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A framework for selecting fish health indicators for ports and estuaries in Northern Australia

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Ports and estuaries in Northern Australia

- **Ports** are vital to Australia's economy but activities can impact on natural coastal environment
- **Estuaries** are complex, dynamic and vulnerable to terrestrial impacts
- Queensland: 20 major ports, 12 in or near Great Barrier Reef World Heritage Area, including the Port of Gladstone
- Some ports are within estuaries

Fish health in the Port of Gladstone

- Gladstone fish health concerns following flood event in 2011-12
- Gladstone Harbour Report Card – 2014
  - Communicate relative environmental performance
  - Range of indicators – environmental, economic, social, cultural
  - Environmental – water quality, seagrass, coral, fish recruitment, mud crabs
- Fish health indicator – 2018

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Fish as indicators


Image: fish.wa.gov.au

- Continuously exposed
- Ubiquitous in aquatic ecosystems
- Play important ecological roles
- Relatively few, easily identified, species
- Direct measure of ecological consequences of environmental impacts
- Relatively long lived (show cumulative impacts, bioaccumulation)
- High public profile and socioeconomic value

What is fish health?

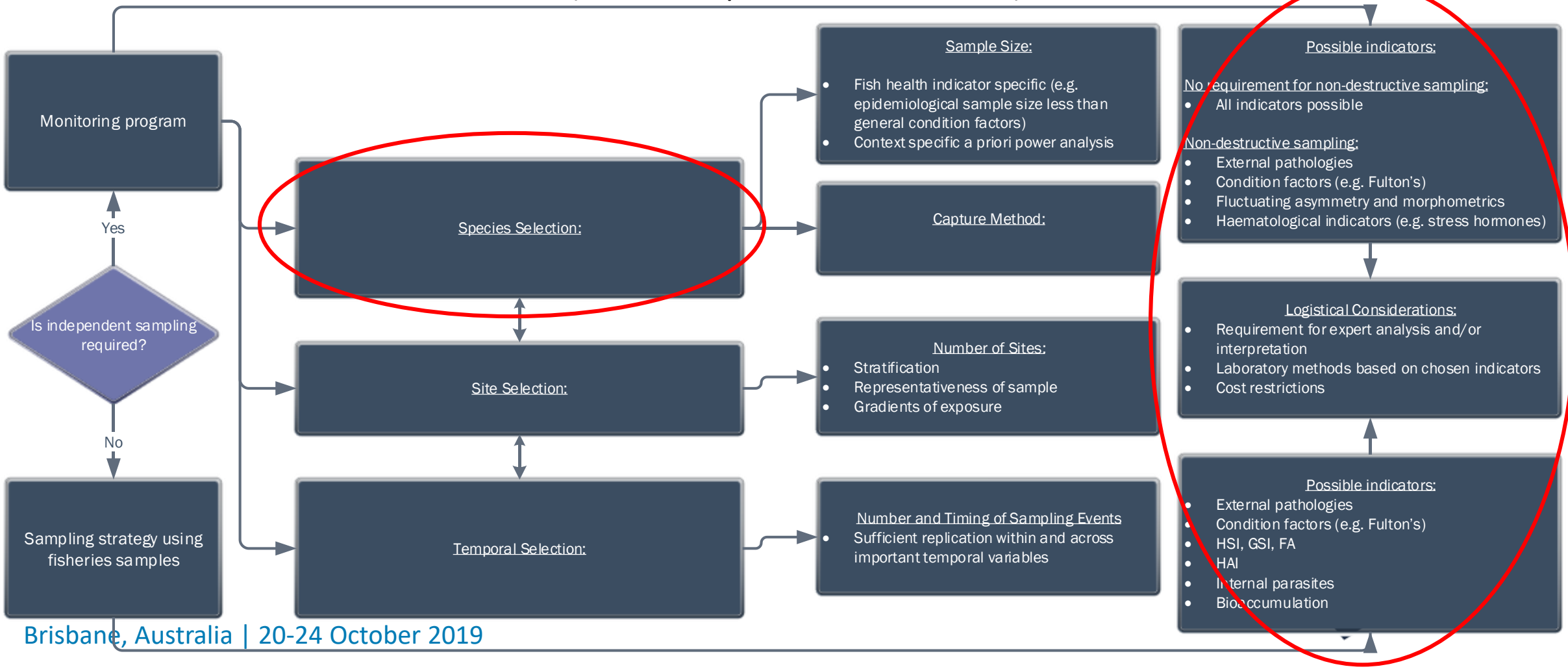
- Most report cards use population- and community-level fish abundance and diversity indices

- But, we needed to trial individual-level indicators of fish health that would be suitable for report cards

- Definition of fish health in this context: structural and morphological health and functioning in terms of the physiology of the organism (Whitfield and Elliot, 2002)

Whitfield, A. K., & Elliott, M. (2002). Fishes as indicators of environmental and ecological changes within estuaries: A review of progress and some suggestions for the future. *Journal of Fish Biology, 61*(SUPPL. A), 229-250.

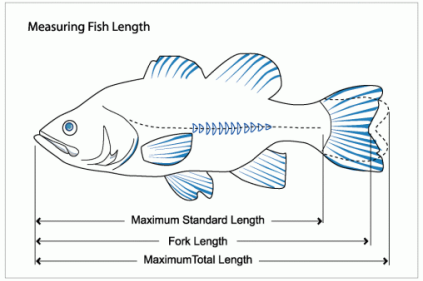
We developed a framework for fish health indicator selection (the simplified version!)



Possible indicators

- Condition measures (e.g. Fulton's K, hepatosomatic index, gonadosomatic index)
- Gross pathology (e.g. Health Assessment Index, parasite analysis)
- Fluctuating asymmetry
- Biomarkers
- Histopathology
- Bioaccumulation

Cowled, B. (2016). *Final review of the use of fish health methods worldwide and their potential use in Gladstone Harbour* (Project ISP016a). Retrieved from: www.ghhp.org.au



Condition measures

- Fulton's condition factor, K, (weight: cube length)
- Hepatosomatic index (liver weight: body weight)
- Gonadosomatic index (gonad weight: body weight)
- All require large datasets
- All can be naturally (e.g. seasonally) variable
- Rapid and inexpensive, if you already have the fish

Image: nt.gov.au

Fluctuating asymmetry

- Various meristic and measured bilateral characters
  - Otoliths
  - Pelvic and pectoral fin ray counts
  - Eyes, orbit, etc
- Random deviations in size/shape
- Sign of developmental instability
- Mixed outcomes in the literature
- Very limited data from Australia

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Image: ABC News

Gross pathology

- Health Assessment Index, HAI (Adams, 1993)
- Scores for gross condition of multiple organs and tissues, and overall parasite load
- Combined to reflect acute and chronic stressors
- Good for comparisons
- Relatively rapid analysis by trained technical staff

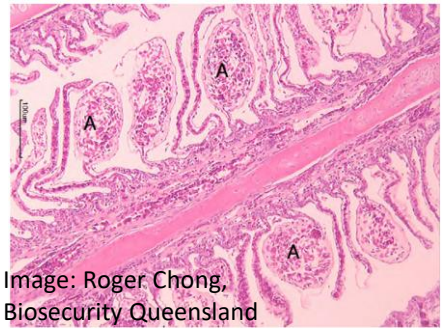

Image: Roger Chong, Biosecurity Queensland

Histopathology

- Cumulative and chronic environmental stress causes physiological changes visible as tissue changes
- Histopathological change frequently linked to water pollution
- Highly specialised, time consuming
- Post-mortem degeneration of tissues so need to extract fish organs immediately after death

Adams, S. M., Brown, A. M., & Goede, R. W. (1993). A Quantitative Health Assessment Index for Rapid Evaluation of Fish Condition in the Field. *Transactions of the American Fisheries Society, 122*, 63-73.

Wesche, S., Lucas, T., Mayer, D., Waltisbuhl, D., & Quinn, R. (2013). *Gladstone Harbour Fish Health Investigation 2011–2012*. Queensland Government Department of Agriculture and Fisheries, Brisbane, Queensland.

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Biomarkers

Image: Sussman, J.L.

- Currently not well categorised for fish and not ready for application (Kroon et al., 2017)
- Widely used early warning signals
- Highly variable on a variety of scales, including biological characteristics
- Most well categorised is EROD (ethoxyresorufin-O-deethylase)

Bioaccumulation

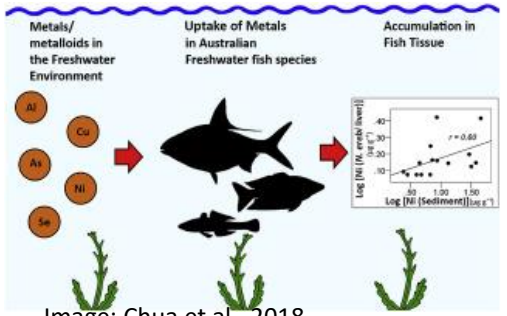

Image: Chua et al., 2018

- Take up and retention of toxins in tissues
- Via gills, skin, ingestion, or contaminated food (biomagnification)
- May not reflect environmental concentrations
- May not actually impact on fish health

Chua, E., Flint, N., Wilson, S., and Vink, S. (2018). Potential for Biomonitoring Using Fish Tissue Metals Analysis in a Major Agricultural and Coal Mining Region. *Chemosphere* **202:** 598-608.

Kroon, F., Streten, C., & Harries, S. (2017). A protocol for identifying suitable biomarkers to assess fish health: A systematic review. *PLoS One, 12*(4), e0174762. doi:10.1371/journal.pone.0174762

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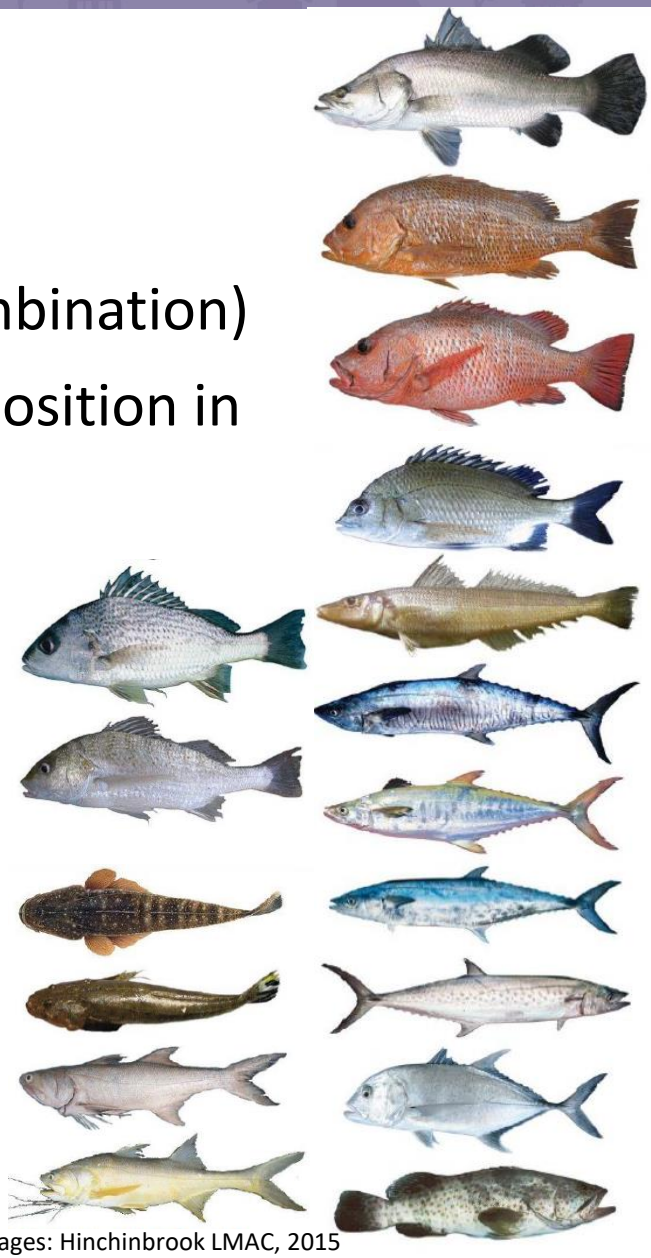
Selecting species

- Objectives of monitoring (fish health, environmental health, combination)
- Likelihood of exposure to relevant environmental impacts (e.g. position in the water column, trophic level, size, life history)
- Previous known disease or condition concerns
- Relevance to the community
- Fish movements relative to study area



Images: Hinchinbrook LMAC, 2015

Selecting species

- Fish movements relative to study area

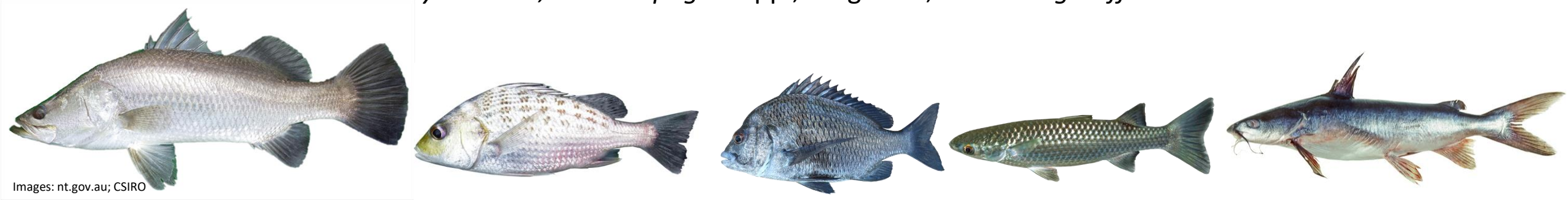
Straight line distance travelled by recaptured pikey bream from Stanage Bay, Gladstone and Baffle Creek, n = 184. (Data source: SunTag).

Straight line distance travelled by recaptured barramundi from Stanage Bay, Gladstone and Baffle Creek, n = 1817. (Data source: SunTag).

Fish health indicators for Gladstone

- Preferred indicator: Health Assessment Index, modified from Adams et al. (1993), checks for specific parasites and overall parasite load
- Research & development for Fluctuating Asymmetry (CQUni Masters candidate) and condition measures (long term database development)
- Histopathology – organs retained and stored as a backup data source
- Bioaccumulation – tissue samples retained for possible analysis in future

Lates calcarifer, Pomadasys kaakan, Acanthopagrus spp., Mugilidae, *Neoarius graeffei*



Images: nt.gov.au; CSIRO

Ports and Estuaries in Northern Australia

- Fish make useful biological indicators of environmental contamination, currently underutilised in Australia
- Use of a framework to select species, indicators, sampling parameters, provides greater accountability (e.g. for public reporting)
- Various combinations possible depending on site, monitoring objectives and budget
- Consistent monitoring of at least some indicators and species across northern Australia would be ideal

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More information and acknowledgements

- Flint, N., Anastasi, A., Irving, A., De Valck, J., Chua, E., Rose, A., French, K. and Jackson, E.L. (2018). Fish Health Indicators for the Gladstone Harbour Report Card, Final Report to GHHP. CQUniversity Australia, available at: https://dims.ghhp.org.au/repo/public/5f8d35

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