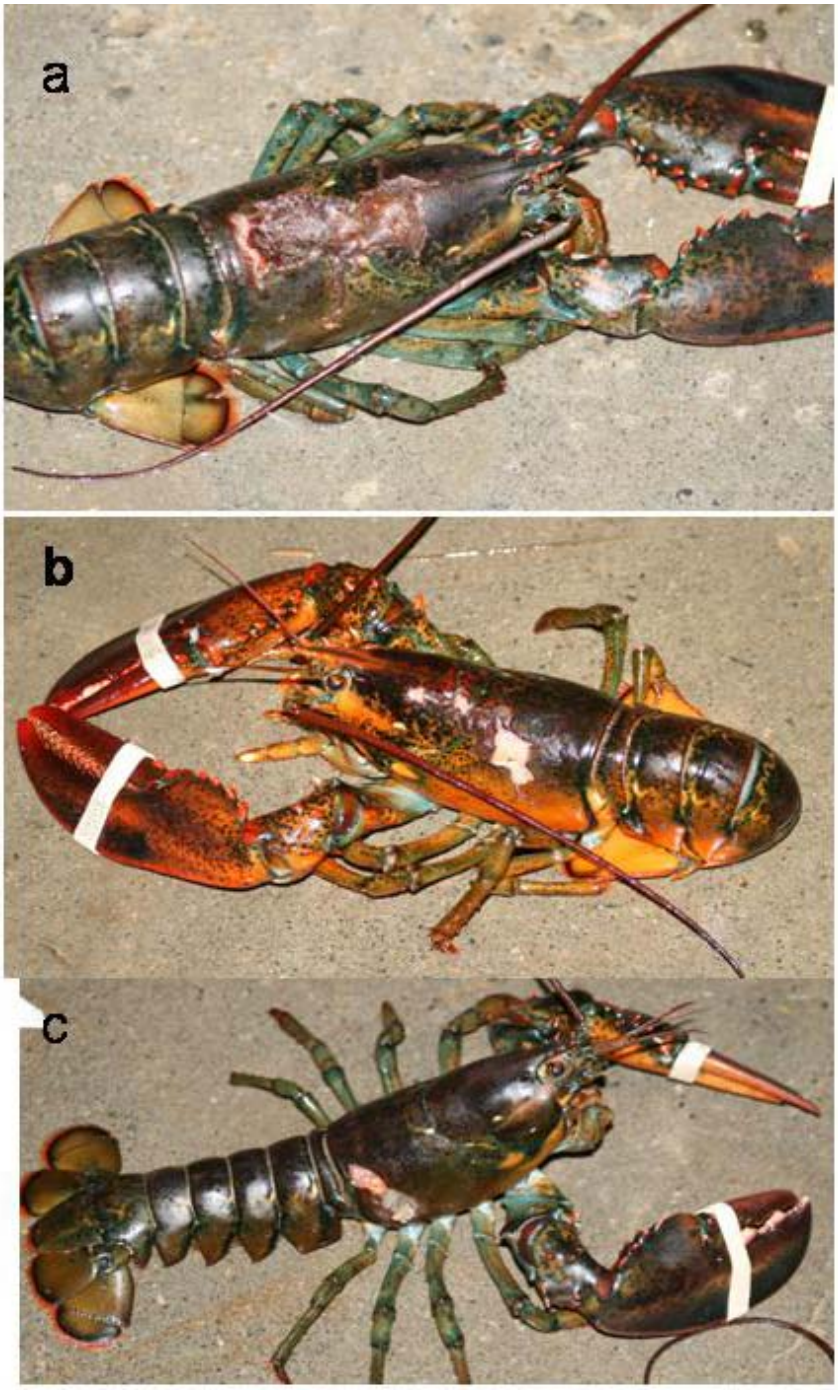


Fig. 2. Examples of damaged lobsters from the Cape Sable Island area. Courtesy of Mike Newell, Cape Sable Island fisherman.

Fig. 2. Cont'd. Examples of damaged lobsters. d-e) Cape Sable Island area from M. Newell, Cape Sable Island fisherman; f) Cape Sable Island area from Darrell Frotten, DFO port technician.

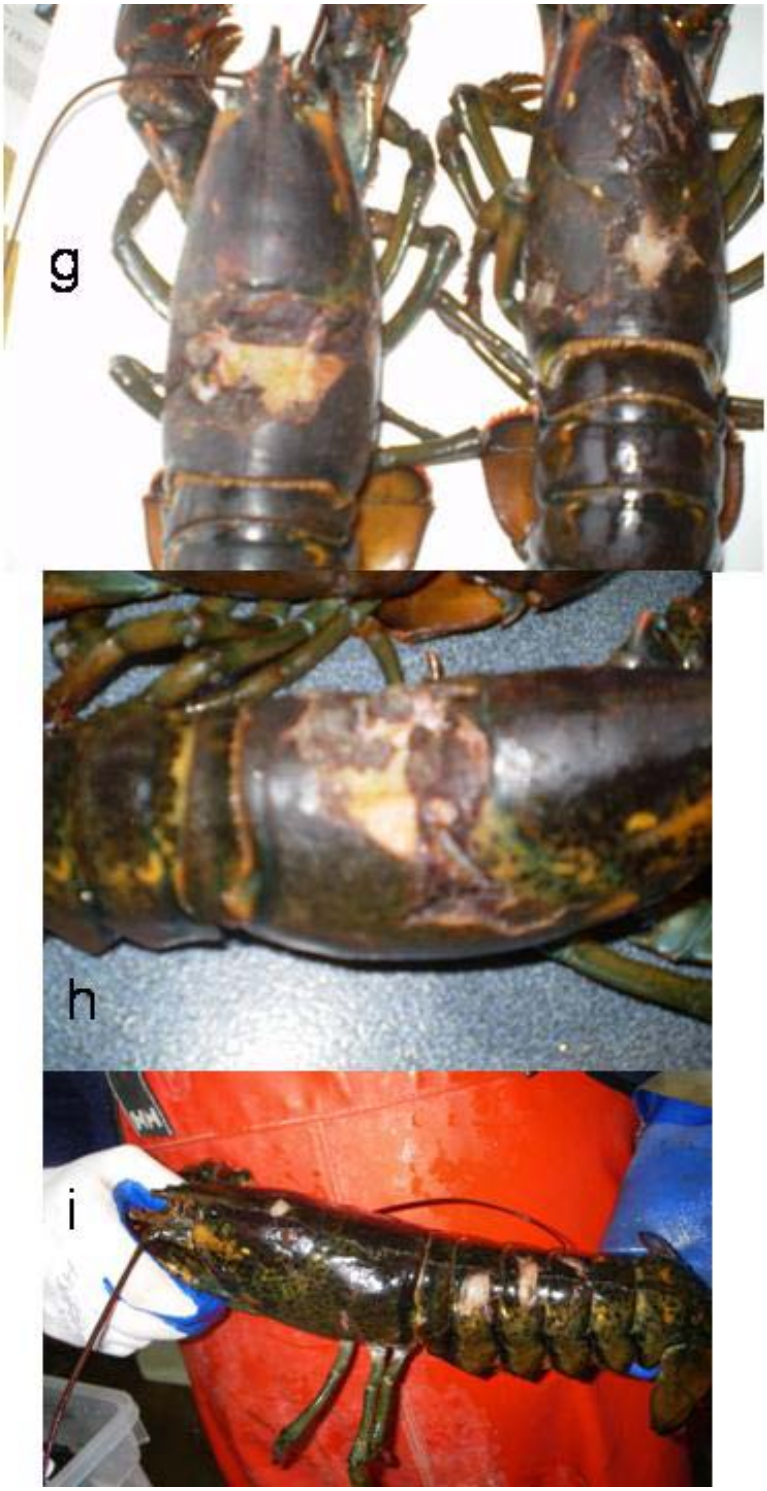


Fig. 2. Cont'd. Examples of damaged lobsters. g-h) Cape Sable Island area from Darrell Frotten, DFO port technician; i) Sambro area from Jeff Graves, FSRS technician.

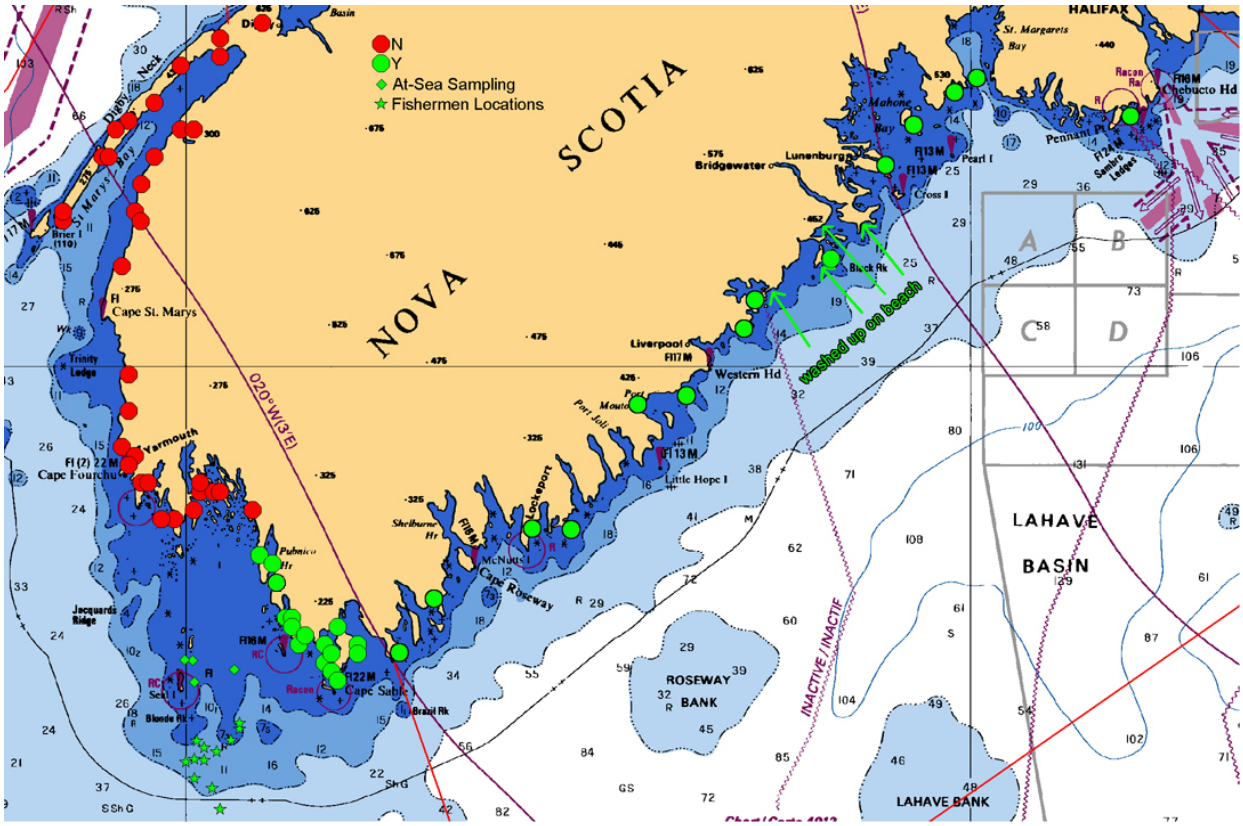
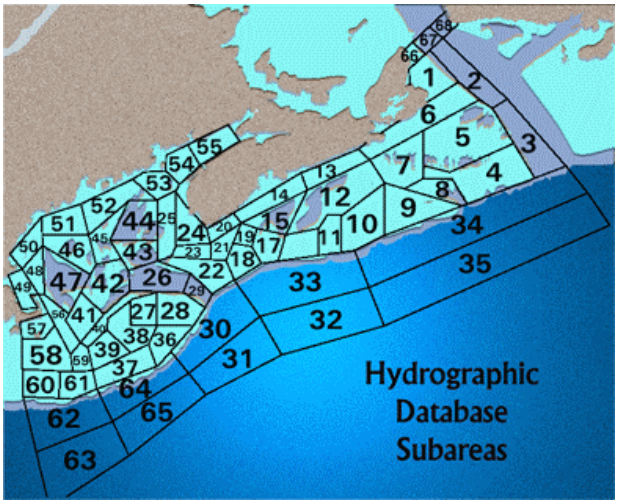


Fig. 3. Observations of damaged lobsters during the 2007-08 lobster fishery based on interviews of fishermen in LFAs 33 and 34 in Feb. 2008. Green circles indicate ports of fishermen who saw damaged lobsters or knew of fishermen who had; red circles indicate the ports of fishermen that had no reports of damaged lobsters. LFA 34 circles are all from port representatives and they spoke for the ports they represent. Green stars show an individual fisherman's reported locations; green diamonds show damaged lobster locations during two at-sea samples (D. Frotten). In LFA 33 lobsters were observed washed up on the beach in several locations in the area of the La Have Islands.



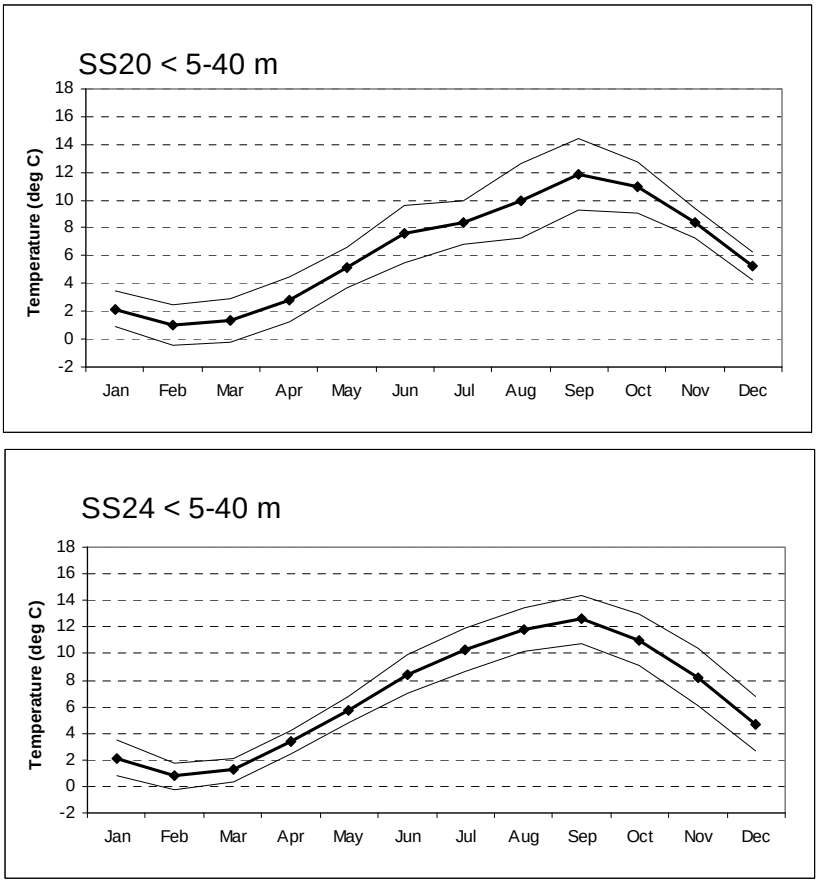


Fig. 4. Mean seasonal temperature cycles. Bold line in each plot is mean; other lines are plus and minus one standard deviation. Map shows locations of area SS20 (Shelburne county area) and SS24 (portion of southwest Nova Scotia including Cape Sable Island). Data obtained from DFO's Coastal Time Series database: http://bluefin.mar.dfo-mpo.gc.ca/ctsqry/servlet/MainServlet

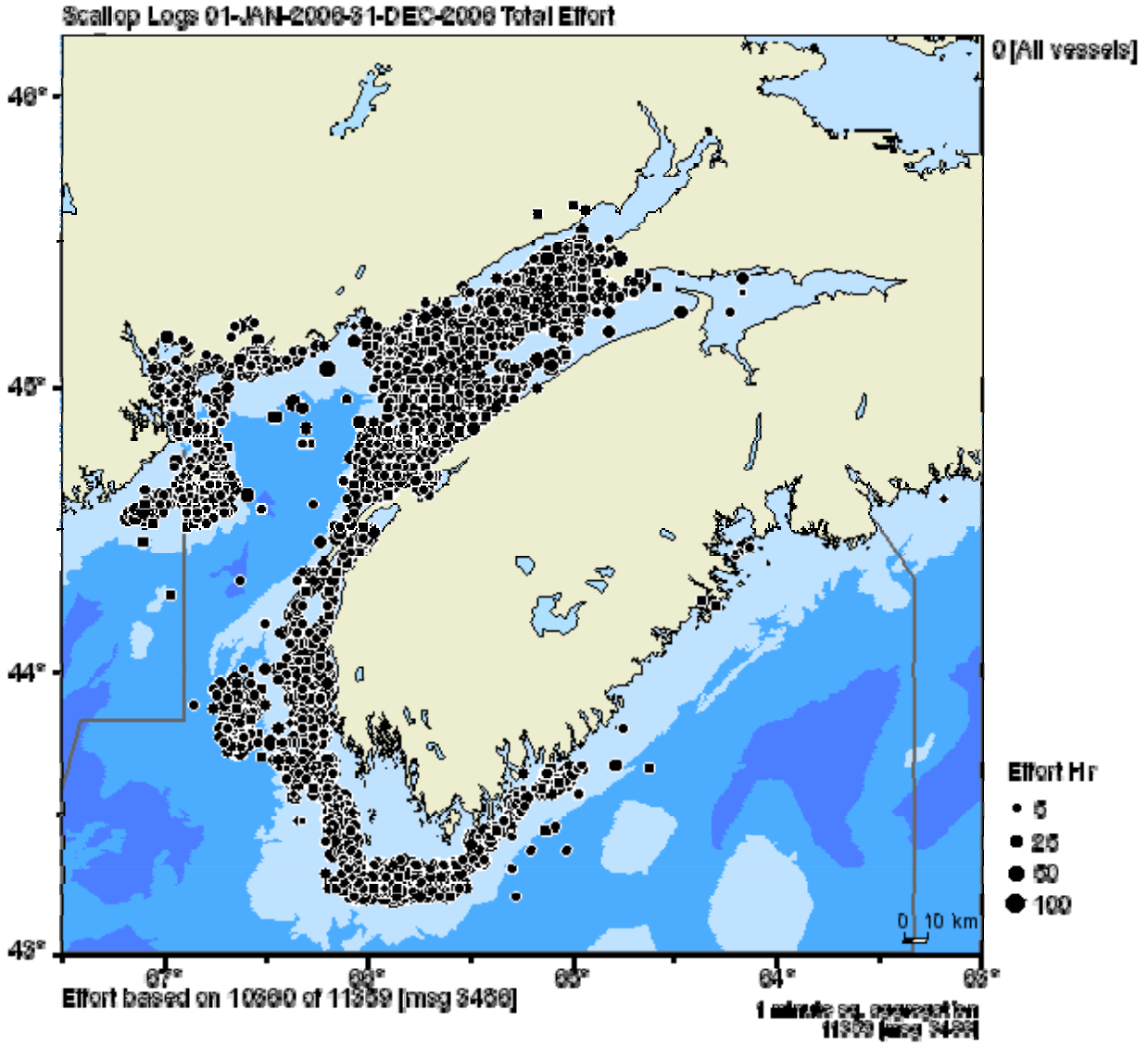


Fig. 5. Scallop fishing effort in 2006 (data not readily available for 2007 because a new system/view is under development on VDC). Note that it cannot be verified that the absence of fishing log positions is the same as the absence of scallop fishing in these areas.

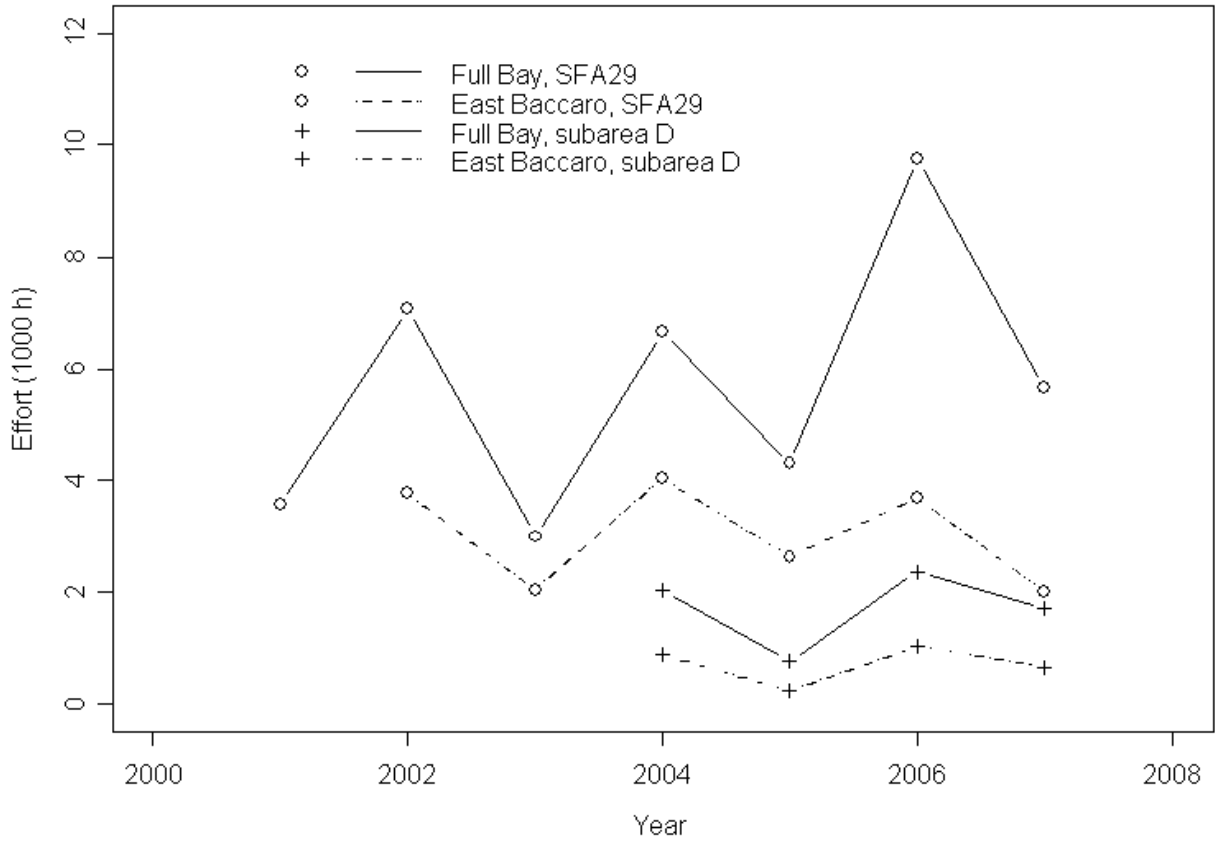


Fig. 6. Trends in scallop fishing effort for all of SFA 29 and for subarea D (adjacent to Cape Sable Island) by fleet.

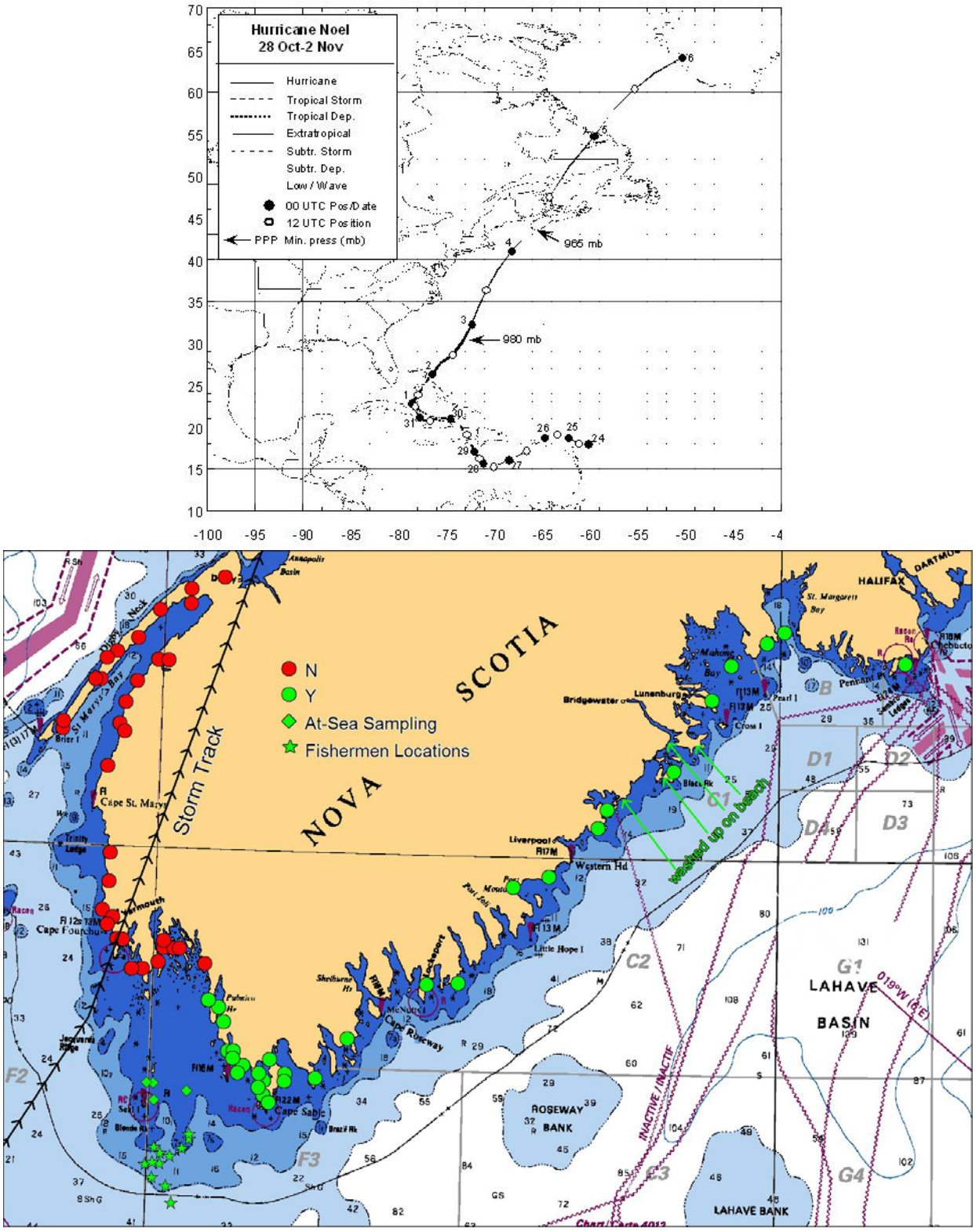


Fig. 7. Upper map: Best track of Tropical Storm Noel as it progressed from U.S. waters. Lower map: Noel as it passed over southwestern NS superimposed on observations of damaged lobsters (See Fig. 3 for description). Storm track positions obtained from U.S. National Hurricane Centre document (Tropical Cyclone Report Hurricane Noel (AL162007) 28 October-2 November 2007. Daniel P. Brown. National Hurricane Center 17 December 2007).

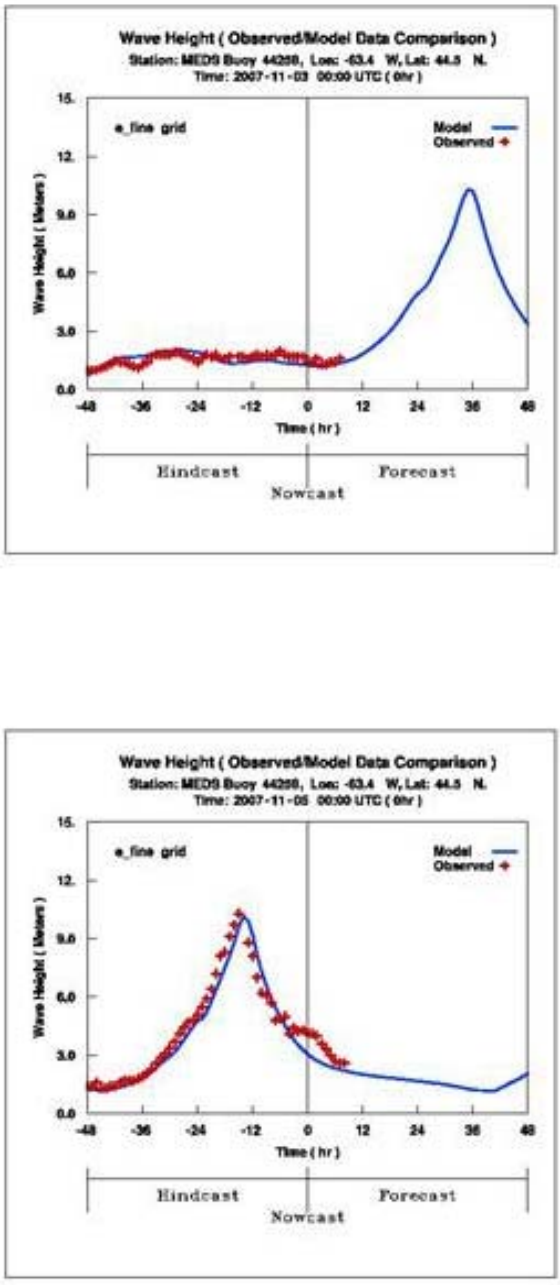


Fig. 8. Predicted and measured wave heights at Halifax (Chebucto Head). Upper panel shows predicted wave heights during Noel approximately 35 h in advance of the peak of the storm. Lower panel shows observed wave heights (measured at wave buoy) versus predicted.

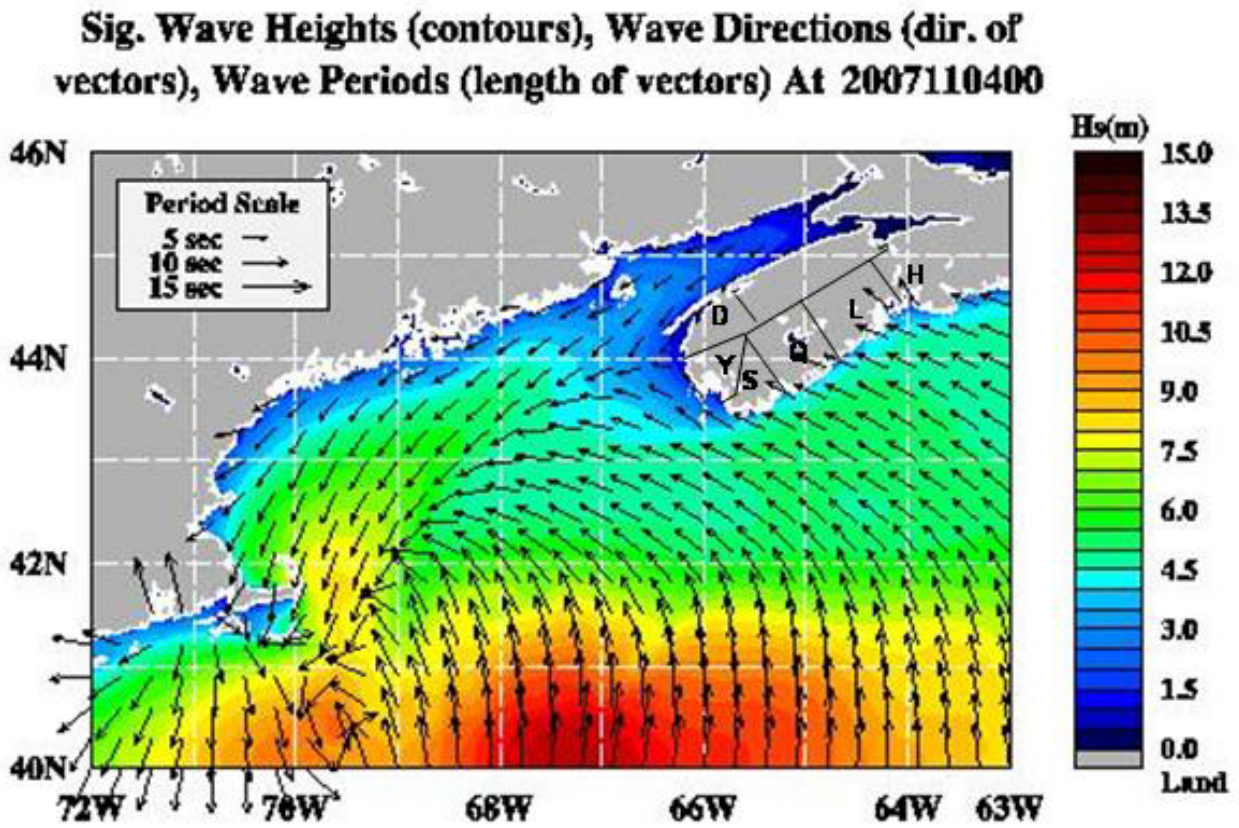


Fig. 9. 12 h forecast valid for Nov 4 0000 GMT (issued Nov 03 1200 GMT) of modeled significant wave heights (Hs) as Noel approached Nova Scotia. Counties added to map for this presentation.

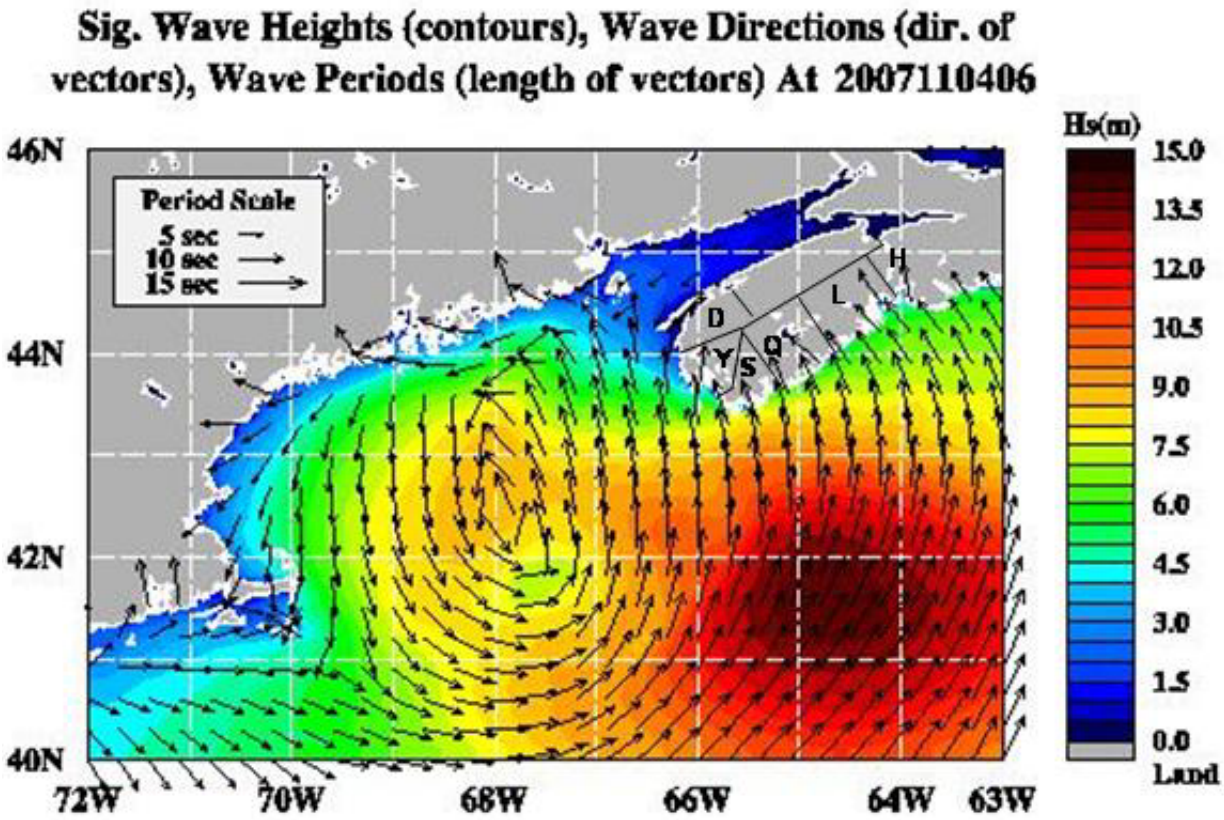


Fig. 10. 18 h forecast valid for Nov 4 0600 GMT (issued Nov 03 1200 GMT) of modeled significant wave heights (Hs) as Noel approached Nova Scotia. Counties added to map for this presentation.

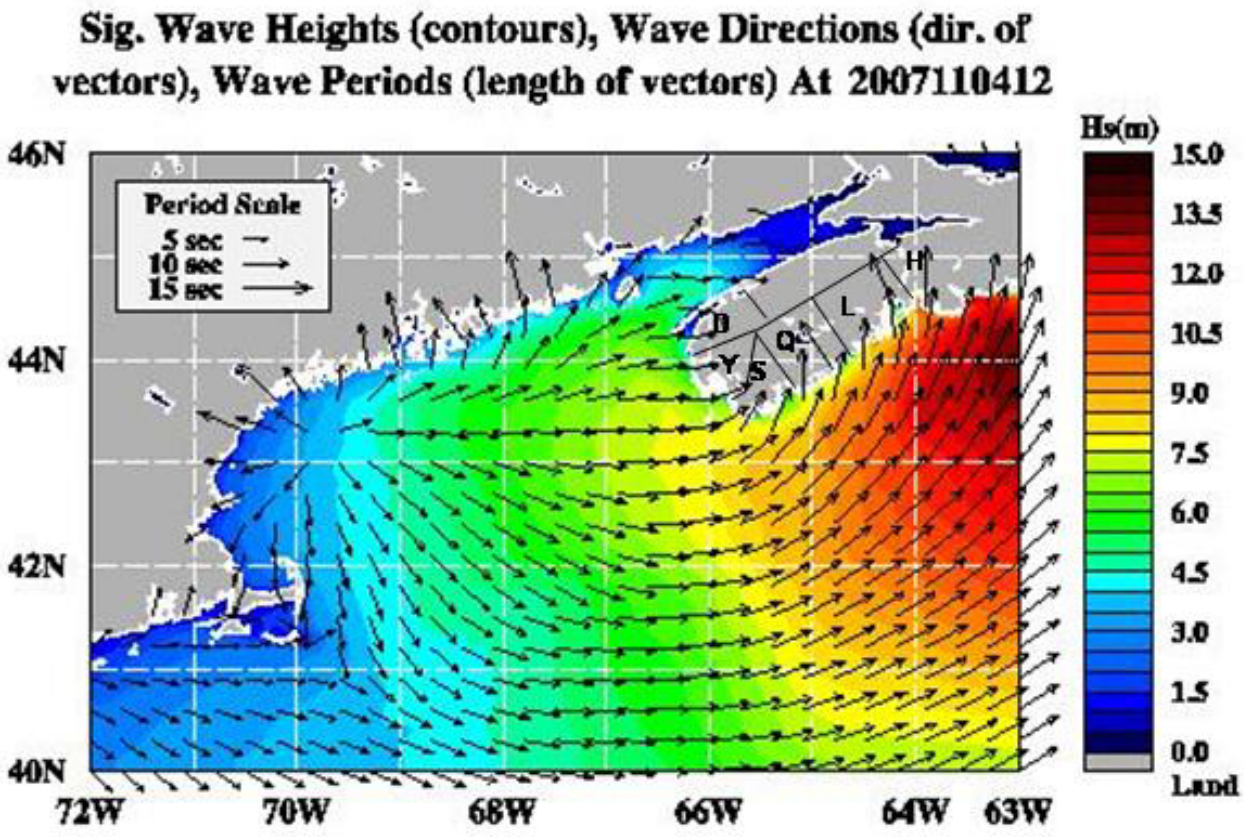


Fig. 11. 24 h forecast valid for Nov 4 1200 GMT (issued Nov 03 1200 GMT) of modeled significant wave heights (Hs) as Noel approached Nova Scotia. Counties added to map for this presentation.

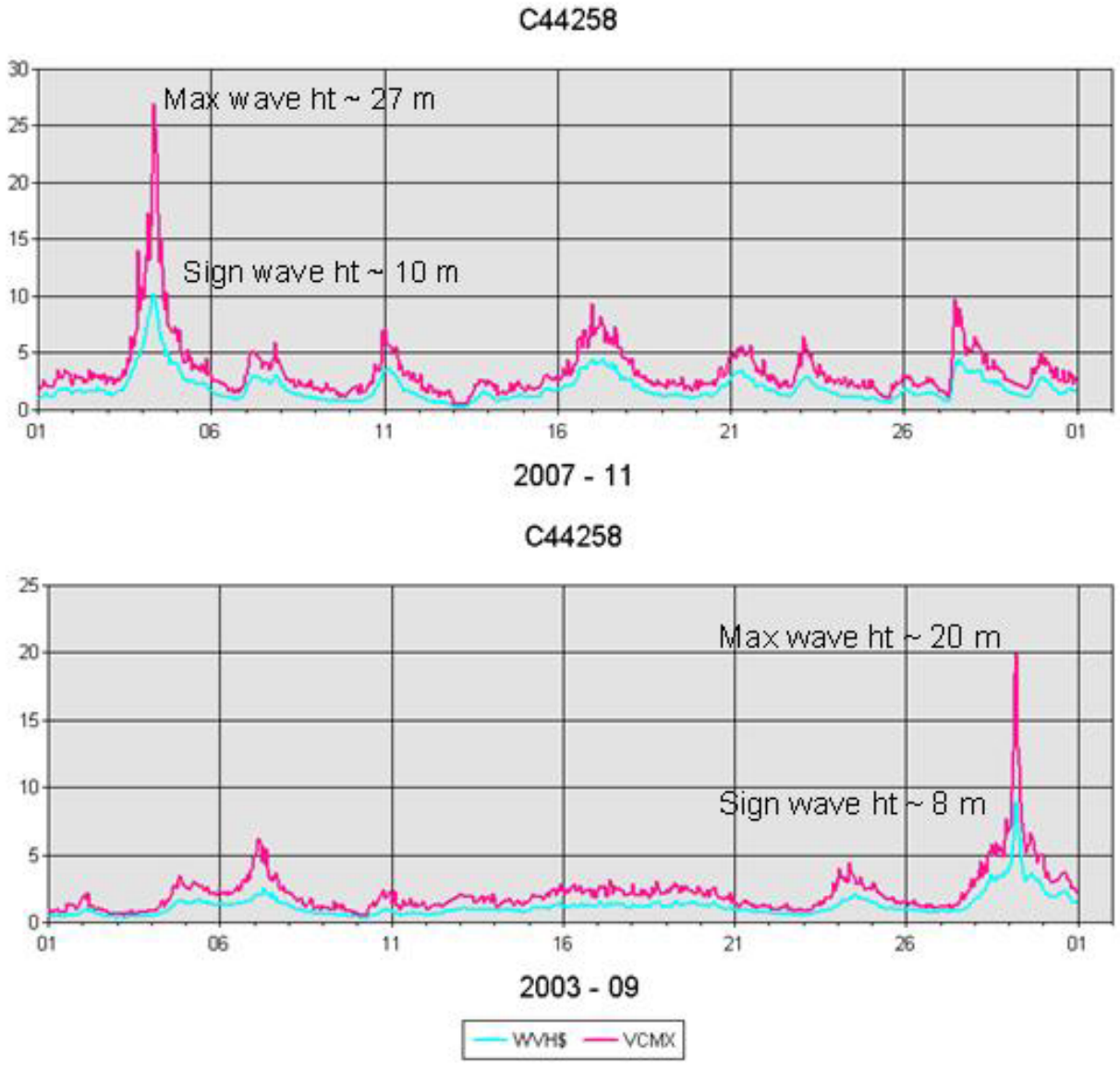


Fig. 12. Wave heights during Noel versus Hurricane Juan. Shown are maximum and significant wave heights observed at Chebucto Head Buoy - C44258 during November 2007 (upper panel) and September 2003. Wave heights during Noel were higher and were elevated for a longer period than during Juan.

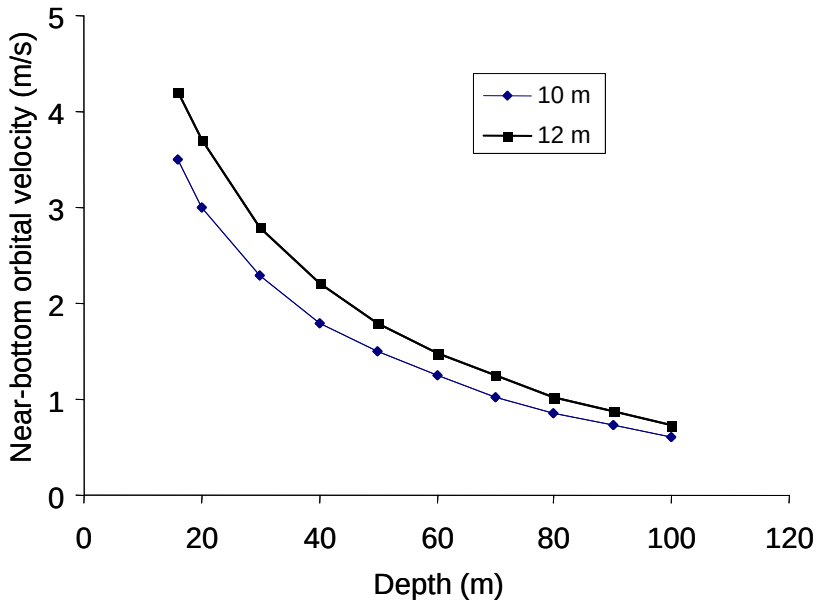


Fig. 13. Effect of wave height on bottom water current velocity. Shown is effect of 10 and 12 m wave heights based on a wave period of 14.5 seconds. Estimates taken from calculator on Woods Hole Science Center website (C. R. Sherwood): http://woodshole.er.usgs.gov/staffpages/csherwood/sedx_equations/RunWaveCalcs.html.

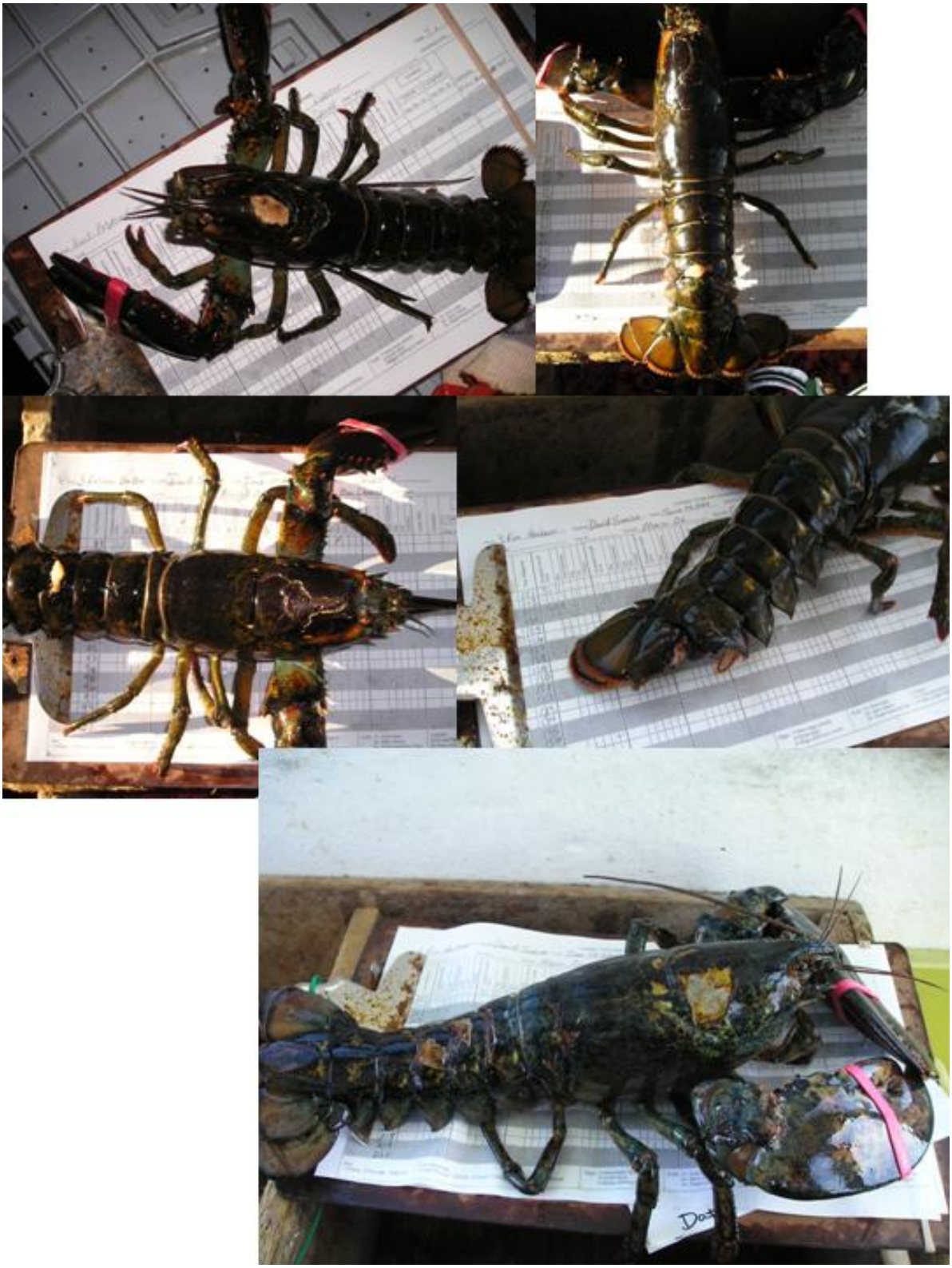


Fig. 14. Examples of damaged lobsters in Petpeswick and Three Fathom Harbour (LFA 32). Taken in spring 2004 fishery, 7-8months after Hurricane Juan (Sept 29 2003). Courtesy of Carl MacDonald, FSRS.

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