Identifying hazards in complex ecological systems – Part II: Infection Modes and Effects Analysis for Biological Invasions

Dr. Keith R. Hayes

Centre for Research on Introduced Marine Pests

CSIRO

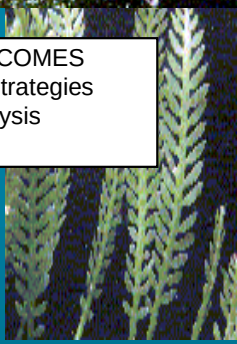
MARINE RESEARCH



Overview

- Introduction - Risk assessment and hazard analysis
- Methods - Infection Modes and Effects Analysis
- Methods – Workshops in Southeast Australia
- Results


Risk assessment & hazard analysis



SOCIAL APPRAISAL
- social values and the significance of risk

CALCULATE RISK

MONITOR OUTCOMES
- sampling strategies
- power analysis

IDENTIFY HAZARDS
- checklists
- logic trees
- HAZOP
- FMEA
- HHM

FREQUENCY ASSESSMENT
- likelihood of undesired events

CONSEQUENCE ASSESSMENT
- impact of undesired events

QUANTIFY UNCERTAINTY

Define the problem - define scope, boundaries and endpoints

PROBABILITY THEORY
- classical
- bayesian

EVIDENCE

Data

Models

Theory

Hazard identification



- Simplest = wait and see!
  - simple and effective but not proactive!
- Usual approach = unstructured, deductive
  - e.g. checklists, unstructured brainstorming
- Better techniques = inductive, structured, team based approaches
  - Fault and Event trees
  - Failure Modes and Effects Analysis
  - Hazard and Operability Analysis
  - Hierarchical Holographic Modelling
- Why adopt these techniques
  - rigorous, systematic, transparent and will usually identify more hazards

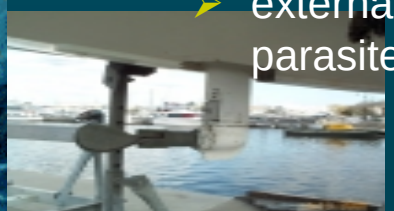

Infection Modes and Effects Analysis



- Infection modes and effects analysis (IMEA)
  - based on industrial failure modes and effects analysis (FMEA)
  - inductive, team-based hazard identification

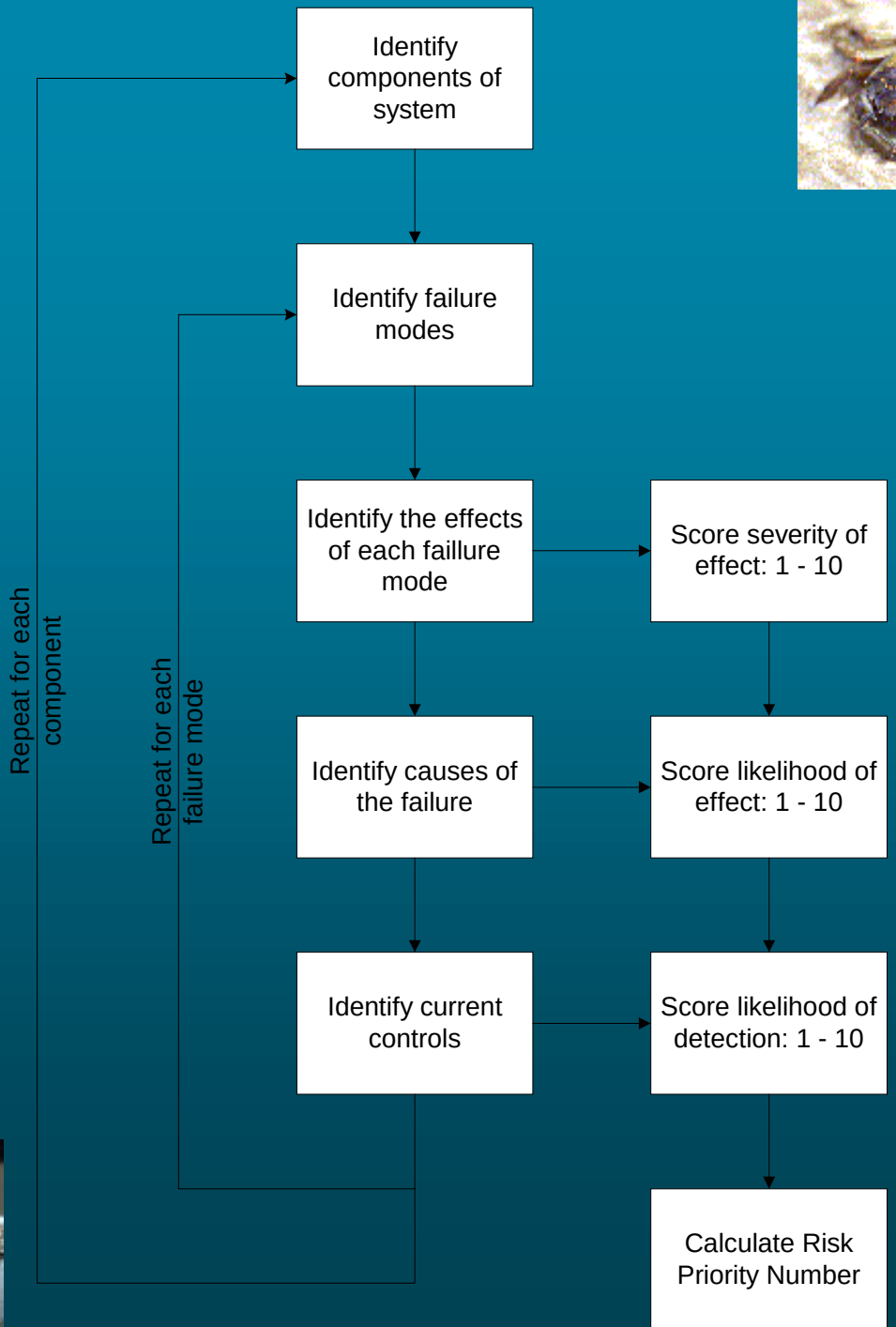
- Small-craft vector hazard analysis
  - how do small-craft spread marine organisms
  - identify vessel “components”
  - identify “infection modes”
  - rank importance of component infection modes

- Components
  - hull; propeller, rudder & anchor; internal spaces; deck; fishing gear



- Infection modes
  - external fouling; internal fouling; sediment retention; water retention; parasites; bait; refuge; borer

Failure Modes & Effects Analysis



Infection Modes & Effects Analysis

Identify vessel components

Identify infection modes

Describe the environmental characteristics

Score minimum and maximum environmental suitability: 1 - 10

Identify causes of the infection

Score minimum and maximum likelihood of infection: 1 - 10

Identify current controls

Score minimum and maximum likelihood of detection: 1 - 10

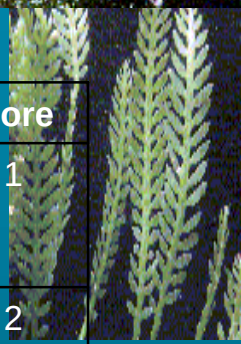
Calculate minimum and maximum Risk Priority Number

Repeat for each component

Repeat for each infection mode

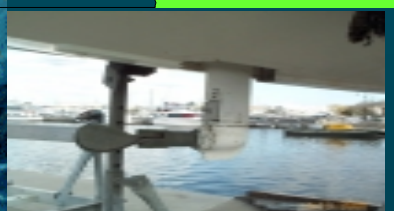
IMEA Ratings





Environmental suitability	Occurrence	Detection	Score
The environment is not suitable for survival of any marine organisms	The infection is extremely remote, highly unlikely	Almost certain to detect	1
The environment is suitable for the survival of only resistant diapause/resting stages	The infection is remote, unlikely	Very high probability of detection	2
The environment is suitable for the survival of a lot of species	An occasional number of infections are expected each year	Medium detection	5
The environment is suitable for the survival of most species	The infection has a moderate occurrence frequency per year	Low chance of detection	6
The environment is suitable for the survival, growth and reproduction of tolerant species	There is a very high occurrence of the infection each year	Remote chance of detection	9
The environment is suitable for the survival, growth and reproduction of most species	The infection is certain	Almost impossible to detect	10


Workshops



- Abalone
- Shark
- Spiny lobster
- Scallop
- Squid
- Danish/purse seine
- Board trawler (fish and prawn)
- Long-liner (tuna)
- Motor cruisers
- Yachts
- Open aluminium craft
- Dredge
- Charter (eg dive, tourist)
- Ferries
- Tugs
- Tankers (gas and fuel)



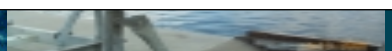
Results

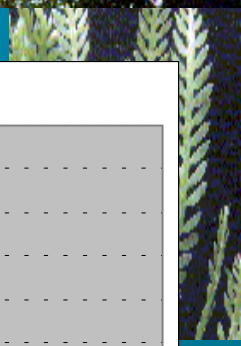
- Displacement vessels
  - 7 components – divided in sub-components (e.g. surface of the hull)
  - 8 infection modes
  - 215 sub-component/infection mode combinations

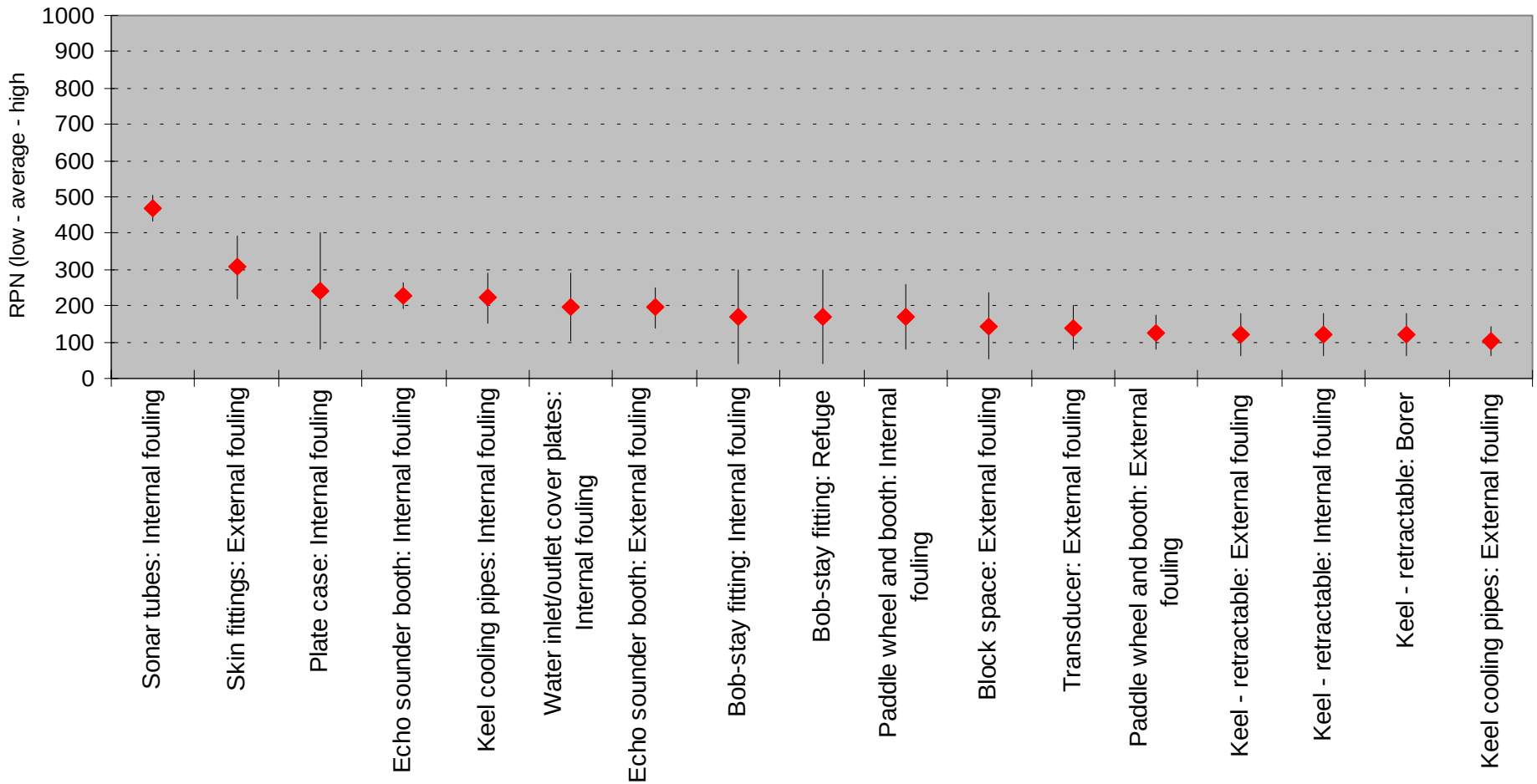
- Trailerable vessels
  - 7 components – divided in sub-components (e.g. internal spaces of hull)
  - 8 infection modes
  - 71 sub-component/infection mode combinations

- Full results can be viewed at: http://crimp.marine.csiro.au/hayes/IMEA.htm


Results: Hull of displacement vessel, RPN >100

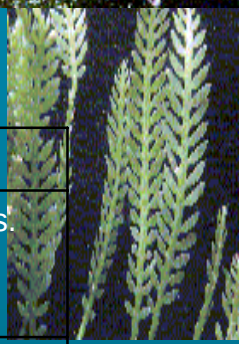






Results – variance





COMPONENT - INFECTION MODE	REASONS FOR HIGH VARIANCE
Sewage holding tank: Water retention Sewage holding tank: Sediment retention Sewage holding tank: Refuge	Wide range given to environmental suitability and occurrence ratings. Range reflects difference between the effects of seawater and chemical flushes on marine organisms.
Bilge - closed: Water retention Bilge - closed: Sediment retention Bilge - closed: Refuge	Non-consensus between scores given to all the ratings. Disagreement reflects operational difference between fishing vessels (bilge is very dirty and inaccessible) and motor cruisers (bilge is kept clean and is largely accessible).
Propeller surface: External fouling Propeller shaft: External fouling	Non-consensus between scores given to environmental suitability and occurrence. Disagreement reflects the extent to which the propeller and shaft are stationary. For fishing vessels this is rare; for yachts this is more common.
Zinc blocks: Internal fouling	Zinc blocks on some vessels are bolted directly onto the hull. On other vessels they are bolted onto a bracket, leaving a small space behind the block. Variance reflects disagreement between scores given to environmental suitability and occurrence due to different interpretation of “internal” in this context.


Results – empirical comparison



- Willan *et al*., (2000) routine inspections of ocean-going yachts in Darwin
  - marine organisms in vessel's seawater inlets and outlets
- Johnson & Padilla (1996) survey of trailerable vessels in USA:
  - zebra mussels in live wells, bilges, bait buckets, cooling systems
- IMEA predicts hotspots:
  - bait buckets, anchor wells, open bilges, bilge pumps, floatation pods,
  - heat exchangers, sea/grey water inlets, transducers