**Supplementary Table 1.** The words and phrases used in each component of the final string for both databases. Each entry corresponds to a bracketed group of words and phrases that were separated by the OR operator. The bracketed phrases were separated by the AND operator. This informs the database to search for any of the terms within each bracket and must include a term from all 3 brackets in Scopus and 4 brackets in Web of Science. Wildcards (\*) are used to search for all potential word endings, e.g. connect\* would return words such as: connected, connectivity, connection, etc.

|  |  |
| --- | --- |
|  | **Search database** |
| **Theme of search string component** | **Scopus** | **Web of Science** |
| (i) Functional connectivity | Connect\*, “functional connectivity”, ontogen\*, “long distance dispers\*”, juvenile\*, impotan\*, enhance\*, nurser\*, “habitat connectivity” | Connect\*, “functional connectivity”, ontogen\*, “long distance dispers\*”, nurser\*, “habitat connectivity”, |
| (ii) Marine species that use different habitats at different life stages | Fish\*, reef fish\*, coral\*, mangrove\*, seagrass\*, “multihabitat species”, juvenile\*, “different habitat\*”, “life cycle stage\*”, “life cycle\*, “life stage\*”, “multihabitat use”, “habitat use”, nurser\* | Fish\*, reef, coral\*, mangrove\*, seagrass\*, “multihabitat species”, juvenile\* |
| “different habitat\*”, “life cycle stage\*”, “life cycle\*”, “life stage\*”, “multihabitat use”, “habitat use”, nurser\* |
| (iii) Terms relating to the type of study, data collection, themes of the paper | Habitat\*, spatial, threatened species, model\*, hypothesis, paradigm, protection, “marine reserve\*”, “marine protected area\*”, pattern\* | Spatial, threatened, model\*, “marine reserve\*”, “marine protected area\*” |

**Supplementary Table 2.** Demographic parameter values used for Leslie matrix modelling, assuming no additional mortality from external sources.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value: linear regression** | **Value: negative exponential** | **Source/Rationale** |
| Fecundity | 2.2 |  | Rmax of 2.2, Kellner et al but assuming a survival of 100% for these 2.2 individuals, therefore incorporating high juv mortality of broadcast spawners without added computational complexity |
| Juvenile Survival | .5 |  | Back calculated for when lambda=1 for the rest of these values at a distance of 13km between mangrove and coral reef (Dohrenbosch et al 2006) |
| Juvenile Transition probability | .9 |  | Assume almost all surviving individuals transition to subadult stage after one year |
| Subadult survival | .65 |  | Maximum rate (intercept of linear relationship) is assumed to be similar to adult, Kellner et al 2010 |
| Subadult transition probability | .65 |  | Become mature between 2-5 years, so each year .35 stay behind. |
| Adult Survival | .67 |  | Kellner et al 2010, Appendix B |
| Fishing mortality | 0-0.15 |  | Kellner et al 2010, Appendix B |

**Supplementary Table 3.** Leslie matrix used for population projection and calculation of λ, the rate of population increase.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Age 0** | **Juvenile** | **Subadult** | **Adult** |
| Age 0 | 0 | 0 | 0 | 2.2 |
| Juvenile | 1 | .035 | 0 | 0 |
| Subadult | 0 | .315 | .2535 | 0 |
| Adult | 0 | 0 | .3965 | .67 |

**Appendix S1.** The 29 publications used to test different combinations of search string terms and to extract words and phrases to be used in the final search strings. Those shown in **bold** represent the four that were not detected using the final search string used to conduct the review. Those marked with an asterisk (\*) represent those which were included in 69 eligible publications in the review.

Adams AJ, Ebersole JP (2002). Use of back-reef and lagoon habitats by coral reef fishes. Mar. Ecol. Prog. Ser. 228: 213–226

Archambault B, Rivot E, Savina M, Le Pape O. (2018). Using a spatially structured life cycle model to assess the influence of multiple stressors on an exploited coastal-nursery-dependent population. Estuar. Coast. Shelf Sci. 201:95–104.

\*Claydon J, Calosso MC, De Leo GA, Peachey RBJ (2015). Spatial and demographic consequences of nursery-dependence in reef fishes: An empirical and simulation study. Mar. Ecol. Prog. Ser. 525:171–183.

**Cocheret De La Morinière E, Nagelkerken I, Van Der Meij H, van der Velde G. (2004). What attracts juvenile coral reef fish to mangroves: Habitat complexity or shade? Mar. Biol. 144:139–145.**

Cocheret De La Morinière E, Pollux BJA, Nagelkerken I, van der Velde G. (2002). Post-settlement life cycle migration patterns and habitat preference of coral reef fish that use seagrass and mangrove habitats as nurseries. Estuar. Coast. Shelf Sci. 55(2):309–321.

Cowen RK, Sponaugle S. (2009). Larval Dispersal and Marine population Connectivity. Annu. Rev. Mar. Sci. 1(1):443-446.

\*Dorenbosch M., Grol M, Christianen M, Nagelkerken I, Velde GV. (2005). Indo-Pacific seagrass beds and mangroves contribute to fish density and diversity on adjacent coral reefs. Mar. Ecol. Prog. Ser.302:63-76

**Dorenbosch M., Van Riel MC, Nagelkerken I., Van Der Velde G. (2004). The relationship of reef fish densities to the proximity of mangrove and seagrass nurseries. Estuar. Coast. Shelf Sci. 60(1):37–48.**

\*Dorenbosch M., Grol MGG, Nagelkerken I, van der Velde G. (2006). Seagrass beds and mangroves as nurseries for the threatened Indo-Pacific Humphead wrasse, *Cheilinus undulatus* and Caribbean Rainbow parrotfish, *Scarus guacamaia*. Biol. Conserv. 129:277-282

Honda K, Nakamura Y, Nakaoka M, Uy WH, Fortes MD. (2013). Habitat Use by Fishes in Coral Reefs, Seagrass Beds and Mangrove Habitats in the Philippines. PLoS ONE:*8*(8).

Jones DL, Walter JF, Brooks EN, Serafy JE. (2010). Connectivity through ontogeny: Fish population linkages among mangrove and coral reef habitats. Mar. Ecol. Prog. Ser. 401:245–258

Kimirei IA, Nagelkerken I, Griffioen B, Wagner C, Mgaya YD. (2011). Ontogenetic habitat use by mangrove/seagrass-associated coral reef fishes shows flexibility in time and space. Estuar. Coast. Shelf Sci. 92(1):47–58.

Kimirei IA, Nagelkerken I, Mgaya YD, Huijbers CM. (2013). The Mangrove Nursery Paradigm Revisited: Otolith Stable Isotopes Support Nursery-to-Reef Movements by Indo-Pacific Fishes. PLoS ONE:8(6).

Machemer E, Walter III JF, Serafy JE, Kerstetter DW (2012). Importance of mangrove shorelines for rainbow parrotfish *Scarus guacamaia*: habitat suitability modelling in a subtropical bay. Aquat. Biol. 15(1):87–98.

McCook LJ, Almany GR, Berumen ML, Day JC, Green AL, Jones, GP, … Thorrold SR. (2009). Management under uncertainty: Guidelines for incorporating connectivity into the protection of coral reefs. Coral Reefs 28:353–366.

\*McMahon KW, Berumen, ML, Thorrold SR. (2012). Linking habitat mosaics and connectivity in a coral reef seascape. PNAS. 109(38):15372–15376.

Mumby PJ (2006). Connectivity of reef fish between mangroves and coral reefs: Algorithms for the design of marine reserves at seascape scales. Biol. Conserv. 128(2):215–222.

\*Mumby PJ, Edwards AJ, Arias-González JE, Lindeman KC, Blackwell PG, Gall A., … Llewenyn G. (2004). Mangroves enhance the biomass of coral reef fish communities in the Caribbean. Nature, 427(6974):533–536.

\*Mumby PJ, Hastings A. (2008). The impact of ecosystem connectivity on coral reef resilience. J. Appl. Ecol. 45(3):854–862.

\*Nagelkerken I, Dorenbosch M, Verberk WCEP, Cocheret de la Moriniere E, Van der Velde G. (2000a). Importance of shallow-water biotopes of a Caribbean bay for juvenile coral reef fishes: Patterns in biotope association, community structure and spatial distribution. Mar. Ecol. Prog. Ser. 202:175–192.

Nagelkerken I, Van Der Velde G, Gorissen MW, Meijer GJ, Van’t Hof T, Den Hartog C. (2000b). Importance of mangroves, seagrass beds and the shallow coral reef as a nursery for important coral reef fishes, using a visual census technique. Estuar. Coast. Shelf Sci. 51(1):31–44.

**Nagelkerken I, Roberts CM, van der Velde G, Dorenbosch M, van Riel CM, Cocheret de la Moriniere E, Nienhuis PH. (2002). How important are mangroves and seagrass beds for coral-reef fish? The nursery hypothesis tested on an island scale. Mar. Ecol. Prog. Ser. 244:299– 305.**

Nagelkerken I (2007). Are Non-Estuarine Mangroves Connected to Coral Reefs Through Fish Migration? Bull. Mar. Sci. 80(3):595-607.

\*Nagelkerken I, Huebert KB, Serafy JE, Grol MGG, Dorenbosch M, Bradshaw CJA. (2017). Highly localized replenishment of coral reef fish populations near nursery habitats. Mar. Ecol. Prog.Ser. 568:137-150.

Olds AD, Albert S, Maxwell PS, Pitt KA, Connolly RM. (2013). Mangrove-reef connectivity promotes the effectiveness of marine reserves across the western Pacific. Glob. Ecol. Biogeogr. 22(9):1040–1049.

Pérez-Ruzafa A, De Pascalis F, Ghezzo M, Quispe-Becerra JI, Hernández-García R, Muñoz I, … Marcos C. (2019). Connectivity between coastal lagoons and sea: Asymmetrical effects on assemblages’ and populations’ structure. Estuar, Coast. Shelf Sci. 216:171– 186.

\*Unsworth RKF, De León PS, Garrard SL, Jompa J, Smith DJ, Bell JJ. (2008). High connectivity of Indo-Pacific seagrass fish assemblages with mangrove and coral reef habitats. Mar. Ecol. Prog. Ser. 353:213–224.

Vasconcelos RP, Eggleston DB, Le Pape O, Tulp I. (2014). Patterns and processes of habitat-specific demographic variability in exploited marine species. ICES J. Mar. Sci. 71(3):638–647

**Verweij MC, Nagelkerken I, Hol KEM, Van Den Beld HJB, Van Der Velde G. (2007). Space use of *Lutjanus apodus* including Movement between a Putative Nursery and a Coral Reef. Bull. Mar. Sci. 81(1):127-138.**

**Appendix S2.** Exact search strings used for a. Scopus and b. Web of Science. Note the different terminology in the two databases’ search function. With Scopus, the phrase “TITLE-ABS-KEY” is used to search the titles, abstracts, and keywords for the phrases in the following brackets. For Web of Science, the phrase “TOPIC” is used to perform the same function. Wildcards (*e.g.* \*) are used to search all possible endings for words or phrases. For example, “nurser\*” would return search terms such as “nursery” and “nurseries”.

**a.** ( TITLE-ABS-KEY ( ( connect\* OR "functional connectivity" OR ontogen\* OR "long distance dispers\*" OR juvenile\* AND migration OR importan\* OR enhance\* OR nurser\* OR habitat AND connectivity ) ) AND TITLE-ABS-KEY ( ( fish\* OR reef AND fish\* OR coral\* OR mangrove\* OR seagrass\* OR "multihabitat species" OR juvenile\* OR "different habitat\*" OR "life cycle stage\*" OR "life cycle\*" OR "life stage\*" OR "multihabitat use" OR "habitat use" OR nurser\* ) ) AND TITLE-ABS-KEY ( ( habitat\* OR spatial OR threatened AND species OR "model\*" OR "hypothesis" OR "paradigm" OR protection OR "marine reserves" OR "marine protected areas" OR pattern\* ) ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) ) AND ( EXCLUDE ( SUBJAREA , "SOCI" ) OR EXCLUDE ( SUBJAREA , "ENGI" ) OR EXCLUDE ( SUBJAREA , "MEDI" ) OR EXCLUDE ( SUBJAREA , "NEUR" ) OR EXCLUDE ( SUBJAREA , "IMMU" ) OR EXCLUDE ( SUBJAREA , "DECI" ) OR EXCLUDE ( SUBJAREA , "COMP" ) OR EXCLUDE ( SUBJAREA , "ECON" ) OR EXCLUDE ( SUBJAREA , "ENER" ) OR EXCLUDE ( SUBJAREA , "MATH" ) OR EXCLUDE ( SUBJAREA , "PHYS" ) OR EXCLUDE ( SUBJAREA , "ARTS" ) OR EXCLUDE ( SUBJAREA , "CHEM" ) OR EXCLUDE ( SUBJAREA , "VETE" ) OR EXCLUDE ( SUBJAREA , "CENG" ) OR EXCLUDE ( SUBJAREA , "MATE" ) OR EXCLUDE ( SUBJAREA , "PHAR" ) OR EXCLUDE ( SUBJAREA , "BUSI" ) )

**b.** TOPIC: ((connect\* OR “functional connectivity” OR ontogen\* OR “long distance dispers\*” OR “juvenile migration” OR nurser\* OR “habitat connectivity”)) AND TOPIC: ((fish\* OR reef OR coral\* OR mangrove\* OR seagrass\* OR “multihabitat species” OR juvenile\*)) AND TOPIC: ((“different habitat\*” OR “life cycle stage\*” OR “life cycle\*” OR “life stage\*” OR “multihabitat use” OR “habitat use” OR “nurser\*”)) AND TOPIC: ((spatial OR threatened OR model\* OR “marine reserves” OR “marine protected areas”)).

Refined by: LANGUAGES: ( ENGLISH ) AND WEB OF SCIENCE CATEGORIES: ( MARINE FRESHWATER BIOLOGY OR MATHEMATICAL COMPUTATIONAL BIOLOGY OR OCEANOGRAPHY OR ECOLOGY OR FISHERIES OR ENVIRONMENTAL SCIENCES OR BIODIVERSITY CONSERVATION OR ZOOLOGY OR MULTIDISCIPLINARY SCIENCES OR LIMNOLOGY OR EVOLUTIONARY BIOLOGY OR BIOLOGY OR GREEN SUSTAINABLE SCIENCE TECHNOLOGY OR GENETICS HEREDITY OR ENVIRONMENTAL STUDIES OR BIOCHEMISTRY MOLECULAR BIOLOGY OR BEHAVIORAL SCIENCES ). Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.

**Appendix S3.** The defined inclusion and exclusion criteria for the second (title/abstract/keywords) and third (full text) screening process. These criteria were discussed and agreed upon by the author and the three academic supervisors at The University of Aberdeen.

Second screening phase: Titles, abstracts, and keywords

**Include records based on the following criteria:**

 *Context of the study:*

* Mention a marine species that use different habitats at different stages, and incorporate an element of connectivity between these habitats
	+ Ideally the publication would address *functional* connectivity, however structural and/or larval are acceptable
	+ Can focus on disrupted connectivity between the life cycle habitats
		- Disruption can be due to habitat loss, fragmentation, barriers, climate change, or anything else of relevance
		- Ideally, the *importance* of connectivity could be emphasised. This could be due to increased gene flow, population resilience, completion of a life cycle, protected species, *etc*.
* The species does not have to strictly be a marine species, it can be estuarine or freshwater, if it migrates to a marine habitat for a portion of its life cycle:
	+ Estuarine/brackish environments are acceptable
	+ Diadromous species (Amphidromous, Anadromous or Catadromous are acceptable, Potamodromous are not)
	+ Once in the marine habitat, the species must be able to survive in the water for over 24 hours
		- Therefore, pinnipeds and seabirds would be excluded
		- Species such as sea turtles and larvae of freshwater species would be included

*Motivation for the study:*

* Is the study about connectivity between and within MPAs/protected areas (ideally functional connectivity, but structural and larval is acceptable)?
	+ Is it relevant to the topic based on the information above?
		- Including species with different habitats in their life cycles?
		- If so, include
* Is it modelling/discussing/experimenting marine connectivity between life cycle habitats (ideally functional connectivity, but structural and larval is acceptable)?
	+ If so, there must be mention of species using multiple habitats in their life stages
	+ One of these habitats must be marine
	+ If so, include
* Is it a review?
	+ Is it relevant, based on the criteria above?
	+ Does it contain results/meta-analyses that could be extracted for this review?
	+ If so, include
* Fisheries science
	+ Does it address the biology/ecology/multihabitat use/ontogenetic migrations of the species, not just state the biomass/catches/stock statistics?
	+ Is it relevant, based on the criteria above?
	+ If so, include
* Invasive species
	+ Is it relevant, based on the criteria above?
	+ If so, include

**Screen out records that are:**

* Obviously irrelevant:
	+ Terrestrial or botanical
	+ Solely freshwater (*e.g.* Potamodromous species)
	+ Other fields of study (*e.g.* medicine, chemistry)
	+ Fisheries studies that are not addressing connectivity
* Focussing on species that are not strictly marine for a large portion of their life cycle:
	+ Birds, including seabirds
	+ Freshwater non-migratory fish, freshwater turtles, amphibians, *etc.*
* Only focussing on one habitat (*e.g.* coral reefs) with no mention of connectivity to other life cycle habitats (*e.g.* seagrass nurseries, pelagic larval habitats, *etc.*).
* Only focussing on habitat use within single or multiple habitats without incorporating elements of connectivity between habitats.
* Only focusing on single/multiple species’ life cycle but are otherwise not mentioning connectivity between habitats within the life cycle.
* Only focussing on daily migrations between habitats (*e.g.* for feeding) but not on ontogenetic migrations between habitats depending on the stage of the life cycle.
* Reviews or secondary or grey literature that do not contain results/meta-analyses that are extractable to use in this review.

Third screening phase: Full text

**The inclusion criteria were the same as above.**

**Screen out records that, upon reading the full text, are:**

* Not about the importance, presence, loss, potential loss, *etc.* of connectivity, functional connectivity, larval connectivity from one habitat to another
* Too focussed on an individual habitat that a species uses and do not incorporate/acknowledge connectivity *between* habitats.
	+ *E.g.* Only focussed on the abundance/biomass of species in a single habitat
* Only implying themes of functional/structural/larval connectivity, not directly measuring/modelling/discussing it.
* A review or piece of secondary or grey literature that does not provide a meta-analysis/results that are extractable and applicable to this review.
* Addressing connectivity between habitats used for daily migrations, such as feeding, and not ontogenetic migrations between life cycle habitats.