A LEARNING RESOURCE

Unit Standard 20306

Describe the biology of a species of Aquatic Crustacea

(Red Rock Lobster)

NEW ZEALAND seafood ITO

Contents

This resource was updated for SITO by NIWA, Wellington

Introduction

This book provides support information to prepare for:

Unit standard 20306 (version 2) Level 3, credits 5.
Describe the biology of Aquatic Crustacea

This learning resource is written for **the Red Rock Lobster *(Jasus edwardsii)***

The learning resource and unit standard 20306 covers:

1. The description of the Red Rock Lobster:
   (a) the scientific & common name of the species
   (b) features that distinguish it from other common rock lobster species
   (c) its habitat
   (d) its geographical location in New Zealand.

2. The location & identification of the main anatomical features of Red Rock Lobster:
   carapace, reproductive organs, gills, feeding track, gut, anal track.

3. A description of Red Rock Lobster's:
   (a) feeding method and food sources
   (b) stages of the reproductive cycle including embryo development & triggers for spawning
   (c) stages of the life cycle

4. A description of four factors that impact on the growth of Red Rock Lobsters, including:
   (a) four factors that can affect lobster growth
   (factors such as: water temperature, water quality, weather patterns, food availability, habitat, species age, stress)
   (b) the impact of each factor on lobster growth.

5. A description of abnormal features and/or behaviours that could indicate potential health issues:
   (a) five abnormal features and/or behaviours that could indicate a potential health issue
   (b) the action to take if abnormal features and/or behaviours are identified
   (c) two reasons why this action is important.

This learning resource is designed to accompany a course that includes examination of live lobsters. Here is some information about how the book is set out:

- Each section matches a separate element of the unit standard. So, for example, Section 1 of the book covers all of element 1.

- Activities to assist in learning are presented throughout the text in *blue italics*. So if you see writing in blue italics, you know that it is something that you have to do.

- **Key words or phrases** have been marked in **bold.** This is to help you revise the information easily.

- Self test questions are included at the end of each block of learning, covering the knowledge required for the unit standard.

- Throughout the text the sources of information are referenced using superscript numbers in square brackets – like this: [27]. These numbers refer to a list of references that is presented in the back of the book. So if you want more detail about a particular subject, note the number in the bracket, and then use the number to find the reference from the "References" section at the end of the book.

1. Describe the Red Rock Lobster & its natural habitat

1A Naming the crustacean species

Lobsters are strictly marine. They are 10 legged and all have the same basic body plan (head, tail, 2 pairs of antennae, no less than 6 pairs of mouthpart appendages and 5 pairs of legs.

Note 'Crayfish' or 'Cray' are strictly freshwater and are clawed i.e. NZ's Koura. Unfortunately 'Cray' is a common term used for NZ's marine lobsters. Koura is the general Maori name for both (freshwater) crayfish and (marine) lobsters.

New Zealand has four species of rock lobsters (spiny lobsters), the most common of which is the **Red Rock Lobster.** The scientific name of the Red Rock Lobster is ***Jasus edwardsii***. In Australia this species is known as the 'Southern Rock Lobster'.

The other species found in New Zealand are the:

- Packhorse Rock Lobster (Green Rock Lobster). The scientific name is Sagmariasus verreauxi. This lobster is less than 1% of commercial rock lobster landings. It is the world's largest rock lobster.
- Deepwater Rock Lobster (*Projasus parkeri*) is taken occasionally as bycatch from trawling but is not marketed.
- a Tropical Rock Lobster species (*Panulirus sp*.) found only at the Kermadec Islands[1].

1B Distinguishing Features

The Red Rock Lobster is dark red and orange above, paler and yellowish below. The body is spiny, especially on the head. They can weigh up to 8kg and reach lengths of about 60cm (excluding the feelers).

In contrast the Packhorse lobster is green not red, has a distinctive 'carapace' (the protective shell of the head & thorax). The Packhorse's carapace has a distinctive shape at the front part and distinctive patterns of spines. The Packhorse also has a lack of sculpting on its tail. As the world's largest rock lobster it has been found to weigh up to 20kg and reach lengths of 70cm.

Photo. J McKoy

The Deepwater Rock Lobster has a distinctive apricot colour, two prominent rows of spines on its carapace and a central ridge along the top of its tail. It is a much smaller rock lobster reaching lengths of 25cm.

The Tropical Rock Lobster species is a medium sized species of the western pacific. They have a distinctive structure at the base of each feeler that produces a sharp, rasping sound when the feelers move.

1C Habitat and Geographic Location

Habitat
Very small lobsters usually shelter alone in small cracks or holes. As they grow they become more gregarious and can be found in groups of 50 or more. This behaviour helps to protect them from predators. Once they become sexually mature their willingness to share dens varies seasonally especially for males (see section on reproduction).

During the day Red Rock Lobsters are normally found in rock crevices (dens), which provide shelter from predators, storms, and the sun. They generally leave the dens around dusk to forage for prey, returning just before dawn

The Deepwater Rock Lobster is a very deepwater lobster, found between 500m and at least 900m. Our knowledge of its deep rocky habitats is very limited.

Distribution
The Red Rock Lobster, *Jasus edwardsii*, is found throughout New Zealand, on seamounts in the Tasman Sea and around southern Australia. In New Zealand they are found from the Three Kings Islands in the north all the way to the Auckland Islands in the south and to the Chatham Islands in the east. They are also found on shallower seamounts to about 300 m depth throughout New Zealand's Exclusive Economic Zone. The Red Rock Lobsters found at the Auckland Islands are the southern-most rock lobsters in the world.

The rarer Packhorse Rock lobster are widely distributed, as far north as thew Kermadec Islands, south to Foveaux Strait, and east to the Chatham Islands. They are fished mainly in the far north of NZ. (It also occurs in eastern Australia, where it is commonly called the Eastern Rock Lobster.

The Deepwater Rock Lobster is widespread in the southern oceans. Most commonly found in the Bay of Plenty, off Wairarapa and the Chatham Rise.

Self Test Questions **Element 1**

1. What is the scientific name and common name of the Rock Lobster you are to be assessed on?

2. Name three features that distinguish Red Rock Lobster from another rock lobster species.

3. Describe the habitat of the Red Rock Lobster.

4. In what areas of New Zealand are Red Rock Lobster found? Is it found overseas?

2A External Features - location and identification

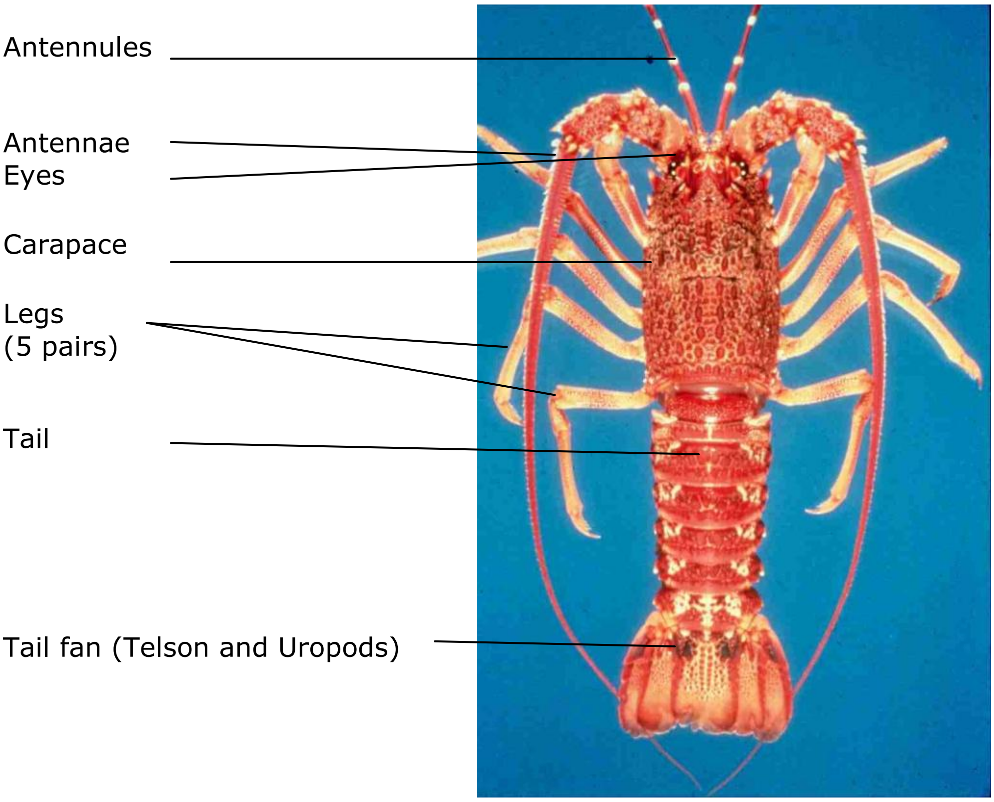


Photo: A. Blacklock

External features and their function

External Feature	Function
Eye	Compound eyes at the tip of the eye stalks
Antennae	Long "feelers" that can be rotated around to fend off predators. They also have some sensory function.
Antennules	The short slender appendages are capable of detecting food (tasting), danger, and pheremones
Legs	5 pairs of legs used for walking and feeding
Carapace (or cephalothorax, the head & thorax)	Protection of vital organs such as the liver, stomach, gonads, gills and heart by the exoskeleton case
Tail (or abdomen)	Consisting of 6 separate, moveable parts, plus the tail fan (telson and uropods). The main muscle for movement (swimming) away from danger. Under the tail are paired feather-like appendages (pleopods).

ACTIVITY 1
Examine a live Red Rock Lobster.
Identify the: *Carapace*
Reproductive organs

2B Internal Features – location and identification

ACTIVITY 3
To complete this section of learning it is helpful to actually look at a Red Rock Lobster as you work through the book. Cut a Red Rock Lobster carefully in half.

Look at your lobster carefully and see if you locate each of the following features:
- *Gills*
- *Feeding Track*
- *Gut*
- *Anal Track*

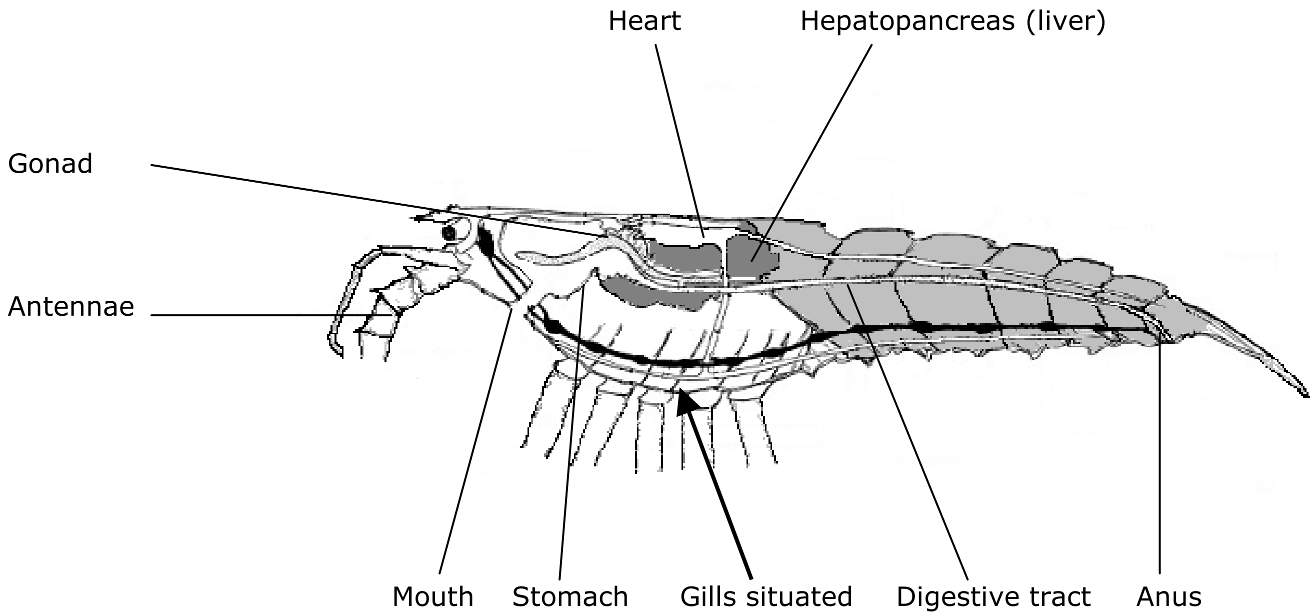


Figure: G. Moss

Internal Feature	Function
Mouth	The mouth is for the ingestion of food. It has a series of appendages associated with it that help bring the food to the mouth and crush it before ingestion.
Gills	The gills, which sit under the carapace at the base of each leg, are used for the uptake of oxygen from the water and release of carbon dioxide
Heart	The heart pumps the blood around the body of the lobsters
Gonad	The gonad produces eggs or sperm for reproduction.
Hepatopancreas (or liver)	The hepatopancreas (or liver) produces the digestive fluids which break down the food that is eaten
Digestive track	The digestive tract is used to absorb the nutrients from the food
Anus	The waste products of digestion are excreted through the anus

2C Sexual differences

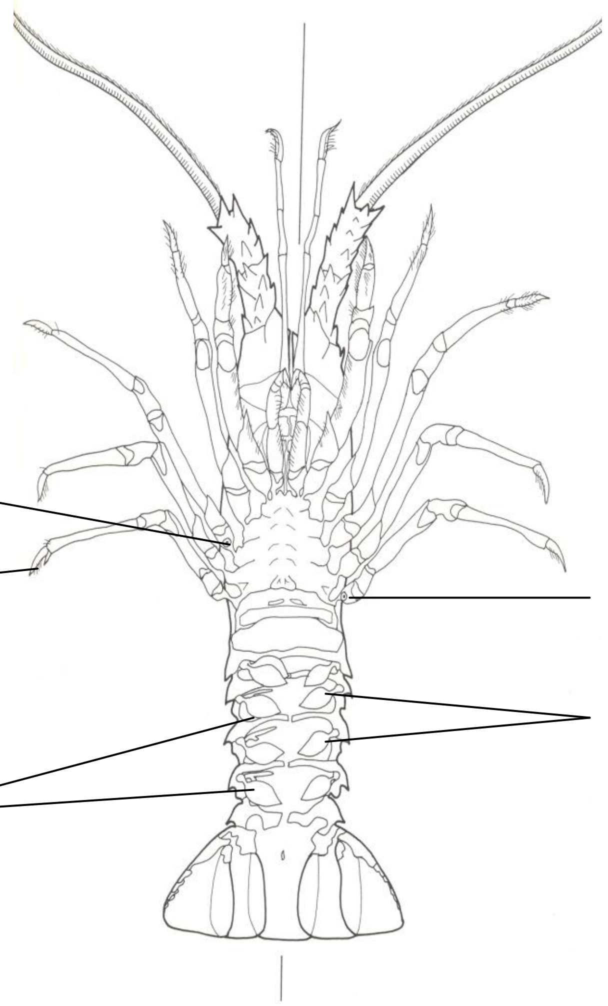


Figure. P. James

Difference	Function
Genital pores	**Females**. Positioned on the base of the 3rd walking leg for females so the eggs are extruded and pass through the sperm package the male deposits on her abdomen before attaching to the pleopods **Males**. Positioned on the base of the 5th walking leg for males so the sperm package is deposited below the female genital pores
Grooming claw	Present on the 5th leg of the **female** only, it is used for grooming the eggs when they are attached to the pleopods Not present on the **males**
Pleopods	**Females** have biramous (or double) pleopods. The innermost branches of the pleopods are covered with long hairs for the attachment of the eggs. The female keeps the eggs aerated by slowly beating her pleopods. **Males** have single pleopods

2C Sexual differences - continued

Female red rock lobsters have broader tails than male red rock lobsters of the same body size, so the minimum legal size is different for each sex. By law the minimum tail width of a Red Rock Lobster that can be taken is:

- at least 54mm for a male Red Rock Lobster
- at least 60mm for a female Red Rock Lobster

ACTIVITY 4

a. Are you able to identify whether the lobster you have opened is a male or a female?

b. Note the reasons for your decision

Self Test Questions **Element 2**

Look at a live Red Rock Lobster.

1. Can you identify the carapace and reproductive organs of the Red Rock Lobster?

2. Locate the following features:

Gills
Feeding Track
Gut
Anal Track

3. Feeding, Reproductive Cycle and Life Cycle

3A Feeding

Food and feeding
Lobsters feed on a wide range of small shellfish, crabs, starfish and kina, depending on local availability. They generally hold the prey with their front legs and crush it in their mandibles (or mouthparts).

In captivity they are usually fed fresh mussels (both blue mussels and Greenshell™ mussels). Feeding green mussels over a prolonged period produces a characteristic purple coloured lobster. Several artificial diets have been developed but these have yet to be shown to be a complete diet.

Photo: A Blacklock

Self Test Questions	**Element 3**
1. Describe the food sources and feeding methods of Red Rock Lobster.	

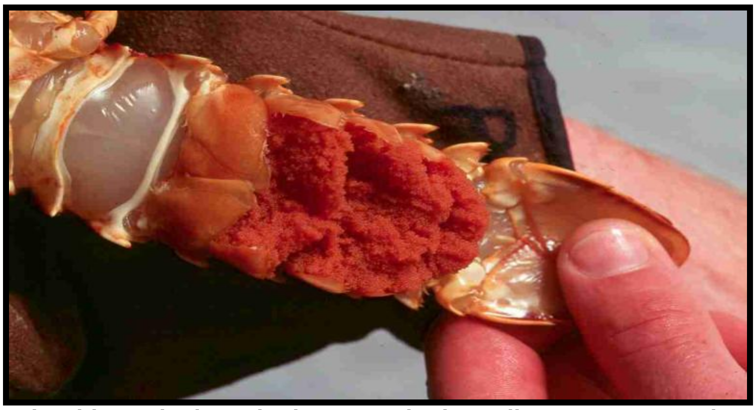
3B Reproductive Cycle of Red Rock Lobster

Moulting and mating
Female lobsters can only mate when the carapace is soft (i.e. within a few weeks of moulting). Red rock lobsters moult as early as late February in southern waters, but not until late June in warmer northern waters, and shortly after moulting (2 hours to 63 days) do they mate[2]. Lobsters are selective about who they mate with, large males prefer to mate with large females and females also prefer the largest male available.

Once a mate has been selected the lobsters begin courtship which may last just a few minutes or several days. When they are ready to mate they rear up, belly to belly and embrace before toppling over with the female uppermost. The male then deposits a sperm package (or spermatophore) onto the belly of the female.

The sperm package begins to disintegrate immediately, so the female rapidly starts to extrude her eggs. Normally she will cling to a rock face head up and form a brood chamber with her tail, spreading the tail fans to cover the genital pores and the sperm mass. Eggs are extruded from the genital pores and fertilised as they pass through the sperm package before attaching to the long hairs on the pleopods, under the tail. Small females may extrude as few as 20,000 eggs while large females may produce up to half a million. The fertilised eggs are carried for between 3 and 5 months, before hatching.

3B The Reproductive Cycle of Red Rock Lobster - continued



Berried female with newly deposited eggs under her tail ***Photo: A. Blacklock***

Large males become aggressive during the mating season, which usually results in one male per den. Females are also less likely to shelter together during mating when they are competing for the large males.

Self Test Questions **Element 3**

1. What factors determine that the female is ready to mate?
2. Describe what you would see if you witnessed two lobsters mating

3C Life Cycle of Red Rock Lobster

Adult lobsters
(sexually mature,
up to 50cm long)

Fertilized egg
(About 1mm across.
Carried under the
tail of the female
for 3-5 months
until hatching)

1st Larva stage
'Naupliosoma larva'
(about 2mm across)

2nd Larva stage
'Phyllosoma larva' (17 instars)
(18-24 months, about 4cm long)

3rd **Larva** stage
'Puerulus larva'

Newly settled **juveniles**
(about 5cm long)

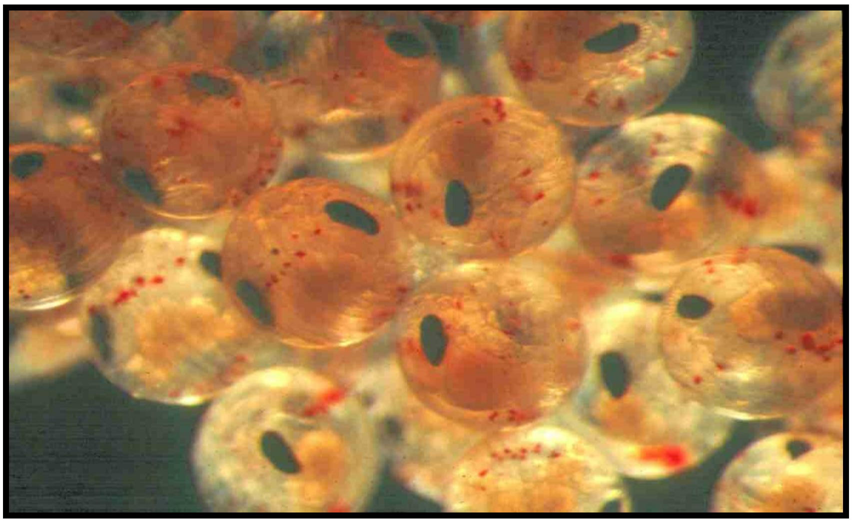
Juveniles
4-5 years

Life Cycle Summary

- Lobsters have a long and complex life history
- The adults mate and the females carry eggs (berried) for 3-5 months
- Larvae hatch and swim in the open ocean for 18-24 months, during which they undergo numerous moults and changes (11 phyllosoma stages)
- The puerulus stage settles and moults into the juvenile stage
- Juveniles mature and become adults after 4-5 years

3C Life Cycle of Red Rock Lobster - continued

Eggs and hatching
Females carry the eggs under the tail for 3-5 months. During this time the female keeps the eggs aerated by slowly beating the pleopods and groomed using small pincers on her rear walking legs. The embryos in the eggs develop through a number of stages, developing prominent eyes and legs (below), before becoming ready for hatching [3].



Well developed eggs just prior to hatching ***Photo: L. Tong***

Hatching occurs at daybreak during the spring. The female stands on tips of her legs with her tail held upright into the water current. She vigorously beats her pleopods for a few seconds, which releases a swarm of the first larval stage (naupliosoma). The eggs hatch into spider-like larvae which drift in the water for 12 -15 months, growing to around 50mm in length before returning to inshore areas to settle on the seafloor.

Larval stages
Naupliosoma larvae swim up to the light and within minutes moult into the transparent second stage Phyllosoma larva (below left). This small spider like creature has a body about 2 mm in length.

Phyllosoma Larva in 2 different stages

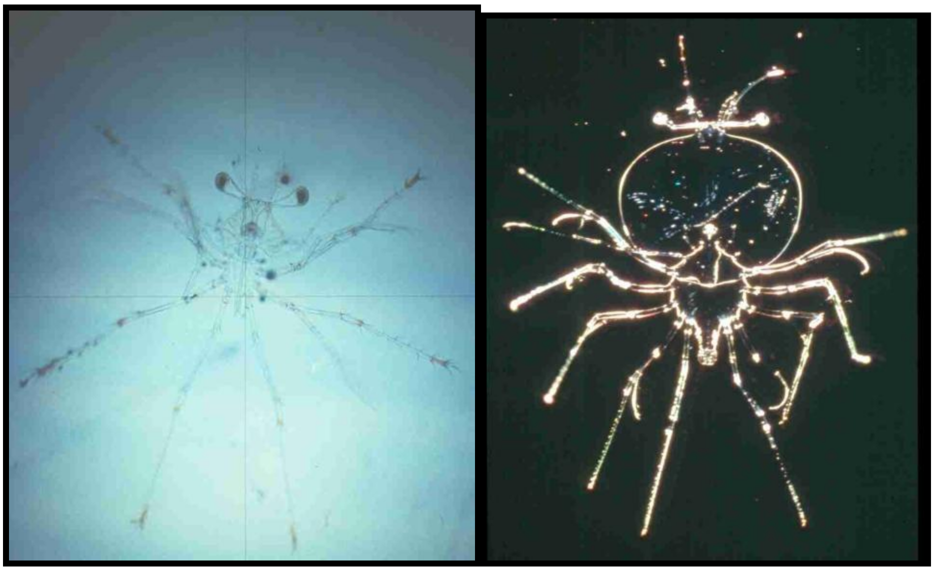


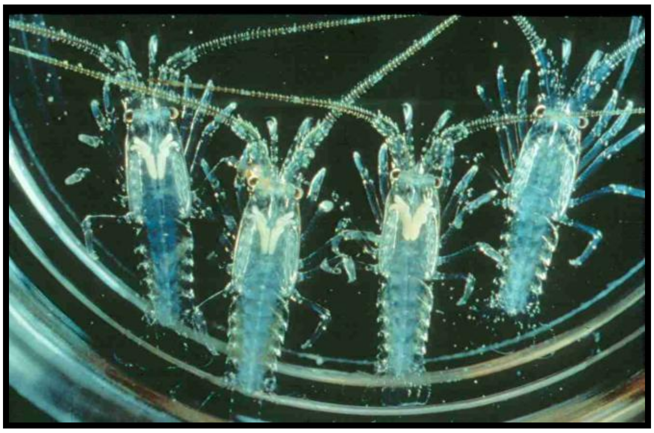
Photo: G. Moss ***Photo: A. Blacklock***

The phyllosoma stages are carried seaward by ocean currents and spend the next 18-24months growing through XI phyllosoma stages and 17 instars, up to 1000km from the shore. The long larval life and poor swimming of the phyllosomas mean that they get carried about by currents and caught up in eddies.

3C Life Cycle of Red Rock Lobster - continued

When they reach about 35-50 mm, the leaf-shaped phyllosomas (above right) metamorphose into the puerulus stage.

Pueruli look like small (25mm) transparent juvenile lobsters (below). They are good swimmers and can swim up to 150 km to the shore. During this stage they do not feed and survive on fat stores laid down by the phyllosoma stages.



Puerulus stage ***Photo: A. Blacklock***

Settlement, juvenile stage
Pueruli that successfully reach the shore, settle into small holes and crevices on shallow reefs and within 2-3 weeks moult into the juvenile stage and start to feed. Juveniles mature and become adults after 4-5 years.

Growth of lobsters

Moulting and growth
Lobsters have a hard shell (or 'exoskeleton') and in order to grow they must shed this shell (below) and replace it with a bigger one.

Before moulting ('ecdysis') the lobster begins to grow a new layer of exoskeleton beneath the old shell and begins to remove calcium from the old skeleton. When the lobster is ready to moult the membrane on the back of the lobster, between the carapace and the tail, splits and then the animal pulls itself out of the old shell. The lobster then takes up water, to swell up and enlarge the new shell, before redepositing the calcium and hardening the new shell.

This process of shedding the shell (or 'moulting') occurs frequently in small lobsters (4-6 weeks) when they are growing rapidly but usually occurs once a year in adult lobsters. The amount of growth is dependent on the size of the lobster the temperature of the seawater in which it has been held and the amount and type of food it has eaten.

Photo: G. Moss

Intact moult from a juvenile lobster ***Photo: G. Moss***

Migrations
In spring and early summer some juveniles migrate against the prevailing current. It is believed these migrations help counter the effect of downstream larval drift. Adult lobsters undertake seasonal inshore-offshore movements associated with moulting, breeding and feeding.

Maturation
At sexual maturity (70-120 mm carapace length depending on location) the female lobster's pleopods increase in size and the inner branch grows a fringe of pale hairs to which the eggs attach after mating. The males mature at about the same size but there are no obvious external changes. Large male red rock lobsters have been measured at 23 cm carapace length (54 cm body length) and weighing 5.4 kilograms. Females have reached 17 cm carapace length (45 cm body length) and weighing 2.3 kilograms [5].

Self Test Questions **Element 3**

1. Outline the main stages in the life cycle of a Red Rock lobster (Include a brief description of what each stage looks like, roughly how big it is at each stage and how long each stage lasts).

2. Describe how the female carries the fertilised eggs

3. Describe how the larvae stages are transported during their life span

4. Describe how pueruli increase their chances of survival

5. Describe why lobsters need to 'moult' their shell as they grow

6. About what size are male and female Red Rock Lobsters when they reach maturity

4. Factors that Impact on Growth

Factors	Impact
water temperature	• preferably stable with minimal daily and annual fluctuations. • the preferred range for growth is between 13 and 20^oC (optimum temperature for growth is around 18-20 ^oC)
water quality	• oxygen levels should be maintained between 85-105% saturation • salinity should be that of normal seawater (33 ppt) however juvenile lobsters can withstand periods of levels as low as 18ppt • waste products: Ammonia (toxicity varies with temperature and pH but TAN less than 0.5 mg/l); Nitrite (less than 1 mg/l); Nitrate (safe upper limits are 100 mg N/l for short term exposure and 50 mg N/l long term exposure) • optimum pH 7.8-8.2 • alkalinity should be maintained above 100 mg/l
stocking density	• the optimum density for growing juvenile lobsters (<30 mm carapace length) in tanks is 100/m^2
husbandry techniques	• lobsters kept at high densities in captivity require shelter to avoid cannibalism • light levels can also be reduced by providing shelter • lobsters prefer low light levels, they are prone to eye damage in bright light • minimising handling can help reduce infections by a range of pathogens
sediments	• appropriate filtration required for site and life cycle stages being reared • larvae and post-larvae are very susceptible to fine silts and 1 micron filtration is recommended • juveniles are somewhat less susceptible to fine silts but are still troubled by larger particles
biological contamination	• bacterial infections can be controlled by filtration and UV sterilization of the seawater • toxic algae can have an effect on survival of lobsters but can be controlled by treatment of incoming water with ozone
food and feeding	• lobsters eat a range of animals, shellfish, crabs and small fish • blue mussels (Mytilus galloprovincialis) and Greenshell™ mussels (Perna cannaliculus) can be fed to produce good growth rates • lobsters can be fed live mussels and can open them themselves • lobsters prefer and grow best when food is fresh not frozen • a number of experimental diets are being produced but have yet to prove to be complete replacement diets for mussels • feeding rates are dependent on temperature and other factors

Self Test Questions **Element 4**

1. Name four things (factors) that can influence the growth of Red Rock Lobsters.

2. Describe how each of these factors impact on the growth rate.

5. Potential Health Issues

A. What is disease?

Disease can be defined as **an abnormal condition that affects the performance or vital functions of the affected animal** [8].

Viruses, bacteria, fungi, protozoa, (all of which are organisms that are microscopic in size) and parasites of a variety of types and sizes can cause infectious diseases. Infectious diseases can often be passed directly from one organism to another (e.g. paua to paua, paua to mussel).

Non-infectious diseases cannot be passed from one organism to another, but are caused by external factors such as nutrition (e.g. availability or quality), environment (e.g. toxic phytoplankton blooms, smothering by competitors) or physical trauma (e.g. predator damage).

Quick action can prevent new infectious diseases from spreading, so if you think that your lobsters have some sort of disease, seek professional advice immediately.

B. How to tell if a lobster is sick

Following is a list of the kinds of symptoms that might indicate the possibility of disease in lobsters:

- high levels of mortality;
- low to moderate mortalities during the moult;
- white spots under the cuticle;
- loose shells
- fouling of the carapace and gills, lethargic behaviour;
- brown/black lesions at the base of gills near the insertion of the walking legs;
- larvae are luminous when viewed in the dark;
- erosion & blackening of the carapace, tail fan and walking legs;
- juveniles and adults become lethargic & stop feeding. The liver may become turbid &/or reddened;
- blackened lesions in the liver;
- fluid filled, swollen arthrodial membranes.

C. What to do

Some diseases can be minimised by managing the holding/growing conditions of the lobsters (for example, by minimising lobster stress). However, many of the diseases caused by micro-organisms like bacteria and viruses cannot be effectively treated once they are present. In these cases, the only course of action may be prevention of the spread of the disease by preventing the movement of lobsters from one holding tank to another.

Some diseases observed in cultured or 'held' lobsters have been an indicator of suboptimal conditions.

Response to common diseases:

Some things that cause health issues in lobsters are relatively common or well-known within the New Zealand lobster industry. In such cases, recommended management practices for dealing with such issues will already be established within the industry, and these practices should be implemented(e.g. improvement of water quality and /or holding conditions may be required).

Response to abnormal or unexplained illness:

The observation of abnormal or unexplained illness or mortality is potentially a much greater cause for concern. Identifying the cause of such problems, and if possible solving them, is a job for people with expertise in shellfish diseases.

- **Quick action can prevent new diseases from spreading, so don't hang back if you think there is a potential problem –** its better to be reassured that there is no problem than to do nothing and end up with widespread lobster mortality or illness.

- **Talk to the right people:**

  - If you are a new lobster farmer, or holder of lobsters, and not sure whether what you are observing is unusual or not, ask advice from several more experienced people in the industry (other farmers or processors).

  - Talk to members of your local Delivery Centre to find out how widespread to problem is in your area.

  - If it seems to be an unusual or new health issue, seek early advice from a scientist with expertise in crustacean diseases (the NZ Rock Lobster Association will be able to provide information on who to talk to). Depending on the type of disease, MAF Biosecurity may need to be informed of the problem.

  - Use established channels of communication within the industry – uncontrolled media releases before the nature of the problem has been properly established could result in significant unnecessary harm to the industry (see Section 5.4 below).

- **If there is a significant problem, follow the advice of the experts and regulatory officials** – for example, if controls on the movement of shellfish from one area to another are instituted, make sure that you comply to prevent the problem from spreading.

Remember, it is the people working with lobsters that are the "eyes of the industry". If you notice unusual symptoms in lobsters make sure that you inform the management of your organisation so that they can take appropriate action. If you are the management, listen to your staff and take action quickly.

D. Diseases that impact on Red Rock Lobster in NZ

Information about diseases in NZ aquaculture species, their gross signs, the causative agents, and any treatments or preventions is contained in the following handbook [8]:

Diggles, B.K., Hine, P.M., Handley, S., Boustead, N.C. (2002). A handbook of diseases of importance to aquaculture in New Zealand. NIWA Science and Technology Series No. 49. 200pp.

For convenience, extracts from this handbook on the following diseases that can impact Paua are provided on the following pages courtesy of NIWA.

A. Viral disease
- **White spot disease** *see Appendix 1*

B. Microbial disease
- **Bacterial enteritis** *see Appendix 2*
- **Epibiont fouling** *see Appendix 3*
- **Gill mycosis** *see Appendix 4*
- **Luminous vibriosis** *see Appendix 5*
- **Shell disease** *see Appendix 6*
- **Vibriosis (septicaemia)** *see Appendix 7*

C. Unknown causes
- **Black hepatopancreas disease** *see Appendix 8*
- **Turgid lobster syndrome** *see Appendix 9*

E. Non Disease Impacts - Environmental Stress

While not a disease many of the symptoms of environmental stress are similar to those of diseases. Signs that some environmental parameter may be causing lobster stress include:
- unusual behaviour,
- lethargy,
- loss of appetite, and
- death.

Self Test Questions **Element 5**

1. Describe five things that you might observe that could indicate a potential health issue in a Red Rock Lobster.

2. What actions need to be taken if mortality or illness is observed in lobsters? (Include what to do if the illness is one that is already known to the industry, and what to do if unexplained mortality or illness is observed).

3. Give two reasons why it is important that these actions are taken.

6. Glossary of Terms

Term	Explanation
Alkalinity	The pH buffering ability of the seawater
Ammonia	Waste product produced by lobsters as the result of feeding and growing.
Cannibalism	Where one animal eats another of the same species
Carapace	The part of the shell that covers the head and body of the lobster
Carbon dioxide	The waste product of respiration it passes out of the gills. Carbon dioxide dissolves in water to form a weak acid
Compound eyes	An eye, like that of insects, made up of numerous separate light sensitive units.
Eddies	Currents of water that move in a circular motion, like giant whirlpools.
Exoskeletion	The hard external skeleton (or shell) of the lobster
Filtration	Removal of particles from the water by mechanical means
Gregarious	Living together in groups
Maturity	When the lobster becomes an adult and is able to reproduce
Membrane	The skin covering a part of the body
Metamorphose	To undergo a complete change of physical form from the larval stage to the juvenile stage
Migrate	To move from one area or habitat to another
Moulting	The process of shedding the hard shell (or exoskeleton) in order to grow a new and bigger shell.
Naupliosoma	The first stage larva that hatches from the egg. It lasts only a few minutes before moulting into a phyllosoma
Nitrate	The end product of the breakdown of ammonia, it is relatively non-toxic
Nitrite	An intermediate product in the breakdown of ammonia
Oxygen	Oxygen is a soluble gas that is vital for life. Lobsters absorb oxygen from the water that passes over their gills
Ozone	A colourless gas which is a strong oxidizing agent used to sterilize water
pH	The acidity of the seawater, which affects the oxygen carrying capacity of the blood. Normal seawater pH is 8.0 - 8.6
Phyllosoma	The majority of the larval stages of the lobster. Phyllosoma spend 18 months to 2 years floating (and swimming in the plankton).
Pueruli	The final larval stages of the lobster. Pueruli actively swim to shore to settle and become juvenile lobsters
Salinity	The amount of salt in the seawater. This can change in seawater with evaporation or inflow of freshwater from rain or rivers
Seamounts	Underwater mountains rising from the ocean floor

7. References

1. MacDiarmid, A., Booth, J. (2003). Crayfish. Pp120-127 in Andrew, N. and Francis, M. (eds). The living reef. The ecology of New Zealand's Rocky Reefs. Craig Cotton Publishing, Nelson, New Zealand

2. MacDiarmid, A. B. (1989). Moulting and reproduction of the spiny lobster *Jasus edwardsii* (Decapoda: Palinuridae) in Northern New Zealand*. Marine Biology* 103, 303-10.

3. Tong, L. J.; Moss, G. A.; Pickering, T. D.; Paewai, M. M. (2000). Temperature effects on embryo and early larval development of the spiny lobster *Jasus edwardsii*, and a description of a method to predict larval hatch times. Marine and Freshwater Research 51: 243-248

4. Kittaka, J., and MacDiarmid, A. B. (1994). Breeding. Pp.384-401 in Phillips, B. F. Cobb J. S. Kittaka J. (eds). Spiny Lobster Management', Fishing News Books, London.

5. Paul, L., (2000). New Zealand Fishes. Reed publishing (NZ) Ltd, Auckland

6. Diggles, B.K., Hine, P.M., Handley, S., Boustead, N.C. (2002). A handbook of diseases of importance to aquaculture in New Zealand. NIWA Science and Technology Series No. 49. 200pp.

A. Viral disease

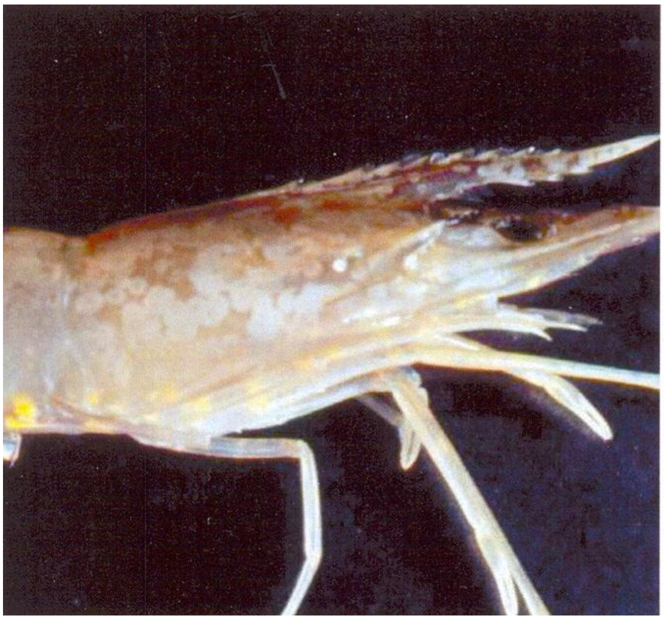
Appendix 1

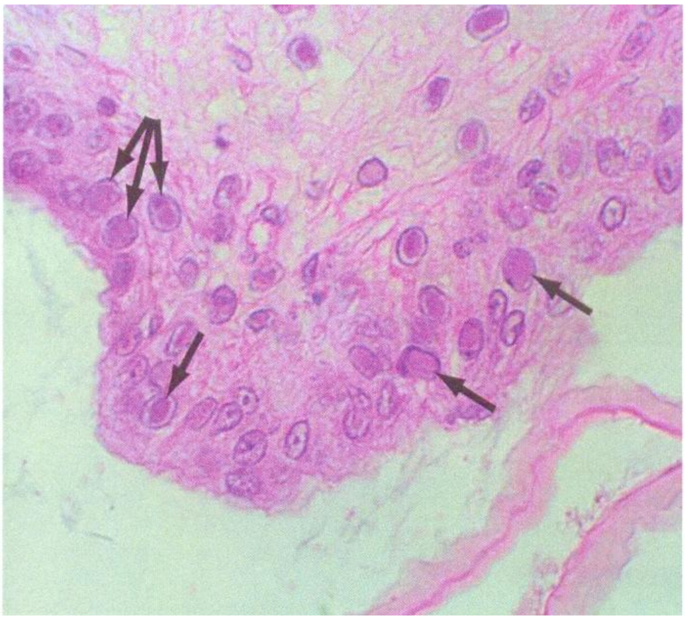
- **White spot disease (WSD) (white spot baculovirus, penaeid rod shaped DNA virus, systemic ectodermal and mesodermal baculovirus, and other names)**

Issue	Explanation
Species and life stage affected	A wide range of crustaceans, particularly penaeid prawns, but also crabs, spiny lobsters, copepods, and other arthropods
Gross signs	Cessation of feeding, formation of white spots (0.5-2 mm diameter) under the cuticle, loose shells followed by a rapid increase in mortality (up to 100% within 5-10 days).
Causative agent	White spot syndrome virus (WSSV) complex, a closely related group of double stranded DNA baculo-like viruses.
Diagnosis	Presumptive diagnosis is sometimes attempted upon viewing white spots on the cuticle, but this is unreliable as similar lesions can occur from infection by other disease agents (e.g., Wang et al. 2000), and some species do not display lesions (Rajendran et al. 1999). A minimum of histopathology is required to demonstrate the presence of characteristic basophilic inclusion bodies in the nuclei of tissues of ectodermal and mesodermal origin. Definitive diagnosis requires a combination of one or more of the following methods; PCR, ISH, western blot analysis, or TEM (Lightner 1999, OIE 2000).
Treatment and prevention	No treatment available. Once WSD is confirmed in an aquaculture facility, slaughter followed by disinfection and drying out are required. WSSV can be deactivated using UV irradiation (9 x 105 IlW/ml), heat treatment (55°C for 90 min, 70°C for 5 min), acidity (pH 3 for 1 h, alkalinity (pH 12 for 10 min), ozone (0.5 Ilg/ml for 10 min) and bleach and povidone iodine (l00 ppm for 10 min) (Chang et al. 1998). Avoidance is through exclusion of wild crustaceans which are potential reservoirs of infection, PCR testing of broodstock, and development of resistant stocks. The virus survives freezing and can be introduced via imports of frozen prawns and crabs originating from areas where the disease occurs.
Distribution worldwide	WSD was first reported in farmed Penaeus japonicus in Japan in 1993, and has since been spread throughout China and to other prawn farming areas in Asia, India, Europe, the Middle East, the United States and South America.
Distribution in New Zealand	Unreported, but as WSSV infects a wide range of crustaceans, it may be a potential threat to culture of crustaceans in New Zealand. WSD IS AN INTERNATIONALLY NOTIFIABLE DISEASE. IF YOU SUSPECT THAT YOUR STOCK HAVE THIS DISEASE. RING MAF ON 0800-809-966
General comments	WSSV has naturally or experimentally infected over 50 species of crustaceans, including most species of penaeid prawns (Lightner 1999), several genera of crabs, spiny lobsters (genus Panulirus) and freshwater prawns (Macro brachium sp.) (Rajendran et al. 1999), and freshwater crayfish. Many of these species can act as asymptomatic reservoirs of infection. Total losses of 100% of stock and 80% of total production are common in countries where penaeid culture has been newly affected by WSD (Gillespie 2000, Nair 2000). Total financial losses to aquaculturists worldwide attributed to WSD between 1993 and 2000 are thought to approach US$ 4 to 6 billion (Lightner 1999).

Issue	Explanation
References	Chang, P.; Chen, LJ; Wang, Y.C. (1998). The effect of ultraviolet radiation, heat, pH, ozone, salinity and chemical disinfectants on the infectivity of white spot syndrome baculovirus. Aquaculture 166: 1-17. Gillespie, D. (2000). Peru turns to tilapia as disease devastates shrimp. Fish Farming International 27(2): 4. Lightner, D.V. (1999). The penaeid shrimp viruses TSV, IHHNV, WSSV, and YHV: current status in the Americas, available diagnostic methods and management strategies. Journal of Applied Aquaculture 9: 27-52. Nair, M.R. (2000). History and present status of white spot baculovirus (WSBV) and other shrimp diseases in India. World Aquaculture 31: 10-13. O.I.E. (2000). White spot disease, In: Diagnostic manual for aquatic animal diseases. 3rd edition, pp 182-191. Office International des Epizooties, Paris, France. Rajendran, K.V.; Vijayan, K.K.; Santiago, T.C.; Krol, R.M. (1999). Experimental host range and histopathology of white spot syndrome virus (WSSV) infection in shrimp, prawns, crabs and lobsters from India. Journal of Fish Diseases 22: 183-191. Wang, Y.G.; Lee, K.L.; Najiah, M.; Shariff, M.; Hassan, M.D. (2000). A new bacterial white spot syndrome (BWSS) in cultured tiger shrimp Penaeus monodon and its comparison with white spot syndrome (WSS) caused by virus. Diseases of Aquatic Organisms 41: 9-18.

White Spot Disease in cultured prawns. Photos: D. Lightner.





Left: Gross appearance of WSSV infected *Penaeus monodon* exhibiting classical WSD lesions on the carapace.
Right: Histological section through the stomach of a penaeid prawn showing the presence of WSSV intranuclear inclusion bodies (arrows) within cuticular epithelium.

Reproduced from Diggles et al. (2002) courtesy NIWA

B. Microbial disease

• Bacterial enteritis

Issue	Explanation
Species and life stage affected	Larval, juvenile, and adult red rock lobsters *(Jasus edwardsii).*
Gross signs	**No specific gross signs. Lobsters with advanced infections may stop feeding and become lethargic**
Causative agent	Probably numerous types of opportunistic marine bacteria, including *Vibrio harveyi.*
Diagnosis	Bacterial erosion of the hepatopancreas tubules, usually without septicemia, detected by histopathology. Complete erosion of the epithelium may elicit a host reaction. If culture of implicated bacteria is attempted, discriminating causative agents from the bacterial flora normally present in the hepatopancreas is difficult.
Treatment and prevention	Bacterial diseases usually result from injury or sub-optimal culture conditions, so improvement of water quality, food quality, or rearing system design may be required to improve the health of stock and prevent reoccurrence of disease. Antibiotic treatment may be possible if the bacteria involved can be identified and their antibiotic sensitivities can be determined, though problems with development of resistant strains of bacteria may occur with prolonged antibiotic use.
Distribution worldwide	Has also been recorded in *J. edwardsii* from Australia (Handlinger et al. 2000).
Distribution in New Zealand	Observed in lobsters held throughout the country. Possibly a problem wherever lobsters are cultured intensively under suboptimal conditions.
General comments	Bacterial enteritis is usually recorded in heavily fouled and/or moribund lobsters and may be related to cessation of feeding
References	Handlinger, J.; Carson, J.; Ritar, A.; Crear, B., Taylor, D.; Johnson, D. (2000). Disease conditions of cultured phyllosoma larvae and juveniles of southern rock lobster *(Jasus edwardsii). In:* Evans, L.H.; Jones, J.B. (eds) Proceedings of the International Symposium on Lobster Health Management, pp. 75-87. Adelaide (Australia), 19-22 September 1999.

B. Microbial disease

- **Bacterial enteritis** continued

Histology of bacterial enteritis in *Jasus edwardsii.* Photos: J. Handlinger

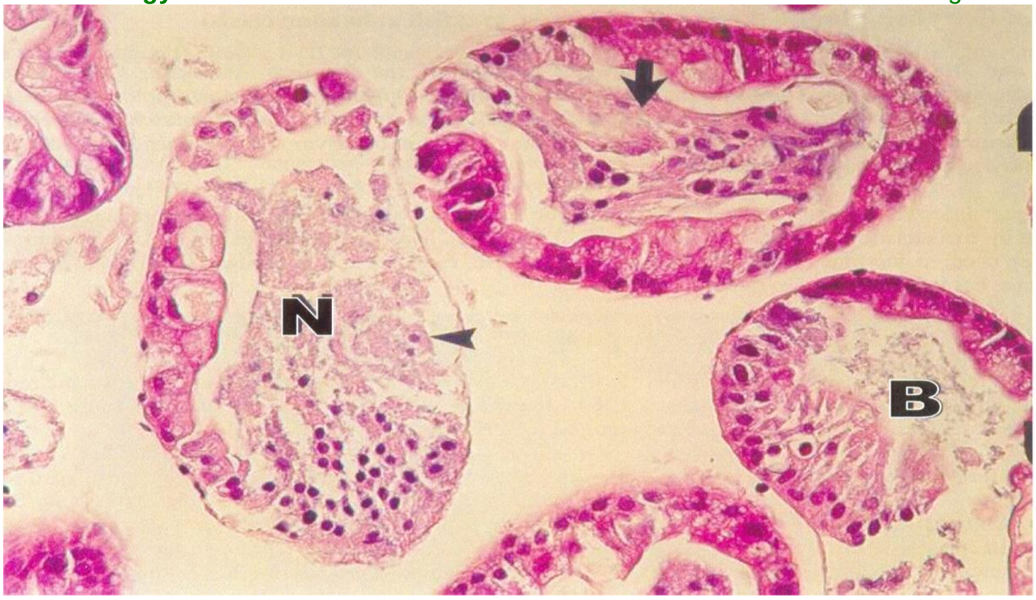


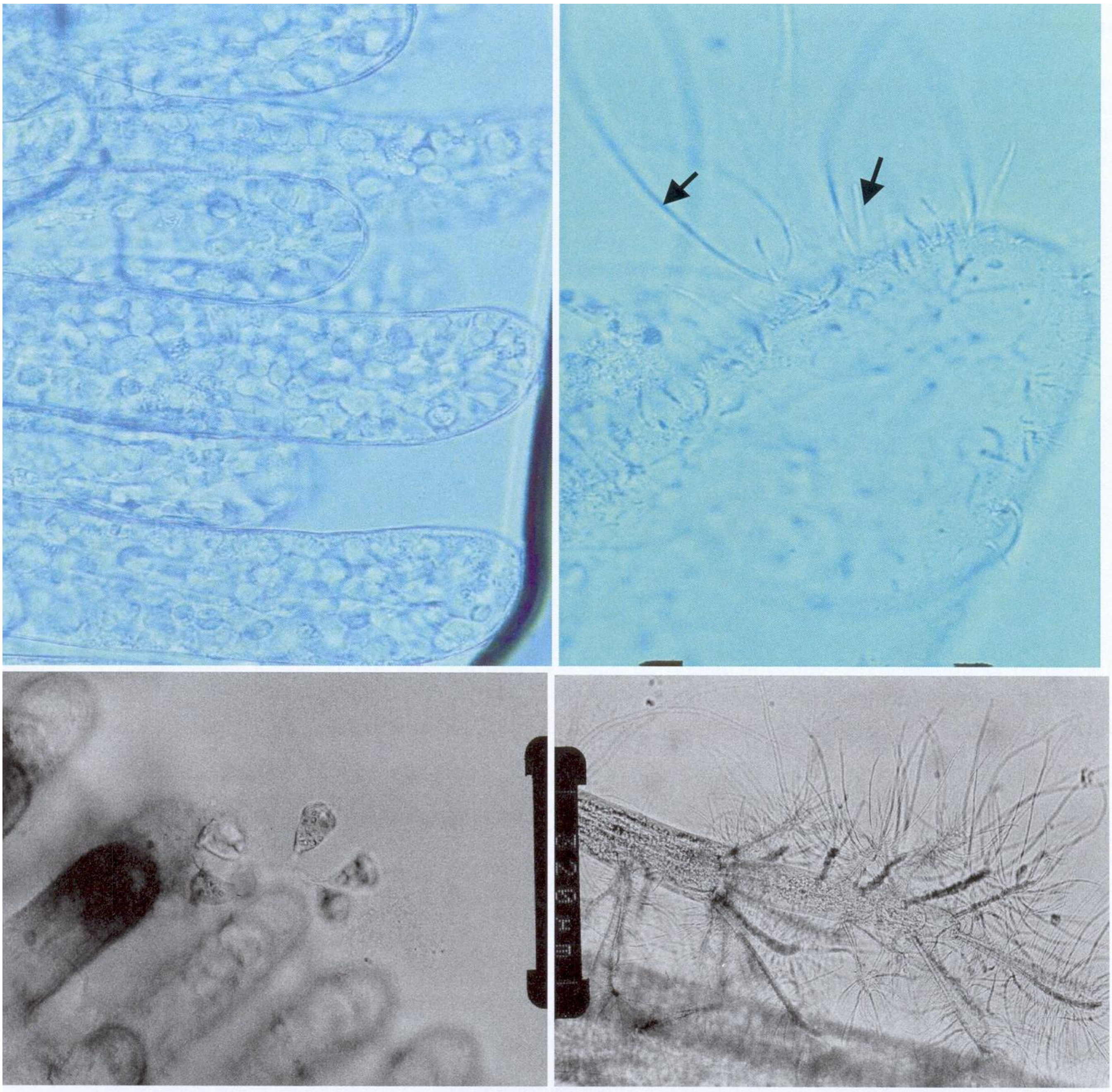
Photo above: Note generalised necrosis of hepatopancreocytes (N, arrowhead) in one hepatopancreas tubule, 1 bacteria (B, arrow)) in the lumen of other tubules of a juvenile lobster.

Photo above: Areas of focal erosion hepatopancreas epithelium (arrowheads) associated with bacteria in an adult lobster

Reproduced from Diggles et al. (2002) courtesy NIWA

• Epibiont fouling

Issue	Explanation
Species and life stage affected	Phyllosoma larvae, puerulus larvae, and juveniles of red rock lobsters *(Jasus edwardsii)* and packhorse lobsters *(J verreauxi).* Adult paddle crabs *(Ovalipes catharus).*
Gross signs	**Fouling of external surfaces, especially the carapace and gills, with microbial epibionts and organic detritus, lethargic behaviour, low to moderate mortalities, especially during the moult.**
Causative agent	Various types of filamentous *Leucothrix-like* bacteria, sessile ciliates *(Carchesium* sp., *Epistylis* sp., *Zoothamnium* sp.), free living nematodes.
Diagnosis	Mixed growths of filamentous *Leucothrix-like* bacteria, rod shaped and gliding bacteria, sessile stalked ciliates, and sometimes free living nematodes and detritus are evident when whole larvae or affected areas of gills of juveniles are examined using wet squashes or histology. Heavy fouling may be associated with gill necrosis in juvenile lobsters and adult paddle crabs.
Treatment and prevention	Increasing water flow and aeration can reduce fouling problems. Chemical baths with formalin, chelated copper compounds, and algicides may also reduce epibiont loading. Prevention is via increased water flow and improved system hygiene. High temperatures (over 20°C) increase the need for adequate water flow. Decontamination of *Artemia* used as live food for phyllosoma larvae is important to prevent *Artemia* acting as vectors for fouling organisms.
Distribution worldwide	Epibiont fouling is a ubiquitous problem in the intensive culture of crustaceans worldwide, including homarid lobsters (Fisher et al. 1978) and penaeid prawns (Lightner, 1983).
Distribution in New Zealand	Observed in samples taken from throughout the country, but particularly in the North Island where water temperatures are higher. Possibly a problem wherever lobsters and crabs are cultured intensively under sub-optimal conditions.
General comments	Mortalities of juvenile lobsters in rearing systems using recirculated seawater can be associated with moderate to heavy growths of epibionts. Affected animals are sluggish and exhibit brown coloration in the gills. Most deaths occur at night just before or during the moult, probably because oxygen demand increases at night, when moulting usually occurs, and the heavy epibiont growth reduces respiratory effectiveness. Epibionts appear to be gradually accumulated over time. Their presence indicates poor system hygiene or poor water flow. Heavy epibiont growth on phyllosoma larvae is common in upwelling systems using a high percentage of recirculated water.
References	Fisher, W.S.; Nilson, E.H.; Steenbergen, J.F.; Lightner, D.V. (1978). Microbial diseases of cultured lobsters: a review. *Aquaculture* 14: 115-140. Lightner, D.V. (1983). Diseases of cultured shrimp. *In:* McVey, P.V. (ed). CRC handbook ofmariculture, Vol. I. Crustacean aquaculture, pp. 289-320. CRC Press, Boca Raton.



Epibiont infestations in *Jasus* spp..   Photos: B. Diggles.

Above left: Wet preparation of normal gills of a juvenile *J. edwardsii.*
Above right: Wet preparation of lobster gills with a moderate infestation of a *Leucothrix-like* filamentous bacteria (arrows).
Below left: Sessile ciliate *(Carchesium* sp.) attached to gill of a juvenile lobster.
Below right: Wet squash of the leg of a phyllosoma larva of *J. verreauxi* showing heavy fouling by a *Leucothrix-like* filamentous bacteria.

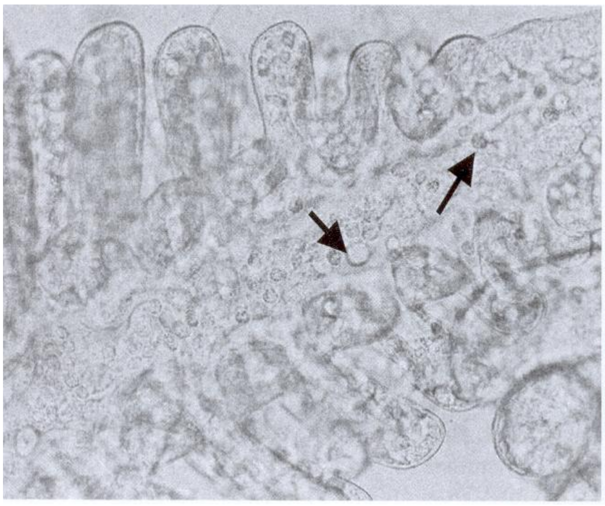
- **Gill mycosis**

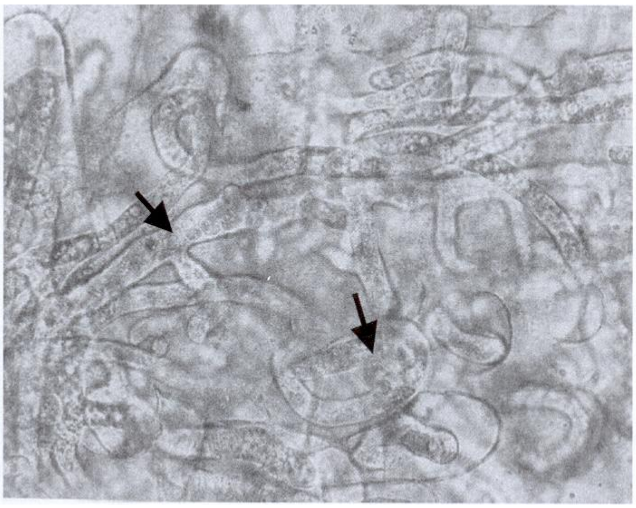
Issue	Explanation
Species and life stage affected	Red rock lobster *(Jasus edwardsii)* puerulus larvae and juveniles up to 30 mm carapace length
Gross signs	**Brown/black lesions at the base of the gills near insertion of the walking legs, lethargic behaviour, low to moderate mortalities, especially during the moult.**
Causative agent	An invasive fungus, *Haliphthoros* sp.
Diagnosis	Fungal mycelia are easily observed under the microscope in wet preparations of the gill filaments adjacent to the blackened areas, or by using routine histopathological methods. Specific identification of the causative fungus can be obtained by inoculating infected gill filaments into marine agar 2216 (Difco) containing antibiotics to culture the fungus. Identification can then be performed using morphological and/or molecular techniques.
Treatment and prevention	The fungal spores are susceptible to a variety of chemical treatments, including trifuralin, formalin, and malachite green (Diggles 2001), but the disease can be prevented by improving husbandry such as removal of uneaten food and regular cleaning of detritus from tanks.
Distribution worldwide	Invasive mycoses caused by the fungus *Haliphthoros milfordensis* have been recorded in homarid lobsters in the Northern Hemisphere (Fisher et at. 1975, Fisher & Nilson, 1977).
Distribution in New Zealand	Has been observed in onshore experimental grow-out facilities on the southeast coast of the North Island. Not known from wild lobsters.
General comments	This disease has been associated with significant mortalities in puerulus and juvenile *J. edwardsii* held for ongrowing at water temperatures between 10 and 18 °e. Up to 30 50% of animals were affected in poorly maintained systems. The disease generally does not affect lobsters greater than 30 rom carapace length. Death of affected lobsters usually occurs just before or during the moult, perhaps from restriction of moulting due to extensive melanisation (Fisher et at. 1975, Fisher & Nilson 1977), though secondary bacterial infection may also be implicated in some cases
References	Diggles, B.K. (2001). A mycosis of juvenile spiny rock lobster *Jasus edwardsii* (Hutton, 1875) caused by *Haliphthoros* sp., and possible methods of chemical control. *Journal of Fish Diseases* 24: 99-110. Fisher, W.S.; Nilson, E.H.; SWeser, R.A. (1975) Effect of the fungus *Haliphthoros milfordensis* on the juvenile stages of the American lobster *Homarus americanus. Journal of Invertebrate Pathology* 26: 41-45. Fisher, W.S.; Nilson, E.H.; Steenbergen, J.F.; Lightner, D.V. (1978) Microbial diseases of cultured lobsters: A review. *Aquaculture* 14: 115-140.

Gill mycosis in juvenile *Jasus edwardsii*. Photos: B. Diggles.

Above: A black/brown lesion in the gills (arrow) at a site of fungal infection. Melanisation is particularly apparent at the base of the walking leg.

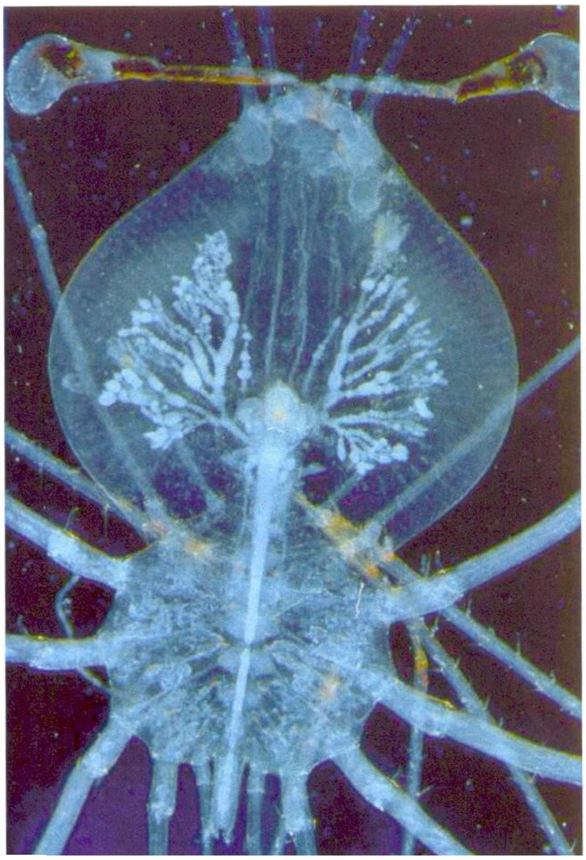
Below left: Wet squash of nonnal gill, containing haemocytes (arrows).
Below right: Wet squash of gill from a gill lesion showing fungal hyphae (arrows) inside the gill cuticle.





• Luminous vibriosis

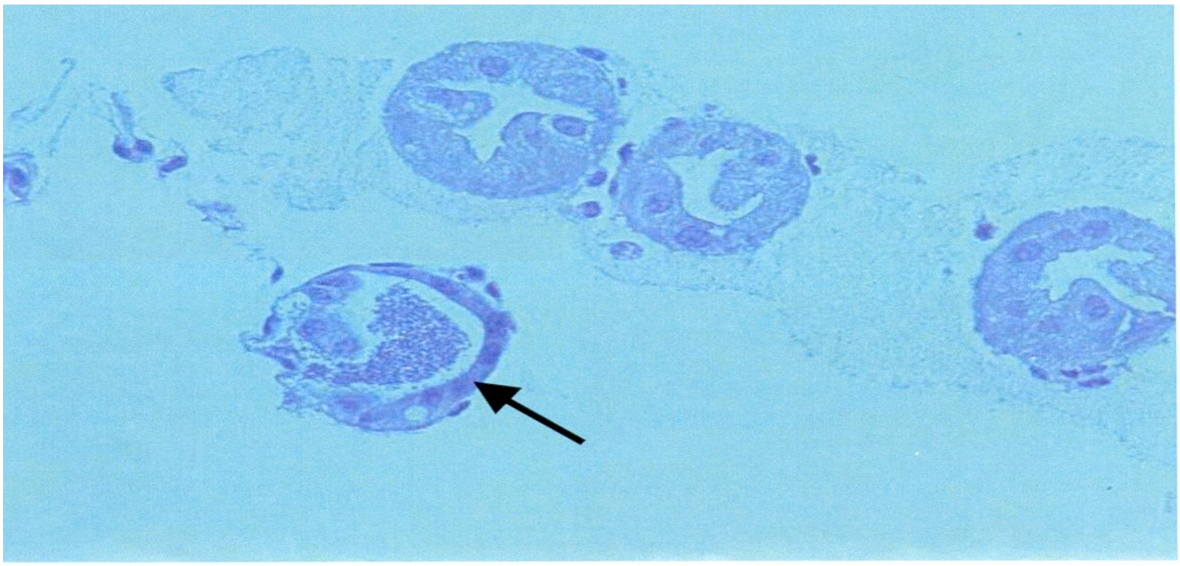
Issue	Explanation
Species and life stage affected	Phyllosoma larvae of packhorse rock lobster *(Jasus verreauxi).*
Gross signs	**Larvae are luminous when viewed in the dark, moderate to heavy mortalities.**
Causative agent	Luminescent marine bacteria, particularly *Vibrio harveyi*
Diagnosis	Presumptive diagnosis can sometimes be obtained by observing larvae in complete darkness. Those affected by *V. harveyi* can be faintly luminous in the dark. Massive bacterial plaques will be evident in the lumen of hepatopancreas tubules using histopathology. Definitive diagnosis requires culture ofluminescent bacteria such as *V. harveyi* from internal organs followed by biochemical or molecular characterisation.
Treatment and prevention	*Vibrio harveyi* may be introduced into larval culture tanks through the water or via live food such as *Artemia,* so thorough decontamination of water, live food, and tank surfaces is recommended to minimise bacterial growth. Any handling that may injure larvae will increase mortality rates. Infection may be transferred by cannibalism, so removal of dead larvae from affected systems is recommended. Treatment with antibiotics may be successful initially, but deformities of larvae may occur and antibiotic resistance is likely to develop over time. Conditioning of culture water and/or live food with probiotic bacteria (Moriarty 1998) are worth investigation as possible methods of prevention
Distribution worldwide	Luminous vibriosis is a persistent problem in rearing of larval and juvenile penaeid prawns worldwide (Lightner 1983, Lavilla-Pitogo et al. 1998). It also occurs in phyllosoma larvae of *J. edwardsii* in Tasmania (B. Crear, personal communication).
Distribution in New Zealand	Has been recorded in experimental culture of phyllosoma larvae of *Jasus verreauxi* in Wellington. Possibly a problem wherever phyllosoma larvae are cultured intensively under sub-optimal conditions
General comments	Onset of disease in *J. verreauxi* phyllosoma larvae occurs as early as the 1st instar at water temperatures of 23°C, and can affect larvae at temperatures down to 16 °C (Diggles et al. 2000). Losses of up to 80% of stock have been attributed to the disease
References	Diggles, B.K.; Moss, G.A.; Carson, J.; Anderson, C.D. (2000). Luminous vibriosis in rock lobster *Jasus verreauxi* (Decapoda: Palinuridae) phyllosoma larvae associated with infection by *Vibrio harveyi. Diseases of Aquatic Organisms* 43: 127-137. Lavilla-Pitogo, C.R.; Leano, E.M.; Paner, M.G. (1998). Mortalities of pond-cultured juvenile shrimp, *Penaeus monodon,* associated with dominance ofluminescent vibrios in the rearing environment. *Aquaculture* 164: 337-349. Moriarty, D.W. (1998). Control ofluminous *Vibrio* species in penaeid aquaculture ponds. *Aquaculture* 164: 351-358. Lightner, D.V. (1983). Diseases of cultured shrimp. *In:* McVey, P.V. (ed), CRC handbook ofmariculture, Vol. I. Crustacean aquaculture, pp. 289-320. CRC Press, Boca Raton.



Luminous vibriosis of phyllosoma larvae of *Jasus verreauxi*. Photos: B. Diggles.

Above left: Uninfected larvae, note transparent appearance.
Above right: Fourth instar phyllosoma infected with *Vibrio harveyi.* Note the opaque hepatopancreas and appendages filled with luminescent bacteria, and melanised base of the eye stalks.

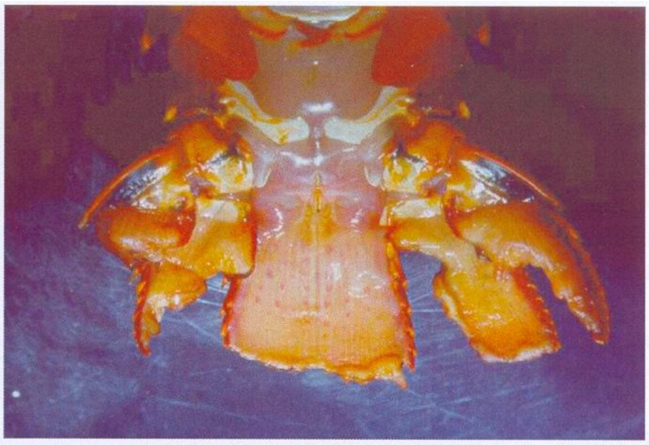
Below: Histopathology of hepatopancreas tubules of a luminous phyllosoma. Note atrophy of the lower tubule (arrow) which contains masses of bacteria.

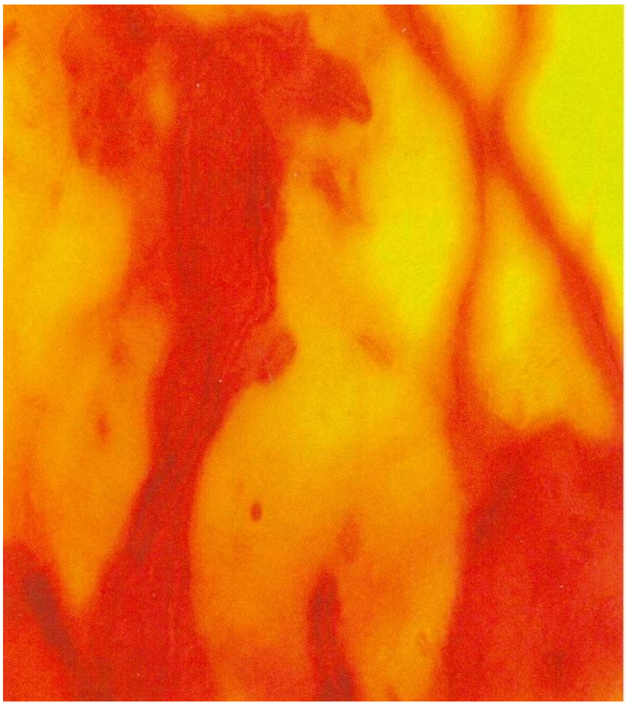


• Shell disease

Issue	Explanation
Species and life stage affected	Juvenile and adult red rock lobsters *(Jasus edwardsii),* adult packhorse lobsters *(J. verreauxi),* and adult paddle crabs *(Ovalipes catharus).*
Gross signs	**Erosion and blackening of the carapace, tail fan, and walking legs. Blister-like lesions on the tail fan may also occur, but their cause may be distinct from classical shell disease.**
Causative agent	Presumably chitinoclastic bacteria *(Vibrio* sp., *Pseudomonas* sp., *Aeromonas* sp.), and/or unidentified fungi.
Diagnosis	Erosion and/or blackening of affected areas of the cuticle are easily observed with the naked eye. Microscopic examination of the affected areas can be used to attempt to determine whether disease is associated with bacterial or fungal invaders. Both may be visible in wet preparations. Culturing causative agents and demonstrating their involvement is usually difficult due to the high numbers of naturally occurring heterotrophic bacteria present on the carapace.
Treatment and prevention	Occurrence of shell disease in cultured crustaceans indicates that improvement of water quality and/or holding conditions may be required. Elimination of potential sources of injury should assist in reducing the prevalence of shell disease and also tail blisters
Distribution worldwide	Shell disease is ubiquitous and occurs in both marine and freshwater crustaceans worldwide (Getchell 1989, Sindermann 1990, Noga et al. 2000). Tail blistering apparently has been reported only from *Jasus edwardsii* in Australia and New Zealand.
Distribution in New Zealand	Occurs throughout New Zealand.
General comments	Shell disease has been recorded in both wild and captive *Jasus edwardsii* and *J. verreauxi.* In these species, shell disease lesions are most obvious on the ventral part of the tail fan and other areas of the carapace in contact with bottom surfaces or subject to injury. Superficial lesions are usually eliminated during moulting. The cause is assumed to be infection of wounds or abrasions by chitinoclastic bacteria. However, fungi are occasionally implicated. Blistering of the tail fan may be a syndrome distinct from classical shell disease and its cause requires further investigation.
References	Getchell, R.G. (1989). Bacterial shell disease in crustaceans: a review. *Journal of Shellfish Research* 8: 1-6. Noga, EJ.; Smolowitz, R.; Khoo, L.H. (2000). Pathology of shell disease in the blue crab, *Callinectes sapidus* Rathburn (Decapoda: Portunidae). *Journal of Fish Diseases* 23: 389-399. Sindermann, C.l. (1990). Bacterial diseases of crustaceans. *In.* Principal diseases of marine fish and shellfish. Vol. 2, 2nd edition, pp. 48-70. Academic Press, San Diego.

Shell disease and tail blistering in lobsters. Photos: B. Diggles and N. Raethke





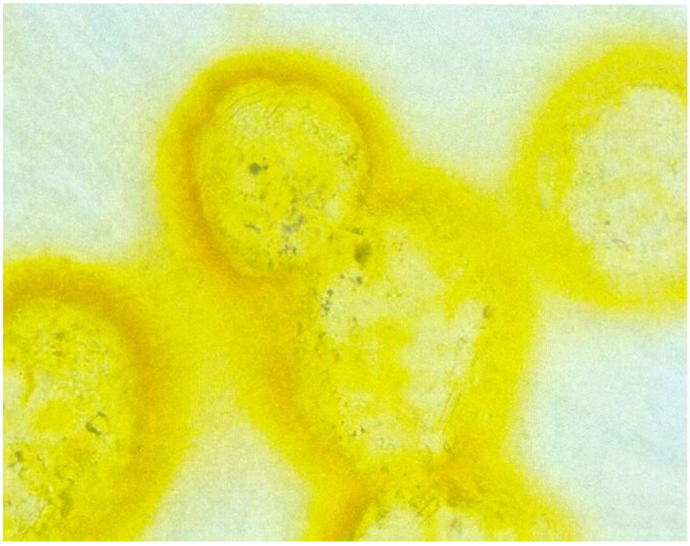
Above left: Tail blisters (arrows) in *J. edwardsii* held in a concrete tank.

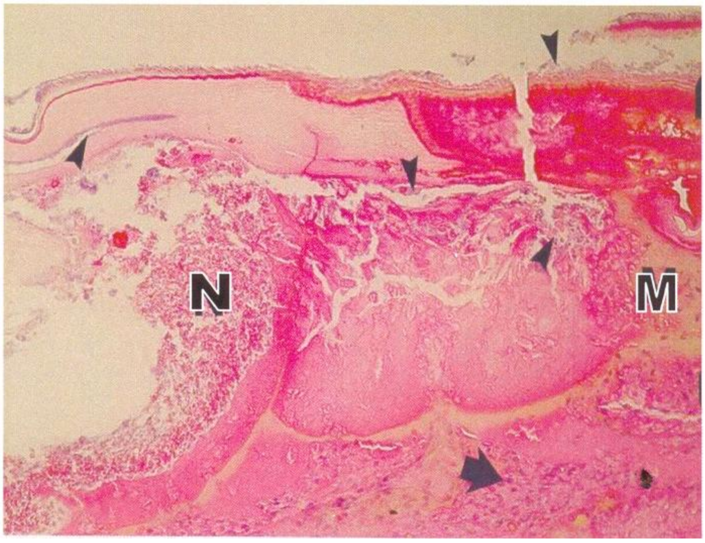
Above right: Erosion of the tail fan of a *J. edwardsii* held in a concrete tank.

Left: Wet preparation of a shell disease lesion in *J. verreauxi* showing melanised tracks caused by fungal hyphae.

Below left: Wet preparation of carapace of *J. verreauxi* showing melanisation at edges of circular lesions caused by chitinoclastic bacteria.

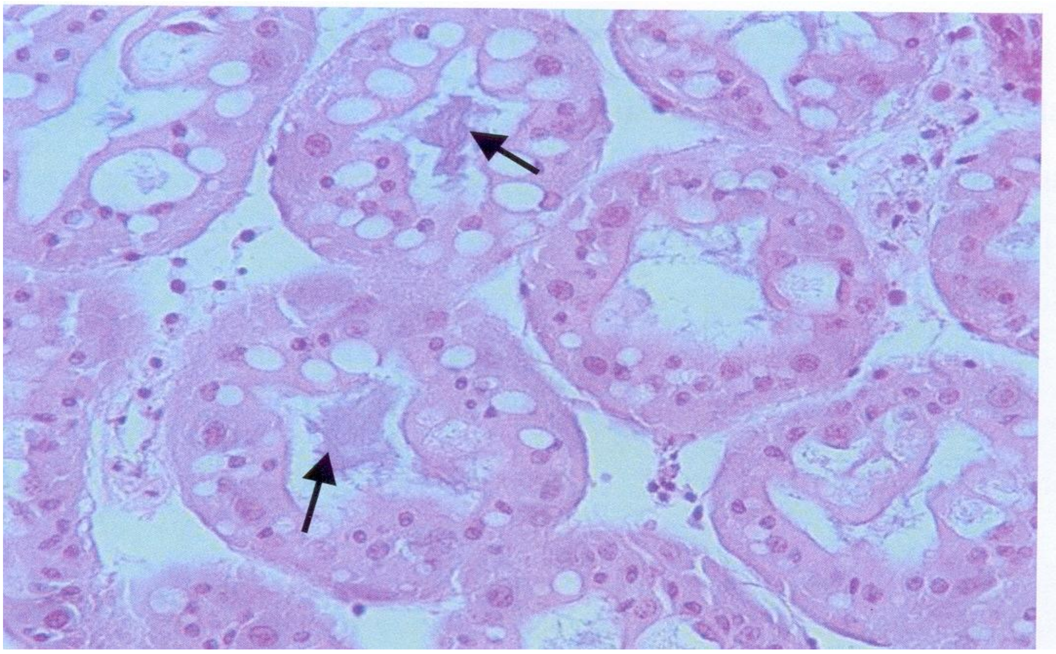
Below right: Histopathology of a tail blister lesion in *J. edwardsii* showing numerous bacteria (arrowheads) inside the cuticle and areas of necrosis (N), melanisation (M), and haemocyte infiltration (arrow).





- **Vibriosis (septicaemia)**

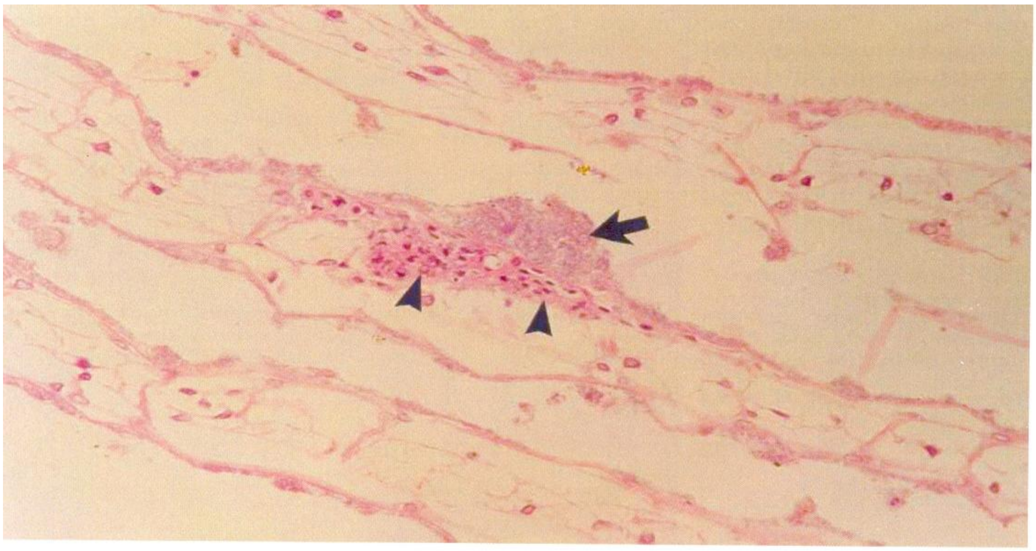
Issue	Explanation
Species and life stage affected	All life stages of red rock lobsters *(Jasus edwardsii),* packhorse rock lobster *(J. verreauxi),* and paddle crabs *(Ovalipes catharus).*
Gross signs	**Can vary between species. Phyllosoma larvae may become opaque or exhibit blackened areas on the carapace. Affected juvenile and adult lobsters and crabs are usually lethargic and stop feeding. The haemolymph may become turbid and body musculature may become opaque. A reddening of the haemolymph has been observed in moribund paddle crabs.**
Causative agent	Opportunistic bacteria of the genus *Vibrio.* Both *Vibrio splendidus* I and *Vibrio harveyi* have been isolated from the haemolymph of adult *J. edwardsii* in New Zealand
Diagnosis	Septicaemia is defined by an infection of the bloodstream, hence diagnosis is based on isolation of bacteria from the haemolymph. Once bacteria are isolated in culture on bacteriological media, they can be identified using biochemical or molecular methods.
Treatment and prevention	Occurrence of bacterial disease usually results from injury and/or sub-optimal culture conditions. Elimination of potential sources of injury, and improvement of water quality, food quality, or rearing system design may be required to improve the health of affected stock and prevent reoccurrence of septicaemia. Antibiotic treatment may be possible if the bacteria involved can be identified and their antibiotic sensitivities can be determined, but routine use of antibiotics will promote development of resistant strains of bacteria and is not a viable long-term alternative to good husbandry practices.
Distribution worldwide	Opportunistic bacteria of the genus *Vibrio* are ubiquitous in the marine environment hence vibriosis is a problem worldwide wherever crustaceans are injured, stressed or held under sub-optimal conditions (Brinkley et al. 1976, Lightner 1983, Sindermann 1990).
Distribution in New Zealand	Opportunistic bacteria of the genus *Vibrio* are ubiquitous in the marine environment and can infect crustaceans throughout New Zealand if they are held or cultured under sub-optimal conditions.
General comments	Vibriosis, like other bacterial diseases of crustaceans, is caused by opportunistic pathogens which become invasive and destructive when host defences are breached by injury or lowered due to abnormal environmental conditions (Sindermann 1990).
References	Brinkley, A,W.; Rommel, F.A.; Huber, T.W. (1976). The isolation of *Vibrio parahaemolyticus* and related vibrios from moribund aquarium lobsters. *Canadian Journal of Microbiology* 22: 315-317. Lightner, D.V. (1983). Diseases of cultured shrimp. *In:* McVey, P.V. (ed), CRC handbook ofmariculture, Vol. I. Crustacean aquaculture. pp. 289-320. CRC Press, Boca Raton. Sindermann, C. J. (1990). Bacterial diseases of crustaceans. *In.* Principal diseases of marine fish and shellfish. Vol. 2, 2nd edition, pp. 48-70. Academic Press, San Diego.



Vibriosis in lobsters and crabs. Photos: B. Diggles

Above: Vibriosis in juvenile *Jasus edwardsii.* Histology of the hepatopancreas showing large plaques of bacteria (arrows) inside the tubule lumens.

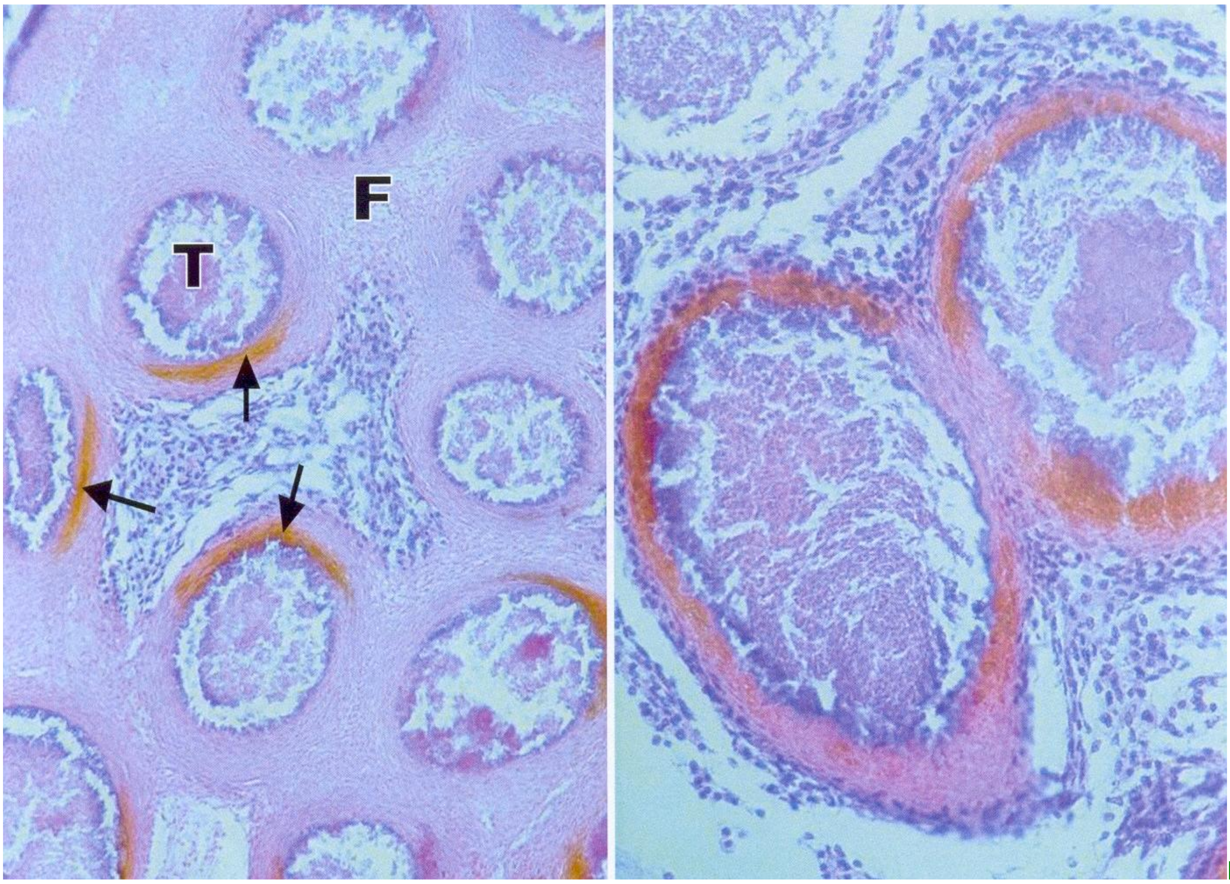
Below: Vibriosis in adult paddle crabs (Ovalipes catharus). Histology of the gill showing that bacteria on the outside of the gill cuticle (arrow) have penetrated the gill cuticle in one area. The presence of the bacteria inside the gill has elicited a host response consisting of clumping of haemocytes (arrowheads) to prevent bacteria entering the haemolymph spaces.



C. Diseases of unknown causes **Appendix 8**

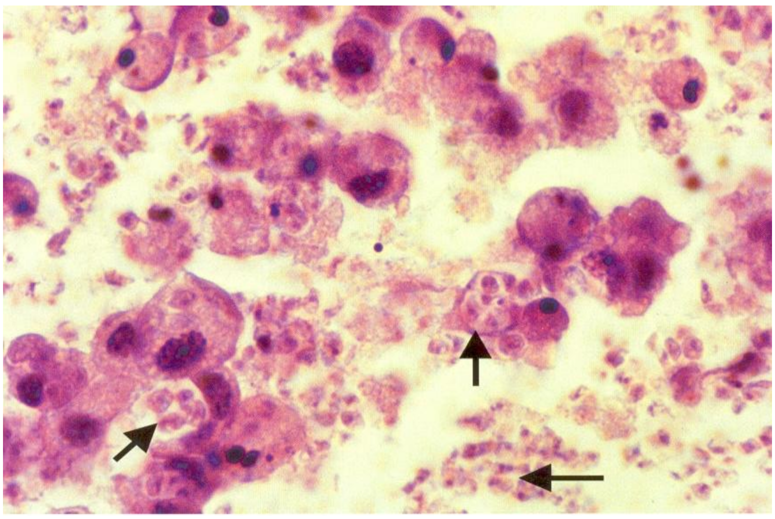
- ### Black hepatopancreas disease

Issue	Explanation
Species and life stage affected	Red rock lobster *(Jasus edwardsii)* sub-adults.
Gross signs	**Lethargy; upon dissection large, hard, blackened necrotic lesions in the hepatopancreas.**
Causative agent	Unknown, possibly related to diet and/or infection with bacteria and/or unknown protozoa
Diagnosis	Affected lobsters are reportedly lethargic, stop feeding, and eventually die. Presumptive diagnosis can be obtained by dissecting lobsters and observing hardened, black, necrotic lumps in the hepatopancreas. Bacteria and protozoan-like cells can be observed in histological section
Treatment and prevention	Unknown. Perhaps provision of an adequate diet will prevent this condition from occurring.
Distribution worldwide	Currently only recorded from lobsters in New Zealand. This disease resembles bacterial necrosis and mummification of hepatopancreas tubules of marron, *Cherax tenuimanus,* in Australia. Disease in marron was thought to be caused by failure to digest an inadequate diet (Langdon et al. 1992).
Distribution in New Zealand	Known only *from* one instance in lobsters used in a dietary experiment in an experimental grow-out facility in the South Island.
General comments	This disease has been observed only once in sub-adult lobsters fed an experimental food containing a high percentage of abalone *(Haliotis* sp.) viscera. Histopathology showed complete necrosis of affected hepatopancreas tubules which were surrounded by a me1anised layer with accompanying fibrosis. Some tubules contained a mass of gram-negative bacteria and also protozoan-like cells. Whether the presumptive protozoa or bacteria playa primary or secondary role in the disease is at this stage unclear.
References	Langdon, J.S.; Buller, N.; Ostle, C.; Thome, T. (1992). Bacterial necrosis and mummification of the digestive gland associated with feeding peas, *Pisum sativum,* to freshwater crayfish, *Cherax tenuimanus. In:* Diseases in Asian aquaculture I. Shariff, M.; Subasinghe, R.P.; Arthur, *J.R.* (eds),), pp. 199-205. Fish Health Section, Asian Fisheries Society, Manila.



His topathology *of* black hepatopancreas disease in *Jasus edwardsii*.
Photos: B.J Diggles and *J.* Handlinger.

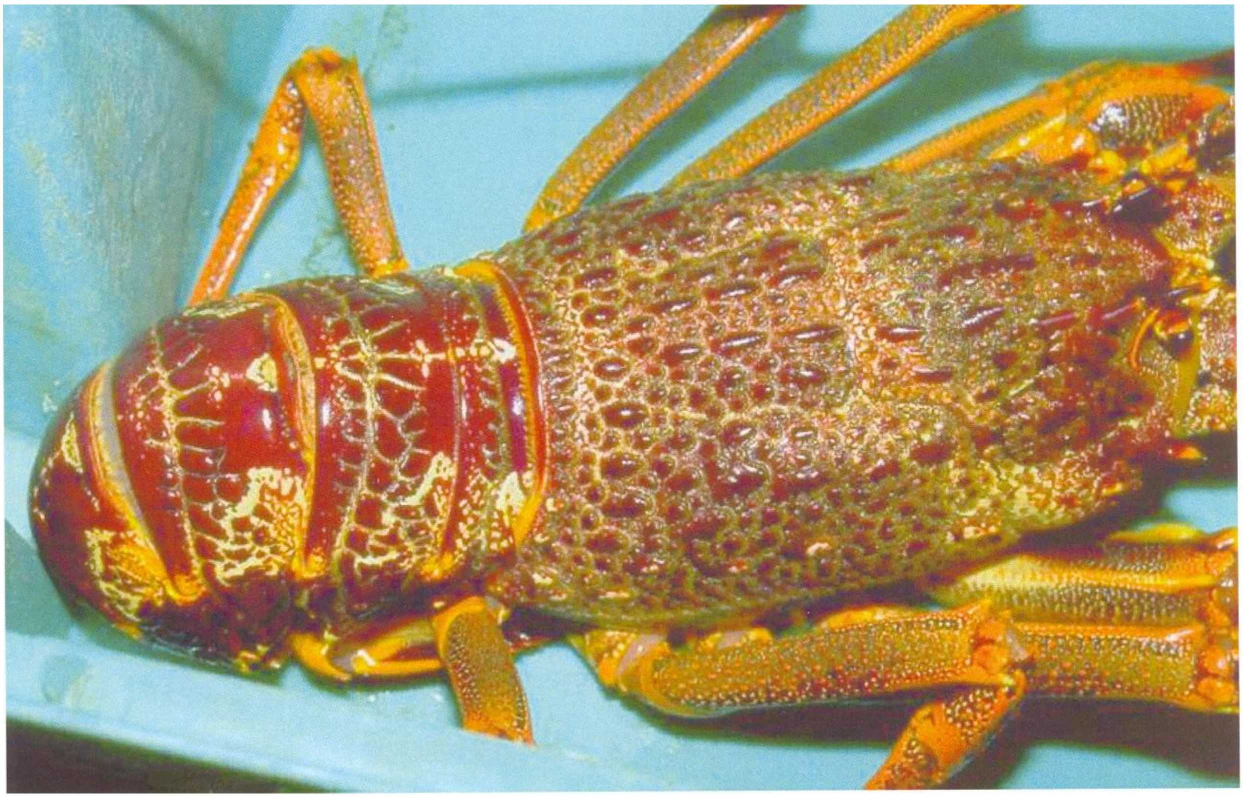
Above right: Necrotic tubule at higher power showing brown layer *of* melanin and cell debris inside remains *of* the tubule.
Above left: Necrotic hepatopancreas tubules showing necrosis *of* tubules (T), melanin deposition (arrows), and extensive fibrosis (F).



Left: High power view *of* cell debris inside tubule showing clumps *of* protozoan-like cells (arrows).

• Turgid lobster syndrome (TLS)

Issue	Explanation
Species and life stage affected	Juvenile and adult red rock lobsters *(Jasus edwardsii).*
Gross signs	**Affected lobsters exhibit fluid-filled, swollen arthrodial membranes apparently caused by an increase in haemolymph volume**
Causative agent	Unknown. May be a nonspecific response to a variety *of* stressors
Diagnosis	TLS is associated with abnormal protrusion *of* the arthrodial membranes, especially between the carapace and abdomen. Haemolymph is expelled under pressure if the membrane is punctured. An increase in the number *of* circulating granulocytes and pre-granulocytes is sometimes noted. In early stages *of* TLS the affected lobsters stop feeding, show limited swelling, and become lethargic, while in later stages they cannot flex their abdomens and mortalities may *occur.* Bacteria such as *Vibrio harveyi* and V. *splendidus* I are occasionally, but not always, isolated from the haemolymph.
Treatment and prevention	Specific methods *of* treatment and prevention are unknown, but reduction or elimination *of* possible sources *of* stress on affected lobsters is recommended. In particular check water quality parameters, especially ammonia and salinity. Some lobsters appear to spontaneously recover without intervention.
Distribution worldwide	TLS-like symptoms have also been reported in J. *edwardsii* and western rock lobster *(Panulirus longipes)* in holding facilities in Australia (A. Brown, W. Hosking, personal communication).
Distribution in New Zealand	Has been observed in lobster holding facilities throughout New Zealand.
General comments	The swelling may be a nonspecific response to a variety *of* stressors. Possible causes may include starvation, as this causes increased haemolymph volume (Dall 1974), poor nutrition, salinity variation, osmotic imbalance, or exposure to toxicants such as pesticides (perhaps at levels below detection limits). Lobsters appear more likely to be affected just before the moult. In one case TLS was associated with hypersalinity (44%0) and the swelling was reversed when salinity was reduced to normal (36%0) (A. Brown, personal communication). In many cases, however, no salinity variation from normal can be detected.
References	Dall, W. (1974). Indices of nutritional state in the western rock lobster, *Panu/irus longipes* (Milne Edwards). I. Blood and tissue constituents and water content. *Journal* of *Experimental Marine Biology* and *Ecology* 16: 167-180.



Turgid lobster syndrome (TLS) in *Jasus edwardsii*. **Photos: B. Diggles**

Above: Normal appearance of the arthrodial membrane between the carapace and abdomen in an adult *Jasus edwardsii.*

Below: Characteristic appearance of the arthrodial membrane between the carapace and abdomen (arrow) associated with TLS.