SYNTHESIS OF WORKSHOP ON MANAGEMENT - FOCUSSED *ASTERIAS* RESEARCH 4 JUNE 2001

1. Attendees

Dr Rob Day (University of Melbourne), Dr Peter Fairweather (Deakin University), Mr John Garnham (NRE), Mr Rod Gowans (NRE), Mr Simon Heislers (MAFRI), Mr Don Hough (NRE), Dr Greg Jenkins (MAFRI), Ms Dana Jindra (University of Melbourne), Prof Craig Johnson (University of Tasmania), Assoc Prof Michael Keough (University of Melbourne), Dr Jo Klemke (NRE), Dr Dennis O'Dowd (Monash University), Dr Greg Parry (MAFRI), Mr Jeff Ross (University of Tasmania), Dr David Smith (MAFRI) *Chair*, Dr Ron Thresher (CSIRO)

2. Introduction– David Smith

The workshop's two key purposes were:

- To consolidate the ecological understanding of *Asterias* that has developed across Victoria and Tasmania and facilitate information exchange among research programs

- To provide technical feedback on NRE's current *Asterias* research directions and programs, and identify the next research directions most relevant to practical management, in the light of this consolidated understanding.

It built upon the similar workshop held in July 2000 but was extended to include presentations from other agencies. The aim was to refine the priority research issues identified in the 2000 workshop in the light of both the understanding that we now have of *Asterias'* ecology, across Victoria and Tasmania, and our key management issues.

3. Background – Rod Gowans

(i) Context – Broad Management Settings & Constraints

- The broad policy setting for *Asterias* management in Victoria is a three-tiered system:
  - Reduction in primary and secondary introductions
  - Early detection, rapid response where viable
  - Containment – reduction of impacts

- Funding is constrained and research must strongly focus on management priorities. NRE's research program focuses on Victorian management issues, although the results are likely to generally assist with managing *Asterias* invasions elsewhere.

- The main tool for advancing the *Asterias* management issue nationally is the *Asterias* National Control Plan

(ii) Priority Research Issues Identified at 2000 Asterias Research Review

- Determine if the seastar will spread to Western Port – early detection
- Monitor dynamics and condition of Bay population, including factors that may correlate with larval survival
- Determine factors affecting settlement / recruitment success
- Determine impacts on benthic and higher trophic levels (eg fish)
- Confirm identification of Asteroid larvae
- Confirm recruitment pattern postulated for 1999
- Explore correlation between establishment and environmental conditions (cf dynamics of other asteroids)
- Monitor parasites

(iii) Action from the 2000 review:

The 2000 review was generally regarded as extremely valuable. Four projects were pursued with the following objectives:

- Refine and implement an early warning system for potential spread of *Asterias* to Western Port by natural larval transport
- Provide basic information on the status of the Bay population and better understanding of the early stages of the invasion process
- Provide better understanding of the factors that limit *Asterias* recruitment success, and hence better ability to predict new locations most susceptible to invasion
- Provide better understanding of impacts
  (Note that a proposal focussing on fisheries impacts was unsuccessful in attracting additional external funds; a proposal focussing on impacts on Bay nitrogen cycling is currently submitted to the ARC Linkage Scheme)

(iv) Key Current Management Issues – Asterias in Victorian waters:

1. Preventing further spread:
   - Natural larval transport
   - Probability of larval survival in ballast water
2. Early detection of arrivals at new locations
3. Options for a rapid response
4. Implications for key Bay management issues:
   - Nutrient cycling
   - Fisheries
5. Options for long-term control / eradication of established populations

These management issues, along with both our current ecological understanding of *Asterias* across Victoria and Tasmania and the priority research issues identified in the 2000 workshop, provided the context for consideration of priority research issues at the 2001 workshop (see section 5)

4. Current understanding of *Asterias* ecology in South-Eastern Australia - Overview of presentations & associated discussions

(i) Asterias spawning and larval stage (TASMANIA) – Craig Johnson

- Modelling suggests that aggregation of *Asterias* (eg around food) has potential to significantly affect fertilisation success. Fertilisation models have been developed which predict effects of factors such as *Asterias* density, spatial arrangement, sex ratio and spawning synchrony on fertilisation success.

- In the Derwent, a significant proportion of *Asterias* reproductive output occurs around wharves.
  - *Asterias* density around the wharves is well correlated with small scale distribution of availability of mussels.
  - *Asterias* gonad indices in these areas remain high after spawning starts, suggesting multiple spawning. This suggests the potential for multiple spawning events during the year in conditions of high food stocks, which is a significant management issue given the current thinking that spawning occurs during a predictable season and hence that there are “safe periods” (ie: no larval uptake in ballast) during the year.
  - Modelling suggests that this ≈ 10% of the population occurring at the wharves (which cover ≈ 0.1% of the total area of the Derwent estuary) contributes 80 – 90% of its reproductive output.

- Removing food inputs at wharves and marinas therefore has potential to significantly affect larval production, although it is not clear whether larval production and recruitment are well correlated.

- *Asterias* density in the Derwent has been assessed using video tows. Although early density estimates probably did not adequately consider density stratification between deep and shallow waters, Craig concludes that density has decreased over time – probably due to diminishing food resources. Current estimate is around 3 million *Asterias* in the estuary below the Tasman Bridge.

- *Asterias'* recruitment success in the Derwent varies strongly between years, apparently having a strong stochastic component.

- A (3 layer) advection model predicts that most larvae are advected out of the Derwent.
  - Building in the following larval behaviours, which have been observed in the laboratory, results in entrainment of larvae at the salt wedge boundary and even lower retention rates.
    - Salinity response – larvae in a salinity gradient column avoid, and will not swim in, salinity <26 ppt
    - Reverse diurnal migration

  Field sampling is now planned to assess larval distribution with salinity and light in the natural environment, and whether most larvae really are advected.

- Few *Asterias* have been found outside the Derwent but there have also been few surveys. Although recruitment occurs onto settlement collectors at more distant marine farms, no adult *Asterias* have been found there. Feasible sources of these recruits include the wharves and closer, currently undiscovered populations.

- If *Asterias* densities are lower outside the Derwent, possible explanations include a less disturbed environment where predators and competitors may play an important role.

(ii) Early warning for detecting transport to Western Port by Natural Larval Dispersal (VICTORIA) – Greg Parry

(for more detail see: Parry, G.D., Werner, G.F. and Cohen, B.F. 2001. Development of an early warning system for the spread of Asterias amurensis from Port Phillip Bay to Westernport through natural larval transport. MAFRI Internal report No. 18 – circulated to workshop participants)

- In 1999 spat collectors of 3 different designs were deployed over three two-month periods (Sept - Nov, Oct – Dec and Nov – Jan) in Port Phillip Bay. Very few *Asterias* were collected (a maximum of one / collector).

- In 2000, similar spat collectors deployed for 3.5 months collected many more *Asterias* than the 1999 deployments. This could be due to differences in deployment duration or differences in settlement rates and / or post-settlement mortality rates between years. Greg considers the longer deployment period probably important as *Asterias* recruitment in 2000 was much lower than in 1999.

- A new, fine-mesh spat collector type deployed in 2000 collected 4 – 6 times more larvae than the other collectors.

- Mussel ropes also seem to act as effective *Asterias* spat collectors, and appear an adequate tool for assessing whether *Asterias* reach Western Port.

- There is potential for spat collectors to accumulate *Asterias* predators and prey as well as *Asterias* themselves, which may affect the abundance and size distribution of *Asterias* present when the collectors are censused. This limits the comparability of *Asterias* recruitment estimates derived from collectors deployed for different durations, as these are likely to be subject to different predation rates.

(iii) The Ecology of Juvenile Asterias amurensis in Port Phillip Bay (VICTORIA) - Dana Jindra

- Initial research questions have been:
  - What are new-settlers feeding on and when do they change from an algal diet to one of infauna?
  - What is the feeding behaviour of new-settlers, do they have any food preferences, and is this exhibited in growth rates?

- Juvenile *Asterias* were commonly found in approximately 17m depth with red algae (*Botryocladia sonderi*, *Spyridia filamentosa*, *Hymenena curideana*).

- Small juveniles (<10 mm) were found as late as May. This could be due to *Asterias'* reproductive period in the Bay, and therefore period when larvae are in the water column, being longer than previously thought or very plastic growth of *Asterias* recruits. Likely to be a combination of these two effects. Jeff Ross noted that some *Asterias* were quite possibly spawning much later than expected in Tasmania – he has found a few *Asterias* with ripe gonads late in the season, and also found small *Asterias* much later than expected from expected spawning time.

- Distribution of juveniles is very patchy.

- Juveniles <25 mm feed on algae and change to feeding on bivalves at approximately 25 mm.

- Juveniles >25 mm exhibit size preferences for mussels, this preference decreases with increasing *Asterias* size.

- The time spent feeding increases with *Asterias* size.

- Stress may be an important factor affecting behaviour, especially for small juveniles.

(iv) Population Dynamics and Distribution of Adult Asterias in Port Phillip Bay (VICTORIA) – Greg Parry

(for more detail see: Parry, G.D. and Cohen, B.F. 2001. The distribution, abundance and population dynamics of the exotic seastar Asterias amurensis during the first three years of its invasion of Port Phillip Bay (incorporating a report on the Bay Pest Day 2 April 2000). MAFRI Report No. 33 – circulated to workshop participants)

- Population dynamics have now been studied at varying intensity for the first 3 years of the *Asterias'* invasion.

- Distribution has been mapped through bay-wide dredge surveys in Mar-Nov 99; Dec – Mar 00; Apr – Nov 00; Mar – Apr 01.

- The 2001 survey extended to new areas; the 2000 cohort appears to occur over most of the Bay (Corio Bay not sampled), including W and S areas where larval transport was predicted by modelling but significant recruitment had not been previously observed. There is considerable recruitment in inshore areas also, particularly between Williamstown and St Kilda, although this is not captured by the dredge surveys.

- Most spawning occurred between mid-July and mid-Sept in 1999 but commenced in mid-June during 2000; based on recruitment timing, larval period is estimated at approx 60 days.

- The population appears to have peaked and declined in the main invasion area (NE); growth declined in 1999; mortality was low in 1999 but seems to have increased in 2000, probably due largely to high mortality of the 1999 cohort in this area

- *Asterias* growth appears faster in areas where there they had not previously been found.

- Analysis of the survey data has assumed negligible movement, and hence that differences over time are due to recruitment and/or mortality. While groups of very mobile *Asterias* have been observed in the Derwent, to date there is minimal evidence of significant migration within the Bay, although small increases in abundance of non-recruitment cohorts on study areas near the edge of *Asterias'* distributional range (Aspendale and Brighton 15m sites) are probably due to migration.

- The likely cause of reduced density in the main invasion area was discussed. Greg attributed the (ultimate) cause to starvation due to decline of resources in the main infestation area. However, resource-limited mortality was questioned as a potential cause – the literature provides no evidence that moderate starvation of seastars causes mortality (they are generalist predators with very plastic resource allocation). Other potential causes discussed include predation and movement. Greg's view on the latter is that, while increased movement may be predicted as a response to resource shortage, in this case the resource shortage appears similar throughout the extensive main invasion area. He believes that net migration would be predicted only when there is a difference in resource availability, which may only be occurring near the edge of the distributional range.

(v) Factors affecting observed distribution of Asterias in Port Phillip Bay – hydrodynamic and potential biological factors (VICTORIA) – Greg Parry

(for more detail see: Parry, G.D., Black, K.P., Hatton, D.N., and Cohen, B.F. 2001. Factors influencing the distribution of the exotic seastar Asterias amurensis during the early stage of its invasion of Port Phillip Bay. 1. Hydrodynamic Factors. MAFRI Report No. 38 – circulated to workshop participants)

- A brief overview was provided of this work, which was presented at last year's workshop.

- Agreement between the models predictions and observed distribution is generally good (particularly when the 2001 distributional survey results are included – although the model is strictly predicting 1998 and 1999 distribution), except for:
  - Observed distributional peak being slightly more north than predicted.
  - Observed sharp decline in density in the shallow NE of the Bay, at the NE boundary of the main invasion area, not predicted.

- It was noted that *Asterias* larvae are now being released over a much larger area than was input to this modelling, which would affect predicted distribution. Due to changes in such input variables, the modelling results are difficult to interpret in relation to current *Asterias* distribution.

- An apparent inverse association with *Asterias* distribution, combined with laboratory feeding trials and field observations, suggests that *Leptomithrax* predation is a main source of *Asterias* sublethal damage. Although *Leptomithrax* is generally more abundant in the W and particularly S of the Bay, its distribution is very dynamic in space and time and its predation will be very patchy. The role of *Leptomithrax* in causing *Asterias* mortality is uncertain, but *Leptomithrax* will eat *Asterias* in the laboratory and a mussel farmer has reported them moving under a mussel farm and eating *Asterias*. A proposal discussed at last year's workshop, that *Leptomithrax* predation limits *Asterias'* distribution in the W and S of the Bay (based on sublethal damage patterns), is no longer supported as these areas now fall within *Asterias*' range.

- Greg attributed the low abundance of *Asterias* in the shallow NE of the Bay to predation by *Coscinasterias*. The rationale presented was[1]:
  - Negative correlation between distribution patterns of *Asterias* and *Coscinasterias* in the Bay.
  - Grannum *et al.* (1995) found a significant negative relationship between the abundance of *Coscinasterias* and the abundance of *Asterias* in the Derwent which they considered "warrants further study".
  - Scaled up predation rates from experiments in laboratory aquaria are 5x greater than would account for the observed lack of *Asterias* in the shallow NE of the Bay (assuming that *Asterias* initially settle at similar density here as in other areas). *Coscinasterias* was the only species of predator tested in these aquaria that consumed equal numbers of *Asterias* in the first and second week of laboratory feeding trials. All other predators consumed more *Asterias* in week 2, which may suggest that *Coscinasterias* does not need to be as hungry as the other predators before they will eat *Asterias*. Note, however, that the realism of these laboratory experiments, and the comparability of results between potential predator species, was questioned at the workshop (see below).

- The review group in general was not convinced by the argument that *Coscinasterias* predation is the most likely cause of the apparent sharp decline in *Asterias* density in the shallow NE of the Bay that was not predicted by the model, or that *Coscinasterias* is an important predator, because for example:
  - The absence of *Asterias* from this area is more likely to be due to absence of settlement cues (which are not captured in the modelling) or very early post-settlement mortality.
  - *Coscinasterias'* diet in the natural environment has been described by other studies and in the literature, and mainly consists of groups such as bivalves, gastropods and polychaetes. It has been rarely observed

---

[1] Note that this reflects the information presented for peer discussion at the workshop. To discuss further related observations / rationale, please contact Greg Parry directly.

to eat seastars and therefore the proposal involves a massive diet shift based on laboratory feeding observations which were preliminary in nature and generally not considered convincing. The identification of *Coscinasterias* as the most significant potential predator among those tested in these experiments was also questioned, due to the experimental conditions.

- This was further discussed in the priority setting session (see section 5)

(vi) Impacts of Asterias (TASMANIA) – Jeff Ross

- *Asterias* does occur on rocky reefs in Tasmania, but this study concentrated on soft sediment impacts.

- Assessing impacts involved multiple approaches (manipulative and correlative) at a range of scales, using a "weight of evidence" approach, due largely to lack of baseline data prior to *Asterias* invasion and potential for confounding effects of other anthropogenic stresses.

- Experiments conducted outside *Asterias'* current range showed impacts on the abundance of some species, particularly surface dwelling bivalves (effect was consistent but of varied magnitude between sites), but not others. It is possible that some further species may have been affected if the experiments were run for longer.

- Observational and experimental evidence suggests that *Asterias* has a significant effect on recruits of the bivalve *Fulvia*; other species were omitted from diet when *Fulvia* was available.

- Apparent relationships between differences in *Asterias* density and infaunal community structure from snapshot surveys were actually better explained by fine scale differences in sediment grain size between sites. A further limitation of such snapshot surveys is that they cannot detect effects on recruitment pulses.

- Various individual bivalve species seem to show some patterns with *Asterias* (eg: *Timolcea* – is a major prey item but reaches smaller sizes in *Asterias'* range); *Mysella* is common in the environment but rare in *Asterias* diet (perhaps due to an escape response?)

- *Asterias* seems to be a generalist predator with strong food preferences; shallow intertidal and epifaunal bivalves (including recruits) are preferred food. It has large effects including some commercial species.

- There does not seem to be a major upper size refuge for bivalves in the Derwent; although not many very large bivalves occur there, *Asterias* also seems to 'attack' prey in groups.

- Wharves provide a food reservoir which seems to sustain the Derwent *Asterias* population. *Asterias* will also feed on mussels up on shallow reefs, where they can be dislodged by wave action.

(vii) Predation on Asterias (TASMANIA) – Jeff Ross

- In situ observations of predation are rare – therefore this study focussed on incidence of sublethal predation (which may / not be correlated with total mortality) and manipulative experiments.

- Sublethal predation levels range to ≈ 20% but are mainly loss of just one arm. These levels seem higher than have been observed for *Asterias* overseas.

- Results of experimental manipulations were equivocal due to potential caging problems and artefacts.

(viii) Asterias biological control options (TASMANIA) – Ron Thresher

- A range of control options for *Asterias* were reviewed at a Hobart workshop 3-4 years ago (see technical report by Goggin).

- A ciliate (*Orchitophrya*) was reviewed as a potential control agent by CRIMP but seems to have low specificity across genera. It has not been found in Tasmanian *Asterias* but could arrive to the Bay, which receives Japanese ballast water.

- Pros and cons of genetic control options:

PROS	CONS
• Inherently species specific	• Effectiveness depends on population dynamics
• Some basic constructions / approaches that could be applied to many pests	• Unknown and still developing knowledge
• Highly targeted to life history stage	• Unknown social acceptability

- Options that have been considered include transgenic sterilisation via diet (genetically manipulating prey species).

- Very preliminary modelling using some genetic techniques developed for fish suggests that there could be potential for *Asterias* control within 15 – 20 years, but better assessment will be possible in the next few years.

- Ron does not consider native predators a solution for *Asterias* eradication in the longer term; he believes that at best it would deliver temporary reduction in numbers.

- Discussion focussed on the implications of natural selection on the effectiveness of genetic techniques, and the likely practicality of control and eradication in the short term. The benefits of actions that contribute to reducing spread were recognised. Ron estimated that thorough development of any of the approaches (including genetic, native predators) was at least 5 – 10 years away, and did not envision that genetic controls would be ready for release within the next decade. The current aim is to get much better information which can then be input to risk assessments and subject to a public comments process.

5. Priority research directions:

The workshop listed the following important research directions within each of the key current management issues described in section 3 (iv). In some cases, rather than particular directions, it identified broad areas where review of existing understanding was recommended to enable more informed assessment of future research needs. The order of these research questions was not intended to reflect a prioritisation - these lists will provide a basis for further consideration by NRE in relation to more specific priority management questions.

(i) Preventing Further Spread[1]

- Identify key mechanisms, and opportunities to reduce their risk.

  A comprehensive review of past and current projects that aim to understand and address potential human-related vectors was beyond the workshop's scope. However, in the light of the *Asterias* research that was presented at the workshop, two more specific priorities were identified:

  1. Duration of *Asterias* reproduction (and hence the period over which larvae occur in the plankton). This information is significant for ballast water management decisions, with information presented at the workshop suggesting that this period may be significantly longer than previously expected.

  2. Importance of hull fouling of recreational vessels as a vector. The workshop recommended assessment of research needs following a review of existing available information on significance and control options (potential Hons project).

([1] Recognise potential link with 4(v), in that reducing *Asterias'* abundance could also reduce potential for spread).

(ii) Early Detection of Arrivals at New Locations (including Vector Identification)

- Western Port
  - <u>Design:</u> deploy collectors at more than one site, given the potential hydrodynamic influences on larval transport patterns.
  - <u>Collectors:</u> fine mesh collectors appear sensitive; mussel ropes are also an option and may have cost-benefits particularly in areas where there are already mussel farms.
  - <u>Duration:</u> although existing work suggests 3.5 months conditioning may be more effective than 2 months, the evidence for this is not substantial and shorter deployment is an option (and may provide benefits).

- Other waters – are there other waters at risk eg: Corner Inlet, Shallow Inlet, exposed coasts?

(iii) Options for Rapid Response

- This was not discussed in detail, although the current lack of practical tools to eradicate a new *Asterias* population was raised in the discussion. However, defending high value areas such as marine parks from invasion was raised as a management priority.

(iv) Implications for key Port Phillip Bay Management Issues

- Nutrient dynamics
  - Better understand impacts on key elements of the Bay's nutrient cycling processes.

    <u>Relevant work in progress</u>:
    - Proposal submitted for ARC Linkage funding to assess the effects of a range of exotic species on denitrification efficiency of Bay sediments.

    <u>Future options:</u>
    - A model has been developed by a PhD student in Craig Johnson's lab, which extends the Bay study "physics" model, that can be used to predict the implications of such denitrification effects at higher trophic levels.

- Fisheries impacts
  - Better understand impacts on demersal fish (continuation of demersal fish surveys has been funded this year) and abalone recruitment.

    <u>Relevant work in progress</u>:
    - Continuation of the Bay demersal fish survey has been funded this year, which will allow correlation between temporal changes in demersal fish and colonisation by *Asterias*. Potential for a student to assess coincident changes in fish diets through analysis of fish guts archived from these surveys.
    - A BSc (Hons) project at VUT is focussing on *Asterias* effects on rocky reefs

(v) Options for Long Term Control / Eradication of Established Populations

(in order of life history stage, not priority)

- Is fertilisation efficiency an important factor affecting the abundance of *Asterias* in Port Phillip Bay as in Tasmania? – *requires further discussion; priority unclear from workshop*

- Modelling of larval transport / settlement:
  - Further explore modelling (with latest data if appropriate) to better understand source / sink relationships, if these are not already well understood
    - Are there anomalies?
    - Include "what-if scenarios" – do some areas of the Bay have disproportionate implications to the larval pool?

- Better understand factors limiting recruitment and settlement, including metamorphosis cues

- Potential causes of the low abundance on the NE side of the Bay which is not predicted by the modelling – does this suggest a potential control mechanism?
  - Use decision tree approach – order of priority:
    - Safe to assume high larval supply
    - Measure recruitment and assess role of potential settlement cues – eg sediment characteristics (silt vs sand)
    - Assess early post-settlement mortality patterns.
    - Assess sources of post settlement mortality – eg predators such as *Coscinasterias*[2]
- Monitor / understand fish predation

Relevant work in progress:

- A 3 year PhD project (Dana Jindra) clearly relevant to a number of the above research directions is underway, focussing on the factors affecting the survival of juvenile *Asterias* in Port Phillip Bay.

- Explore correlation between *Asterias* dynamics (esp recruitment dynamics) and both those of other seastars and environmental parameters
  – remaining priority raised at 2000 workshop; may be addressed through above PhD project.
- Monitor dynamics and condition to provide basic understanding of the population
  – priority raised at 2000 workshop and funded through to 2001 / 02

- Explore cause of the apparently declining density of the 97 cohort in the main invasion area – does this suggest a potential control mechanism?
  - may require further discussion / refinement as it is currently difficult to distinguish 97 and 98 cohorts.
- Annual monitoring of parasites and lesions – [potential student project?]
  – remaining priority raised at 2000 workshop

Discussed but given lower priority:

- Do aggregations at Bay piers contribute disproportionately to *Asterias* reproductive output in Bay as in Tasmania
  – this is not supported by observations to date that the Bay Asterias population spread from the centre of the Bay and that piers have been colonised only relatively recently. Habitats such as piers also cover a much smaller proportion of the Bay than the Derwent.
- Map distribution at finer spatial scales as has occurred in Tasmania – not supported to assess general distribution due to scale of the Bay population, but may be appropriate within targeted studies.

[2] Greg argued that *Coscinasterias* predation should receive higher priority in this decision tree, or be addressed simultaneously with other options, as it is the only of the listed options that he believes is linked to a future potential management option for reducing *Asterias* abundance. However, this was not widely supported by the workshop (see also section (v)). Concern was also expressed about the potential ecological impact of increasing the population of *Coscinasterias*.