A Tiered Assessment Framework for Mark Selective Fisheries

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Mark Selective Fisheries (MSF)

- Benefits in conservation and exploitation come with cost to information
  - Formerly observable fishery mortalities must be indirectly estimated
    - Need to method to estimate ER of unmarked fish (ER^U),
    - Proposed methods of estimating ER^U will depend on size of fishery

Reasons for tiered approach

- Basic equation for estimating the number of unmarked mortalities (U^{SF})

$$U^{SF} = M^{SF} * \lambda * sfm$$

Marked & tagged encounters

Unmark to mark ratio

Selective fishing mortality

- Size of fishery will impart different degree of information about M^{SF} and λ
- Successive MSFs will change λ through time and space

Outline

- Reasons for a tiered approach
- Review of assumptions/requirements
- Options for estimating U^{SF} based on requirements
  - Single index tagging (SIT) – most restrictive
  - Double Index tagging (DIT)
  - Double Index tagging with auxiliary information (DOT)
  - Appropriateness for different fishery sizes

Unknown Mortality Estimation: Requirements

	LOW	MEDIUM	HIGH
	Option (1)	Option (2)	Option (3)
Hatchery Source of λ	□	□	
Intermediate Source of λ		O	□ (DOT)
DIT Required		□	O
Release mortality (*sfm*) known	□	□	□
Equal hatchery and wild encounter rates	□	□	□

Option 1: sfm known, λ constant in all fisheries (MSF and NSF)

- Uses Single Index Tag (SIT)
- Appropriate for small fisheries (low impact)
  - Few CWT recoveries – imprecise estimates of M^{MSF}
  - Little or no observable impact on λ
- Unmarked mortalities:

$$U^{SF} = M^{SF} * sfm$$

where M^{SF} = total CWT landings

- Key Assumption: Mark to unmarked ratio (λ) changes very little

Double Index Tagging (DIT)

- Selective fishery starts to have an impact on λ as number of landed fish increases
  - When fisheries are successive in time and space
- Larger fisheries: increased numbers of CWTs - more (precise) information on M^{SF} (and U^{SF})
- Double Index Tag groups and/or auxiliary information to estimate MS impacts

Option 2: Double Index Tag (DIT)

- 2 groups – Marked and tagged; Unmarked and tagged
- U^{SF} estimated by

$$U^{SF} = M^{SF} * \lambda * sfm$$

- *sfm* known; hatchery based information on λ (λ^{Rel} or λ^{Esc})
- Total M^{SF} from CWT recoveries
  - Size of fisheries increase – more information on M^{SF}

Option 3: Double Otolith Tag (DOT)

- Paired non-selective fishery (NSF)
- Unmark to mark ratio, λ, estimated from NSF occurring with a MSF (e.g., test fishery)

$$U^{SF} = M^{SF} * \lambda^{NSF} * sfm$$

- Can use other mark groups, e.g., ad- and un-clipped fish that are also otolith marked

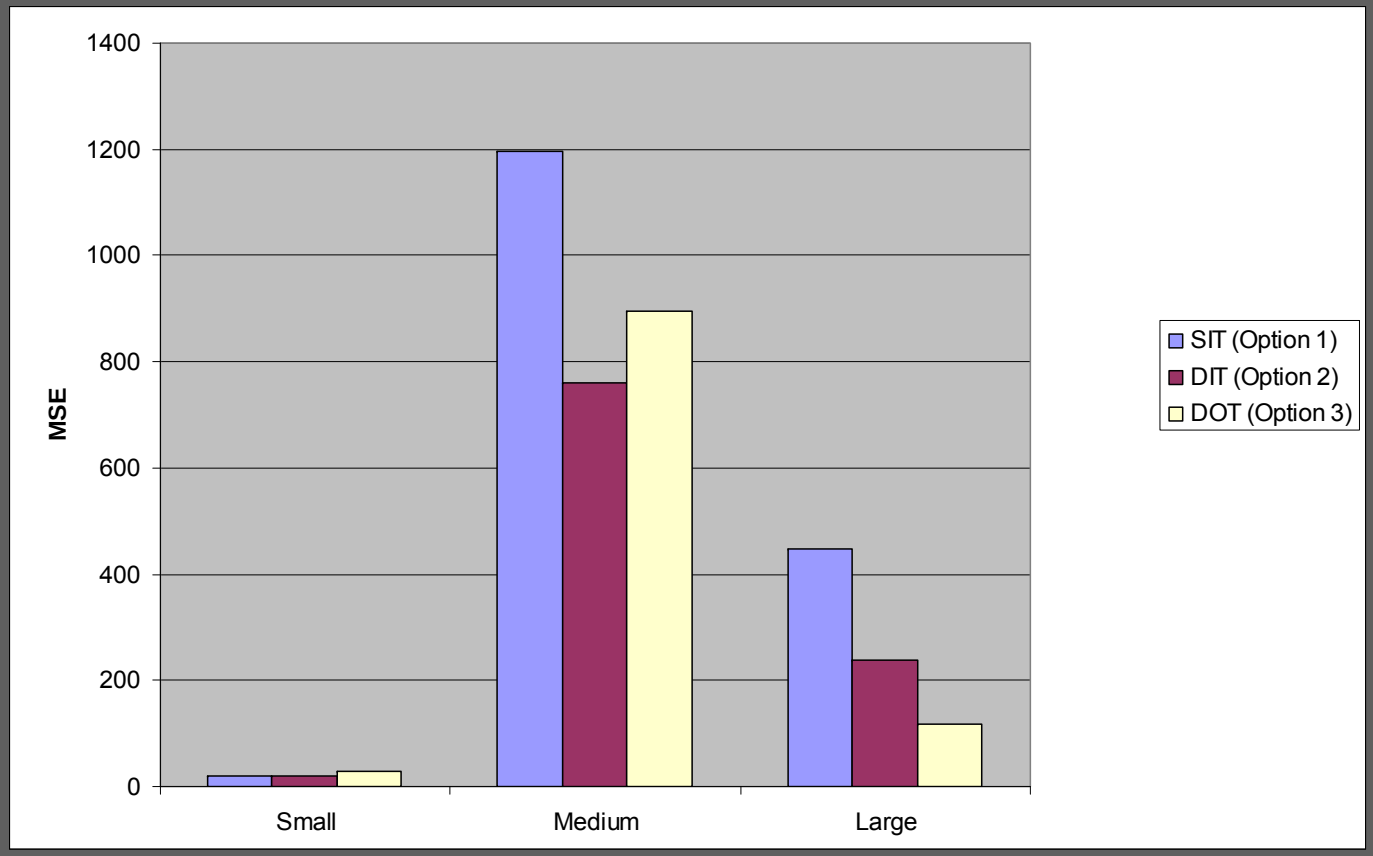
Comparison of methods: SIT, DIT and DOT

- Which method for which fishery?
- Compare methods using Mean Squared Error (MSE)
  - MSE(U^{SF}) = Variance(U^{SF}) + Bias^2
- Examine MSE for Options 1, 2, and 3 for different fishery sizes

Comparison of methods: (continued)

- Simple example: Fish passing 2 fisheries before returning to hatchery
  - Small: 2 small fisheries (Enc. Rates 5%)
  - Medium: both larger
  - Large: both larger than the medium fisheries
  - 1% natural survival, sfm = 20%
- Examined MSE for each option for each fishery type

Comparison of Options: based on fishery sizes



Summary: SIT vs DIT vs DOT

- Small fishery: all methods small MSE
  - Unmark/mark ratio at release – small bias in 2nd fishery
- Medium Fishery: DIT using hatchery based values of λ - smallest MSE;
  - λ^{REL} bias in 2nd fishery – consider λ^{ESC} ?
- Large fishery: DOT - smallest MSE
  - Large release size, small test fishery
  - Unmark/mark ratio changes the most

Mark Selective Fisheries (MSF)

- Benefits in conservation and exploitation come with cost to information
  - Estimation methods depend on size of MSF
  - For high magnitude MSF's, the choice of method will likely depend on viability of implementation and metrics like bias, precision, or both (Mean Squared Error)