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The Lobster NEWSLETTER

ANNOUNCEMENTS

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- The Individual Lobster
- Population Dynamics
- Ecosystems and Food Webs
- The Business of Lobstering

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Symposium Convener:

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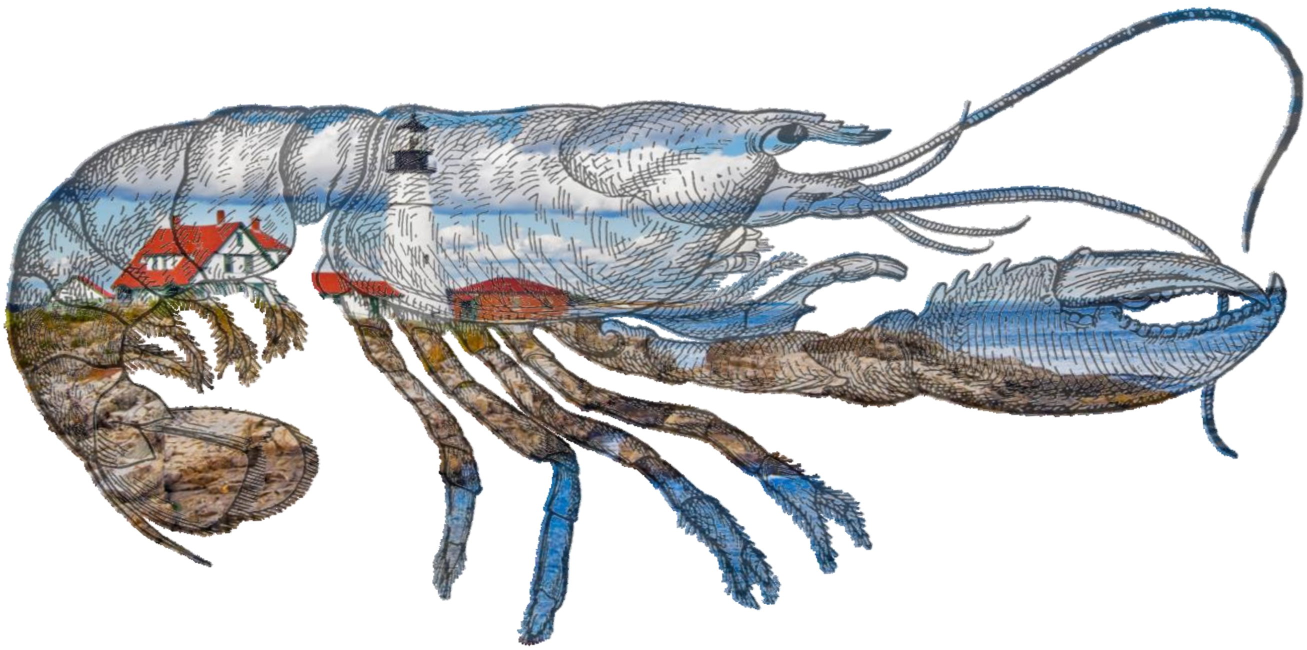

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Additional information will be sent to Lobster Newsletter subscribers… Stay tuned!

FOCUS ON THE MARKET

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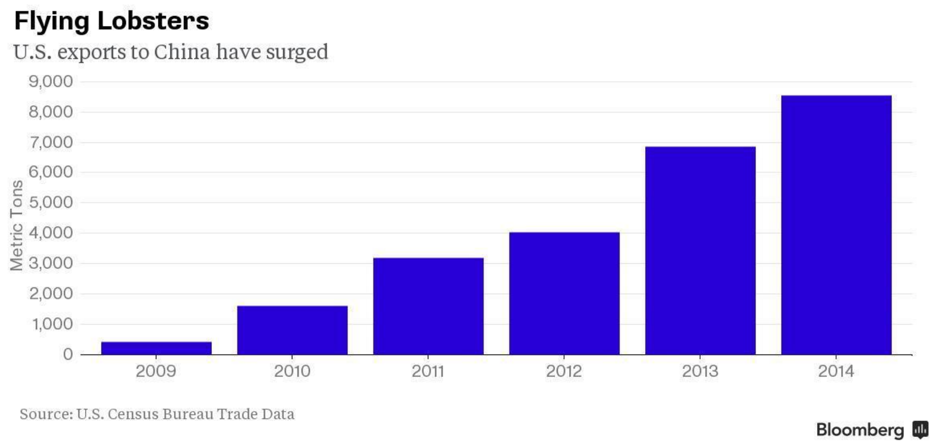
Lucky Lobsters Jam China Flights, Sending U.S. Prices to Record

By Yunita Ong and Lydia Mulvany
Bloomberg News
August 2015

Every Sunday for the past seven months, about 60,000 live North American lobsters packed in wet newspapers and Styrofoam coolers make the 18-hour flight to Asia in a Korean Air Lines Co. cargo plane.

The 7,500-mile (12,000-kilometer) trip from Halifax, Nova Scotia, to Shanghai via South Korea has become a weekly routine this year with a surge in demand from China, where lobsters caught in North Atlantic waters are at least one-third the cost of competing supplies. As a result, exports have skyrocketed from Canada and the U.S., the world's top producers, and American prices are the highest ever.

With no lobster industry of its own, China had relied mostly on Australian imports to satisfy growing demand as its middle class expanded. When the catch began shrinking off Western Australia, and a 2012 glut in the Gulf of Maine sent prices plunging in the U.S. that year, it became more attractive for the world's most-populous nation to buy from halfway around the world.



"When the domestic market collapsed, we looked farther and farther" for buyers, said Stephanie Nadeau, who shipped 2.5 million pounds last year by air to China for The Lobster Co. in Arundel, Maine. "I never sold a lobster to China until 2010. It was the really low price and the dealer's desperation here because we had high catches and a god-awful economy. We had to move the lobster."

Exports Jump

U.S. exports to China rose to 8,560 metric tons (18.9 million pounds) last year, up 22-fold from 2009, U.S. Department of Agriculture data show. Shipments already are up 12 percent in 2015.

It's easy to see why. Chinese importers shopping on Alibaba.com can buy live Canadian lobsters prized for their tail meat and big claws for $6 to $10 a pound, according to the website, compared with $20 to $33 for Australia's Southern rock lobsters -- a different species that doesn't have claws.

Increased demand from Asia provided a new outlet for U.S. producers who saw prices drop after their catches expanded by 66 percent in the decade through 2013 to 68,000 tons.

Lobsters are viewed as a status symbol in China, and their red color is considered lucky. Buyers in Asia want their lobsters live at markets and restaurants. To survive the long trip, the sea creatures should arrive within 48 hours of being removed from water tanks, exporters say. "You don't get paid for dead lobsters," Nadeau said. She added more refrigerated trucks and a storehouse in Canada with a tank to ensure stable supplies all year round, including during the busy Chinese New Year.

More Expensive

Not everyone is cheering the export surge. U.S. supply tightened this year as harsh winter weather slowed the catch in Canada and frigid ocean temperatures in Maine kept lobsters away from shallow waters where they're trapped, delaying the summer harvest, according to Michael Gardner, president of Halifax-based Gardner Pinfold Consulting.

Wholesale Canadian claw and knuckle meat is up 32 percent from a year ago, touching an all-time high of $22.75 a pound on July 31, according to research company Urner Barry, which has been tracking food prices since 1858.

Chinese chefs prepare Boston lobsters at the Auspicious Garden restaurant in Pangu Seven Star Hotel in Beijing
AP Photo/Andy Wong

Steve Kingston, owner of The Clam Shack in Kennebunkport, Maine, has had more difficulty securing the 1,000 to 1,500 pounds he needs every weekend. With costs up as much as 60 percent, he raised prices, though he said sales of lobster rolls are up 10 percent this year from last.

Rising Demand

For now, there's no sign of Chinese demand slowing, and North American supply is a preferred option after declining numbers of baby lobsters reduced Australian supplies by almost half in the decade through 2013, according to government data. In the same period, exports to China fell 60 percent.

China's middle class may surge to 1 billion people by 2030 from about 150 million last year, boosting incomes that will drive demand for all kinds of higher-value foods, including crustaceans, said Abhay Sinha, a senior food and retail analyst at London-based researcher Technavio. The country already consumes 35 percent of the world's seafood, and by 2019 will boost consumption of all crustaceans, including crab and shrimp, by 50 percent from last year.

Lobsters are viewed as a status symbol in China, and their red color is considered lucky, Sinha said. "Cooked lobster does the trick," said Richard Wahle, a marine sciences professor at the University of Maine.

See http://www.bloomberg.com/news/articles/2015-08-03/lucky-lobsters-jamming-china-flights-send-u-s-prices-to-record for the original publication (including video) in *Bloomberg News.*

The following is a summary of a report prepared for the Western Australian Department of Fisheries by Economic Research Associates Pty Ltd. The full report can be found at http://www.fish.wa.gov.au/Documents/rock_lobster/wrl_notice_board/analysis_of_the_demand_for_western_rock_lobster.pdf

An Analysis of the Demand for Western Rock Lobster

Findings

In this report, the trends and drivers in the lobster export market have been analysed. Since the move to ITQ [Individual Transferable Quota] in the western rock lobster fishery in 2010, we have 49 months of detailed export data to assess. Over that period, several notable trends have emerged in export volumes. Most notably:

- Greater China has become a focus for all exporters from Australia and New Zealand and more recently from other jurisdictions, such as the US.
- Western Australian [WA] exports to Greater China have grown to the point where virtually all exports are to Greater China. This has occurred against the backdrop of a reduction in total catch and reflects a distinct switch to China from other markets over the period.
- Since 2008, in part, it appears because of the fall in demand in Europe; the US has ramped up its export volumes to Greater China markedly.

The data suggest that, even though export volumes have grown, prices have not been significantly affected. In $US, export prices for Western and Southern Rock lobster have trended up over the period.

Perhaps even more significantly, the massive volume increases into China from the US have had only a marginal impact on their export price. It has in fact been relatively constant over the period.

One important consequence of these trends is that revenues received have also grown. This is true for exporters experiencing volume and price increases. Western Australia fits into this category. More significantly, it is also true for the US where, despite the large volume increases, the consequential modest price fall has meant that aggregate export revenue increased. The US export price reduction over the period has been more than offset by the volume increase.

It appears that over the period, growth in demand in China has been able to absorb the increase in volumes from these major suppliers without damaging prices and revenues. In effect, demand in China has been growing and outstripping the growth in supply.

This result is confirmed by the estimation of the inverse demand curve for Western Australian export price using the monthly data. The retail sales variable which is a positive influence on price, is a statistically significant variable. Along with the price of substitutes (such as New Zealand Southern Rock lobster price), it is more significant than the export volume for Western Australian Rock lobster. Monthly volume fluctuations affect price, but are less significant than the price of substitutes and demand drivers in China. The equation implies a high price elasticity of demand, consistent with the constant price assumption used by Gordon for modelling of the Canadian lobster export supply chain (Gordon 2011). Modelling beach price indicates that beach price bears a stable relationship to export price measured in AUD and to export prices measured in USD. For both cases, we cannot reject the hypothesis that the estimated coefficient is 1 meaning that a 1% gain in export price increases beach price by 1%.

The beach price might also be explained by a combined model where, in addition to catch, either the export price of the variables determining the beach price are included as explanatory variables. Estimates for these model specifications reinforced findings from the estimation of the inverse demand curve and beach price curve. Export price, and exchange rate are major drivers of beach price and need to be considered in conjunction with catch fluctuations to explain beach price. The same applies to models where more fundamental drivers are included as explanations of beach price in place of export price. The price of substitutes and retail sales are both important in explaining beach price alongside catch volume.

Notwithstanding the consistency of the results across different levels of analysis and different model specifications, it is important to note that the time series is relatively short since the system of ITQs was established. Pricing and marketing will continue to evolve and ultimately a longer monthly time series incorporating variations in TACC [total allowable commercial catch] is required to fully test these various demand propositions and develop forecasting models. This is a consideration when translating results to the future.

Looking Forward

The results suggest that, *if the recent past since the WA ITQ was implemented, can be extrapolated forward,* demand from China will continue to grow and there will be upward pressure on prices, or at least no significant downward pressure.

If this was the case, then an increase in export volumes from Western Australia, New Zealand or other sources in future could be expected to have little impact on prices, so long as the increase was in balance with projected demand growth over the comparable period.

This begs several key questions, namely:

- Will Chinese demand for lobster continue to expand and be the major driver shifting demand to the right at the current rate, or an even higher rate?
- What will be the supply response from competitive jurisdictions? Will this grow as per the US in recent past, stabilize or even decline? For a given expected demand growth, all other things equal, the last scenario implies price rises, while stabilization of supply growth implies more modest price rises. Only a significant supply response could impose a price fall, and only then if it outstripped demand growth.

While the past is relevant, there is a case that specific analysis is needed of future demand drivers, likely supply responses and possible price impacts. In particular, when exports to mainland China switch from the indirect to direct channels under the FTA [free trade agreement] arrangements, will this open up other internal city markets for lobster, growing demand even more? Will European demand resuscitate causing some US supply to divert back?

Past data do not inform these predictions. However, based on the analysis of export data to date, they do suggest that for best guess supply and demand responses, a modest increase in supply by any one exporter is unlikely to stop the general upward price trend.

Whilst demand analysis is valuable in that it directs us to likely price increases, on its own, it cannot, determine the profit maximizing level of exports. Exports are harvested from a managed biomass. Targets relating to biomass, actual expected biomass and CPUE [catch per unit effort] and even the objectives, other than simple profit of fishers, need to be taken into account, as does the risk attitude of managers and fishers to harvesting the biomass and pursuing profit.

Finally, it is worth noting that the trade data capture an equilibrium in which all buyers and sellers are positioning themselves on a daily basis to take advantage of market conditions and do the best for their clients. The monthly trade data over time summarize the outcome of the many demand and supply decisions. In this sense, they indicate that over the recent past, the summary outcome is that demand growth has allowed suppliers, including Western Australia, to position greater export volumes in Greater China without damaging revenues, or in most cases prices. Of course, if any supply response occurred in too short a period, say intra month; it could produce substantial short-term price fluctuations that the market would have to manage. The data suggest that over the recent past, any such outcomes have been managed to produce a balance between demand and supply growth that, as documented in the above analysis, has expanded revenues.

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RESEARCH NEWS

Push / Pull Neuston Net for Sampling Lobster Larvae

From: R.J. Miller and G.R. Siddall

Abstract
A large, low-tech, and robust neuston net is described. It is adaptable to be pushed by an outboard skiff or towed to the side of a larger vessel. It samples 290 m^2 and 145 m^3 of water per minute of tow time. It has no electronics, can be deployed and retrieved by hand, and in both modes has no structure in the water in front of the net. As a push net it is well suited for fine scale resolution of surface phenomena and operation in shoal water. Within 6-hours fifteen samples can be distributed over a linear distance of 50 km.
Key words: lobster larvae, neuston net

Introduction
Abundances of lobster pelagic stages are commonly used for spatial or temporal correlations with older benthic stages (e.g. Scarratt 1973; Fogarty and Idoine 1986; Wahle and Incze 1997; Miller 1997), to provide indices of larval mortality (e.g. Scarratt 1973; Caddy 1979; Harding et al. 1982; Incze et al. 2003; Miller and Hannah 2006), or to model drift trajectories (Harding and Trites 1988; Incze and Naimie 2000; Harding et al. 2005; Xue et al. 2008; Chasse and Miller 2010; Incze et al. 2010). The fourth and final pelagic stage is the most promising for correlations with older stages because of less time for drift and mortality before settling to become part of the benthos. Either all four stages or stages I and IV are used in studies of larval mortality and drift. Estimating abundance of pelagic stages is challenging because of high variance among replicate collections, low densities for stages II, III, and IV, and the range of vertical distribution (e.g. Hudon et al. 1986; Harding et al. 1987; Field et al. 2000; Annis et al. 2007).

Here our purpose is to describe a neuston net that met criteria of low capital cost, easy to maintain, ability to filter large water volumes, no structure in the water in front of the net, easy to transport and handle at sea, and adaptable to different boat designs.

Comparison To Other Nets
Plankton nets have been used for more than a century to sample pelagic stages of American lobster (Herrick 1895). Among these designs are simple round plankton nets, rectangular neuston nets (including stacked vertical compartments), and opening and closing nets. The round nets varied in size and could be weighted to sample subsurface (e.g. Herrick; 1895; Templeman 1937). Wide rectangular neuston nets were developed following results that most of the larvae in nearshore waters were found near the surface (Harding et al. 1982; Hudon et al. 1986; reviewed by Fogarty 1983 and Ennis 1995). Scarratt (1973) used the largest of these rectangular nets at 3.7 m wide by 0.9 m high submerged to a depth of 0.6 m and with a mesh size similar to ours. However, due to slower tow speed the volume filtered (69 m^3/min and 114 m^2/min) was somewhat less than for our net (128 m^3/min and 256 m^2/min). Its large size also limited deployment to a larger boat. Harding et al. (1982) and Hudon et al. (1986) divided their neuston samplers into 3 vertical compartments, each with its own net, either 40 or 78 cm wide and sampling to a depth of 110 or 200 cm. The nets were towed to the side of a vessel from a boom. Opening and closing nets, variations of a Tucker trawl (Bibb et al. 1983, Harding et al. 1987), added the option of sampling at discrete depths and of mounting electronic sensors on the nets. Harding et al. (1987) found larval stages I-III to be below the surface waters on an

offshore bank. In a mid-shore area Annis et al. (2007) found the depth of stage I to be correlated with light intensity, whereas stages II and III were scarce at all depths, and stage IV was mostly at the surface. While expanding the scope of questions that could be asked, these nets were heavier, had electrical connections and more moving parts, and most required large support vessels. When using an opening-closing net over the stern Harding added a neuston net towed simultaneously from the side of the vessel to avoid the vessel's wake (G.C. Harding, Bedford Inst. Oceanography, pers. comm.). Most authors did not report number of samples or distance traveled per day, but we believe our sampling was quicker than most allowing a larger scope of inference for spatial distribution. Because spatial and temporal variation in catches was so great, comparison among reported catches by different net types would not be instructive.

Although developed for fish larvae rather than lobster larvae, Miller (1973) and Kriete and Loesch (1980) described versatile push nets mounted on outboard skiffs. Their fished areas per minute were one-third or less than for the net we describe, and the Kriete and Loesch net had much larger mesh with presumably less drag resistance.

Net Frame

The net frame and arms were constructed mostly of 2.5 x 5.0 cm welded aluminum tubing. The arms were reinforced with 2.5 x 2.5 cm tubing and the opening was reinforced with two vertical flat plates. The inside dimensions for the net opening were 0.6 m high by 2.4 m wide; the widest that could be safely trailered on city streets. Arms on each side of the net were 2.7 m long. Welds were made waterproof and exposed ends of tubing were plugged to prevent water from entering and adding weight to the frame.

When used as a push net, the arm length allowed the front of the frame to clear the bow for sampling as well as to set on the gunnel at the back of the boat when in its traveling position. The ends of the arms were attached to plates hung outboard of the vessel close to the waterline and near mid-ships. Between stations, the net frame was supported by an A-frame mounted on the bow. A rope attached to the top of the net frame and passing through a sheave at the top of the A-frame was used to raise and lower the net and hold it at the desired depth when sampling.

The frame's design was modeled using Finite Element Analysis software to identify areas of high and low stress. The software identified weak points that should be stiffened and components that were stronger than required. Making the frame light weight avoided a motorized handling system

The net resting on the A-frame is pictured in Fig. 1. Additional details are available from the authors.

Figure 1. Net in "push" configuration resting on the bow A-frame.

When in the pull configuration (Fig. 2), additional parts were attached to the frame. A 4 cm diameter aluminum pipe between the ends of the arms prevented them from collapsing inward when being towed from the ends of the arms. A 60 by 60 cm aluminum or plywood plate was attached to the outside of the arm nearest the towing vessel and near the net opening. This deflector plate was set at a 30^0 angle from the long axis of the arm and pushed the frame and net away from the boat. Added floatation, described below, was needed to keep the net at the surface. The frame weight was 24 and 30 kg respectively in push and pull modes.

Figure 2. Net in "pull" configuration setting on the stern of a 10 m lobster fishing boat. Note the plastic pipes attached to the left side of the frame for flotation, the reflector plate at the right rear of the frame, and the spreader bar between the arms.

Net

The 5.5 m long net was constructed of 1.6 mm Nitex™ nylon mesh with heavy nylon cloth collars sewn onto both ends. The collar on the net opening was 20 cm wide with two rows of grommets parallel to the net opening. The collar was placed inside the net frame then folded over the frame such that the front row of grommets lined up with the back row. The net was held on the frame by weaving a light rope through pairs of grommets. The nylon cloth on the cod end formed a cylinder 30 cm long and 15 cm in diameter. Rather than attaching a bucket to the cod end it was rolled tightly and held closed with a Velcro™ strap. This large, soft opening in the cod end facilitated removal of large bunches of seaweed.

Water flow produced a downward force on the net, estimated at 80 kg and 20 kg in the push and pull modes respectively. In pull mode, the net mouth was tipped slightly forward causing the bottom of the nylon cloth collar to act as a depressor. This countered a tendency for the net to be pulled out of the water because the tow point was about 1.5 m above the surface. To keep the net at the surface, sealed plastic pipes were attached to the arms of the frame for flotation. In the push mode, the system was stable because the attachment point of the arms was higher than the bottom of the net. This created a downward force which the A-frame resisted.

The ratio of area of submerged net opening to the open area of submerged mesh was 1:6. This should be more than sufficient to allow unrestricted flow through the net mouth (Tranter and Smith 1968) as was confirmed by near identical readings from flow meters located inside and outside the net.

Larval recovery rate was measured where no ambient larvae were present. In each of seven tows a few kilograms of seaweed and an average of 19 live hatchery-reared stage I lobster larvae were added through the net mouth while towing. Of the 131 added, 111 were separated from the seaweed and recovered when sorting the samples. The relatively large 1.6 mm mesh reduced the effort needed to sort the lobster larvae because fewer animals of other species were retained.

Sampling

Push Mode

The net was deployed from 6 m to 7 m outboard skiffs powered by 90-110 hp engines. These boats could be trailered to the sampling area and travel up to 25 knots between stations when sea conditions permitted.

Once on station, the net was lowered until the opening was submerged 50 cm with 10 cm remaining above water. To reduce wash over top of the net the boat was steered either in the direction of wave movement or at right angles to it. A collection took 9 minutes at 1.6-2.0 m/s, covered about 2300 m^2, and filtered about 1150 m^3 of water. The distance traveled was measured by a flow meter in the net opening.

At the end of the tow, with the net opening lifted onto the A-frame, the boat was powered in reverse for a short distance to wash the contents into the cod end. Next, the contents of the cod end were emptied into a 20 L bucket and the cod end rinsed. We were not concerned whether all the larvae were removed from the net after each tow or some were included with the next tow. Large clumps of rockweed and large jellyfish were rinsed over the bucket before being discarded. However, if the amount exceeded about 15 L the entire sample was discarded and the tow repeated.

The contents of the 20 L bucket were poured through a large funnel that emptied into a standard cod end plankton bucket. The funnel was fitted with a 1 x 1 cm mesh, and animals, plants, and debris retained on the large mesh was rinsed and discarded. The sample, now reduced to less than 1 L, was preserved with 4% buffered formalin.

Net operation required no electronic and few moving parts. It involved two people for safety, although it could be operated by one.

Pull Mode

The net could also be towed from the side of a 9-13 m long lobster boat. In this mode a tow rope was tied to a rope bridle attached to the ends of the two arms of the net frame. The angle of the arms to the net mouth (usually) kept the bar that separated the arms above the water surface. The net flowed away from the frame rather than between the arms as in the push configuration. The tow rope was about 10 m long with adjustment for the height of the tow point. Even with the deflector plate, about 1 m of the net opening was aft of the stern but free of the propeller wash. The overlap could be avoided if the vessel towed in a wide arc in the direction of the tow point. Tow speed and duration were the same as with the push mode. A strain meter measured towing tension at 360 kg (3530 N).

Between stations the net frame rested on the stern deck (Fig. 2). To begin a tow the cod end was thrown over and the frame pushed off the stern with the boat going forward. At the end of a tow, the frame was pulled to the stern and onto the deck by hand; contents were rinsed toward the cod end while the boat went ahead under power. On-deck rinsing and processing were the same as with the push mode.

Sampling required a boat captain and two deck crew. The net mouth was free of obstruction and remained near perpendicular to the direction of tow.

Performance Summary

Moderate capital cost – Frame materials cost $1300 (Can.) with fabrication time about 60 h. Material and fabrication costs for the net are $2000 (Can.).

Easy to maintain - Few moving parts, no electrical components, simple maintenance, and high reliability. Initially, extra stiffening was added to the frame for the push mode, but no further maintenance was required over thousands of tows**.** The net was eventually replaced because of small holes chafed in the fabric during transport.

Filters large volumes – Filtration volume is 128 m^3/min and sampled surface area is 256 m^2/min. Net width was limited by the maximum width of frame that could be safely trailered on city streets, and a frame weight that could be conveniently handled by two people. Large volume was needed because of low density of stage IVs. A high daily average catch was 2 stage IV per tow, although daily averages of 20 stage I per tow were not uncommon. Stages II and III were rare and may have resided below the surface layer during daylight hours.

No structure in front of the net – No bridle was required in the push mode and the bridle was above the water surface in the pull mode. No depressor was needed in either mode. Both configurations allowed the net mouth to remain perpendicular to the water flow and not vary with vessel speed, as would occur if the net was towed from the top of the frame. Turbulence and pressure effects preceding a net may affect catch rate as stage IV can sustain a swimming speed of 9 cm/s (Ennis 1986).

Easy to transport and handle at sea – As a push net it is easily transported attached to the boat and can be operated by one or two people when fishing. Because of the rigid attachment to the boat it can be fished in shallow water and maneuvered to avoid floating objects or to sample features such as wind rows. Because the net and outboard runabout can be trailered to daily work sites large sections of coast can be sampled permitting a large spatial scope of inference. In favorable sea conditions, 15 samples could be distributed along 50 km of coast within a 6 hour period. Usually only 15 min was required to collect and store a 9-min. sample. Using the net in the pull mode required a larger boat so the net was usually trucked between ports. It was easily handled manually by two people and required no adaptation for different boats. A 9-min. sample required about 20-min. to collect and store.

No sampling at depth – Stage I has been shown to vertically migrate, but less so inshore than offshore (see 'comparison to other nets'). In studies using the net described, sampling was usually restricted from 6 am till noon local standard time. Although this included a range of light conditions, the restriction was intended to provide an index of abundance of stages I and IV. Sampling at depth would have compromised most of the above advantages.

We have used our neuston net for ca. 2000 tows. Two fishermen's organizations (Guysborough County Inshore Fishermen's Association, Lobster Fishing Area 27 Management Board) have obtained thousands more tows using nets of the same design at four locations over 5-11 years at each.

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Todd Peters contributed innovative design modifications when fabricating the net frame. G. C. Harding, Daniel Moffatt, M.J. Tremblay, and R.A. Wahle commented on the manuscript.

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The Amazing Diversity of Lobsters in Brazil: Recent Advances

From: Raúl Cruz

The continental shelf of Brazil targets one of the bigger diversity of lobsters in the Atlantic Ocean. Approximately 21 species are distributed in different habitat along the coastal waters, island and oceanic atoll, extending up to a depth of 1000 meters (Silva *et al.*, 2013). Lobster fisheries target the red spiny lobster *Panulirus argus* (Latreille, 1804), the green spiny lobster (*Panulirus laevicauda* Latreille, 1817) and the painted spiny lobster *Panulirus echinatus* (Smith, 1869). Some slipper lobster including *Scyllarides brasiliensis* (Rathbun, 1906), *Scyllarides delfosi* (Holthuis, 1960) and *Parribacus antarcticus* (Lund, 1793), are caught incidentally during spiny lobster fisheries. The southern slipper lobster *Scyllarides deceptor* (Holthuis, 1963) and *Scyllarus chacei* (Holthuis, 1960) are captured as bycatch in shrimp trawls principally (Silva *et al*., 2012).

In spite of the ecological and economic importance of lobsters to Brazil and worldwide, there has not been an integral study to clarify many aspects of the life cycle, the stock-recruitment relationships, variation of the recruitments, the mechanisms of larval transport and their relationship with the adults. Since 2012, a group of professors and post graduate students from various scientific institutions of Brazil (Universidade Federal do Ceará; Universidade Federal Rural da Amazônia; Universidade Federal do Pará; Instituto Federal de Educação, Ciências e Tecnologia do Ceará) have published a series of studies designed to understand different aspects of the biology, ecology and fisheries of the target lobster species and others no less important.

Field studies improved our understanding of the variations in the reproductive potential (number of eggs), stock recruitment and reproductive efficiency (contribution of each female size class to the total number of eggs produced) of spiny lobsters according to location, depth and size class (Cruz et al., 2014). Brazilian spawning lobsters in deeper waters measure 96 mm CL at first capture; this coincides with the size class (90-99 mm CL) with the greatest index of reproductive potential. However, the index of reproductive efficiency was greater in the size classes 120-129 mm CL (2.74; 11% of the egg production) and 130-139 mm CL (2.01; 2.7% of the egg production). In addition, the capture of berried females and older lobsters (>135 mm CL) from deeper waters increases the risk of low recruitment and fishing collapse (Fig.1).

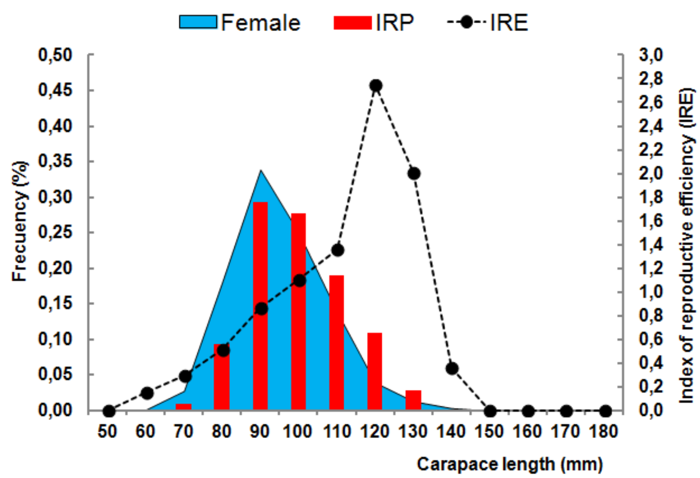

Figure 1. Relative size structure of female spiny lobsters *Panulirus argus* (Latreille, 1804) caught on the continental shelf off Northern Brazil. IRP (Index of reproductive potential) and IRE (Index of reproductive efficiency) for the period 2001-2003. Modified from Cruz *et al.* (2014).

Considering the longevity and absence of reproductive senility in spiny lobsters, management strategies should ideally include the creation of spawner sanctuaries (marine protected areas) capable of restoring and maintaining the biomass of the spawning stock, and the establishment of a maximum catch size of 135 mm (CL) for both sexes along the entire Brazilian coast. We propose to establish spiny lobster sanctuaries (50-100 m) on the continental shelf off northern Brazil, from Amapá (5°25'N 51°0'W) to the western reaches of the coast of Pará (1°11'N 46°27'W, 0°42'N 46°45'W), covering a total surface area of 64 230 km^2 (Cruz *et al*., 2014).

The assessment of wild spiny lobster stocks, the analysis of the impact of lobster size on catches and prediction of commercial spiny lobster landings on the Brazilian continental shelf, are important issues that contribute to the current discussion in the field by assessing the situation of exploited spiny and slipper lobster stocks and by proposing effective control measures capable of protecting and recovering populations of target and non-target species. It is hoped that our findings and recommendations will stimulate further research with a view to establishing a sustainable lobster fishing management plan (Cruz *et al*., 2013a and 2013b).

On the Brazilian continental shelf, *P. argus* is highly exploited, especially undersized animals (≤ 75 mm CL) and older individuals. The size at first capture was estimated to be 61 and 96 mm CL for lobsters in shallow and deep waters, respectively (Fig. 2). The observed decline in spiny lobster landings over the past two decades is believed to be due to growth overfishing in shallow waters, since over half the harvested lobsters are below the minimum legal size (75 mm CL). This is possibly the main cause of the large fluctuations observed in landings, although other factors, such as the interplay between environmental conditions and recruitment abundance, may have to be considered. In shallow waters the enforcement of the minimum legal size (75 mm CL) should result in a harvest of approximately 4 200 t (Cruz *et al*., 2013b).

The current deplorable situation of spiny lobster fisheries (*P. argus*) in the Atlantic waters is the

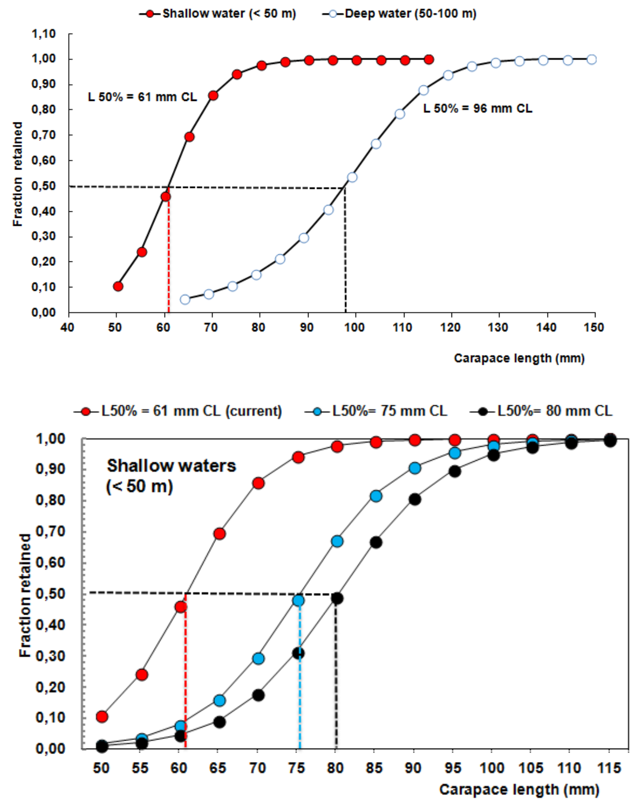

Figure 2. Selection curves for spiny lobster fisheries, *Panulirus argus* (Latreille, 1804) in shallow and deep waters on the Brazilian continental shelf. Modified from Cruz *et al*. (2013b).

result of a steady increase in fishing effort and the use of improper fishing techniques over the last four decades, depleting stocks and degrading the benthic ecosystem. In Brazil, Cavalcante & Furtado-Neto (2012) suggested the first steps towards discussing strategies to the implementation of individual transferable quotas and compulsory landing of live lobsters as a fishery management strategy that is an innovative measure, which must be based in a new management plan and defended with good arguments in the Scientific Sub Committee of Management Lobster Fishery (CGPL, acronyms in Portuguese).

On the other hand, the setting of quotas on catches in any artisanal fishery is in itself insufficient to protect lobster stocks. In Brazil, management efforts should instead focus on the enforcement of control measures in order to increase lobster stocks. According to recommendations recently published we emphasize the following: (1) lobster traps should be furnished with escape gaps for undersized lobsters, (2) the use of undersized lobsters (decoys) in traps should be avoided, (3) gillnets ("caçoeira") and artificial shelters ("marambaia") should be eliminated, (4) an optimal minimum legal size should be established (80 mm CL for all spiny lobster species and 85 mm CL for slipper lobsters), (5) a maximum legal size should be established (135 mm CL for *P. argus* and 100 mm CL for *P. laevicauda* of both sexes), (6) the capture of berried females should be prohibited, (7) a closed season should be instituted to protect ovigerous females and ensure recruitment, (8) establishment of marine reserves or a total closed season to protect the juveniles in nursery areas, (9) a monitoring program collecting catch and effort data should be implemented to help assess lobster stocks adequately, and stratified random sampling must be implemented (see Lobster Newsletter Volume 25, Number 1: April 2012).

Further research is required to clarify the biological impact of fishing gear in the ecosystem. The variety in fishing methods and gear makes lobster fisheries difficult to study and monitor. Not surprisingly, the unit of effort has not yet been well calculated and standardized. We found evidence that the relative abundance (CPUE) for traps and skin diving in natural shelters was likely to remain high despite the decline in abundance (hyperstability), for this reason the methodologies employed by Cruz and Borda (2013) are needed in the continental shelf of Brazil to estimate the true abundance and stock productivity of patchily distributed spiny lobster stock.

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An industry-serviced puerulus collector suitable for deep water

From: Ruari Colquhoun and Graeme Ewing

Changes in southern rock lobster (SRL) larval settlement have led to significant changes in resource allocation in lobster fisheries throughout their distribution in southern Australia; and fishers have benefitted from settlement monitoring through advanced warning of fluctuations in recruitment to the fishery. Similarly, managers have been able to make pre-emptive adjustments to catch limits so as to minimise impacts on industry. In Tasmania, South Australia and New Zealand, fishery-independent monitoring of SRL puerulus settlement has been conducted in shallow inshore waters for an extended period. However, despite significant landings in SRL fisheries from depths exceeding 30 m, settlement monitoring has not been conducted in these deeper waters.

Institute for Marine and Antarctic Studies (IMAS) (University of Tasmania) conducted a Fisheries Research and Development Corporation (FRDC)–funded pilot study in 2012/13 which developed, in collaboration with commercial fishers, a prototype puerulus collector design suitable for deployment into deep water and able to be serviced by vessels in the commercial lobster fleet. This fishery-dependent approach allows cost-effective monitoring of puerulus settlement in deep and/or remote locations. Prototype collectors were deployed into depths of 50 to 110 m on the remote exposed south and south-western coasts of Tasmania. This trial collected puerulus from unprecedented depths (up to 106 m), and established that the collector design could be safely and efficiently deployed and serviced from vessels typical of the Tasmanian commercial lobster fishery.

Following on from this pilot study, IMAS has successfully attracted FRDC funding for a further 2 years (Principal Investigator Professor Stewart Frusher), to further refine the collector design, and construct a larger fleet of collectors (48) to monitor puerulus settlement state-wide and over two puerulus settlement seasons. Again, this will be in collaboration with the Tasmanian local lobster fleet who will contribute to site selection through their knowledge of local fishing grounds, and will deploy and service the collectors. Collectors will be deployed into 4 regions around the Tasmanian coast (NW, NE, SE and SW), and into 2 depth sites per region (approximately 50 m, and 100 m). Data loggers will be attached to a collector at each site to record depth and temperature information.

There has been both national and international interest in the successful performance of the puerulus collectors in the pilot study, with South Australian, Western Australian, and New Zealand lobster sectors keen to deploy these industry-serviced collectors into deeper waters in their fisheries. Consequently, under this project deep-water puerulus collectors will be supplied to Southern Rock Lobster Ltd. for deployment in the Northern Zone of the South Australian fishery, and collector construction plans will be supplied to Western Australia and the New Zealand Rock Lobster Industry Council (NZ RLIC) for trials. Deep water collectors will be deployed in the Bay of Plenty region of the NZ north island and are a good fit for this area because inshore collector arrays are not possible due to resource consent rules.

The collector design features 3 components (Fig. 1). Puerulus settle on a habitat substrate constructed of plywood in a concertina crevice pattern. This substrate is currently used for inshore settlement monitoring of SRL pueruli. The substrate is housed in a sieve box which is open on the up-stream side when retrieved. This allows puerulus access, but retains any flushed from the substrate on retrieval. The sieve box is mounted in a traditional steel lobster trap frame which allows it to be handled on a standard Tasmanian lobster vessel. These 3 components are separated quickly and easily for servicing through the removal of 4 circle clips. The collectors are deployed in strings of 3 to minimise the likelihood of movement (Fig. 2); no movement of collector strings was detected in the pilot study despite exposure to 7 m swells and 60 kt winds.

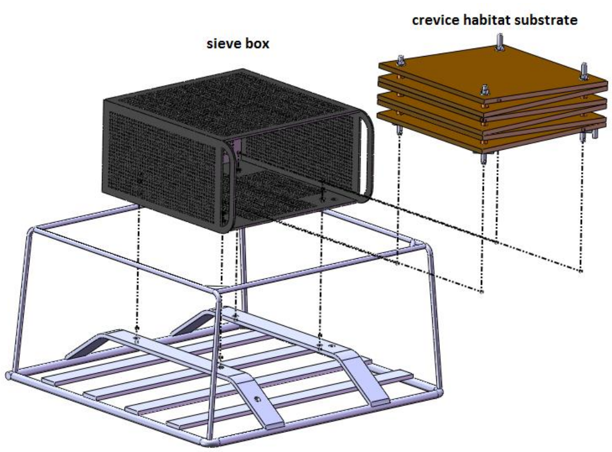

Figure 1: Sample of design plans for construction of deep water puerulus collectors

This project enables the lobster fishing community to become actively involved in managing their fishery and further demonstrates their commitment to a sustainable future. It aims to provide industry and government with an increased ability to forecast fluctuations in future lobster catches, particularly in regions where recruitment indices have previously been impossible to achieve.

Southern Rock Lobster Ltd. and the NZ RLIC have consistently promoted trans-Tasman cooperation in rock lobster fisheries research, assessment and management and this working relationship will be further enhanced by this FRDC project. This will expand the range of settlement monitoring throughout the distribution of SRL and may also shed light on the causes for settlement fluctuations in this vulnerable part of the life cycle of lobsters.

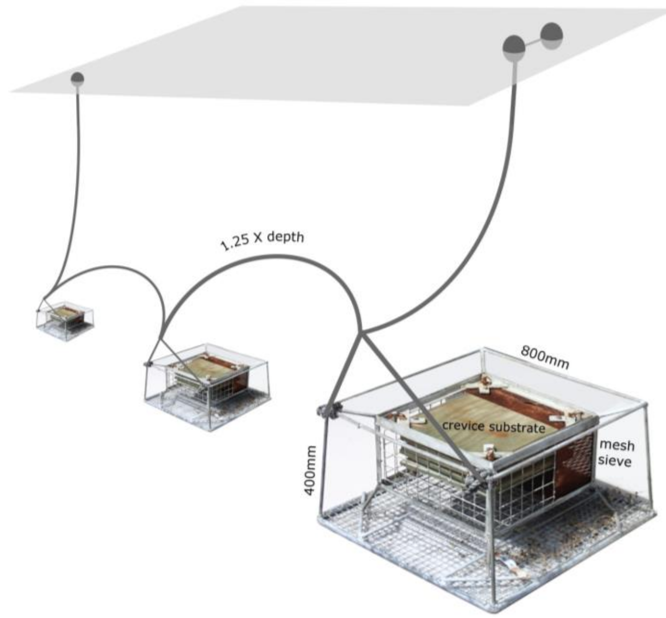

Figure 2: Depiction of the string arrangement for deployment of deep water puerulus collectors.

Acknowledgements
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Toward a modern interpretation of the American lobster shell using X-ray tomography

From: Joseph G. Kunkel, Melissa Rosa and Ali Bahadur

The American lobster shell has been studied as a material structure by many investigators using various techniques. Older studies were typically 2-dimensional using light, electrons, electron generated X-rays and Raman and FTIR spectroscopy to analyze the density or chemistry of thin sections or polished surfaces of cuticle specimens. These 2-D views have provided a basis of numerous theories of the lobster shell structure which have been reviewed and modeled (Nikolov et al. 2010; Kunkel, Nagel & Jercinovic 2012; Kunkel & Jercinovic, 2013; Kunkel, 2013). The prior analytic techniques are informative about structure and chemistry but, being inherently two dimensional, are time and labor intensive, taking many days of sample preparation while not providing a 3-dimensional view of structure. Those types of data collection from individual specimens take long valuable operator and machine time. This delay in sample preparation and data gathering often inhibits the ability to perform a time series within an animal, or results in small and limited sample sizes. These results are due to the practicality of operator-time, effort and machine-time, thus limiting a comprehensive understanding of shell development. None of these previous analytical techniques have allowed us to study some of our most pressing problems about the role of the mineral and polymer structure during the changing stages and different phases of the molting cycle. Now, a new instrument is available that fits many of the needs for rapid analysis of the complex structure of the lobster shell. As it has done in human medicine, X-ray tomography allows structures to be viewed and interpreted in 3-dimensions. This approach is now available on a micro scale and can be applied at the dimensions of interest in lobster cuticle structure. The technique of micro-CT scanning produces massive amounts of data, which can be both a curse and a blessing. For instance a 6 mm cube sample is the largest one that we can practically scan and achieve 0.5 um resolution densities of the component cubes, called voxels. But a 6 mm cube produces 1.7×10^{12} voxels (the 3-D analog of pixels) of density, a formidable amount of data to analyze. However, this amount of data is a blessing in that it can be selectively analyzed *post facto* of gathering, similar to how an MRI allows medical analysts to see all sorts of unsuspected issues in the human spine or surrounding tissue. A production grade machine, the Bruker **Skyscan 1272**, could analyze 2 dozen cuticle samples overnight at 0.5 µm resolution. Samples need no special embedding or fixation. We excise 6 mm cuticle medallions with a coring drill and the hole is repaired with a plastic sheet epoxied to the rim, Fig. 1, allowing further timed samples following development.

A

B

Figure 1. Producing medallions of lobster cuticle from a single or multiple lobsters. **A.** Lobster carapace with drill cored medallion removed and fixed with a clear patch applied to the remaining hole (picture after 4 months). **B.** Five 6 mm medallions after a freeze fix in acetone can represent replicates or sequential samples from one animal in time or space.

Our cored medallion of the carapace was plunged into -50º C acetone to freeze fix and dehydrate the medallion. It is ready in a day to be placed into the **Skyscan 1272** in its carousel auto-sampler that provides unattended X-ray tomography measurement of all samples overnight. As with MRIs, unfixed, live samples are possible! If 24 medallions were scanned 6 mm diameter by 1 mm thick it would produce 3.4×10^{11} voxels of data. The challenge is to develop approaches to study that amount of data efficiently. Bruker has developed software for handling such data in general and we have further developed R-scripts for further analyzing the data to make it intelligible to lobster scientists. Fig. 2 illustrates one small 1000 x 1000 x 1000 = block of 10^9 voxels developed using NIH ImageJ and our R-scripts that interpret a span a cuticle thickness, outer epicuticle to the inner epidermal surface, including 2 primary organules, with their canals running from the surface down to the gland cell (not shown) in the epidermis. The entire 4700x 2024x 3100 pixel original data set can be viewed as a movie of slices in any of the 3 dimensions, or rotated and viewed at any angle using free software from Bruker.

Our sample analytic-interpretation of a small volume of the data in Fig. 2 illustrates discovery of several new structural features missing from prior models of the lobster cuticle (Kunkel, Nagel & Jercinovic 2012; Kunkel & Jercinovic, 2013; Kunkel, 2013). Other analyzed volumes of this same intermolt cuticle medallion of Fig. 2, not shown here, illuminate additional new features of secondary and tertiary organule architecture. The newly revealed structures will need to be coordinated with information from other physical techniques which address the chemical nature of the structures. So, as in human health and mouse research, micro-CT potentially provides a wealth of new information about lobsters. The genesis and development of these newly described structures need to be correlated with our knowledge of the molting process, such as the diagnostic regional softening of the cuticle in the approach to molting (Waddy et al. 1995), and, as well, demand changes in the *ab initio* models of the lobster-shell composite structure (Nikolov et al. 2010).

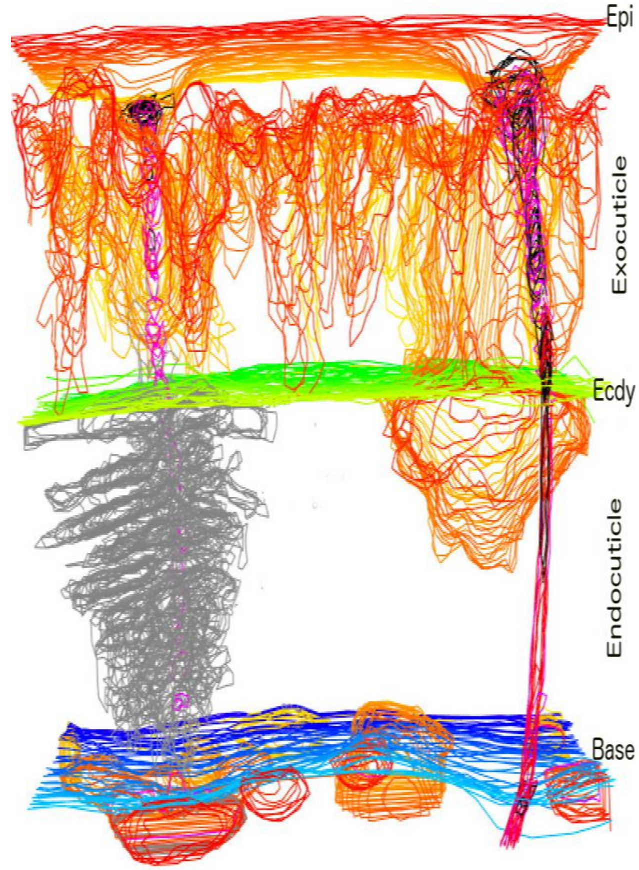

Figure 2. Select contours interpreted from 3D micro-CT voxels of density of Ca CO_3 forming stalactite-like (orange) structures extending down from the surface epicuticle (Epi) into the exocuticle. Black and red outlined canals of two primary organules reach from depressions in the surface to end below the Base layer of the endocuticle (blue). Grey whorls of Ca CO_3 form aligned with the spiral of 'twisted-plywood' chitin lamellae but in groups that suggest they are associated with each epidermal cell. Features with Ca CO_3 like density protrude through the ecdysial line (Ecdy) creating yet another departure from regular structure. Additional formed deposits of dense mineral are accumulated below the Base inner margin of the endocuticle. How do these structures change during the molting cycle? How do they relate to the progress of shell disease? How do they respond to ocean acidification? These questions can only be answered by an easily applied and rapid measurement such as microCT.

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Whale Interactions: Industry adaption to a major social issue

[Abstract of a presentation to the Trans Tasman Rock Lobster Congress 2015]

From: Jason How

The western rock lobster fishery (WRLF) has recently transitioned to a quota-based management system and has consequently seen a progression to year-round fishing as a result of effort-control restriction removal. This has seen fishing now overlapping more with the months when humpback whales (*Megaptera novaeangilae*) migrate along the west coast of Australia. The population of humpbacks which migrate along the West Australian coast from May to November has experienced a large increase in population size. The current population estimates are thought to be over 30 000, although debate exists around the accuracy of this estimate. There is however general agreement that this population is increasing at a rate of about 10% per annum, and hence posing an ever increasing risk of interactions with commercial fishing gear.

The Federal government placed a number of conditions on the Western Rock Lobster Fishery (WRLF) to reduce whale interactions, and this was coupled with pressure from the state regulatory authority (Department of Fisheries Western Australia). Interactions between humpback whales and WRLF gear involve entanglements and other contact with fishing gear. All levels of government acknowledge that WRLF gear interactions with humpback whales do not pose a risk to recovery of the humpback-whale population. Rather they wish to address the social and ethical issues relating to their interactions.

A number of research projects commenced to inform management of options that could be implemented to reduce whale interactions. The primary goal of research was to compile all available information on whale interactions and humpback migration and to test a number of possible gear modifications suggested by industry. The move to year-round fishing had an added financial bonus of between $50-100 million to the WRLF, and therefore options to maintain fishing in the presence of an increasing whale population were examined.

Gear modifications were introduced in June 2014 and were implemented until the end of the whale migration “season” (15 November 2014). Modifications in 2015 were implemented prior to the whale migration (1 May) and conclude on

15 November 2015. Modifications primarily focused on reducing the amount of rope in the fishery, particularly rope on the surface. When fishing deeper than 20 m, fishers are required to use no more than two times the water depth of rope, the first 1/3 of rope being held vertically in the water column (negatively buoyant), and to use a maximum of 3 floats, with only two floats permitted inside of 54 m depth. There are also restrictions on float rig length (less than 9 m) and pots have to be pulled every 7 days.

The introduction of gear modifications has seen a progressive decline in whale interactions. The number of interactions in WRLF gear peaked in 2013, with 18 interactions recorded. In 2014, there were seven interactions with WRLF gear, with four of these occurring prior to the introduction of gear modifications in 2014. At this writing, the 2015 whale migration is close to completion and to date there have been only two reported interactions of whales in WRLF gear. The effect of the gear modifications is currently being analysed as part of a Fisheries Research and Development Corporation project, which accounts for changes in fishing pressure, whale population growth, reporting rates and the impact of gear modifications.

While the impact of gear modifications has not been specifically determined, the decline in interactions with WRLF gear, and industry's adoption of these measures demonstrates the credentials of this fishery to deal with a social issue in a professional manner.

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COMMUNITY

Thanks to Ray George for contributing this light-hearted tribute to rock lobsters and those who study them.

Instructions to a Rock Lobster Scientist

From: Ray George

You're the scientist, young and bold
Go find the life cycle! Do as you're told

Here is a boat, a mesh net and a bottle
Go collect lots of things, it should be a doddle

Out in the boat, bobbing and wallowing
Towing the net, always following, following

Month after month, for over a year
Way offshore and then quite near.

And after he wrestled with all the allusions
The young scientist arrived at many conclusions

Close to the shore on warm summer nights
Rocky and wife get set for delights

As her ripe eggs burst in the night-time gloom
The littlies rapidly swim up to the moon

Strong are the breezes that take them offshore
Will they really disappear for long evermore?

No! Cos the ocean currents swirl them around
In great big circles, until they are found

On the edge of the Shelf, still way off the beach
But the end of their ride is now within reach

They swim to the reefs, they're shy and demure
Then hide in the crevices, nicely secure

For the first part of their life, they are silvery white
But soon colour red, as if in a fright

'How big will I be when I grow up'? Says Joe
Mum says 'Big as an elephant, called Jumbo'

Rockette asks proudly, 'after I marry,
How many golden eggs will I carry'?

'At four and a half and don't just laugh, you'll lay a million
And over your lifetime it's more like a billion'

'And how old will I be, when I die' says young Clive
'I reckon you'll last till at least thirty five

Unless you are caught in a trap near your home
And the fisherman sells you to Norway or Rome'.

Also submitted by Ray George is this amusing piece of lobster philosophy.

"Do Crayfish Dream?"

By Annie de Monchaux

Philosophically as a crustacean, "What is the meaning of life?" would have only two answers; eating and reproduction. In that order. Everything else a crayfish does rates a distant third, because whether they got to be a big crayfish depends a lot on whether they got eaten as a little cray fish.

If I wanted to be a crustacean I could choose from between 150 different species of rock lobster around the world and from nearly as many names; crayfish, hummer, kreeft, languster, marron, crawfish and so on. If I lived here, off the West Australian coast, I'd be formally called, at cocktail parties and exhibition launches, a Western Rock Lobster (based on my tendency to when not served grilled on lettuce leaves, home up under rocky outcrops) My mates, the crabs and so on would be more casual and call me crayfish. This name came from the nostalgic early European settlers who used names from their home and we apparently look like the crayfish they were used to seeing off the coast of England, Ireland and France.

Then of course I'd have a very fancy scientific name *Panulirus cygnus*, which has a delightfully romantic origin. Palinurus was a Greek mythological skipper who fell asleep while at sea. He fell overboard, drifted for days only to be butchered on the shores of Italy. His body was left unburied so his spirit could not cross the river Styx into heaven and was condemned to roam the sea within sight of land but never to come ashore.

Sex for crayfish is fairly elaborate. Goody. The females have a final pre-spawning moult (the equivalent to a serious exfoliation) then wait for optimum weather and food conditions, and it's thought perhaps the lunar cycle or rising water temperature produce the biological urge for courtship. No mull or champagne down there.

If I were a female I'd then be herded onto coral lumps and kept in a harem. Doesn't sound too comfy. Mind you I could look forward to the tangle of legs and a brief upright embrace before the male released sperm packets and sticky cementing substances onto my sternum.

When I'm ready to spawn, I'll sit upright, spreading my tail-fan to form a basket to catch and hold the eggs. The eggs flow and I'll use the claws on my walking legs to scratch and break the tar spot. The delicate beating of swimmerets on my abdomen creates water currents, which mixes the sperm and eggs together. Fertilized they'll stack neatly along fibrous strands forming a bright orange egg-mass or 'berry'. I personally think this colour doesn't suit me but, hey, I'm a crayfish now.

Now a large, mature female (as I'd surely be) can produce up to a million eggs and this is because our parenting instincts leave a little to be desired. We don't contemplate issues of road safety or to-spank-or-not-to-spank. Us crayfish Mums' strategy is to produce a vast number of offspring, and then leave them to the mercy of nature. With a normal life span of say ten to fifteen years and the potential to spawn twice a year a good woman can produce five to ten millions eggs which gives you some indication of the mortality rate before maturity.

Crayfish have a nominated birthday January 1st (like Australian race horses have been given August 1st) When we're about four, and a couple of years off sexual maturity we do our most spectacular exfoliate to date in preparation for a major migration and another phase in lifestyle. Migrating and being nomadic is what we do with favourite dens and great navigational skills.

As a craywoman I won't snack endlessly continuously grazing throughout the day as I do at the moment, which is a bonus. I'll emerge only in the protective cover of darkness and scavenge with my impressive set of cutlery. No dishes!

Location location location. I'd certainly boast that oceans as deep in parts as Mount Everest is high, (about seven miles) and tribes of fish and other twists of life evolved. Good company.

Another fascination we hold over humans lies in our ability to breathe water, it's a tantalizing fantasy and even scuba divers don't get close.

Do cray fish dream? Who knows they don't have eyelids so do they even sleep

I do know I'd have a fairly spectacular party trick to use for avoiding aquatic predators – I'd simply self-amputate a limb. The dropped limb keeping the predator busy while I make good my escape. However this is not without its drawbacks as the ability to find food is reduced, my position in the hierarchy falls and there is definitely a limit to how many legs a decapod can forgo. But, the missing limb is replaced at the next moult, which is a good thing.

Another good thing about being a cray is because I'm part of a lucrative industry I get a great publicity on TV at the start of each season. The down side is I might be caught. The flip side, I'd get to travel overseas. The bummer, I'd be eaten and sometime later, couple of days later, flushed down the toilet.

But us crays have been memorialized on T-shirts, key rings, salad server handles and one of my favourite books is Ernest Hemingway's Old Man and the Sea because he crystallized the meaning of life as grace under pressure in a story about an old fisherman and a giant cray fish. Well, that was the original version later edited to a marlin.

The Lobster NEWSLETTER

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