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Effects of dredging related activities on finfish

DREDGING SCIENCE NODE

WAMSI THEME 8 –PROF. EUAN HARVEY CURTIN

Government of Western Australia
Department of Water and Environmental Regulation

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Activities

1) Workshop
   - 31 October to 1 November 2013

2) Literature review

Objective

a) Assess the known effects of dredging on fin fish

b) Assess gaps in knowledge in Western Australia

c) Identify and prioritise future areas of research

Context - Critical Environmental Windows

A critical analysis of the direct effects of dredging on fish

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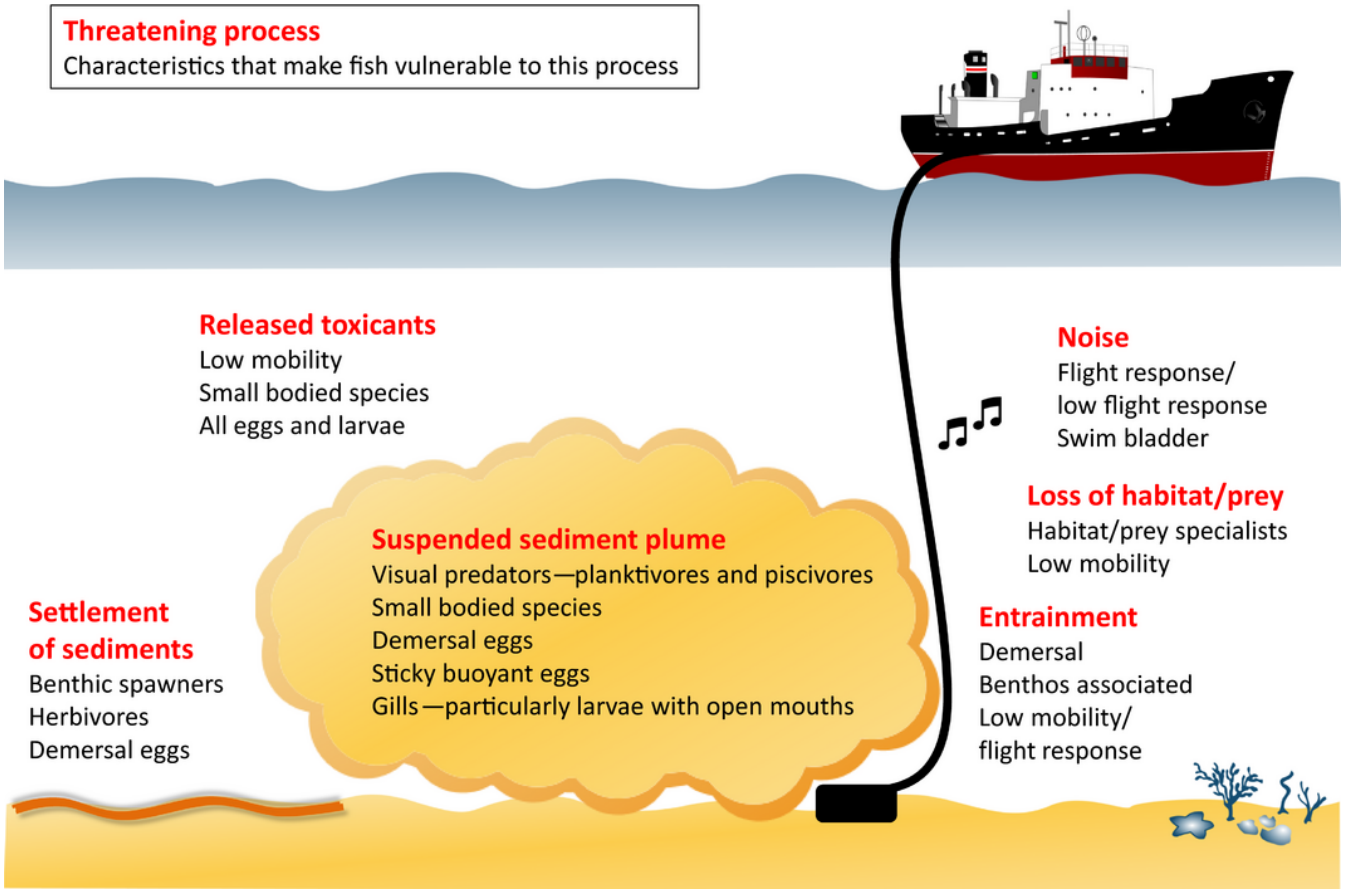

Fish and Fisheries
Volume 18, Issue 5, pages 967-985, 27 MAR 2017 DOI: 10.1111/faf.12218
http://onlinelibrary.wiley.com/doi/10.1111/faf.12218/full#faf12218-fig-0001

Literature review

430 papers were reviewed

Dredging operations

- Shifts in the species composition of fish communities
- Loss of species
- Deformities and bioaccumulation of contaminants from contaminated sediment
- increased rates of disease and decreases in fish catches at sediment disposal sites

Suspended sediment 59 studies (31 effect sizes)
Contaminated sediments 36 studies (25 effect sizes)
Hydraulic entrainment 24 publications (4 studies on fish response)
Dredging related noise 35 studies (16 studies on fish response, 9 effect size)

A critical analysis of the direct effects of dredging on fish

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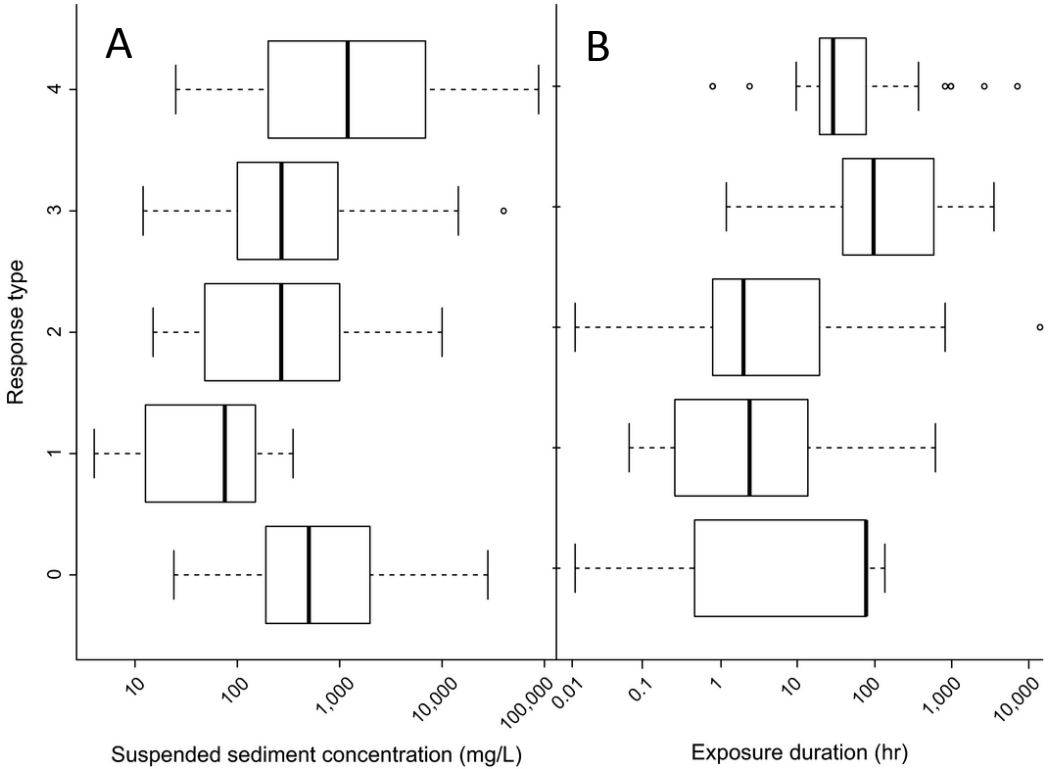

The impact of (a) suspended sediment concentration and (b) exposure duration on the type of effect elicited by suspended sediment.
A response type of 0 = no effect, 1 = minor behavioural changes, 2 = minor physical damage or moderate behavioural changes, 3 = physiological impacts and 4 = increased mortality

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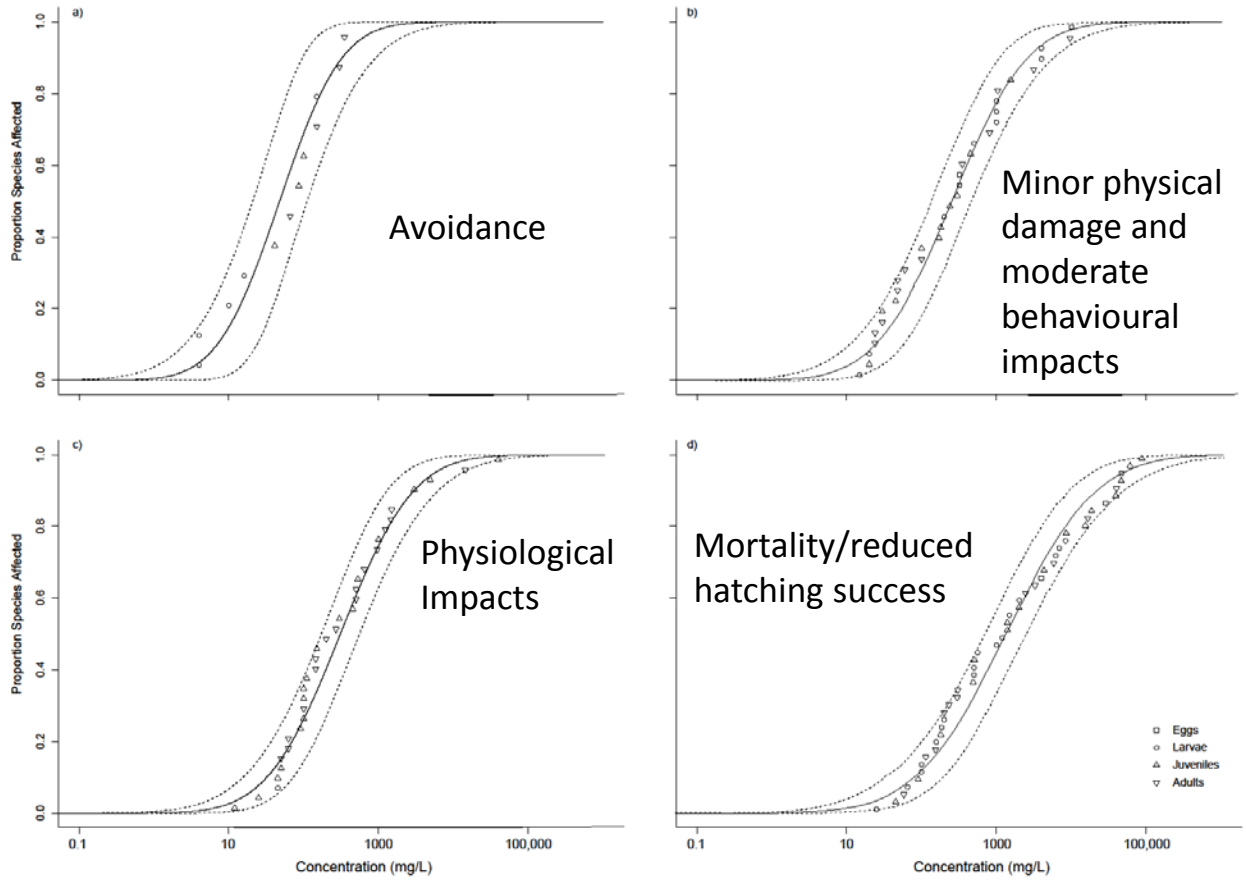
Increased Suspended Sediment

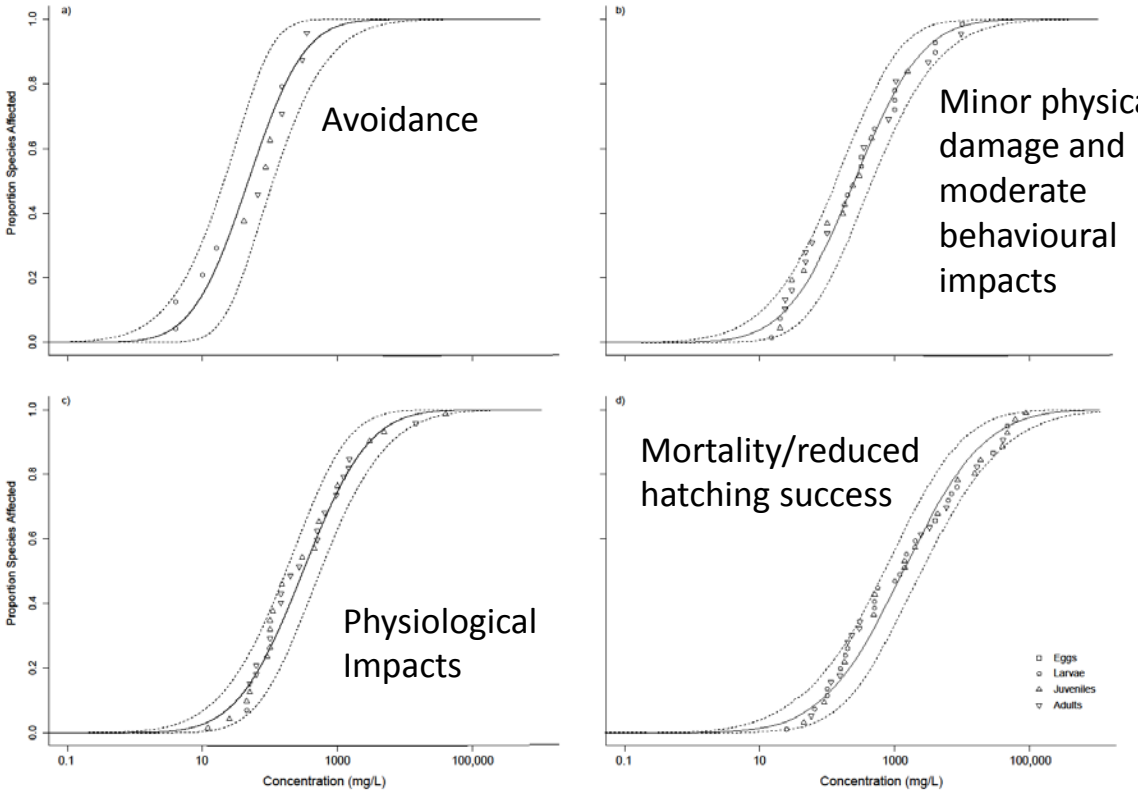


Cumulative probability distribution for suspended sediment concentrations (mg L^{-1})

Dashed lines represent bootstrapped 95% confidence intervals.

A trained random forest model

Increased Suspended Sediment



Threshold reference values
Minor behavioural impacts
2 mg L^{-1} to protect 99% of species to 123 mg L^{-1} to protect 25% of species

Minor physical Impacts
4 mg L^{-1} to protect 99% of species to 896 mg L^{-1} to protect 25% of species

Physical damage or lethal impacts
4 mg L^{-1} to protect 99% of species to 8, 065 mg L^{-1} to protect 25% of species

Traits which make fish vulnerable

- Benthic spawners
- Demersal eggs
- Fish which target highly mobile prey
- Fish from clear water environments
- Fish which have a small home range
- Long pelagic larval duration
- Fish which are visual feeders
- Benthic dwelling fish
- Fish with specific habitat associations
- Fish which are scraping herbivores
- Fish which occupy vulnerable habitats that are restricted in area

Gap analysis (102 species)

	Spawning					Recruitment				Bioregions	References
Arripidae	Time of year	Duration	Habitat	Pelagic larval or propagule duration	Aquatic zone	Time of year	Duration	Habitat	Aquatic zone		
Arripis georgianus	Apr-Jun (peak late May/early Jun)	3 months	West Coast Bioregion only. Reef, sand, weed	Variable between regions- increases with distance from spawning area	Es, Ns	Jun-Sep (variable between regions- increases with distance from spawning area)	4 months- Variable between regions- increases with distance from spawning area	Shallow nurseries with vegetation	Ns	GCB, WCB, SCB	1
Australian Herring											
A.truttaceus	Feb-Jun (peak Apr/May)	5 months	Southern part of West Coast Bioregion	u	Ns	u	u	Soft substrate, shallow sheltered bays	Es, Ns	WCB, SCB	2
Western Australian Salmon											
Berycidae											
Centroberyx gerrardi	Jan-Apr	4 months	Aggregations, Reef	u	In	u	u	u	u	WCB, SCB	Preliminary data

Gap analysis continued

Spawning

a) Spawning periods for 60 (59%) fishes

b) Duration of spawning for 58 species (57%)

c) Pelagic larval duration 18 species (17%)

d) Very little information on spawning locations and habitats

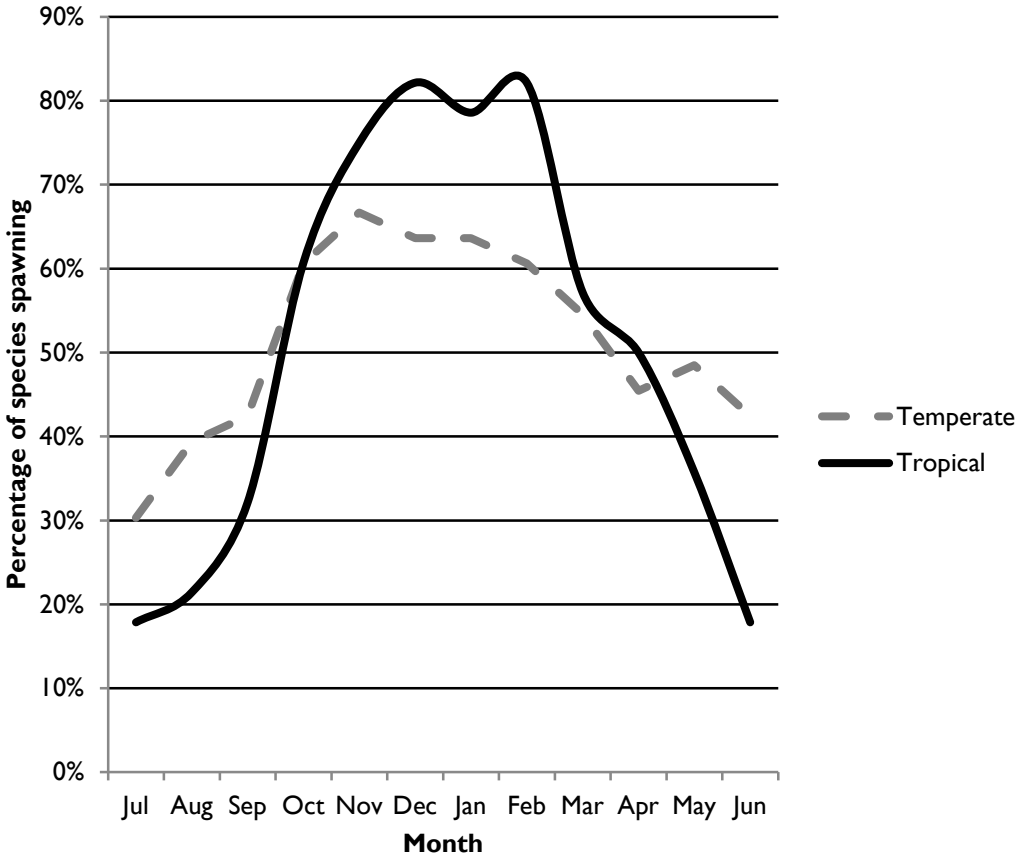
Recruitment

a) Time of year 11 (11%) fishes

b) Duration of recruitment for 7 species (7%)

c) Recruitment locations and habitats for 16 species (16%)

Spawning and Critical Environmental Windows



Spatial variation in spawning

Eg Pink Snapper (*Chrysophys auratus*)

Shark Bay = April to October

Perth = August to January

Albany = September to December

Gap analysis continued

The potential for metals adsorbed to sediment to be taken up by fishes.

- Metals impact reproductive output and early development in fish
- Accumulate in gonad tissues, egg shells and chorion causing developmental delays, changes in time to hatch and larval deformities
- Heavy metals -> reduced sperm motility and death (high levels)

Prioritisation process – how do we decide

Sensitivity index Stekzenmuller et al. 2012

1. Geographical distribution: species with restricted distributions have the highest sensitivity score.
2. Threat status: determined using the IUCN redlist.
3. Importance to fisheries – economic importance to commercial fisheries (price × weight landed).
4. Habitat vulnerability: proportion of habitat vulnerable to dredging with information on habitat position and type and species usage of these habitats.
5. Ability to switch diet: examination of the species trophic guild and the impact of aggregate extraction on its prey.
6. Affinity to seabed: consideration given to species habitat and speed of movement.
7. Reproductive Strategy: position of eggs, position of post-larval stage and fecundity.

Prioritisation process – how do we decide

Scientific name	Common name	Economic significance	Recreational significance	Customary significance	Social significance	IUCN/EPBC significance	Recruitment (year class resilience) significance	Distribution/ endemism significance	Connectivity significance	Habitat specificity significance	Score
Lutjanus sebae	**Red emperor**	**4**	**5**	**1**	**3**	**0**	**2**	**2**	**1**	**2**	**24**
Lutjanus russelli	Saddletail Snapper	3	4	1	1	0	2	2	1	3	19
Epinephelus coioides	Goldspotted Rockcod	3	4	1	1	3	2	2	1	4	23
Plectropomus leopardus	Common Coral Trout	2	5	1	2	3	2	2	1	4	25
Choerodon rubescens	Baldchin Groper	3	5	1	2	2	2	4	3	3	27
Glaucosoma hebraicum	West Australian Dhufish	3	5	1	2	0	3	4	3	2	27
Achoerodus gouldii	Western Blue Groper	2	4	2	3	4	2	3	3	3	30
Coris auricularis	Western King Wrasse	0	2	0	0	0	2	4	3	2	17
Lagocephalus scelaratus	Silver-cheeked toadfish	0	0	0	0	0	1	2	2	1	8
Carcharhinus obscurus	Dusky Shark	3	1	0	2	4	5	2	1	1	23
Pristis zijsron	Green sawfish	0	1	2	3	5	5	2	2	2	27
Hippocampus angustus	Narrow-bellied Seahorse	2	0	0	3	4	2	4	3	4	27
Amphiprion rubrocinctus	Red Anemonefish	2	1	0	3	0	2	3	3	5	23

Fish and dredging management

- There is limited scientific evidence used to support the recommended management interventions,
- There can also be significant direct effects of dredging on fish, which can compound the indirect effects of habitat loss, leading to further impacts.
- Management plans should consider both indirect and direct impacts to fish.

Two main management practices could be used for regulating dredging impacts on fish: threshold reference values and seasonal restrictions

- Threshold reference values are the level at which a particular stressor is considered detrimental to marine life -> trigger management response

- The use of seasonal restrictions has been encouraged during sensitive life history events, such as spawning, flowering, or migration

Research priorities

Identify species of concern

Spawning, Recruitment and effects of dredging

1. What are the spawning times, duration and spawning locations?
2. What is the spawning behaviour (ie single schools at one location)?
3. When does recruitment occur for species of concern and into what habitats?

4. Is the timing of recruitment the same across the entire range of a species?
5. What is the availability (area) of essential habitat throughout the recruitment range?

6. What are the effects of sediment (including metals) and noise on the larvae, recruits and adult life stages?

Questions?