Deep-sea protected coral reproduction study
POP2022_03

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Climate, Freshwater & Ocean Science

NIWA
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Project Objectives

1. Address knowledge gaps in reproductive strategies for protected coral species in the New Zealand region

2. Use available life history and reproductive data to inform relative productivity/vulnerability parameters for relevant concurrent and future research

Background

New Zealand has a rich complement of deep-sea corals

- Studying deep-sea fauna is difficult
- Little is known of their life histories

Without this information we cannot fully understand:

- Population dynamics
- Connectivity between suitable habitats
- Vulnerability and/or resilience to physical disturbance such as bottom trawling

Summary of past research

This project follows DOC project (BCBC2020-01) which:

Summarised existing knowledge of reproduction of protected deep-sea corals in NZ

- Highlighted large knowledge gaps

Summarised available preserved samples within NIWA's Invertebrate Collection and identified species for further study:

- Scleractinians: *Desmophyllum dianthus*, *Goniocorella dumosa*, and *Enallopsammia rostrata*
- Gorgonian octocorals: *Paragorgia arborea* and *Primnoa notialis*

Reproductive strategy: Branching Scleractinia

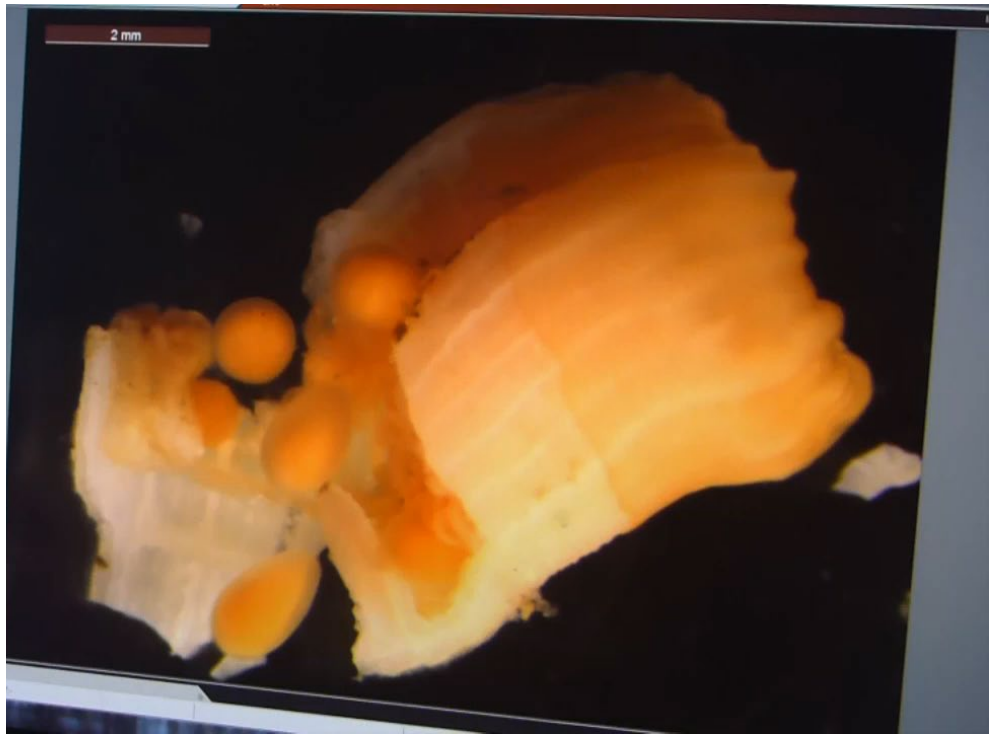
All NZ branching stony corals were thought to be seasonal gonochoric broadcast spawners:

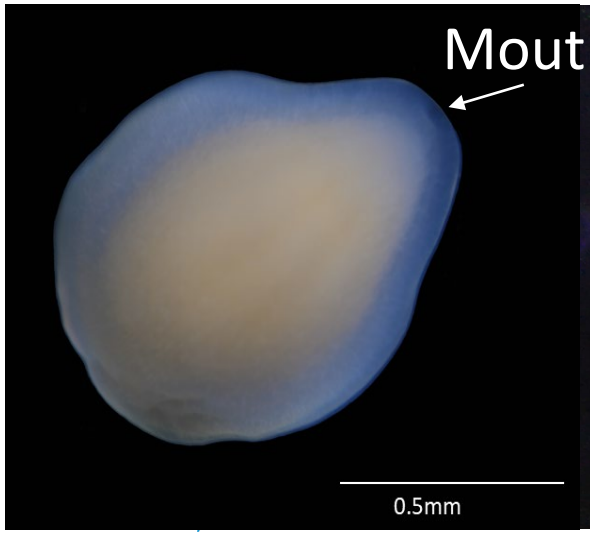
- Seasonal: spawns once per year at the same time of year
- Gonochoric: separate male and female polyps
- Broadcast spawners: male and female gametes are released into the water column. Fertilization is external and planula larvae drift in water column/ocean currents until they find a suitable substrate to settle and grow

Some species also known to reproduce via budding (*Goniocorella dumosa* and *Solenosmillia variabilis*)

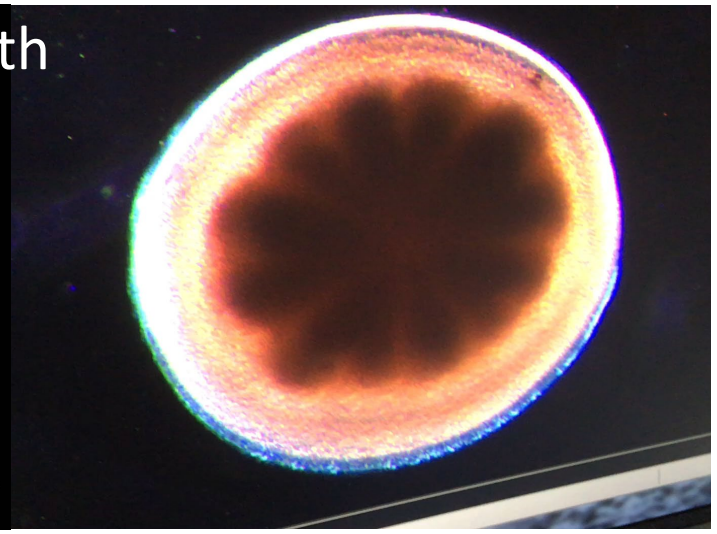
Opportunistic observations of *Goniocorella dumosa* larvae (Sept 2020)

- First observation of NZ deep-sea coral larvae
- *G. dumosa* are brooders
- Large larvae (approx. 1.1 x 0.8 mm in size)
- Covered in cilia with formed mouth
- Pear-shaped (when swimming)
- Up to 10 mature larvae seen inside a single polyp
- Settlement between 2 and 8 days
- One larva still swimming after 88 days

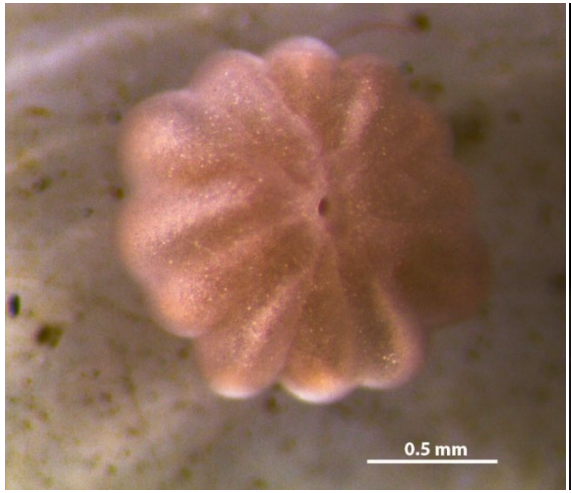




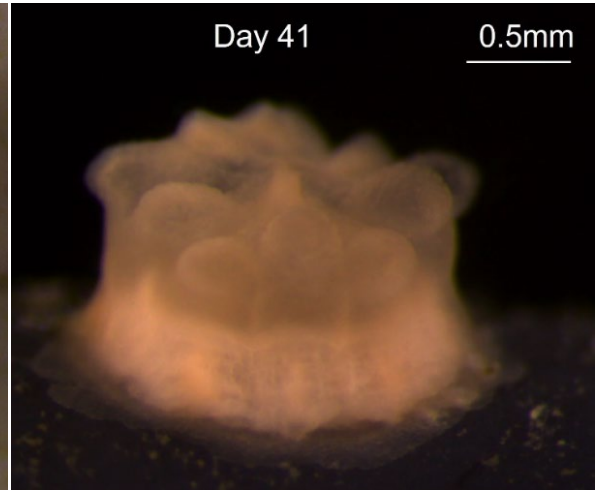
Swimming larva



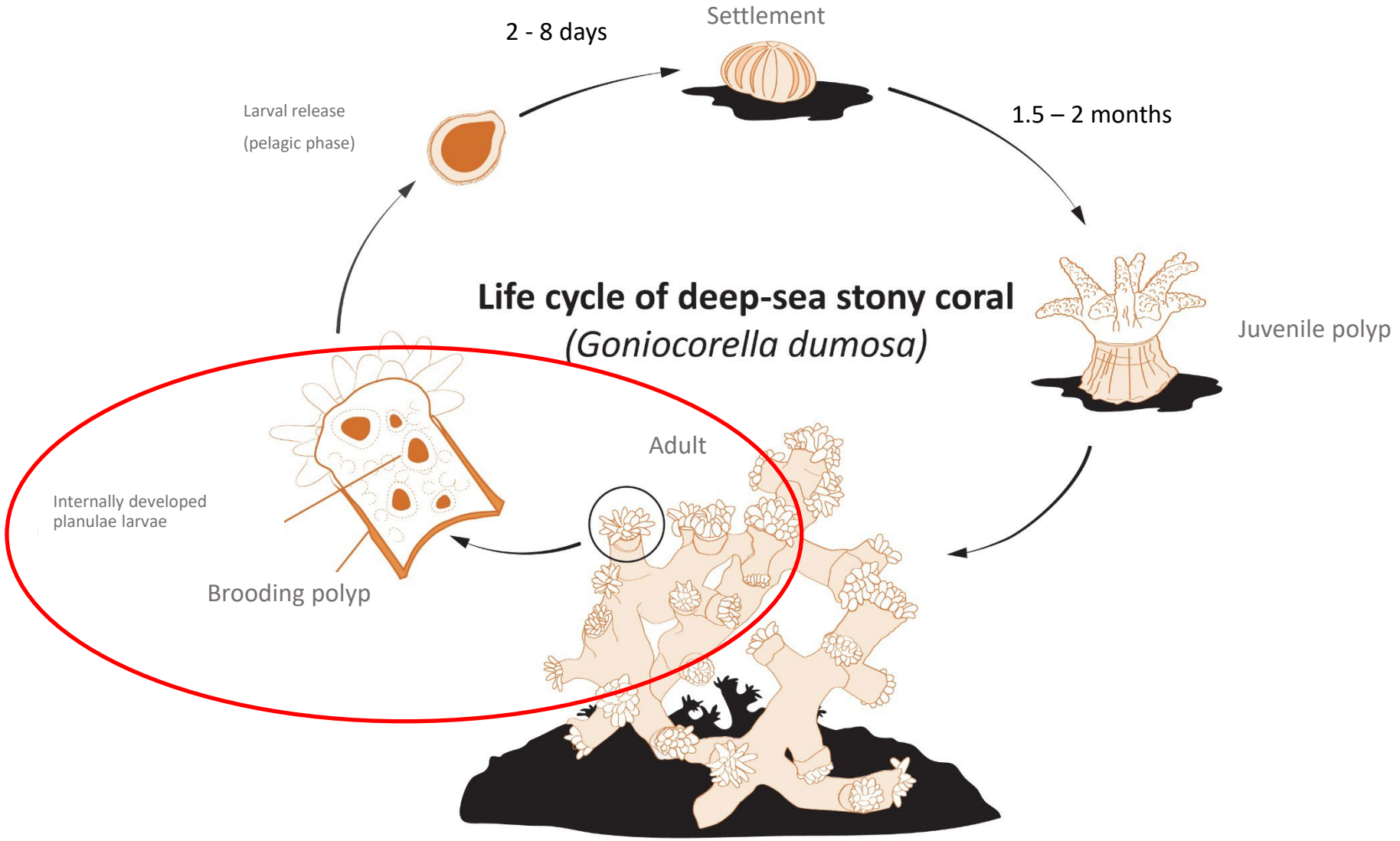
Beating cilia



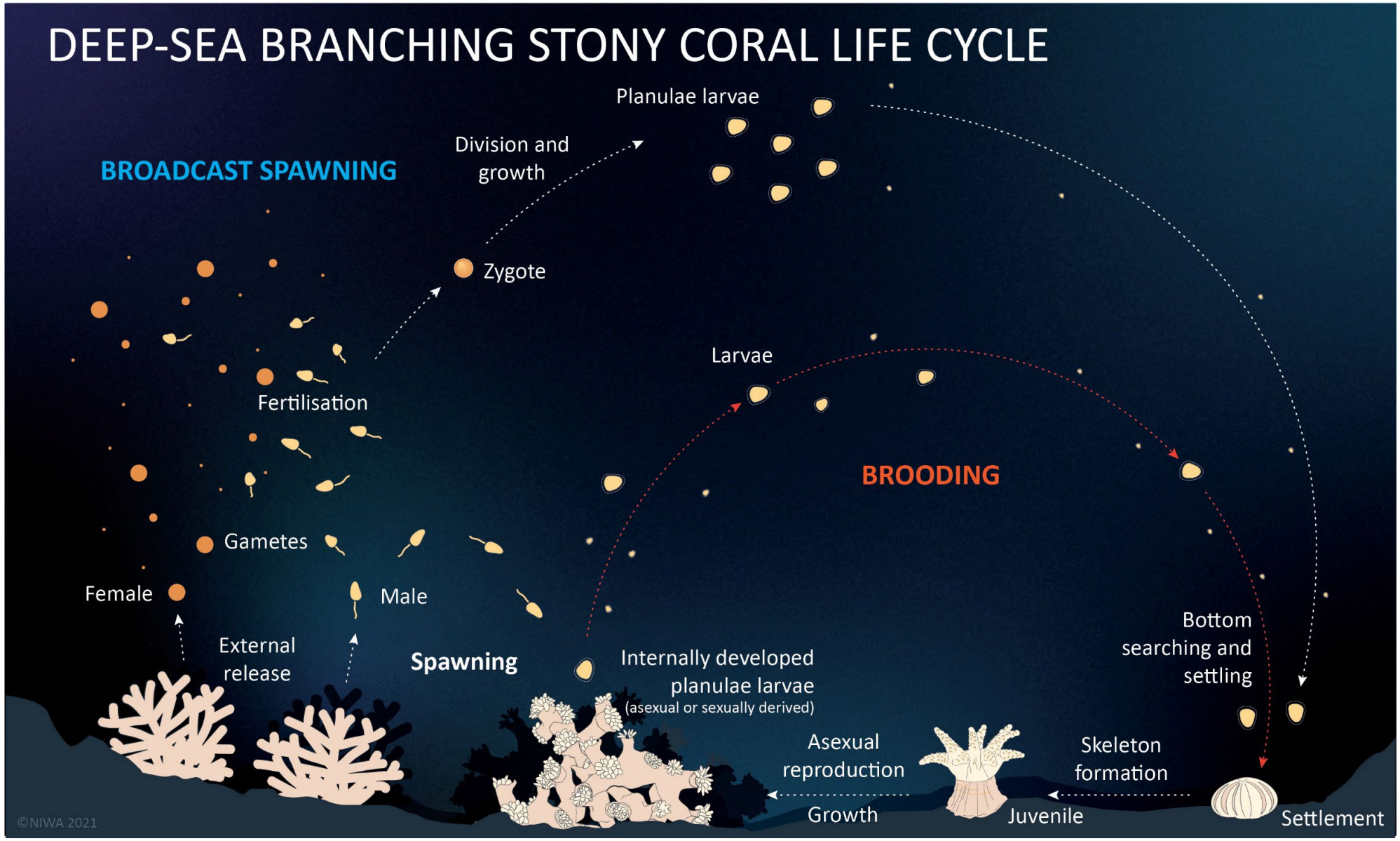
12 hours post settlement



41 days post settlement



Life cycle of *Goniocorella dumosa.* Red circle highlights what we hope to learn in this project



Reproductive modes employed by deep-sea branching scleractinian corals

Reproductive strategies: Scleractinia – cup coral form

No existing NZ deep-sea cup coral reproductive studies

- Genetic data shows *Desmophyllum dianthus* undergoes sexual reproduction & has widespread dispersal

Global studies show no generality in reproductive processes

- *Caryophyllia* spp. can be gonochoric or hermaphroditic
- *Flabellum* spp. from West Antarctic Peninsula are brooders
- *Flabellum* spp. from NE Atlantic are broadcast spawners
- High fecundity compared to other coral groups

Reproduction strategies: Gorgonian octocorals

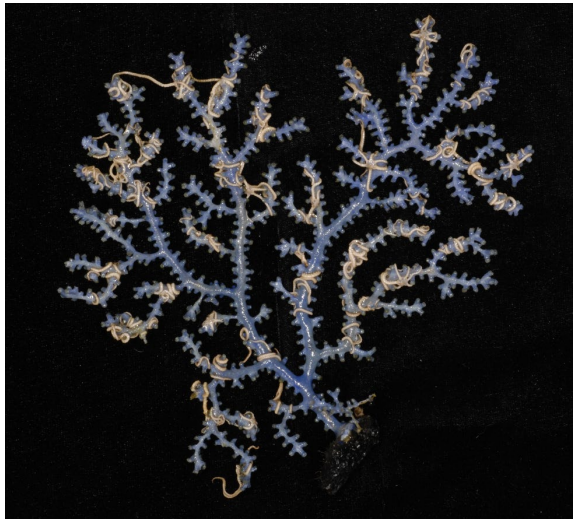
Diverse group with broad range of reproductive strategies

NZ morphological studies indicate several primnoids are gonochoric brooders

Global studies indicate most octocorals are gonochoric with varying reproductive modes and periodicity

- Continuous, quasi-continuous, seasonal spawners, and brooders
- Primnoids *Fanyella* and *Thouarella* spp. are brooders
- Isidids (bamboo corals) and plexaurids appear to be mostly broadcast spawners

Low polyp fecundity but potentially high colony fecundity



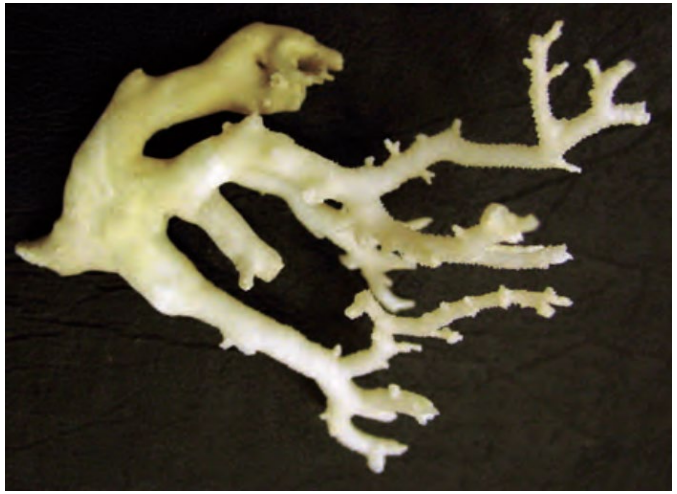
Reproduction strategies: Stylasteridae

Limited reproductive knowledge

NZ morphological studies show stylasterids are typically gonochoric brooders

- similar to Alaskan study

Predicted to have short dispersal due to brooding mode & crawling behaviour of larvae



Reproduction strategies: Antipatharia

NZ Fiordland black coral *Antipathella fiordensis* is a gonochoric, broadcast spawner, produces lecithotrophic larvae with limited dispersal

Globally nearly all black coral species are thought to be gonochoric broadcast spawners

- more deep-sea studies needed to confirm

Black corals have reduced fecundity compared to stony corals

Objective 1. Address knowledge gaps in reproductive strategies for protected coral species in the New Zealand region

Methods:

Examine physical specimens of preserved corals

- Histology: sex ratios, oocyte size, fecundity, reproductive seasonality
- Morphometrics: e.g., polyp density

Note: main focus of study is the scleractinians and octocorals. Hydrocorals and black corals have been included but as proof of concept rather than a detailed study.

Histology methods (branching stony corals)

All samples were processed at the Gillies McIndoe Research Institute in Wellington

Initial trials were conducted to test histological methods

The second round of histology included NIC specimens that had not been fixed in formalin

A hydrochloric acid based decalcifying reagent that also contains formalin was used, thus the tissue was post-fixed as the carbonate skeleton was removed

For budgeting efficiency, multiple polyps were embedded into each cassette

Histology sections

Initial trials:
A limited number of sections were taken from each polyp and assessed for quality and sex of polyp. Reproductive data were generated from these sections where possible

Second round:

An initial 4-micron thick section was taken from midway through the polyp to verify whether the polyp was male or female

If a specimen was **male, no further sections were required**

If a specimen was **female**, then the remaining block (**1/2 polyp**) was sectioned at every 100 microns (with each section being 4 microns thick). Every second section (**so one section every 200 microns**) was stained and mounted into a slide

Sections were stained with Haematoxylin and Eosin in an automated slide staining machine

200 microns was selected as sectioning distance due to previous measurements of *G. dumosa* oocytes (Tracey et al 2021): Stages III (269 ± 87.14 µm), IV (668 ± 139.47 µm) and V (904 ± 157.81 µm)

Histological sections were photographed with a Nikon SMZ25 stereomicroscope. Images were assessed for quality (staining and intactness) and sexed

Female specimens: oocytes were identified, staged (as below), counted, and measured
Stage I, II and III oocytes were only measured where a nucleus was present
Stage IV oocytes and stage V larvae were measured if the oocyte/larvae appeared to present as a representative cross section roughly through the mid-plane of the oocyte/larvae
Atretic (degenerating) oocytes were not counted or measured, but were used to help discern between male and female polyps

Male specimens: assessed for maturity of spermaries (maximum maturity noted)

Developmental stages of oocytes and spermatocytes (adapted from Burgess 2002)

Stage	Maturity	Female (Oocytes/Larvae)	Male (Spermaries)
I	Immature	Oogonia: Enlarged interstitial cells, with large nuclei in mesoglea of mesenteries	Small clusters of interstitial cells
II	Immature	Immature Oocytes (previtellogenic): Accumulation of small amount of cytoplasm around nuclei	Spermatocytes smaller with small nuclei, number of cells within spermatocyst much larger
III	Maturing	Oocytes undergoing Vitellogenesis: variable size, main period of vitellogenesis	Spermatocytes with little cytoplasm, developed flagella not evident, lumen usually present
IV	Mature	Vitellogenic Oocytes: full sized with indented nucleus migrating to edge of oocyte, large vitellogenin bodies fill the cytoplasm, cortical granular layer may be seen	Spermatozoa with fully developed flagella, ready to spawn
V	Mature	Brooding larvae of various stages of development	

Quality of histology sections

The quality of histological slides varied between specimens. Immature oocytes were often difficult to see.

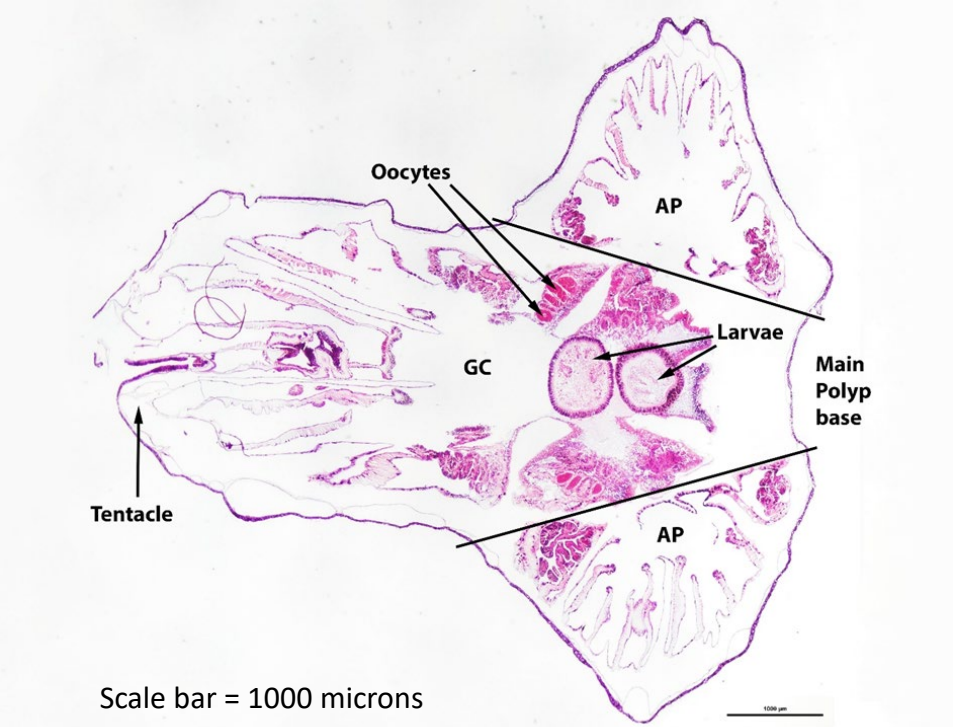
Top figure – poorly stained and oocytes not clearly visible.

Middle figure – staining OK. Oocytes clearly visible. White voids where oocytes may have been present

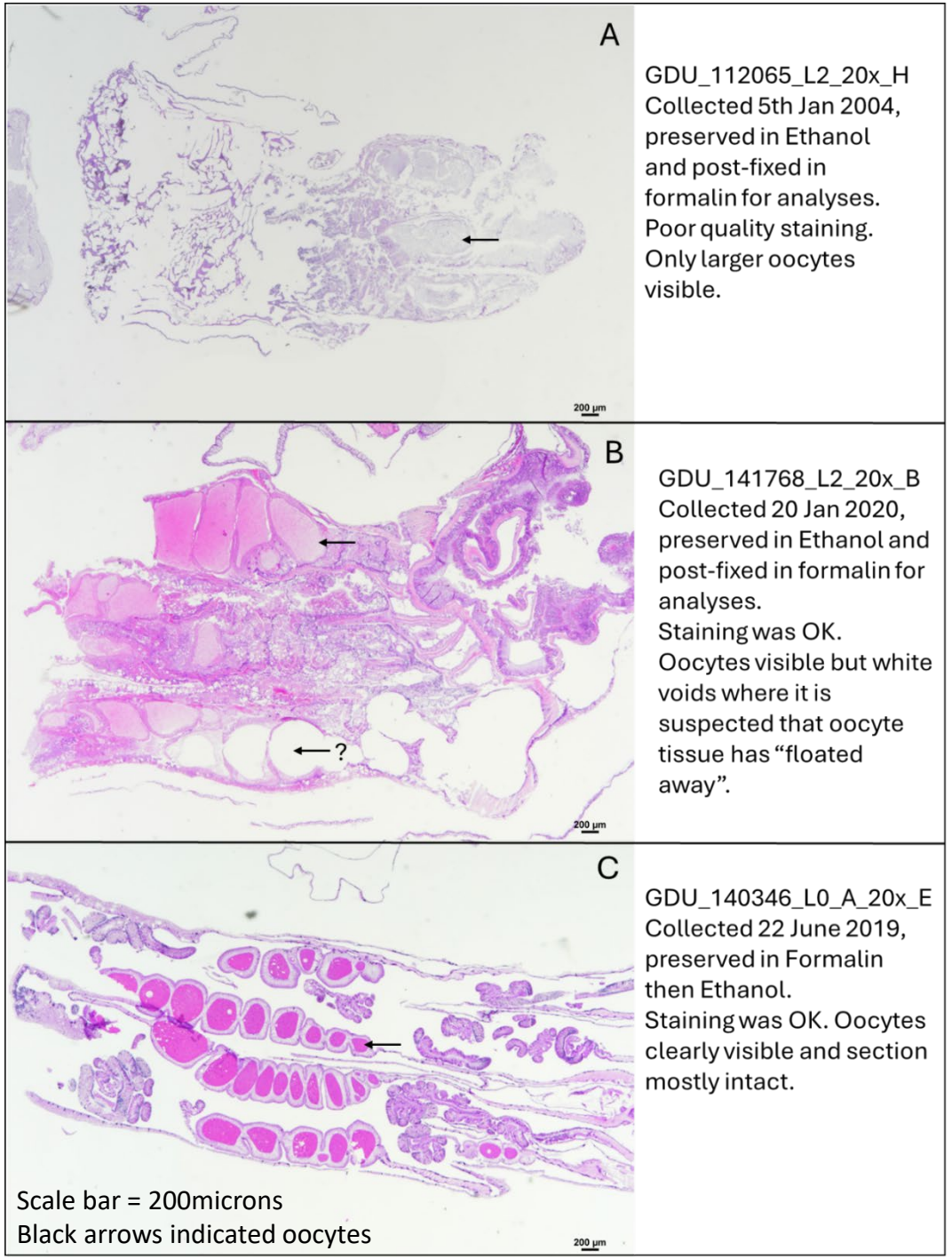
Lower figure – staining OK. Oocytes clearly visible and section mostly intact.

Example of a good section:

- Two mature larvae in the basal gut mesenteries
- Clusters of Stage III oocytes
- Accessory polyps



Scale bar = 1000 microns



GDU_112065_L2_20x_H
Collected 5th Jan 2004, preserved in Ethanol and post-fixed in formalin for analyses.
Poor quality staining. Only larger oocytes visible.

GDU_141768_L2_20x_B
Collected 20 Jan 2020, preserved in Ethanol and post-fixed in formalin for analyses.
Staining was OK. Oocytes visible but white voids where it is suspected that oocyte tissue has "floated away".

GDU_140346_L0_A_20x_E
Collected 22 June 2019, preserved in Formalin then Ethanol.
Staining was OK. Oocytes clearly visible and section mostly intact.

Scale bar = 200microns
Black arrows indicated oocytes

Histology: *Goniocorella dumosa (GDU)*

Of the 12 specimens, 8 were female, 3 were male and 1 was immature/unsexed
Confirmed to be gonochoric (single sex per polyp)
Specimens were either male or female

Summary of the 12 *G. dumosa* specimens analysed for histology: M/F/U = Male/Female/Unsexed (or immature). Ordered by collection day/month.
F = fixed in formalin, EtOH is ethanol. Where the preservation method is "F, EtOH", the specimen has been first preserved in formalin then transferred into ethanol.

Species	NIC number	Collection date	Year	Depth (m)	Preservation method	No. of Polyps analysed	M/F/U	Comment
GDU	88266	1 January	2004	440	EtOH	10	U	Poor histological sections
GDU	112065	5 January	2004	241	EtOH	11	F	Friable sections with poor staining
GDU	141768	20 January	2020	379	EtOH	16	F	
GDU	102639	11 April	2015	570	EtOH	3	F	
GDU	102472	11 April	2015	497	EtOH	2	M	Analysed as part of histology trials
GDU	102566	11 April	2015	622	EtOH	10	M	
GDU	140313	21 June	2019	396	F,EtOH	18	F	
GDU	140326	21 June	2019	387	F,EtOH	22	F	
GDU	140346	22 June	2019	461	F,EtOH	17	F	
GDU	148101	16 August	2020	486	F,EtOH	2	F	Analysed as part of histology trials
GDU	148157	19 August	2020	640	F,EtOH	6	M	Analysed as part of histology trials
GDU	27578	31 December	2006	409	EtOH	12	F	
Total polyps						129		

Female reproductive data (*G. dumosa*)

In total 1084 oocytes were recorded from 101 female polyps analysed

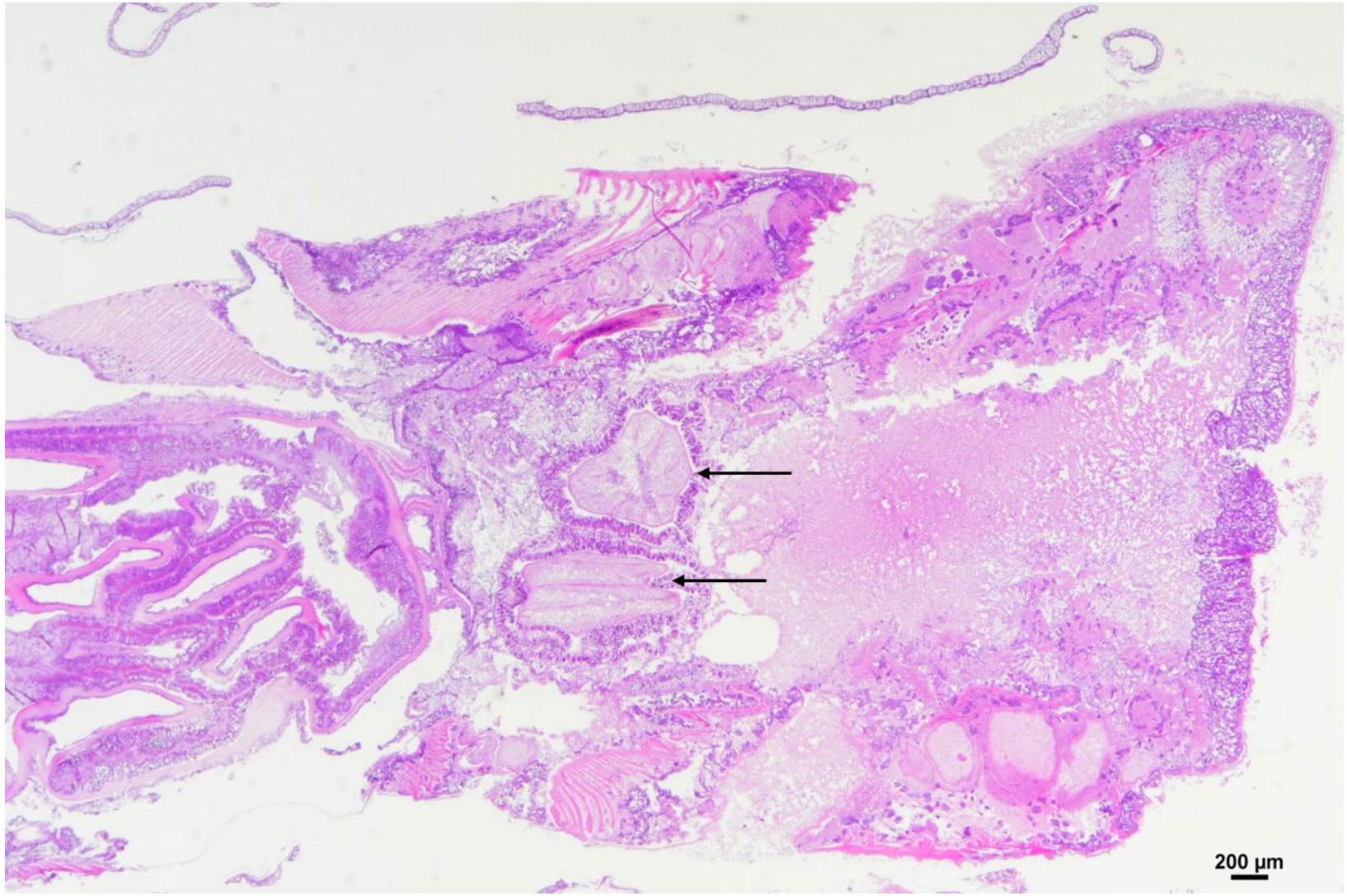
19 were Stage I, 130 Stage II, 401 Stage III, 469 Stage IV, 7 Stage V and 38 were un-staged

Mature (Stage IV or V) oocytes were present in all seasons sampled

The presence of stage V larvae within these specimens confirms that G. dumosa is a brooder in wild populations

Maximum observed maturity of oocytes within female *G. dumosa* specimens

Species	NIC number	Collection date	Polyps analysed	Max F stage	Comment
GDU	112065	5 January	11	IV mature	
GDU	141768	20 January	16	V mature	
GDU	102639	11 April	3	IV mature	
GDU	140313	21 June	18	III maturing	
GDU	140326	21 June	22	IV mature	
GDU	140346	22 June	17	IV mature	
GDU	148101	16 August	2	IV mature	Histology trials (smaller section of polyp analysed)
GDU	27578	31 December	12	IV mature	
Total polyps			101		



Specimen GDU_141768 polyp E with two stage V larvae visible in the centre

Specimen collected 20 January 2020 from Chatham Rise. Stage V larvae indicated with black arrows. Less mature oocytes are visible at centre top and bottom right of the image. Scale bar is 200 microns

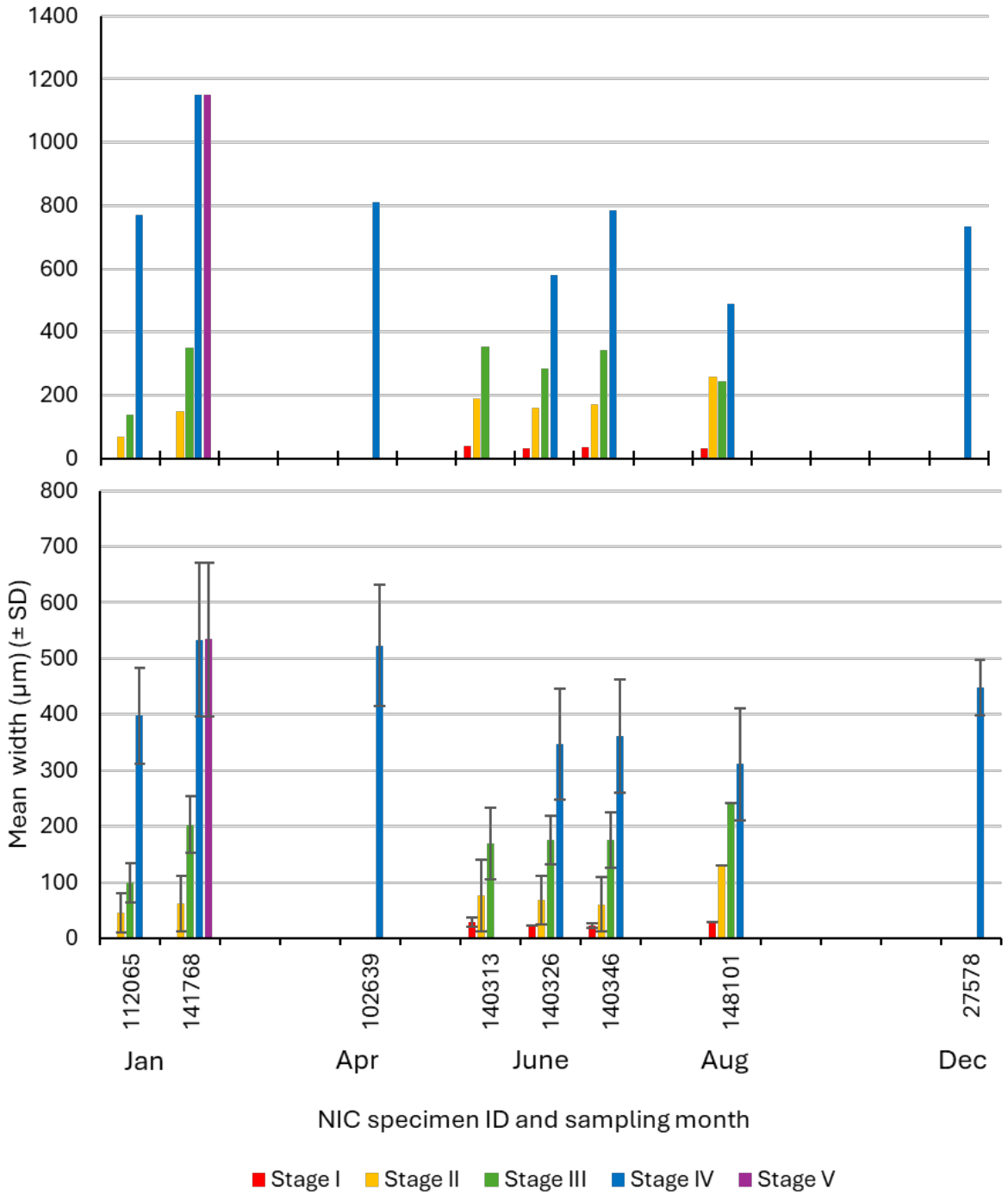
Oocyte size

Stage IV oocytes present in all seasons and in all but one specimen. Largest stage IV oocytes were the same size as stage V

Large oocytes present in all seasons, though mean size of stage IV oocytes was smallest in June and August

Summary measurements of *G. dumosa* oocyte stages: Note that for stages I, II and III only oocytes with a visible nucleus were measured. Stage IV Oocytes and stage V larvae were measured if they were intact and were not obviously tangentially sliced

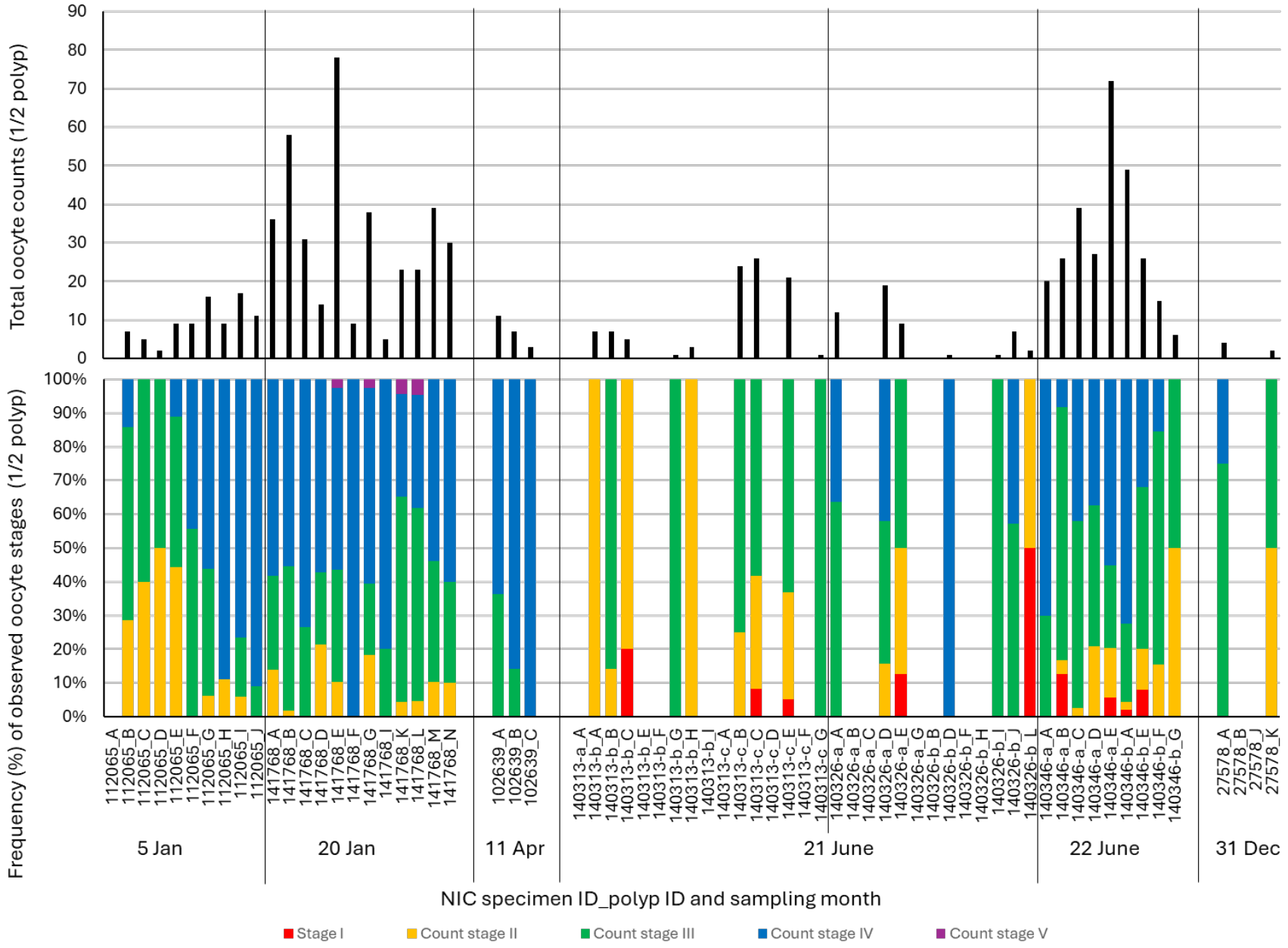
Oocyte stage	Count	Max diameter (µm)	Min diameter (µm)	Mean diameter (µm) ± SD
I	13	38	8	24 ± 5
II	71	258	16	69 ± 33
III	67	355	47	181 ± 54
IV	306	1151	72	465 ± 145
V	7	1142	527	785 ± 112



Oocyte frequency and seasonality

High variability between polyps and specimens within the same season.

- Replication important
- Quality of histology



Total oocyte count and frequency of oocyte stage

Fecundity estimate (polyp)

Histology sections were taken at every 200 µm within half of each polyp

Polyp fecundity was estimated by:

- Doubling Stages III, IV and V
- Quadrupling Stage I and II oocytes

Metric	Specimen	No of polyps	Maximum oocytes per polyp	Minimum oocytes per polyp	Mean ± SD oocytes per polyp
Raw counts: ½ polyp All oocytes	27578	4	4	0	1.5 ± 1.91
	102639	3	11	3	7 ± 4
	112065	10	17	0	8.5 ± 5.42
	141768	**12**	**78**	**5**	**32 ± 20.54**
	140313	16	26	0	5.94 ± 9.18
	140326	13	19	0	3.92 ± 6.06
	140346	9	72	6	31.11 ± 19.80
	ALL specimens	67	78	0	13.76 ± 17.3
Estimated fecundity: Full polyp All oocytes	27578	4	8	0	3.5 ± 4.12
	102639	3	22	6	14 ± 8
	112065	10	36	0	19.4 ± 11.2
	141768	**12**	**172**	**10**	**69.5 ± 44.88**
	140313	16	72	0	16.63 ± 24.47
	140326	13	44	0	9.23 ± 13.99
	140346	9	172	18	70.22 ± 45.59
	ALL specimens	67	172	0	31.37 ± 38.48
Estimated fecundity: Full polyp Stage III, IV and V only	27578	4	8	0	2.5 ± 3.79
	102639	3	22	6	14 ± 8
	112065	10	32	0	14.6 ± 11.04
	141768	**12**	**140**	**10**	**57.67 ± 37.35**
	140313	16	36	0	6.5 ± 11.92
	140326	13	32	0	6.15 ± 10.34
	140346	9	110	6	51.11 ± 33.41
	ALL specimens	67	140	0	22.89 ± 30.44

Fecundity estimate (specimen)

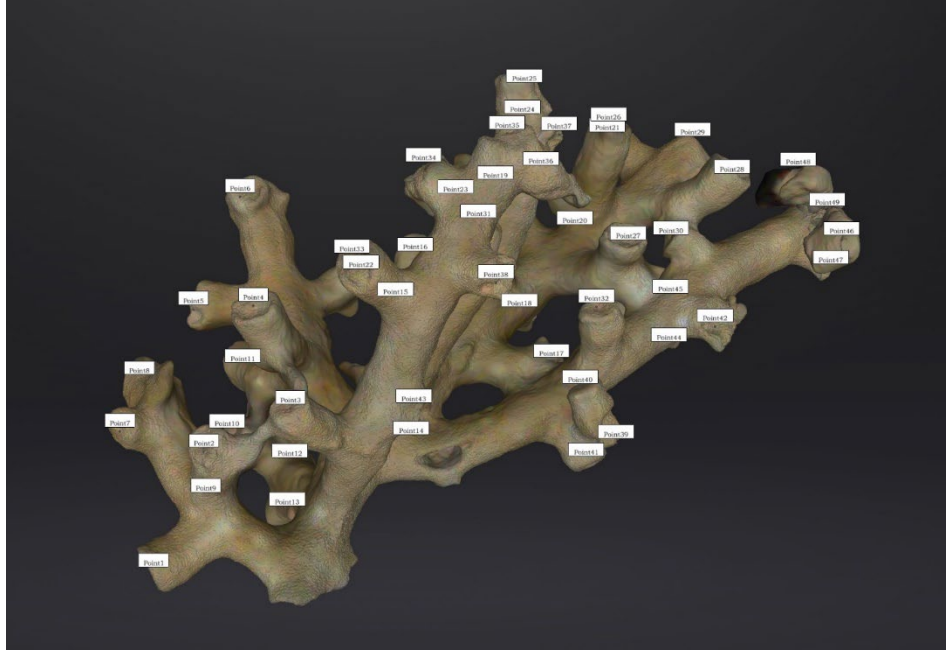
Example: GDU_141768

Using estimated fecundity per polyp (Stages III, IV & V), this fragment could produce 2826 ± 1830 viable larvae in a given year

Estimate assumes all stage III oocytes and up will mature in that given year

Note: Not all oocytes will get fertilised, mature and liberate as functioning larvae

Maximum number of stage V larvae observed in a polyp is 10 (aquarium experiments) or 4 in polyps from wild populations



Example of a 3D image of a GDU specimen and polyp counts: *G. dumosa* specimen NIWA-141768. The 3D model was rotated to identify and mark all individual polyps on the 3D reconstruction

	Fragment dimensions				Oocytes per polyp (mean ± SD)		Estimated oocytes per fragment	
Specimen	Length (mm)	Width (mm)	Height (mm)	Polyps per fragment	All oocytes	Stage III and up only	All oocytes	Stage III and up only
27578	66.01	53	65.93	105	3.5 ± 4.12	2.5 ± 3.79	368 ± 433	263 ± 398
102639	58.34	37.35	36.52	32	14 ± 8	14 ± 8	448 ±256	448 ± 256
112065	72.27	75.65	87.18	219	19.4 ± 11.2	14.6 ± 11.04	4249 ± 2452	3197± 2417
140313	33.14	30.58	43.2	34	16.63 ± 24.47	6.5 ± 11.92	565 ± 832	221±405
140326	25.89	19.13	26.1	16	9.23 ± 13.99	6.15 ± 10.34	148 ± 234	98 ± 165
140346	45.38	45.27	40.9	38	70.22 ± 45.59	51.11 ± 33.41	2668 ±1732	1942 ±1270
141768	**58.43**	**44.9**	**48.58**	**49**	**69.5 ± 44.88**	**57.67 ± 37.35**	3406 ± 2199	**2826 ± 1830**

Male reproductive data (*G. dumosa*)

Only three of the specimens used in this study were male, restricting seasonal spread of data

However, mature spermiaries (stage IV) were observed in both seasons sampled (April and August)

Species	NIC number	Collection date	Polyps analysed	Max stage
GDU	102472	11 April 2015	2	Stage III Maturing
GDU	102566	11 April 2015	10	Stage IV Mature
GDU	148157	19 August 2020	6	Stage IV Mature
Total polyps			18	

Summary (*G. dumosa*)

Confirmed G. dumosa is a **brooder** in wild populations (Stage V larvae observed in Jan 2020 sample)

No evidence of reproductive periodicity/seasonality in *G. dumosa*

- Mature oocytes were present throughout the year (maximum recorded oocyte size was 1142 µm)
- Mature spermiaries were present in all samples examined (April and August)

G. dumosa **may have the ability to reproduce year-round when environmental conditions are favourable**

- Observations of larvae from September – November 2020, in aquaria with a consistent food supply

Up to 78 oocytes in half a polyp – estimated **fecundity up to 172 oocytes per polyp** (mean of 31.37 ± 38.48)

- If only including stage III and up oocytes, max would be 140 oocytes (mean of 22.89 ± 30.44)

Burgess & Babcock (2005):maximum oocyte size of 135 µm & fecundity of 480 ± 216 oocytes per polyp

- Higher due to better detection of immature oocytes (working on recent samples)?
- Function of oocyte maturity?

Histology: *Enallopsammia rostrata (ERO)*

Of the 13 specimens, 5 were female, 6 were male and 2 were immature/unsexed
Confirmed gonochoric (single sex per polyp)
Specimens were either male or female

Summary of the 13 *E. rostrata* specimens analysed for histology: M/F/U = Male/Female/Unsexed (or immature). Ordered by collection day/month.
F = fixed in formalin, EtOH is ethanol. Where the preservation method is "F, EtOH", the specimen has been first preserved in formalin then transferred into ethanol.

Species	NIC number	Collection date	Year	Depth (m)	Location	Preservation method	No. of Polyps analysed	M/F/U	Comment
ERO	102305	4 April	2015	918	Chatham Rise	EtOH	12	U	
ERO	102568	11 April	2015	622	Chatham Rise	EtOH	10	F	
ERO	102631	11 April	2015	570	Chatham Rise	EtOH	12	M	
ERO	43171	17 April	2002	1366	Northern Bay of Plenty	EtOH	2	M	Analysed as part of histology trials
ERO	53483	22 June	2009	820	Chatham Rise	EtOH	9	F	
ERO	53554	25 June	2009	613	Chatham Rise	EtOH	10	F	A few polyps exhibited old well degenerated atretic oocytes. No other female reproductive data available from this specimen
ERO	54027	27 June	2009	760	Chatham Rise	EtOH	8	F	
ERO	54169	27 June	2009	716	Chatham Rise	EtOH	8	M	
ERO	53486	22 June	2009	820	Chatham Rise	EtOH	6	M	
ERO	53719	26 June	2009	641	Chatham Rise	EtOH	11	M	
ERO	148158	19 August	2020	640	Chatham Rise	F, EtOH	2	F	Analysed as part of histology trials
ERO	148159	19 August	2020	640	Chatham Rise	F, EtOH	3	M	Analysed as part of histology trials
ERO	81272	16 December	2000	621	Chatham Rise	EtOH	9	U	Possibly resting male but hard to identify immature spermiaries
Total polyps							103		

Female reproductive data (*E. rostrata*)

In total 345 oocytes were recorded from 29 female polyps analysed

28 were Stage II, 172 Stage III, 143 were Stage IV oocytes

Mature (Stage IV) oocytes were present in all specimens sampled in April and June

Maximum of stage III (maturing) oocytes observed in specimen sampled in August

* Note that this specimen was part of the histology trials. Limited number of histology sections

Maximum observed maturity of oocytes within female *E. rostrata* specimens

Species	NIC number	Collection date	No. of Polyps analysed	Max F stage
ERO	102568	11 April	10	IV mature
ERO	53483	22 June	9	IV mature
ERO	54027	27 June	8	IV mature
ER0	148158	19 August	2	III maturing
Total polyps			29	

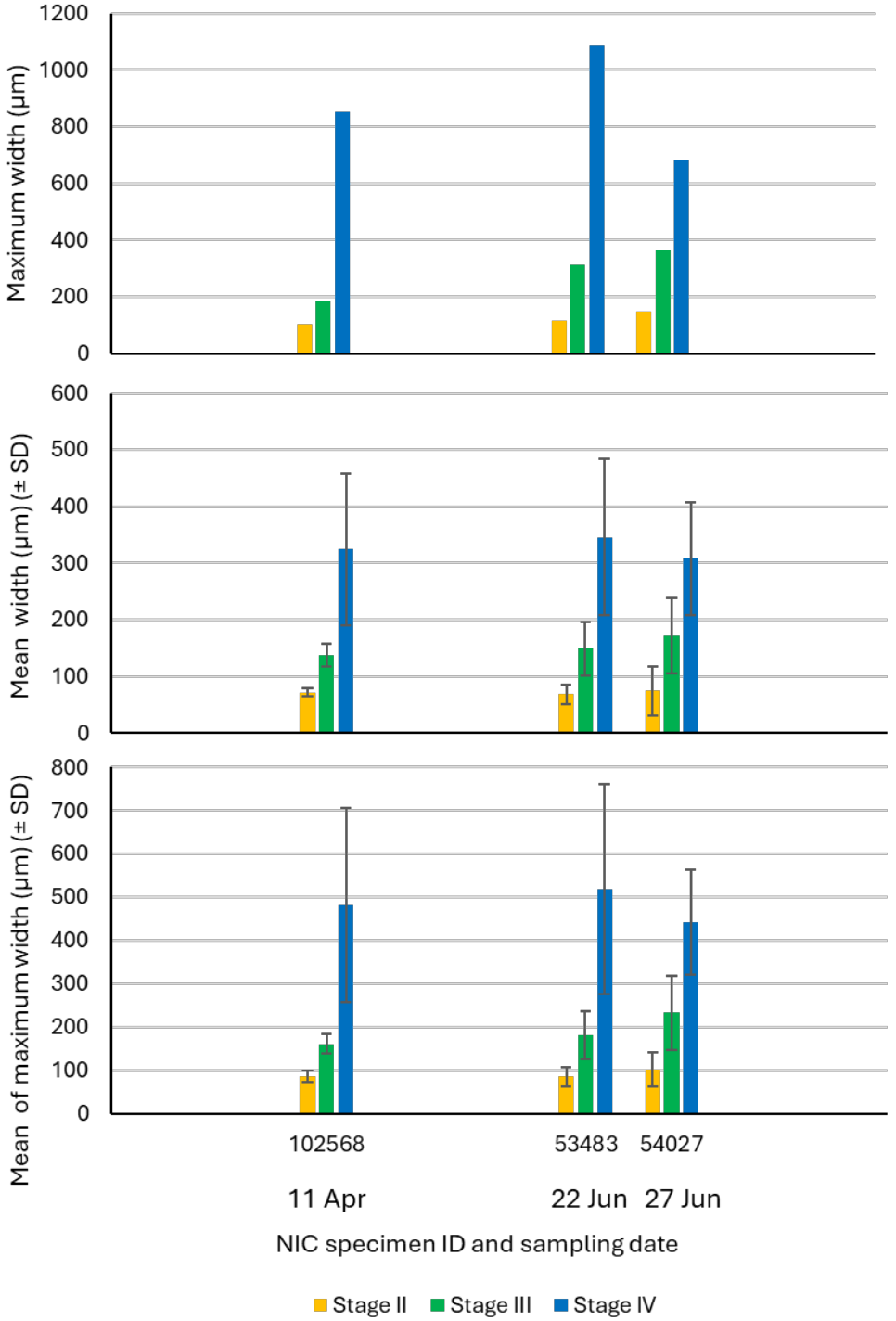
Oocyte size

Stage IV oocytes present in both seasons (where size data available)

Large oocytes present in both April and June

Summary measurements of *E. rostrata* oocyte stages: Note that for stages II and III, only oocytes with a visible nucleus were measured. Stage IVs were measured if they were intact and not tangentially sliced. Oocytes, particularly when more mature, were markedly elongate, hence we have presented mean values as the mean (of maximum and minimum) and the mean of the maximum measurements.

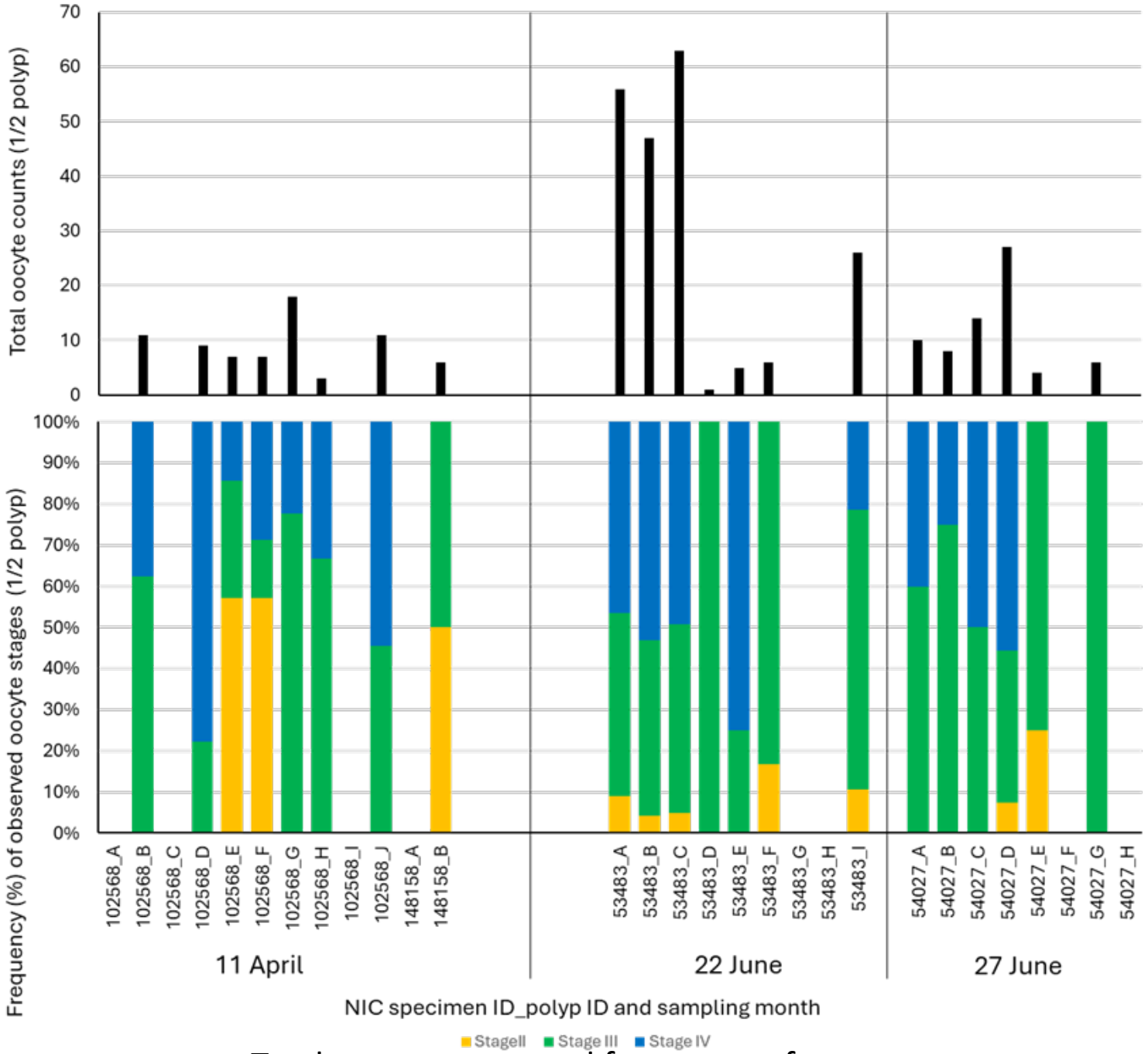
Oocyte stage	Count	Max diameter (µm)	Min diameter (µm)	Mean diameter (µm) ± SD	Mean maximum diameter (µm) ± SD
II	19	147	16	70.47 ± 19.22	88.84 ± 23.10
III	60	366	27	153.31 ± 50.52	191.78 ± 66.07
IV	50	1088	82	333.49 ± 128.13	494.1 ± 216.41



Oocyte frequency and seasonality

High variability between polyps and specimens within the same season

- Replication
- Quality of histology



Total oocyte count and frequency of oocyte stage

Fecundity estimate (polyp)

Histology sections were taken at every 200 µm within half of each polyp

Polyp fecundity was estimated by:

- Doubling Stages III, IV and V oocytes
- Quadrupling Stages I and II oocytes

Metric	Specimen	No. of polyps	Maximum oocytes per polyp	Minimum oocytes per polyp	Mean ± SD
Raw counts: 1/2 polyp All oocytes	102568	10	18	0	6.6 ± 5.95
	148158	2	6	0	3 ± 4.24
	53483	**9**	**63**	**0**	**22.67 ± 26.05**
	54027	8	27	0	8.63 ± 8.83
	All specimens	29	63	0	11.90 ± 16.77
Estimated fecundity: Full polyp All oocytes	102568	10	36	0	14.2 ± 12.24
	148158	2	18	0	9 ± 12.73
	53483	**9**	**128**	**0**	**48.22 ± 54.83**
	54027	8	58	0	18.5 ± 19.09
	All specimens	29	128	0	25.59 ± 35.34
Estimated fecundity: Full polyp Stage III and IV only	102568	10	36	0	11 ± 11.82
	148158	2	6	0	3 ± 4.24
	53483	**9**	**116**	**0**	**42 ± 48.41**
	54027	8	50	0	17 ± 17.10
	All specimens	29	116	0	21.72 ± 31.51

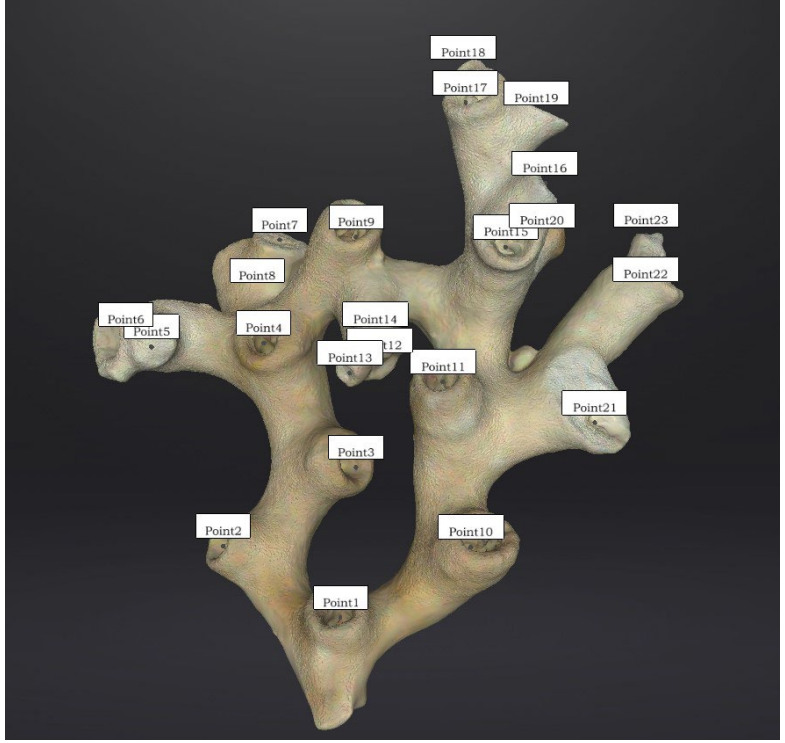
Fecundity estimate (specimen)

Example: ERO_53486

Using estimated fecundity per polyp (Stages III, IV & V), this fragment could produce 714 ± 823 viable larvae in a given year

Estimate assumes all stage III oocytes and up are going to mature in that given year

Note: Not all oocytes will get fertilised, mature and liberate as functioning larvae



Example of a 3D image of an ERO specimen and polyp counts. *E. rostrata* specimen NIWA-53486. The 3D model was rotated to identify and mark individual polyps on the 3D reconstruction

	Fragment dimensions				Oocytes per polyp (mean ± SD)		Estimated oocytes per fragment	
Specimen	Length (mm)	Width (mm)	Height (mm)	Polyps per fragment	All oocytes	Stage III and IV only	Mean oocytes (all)	Mean oocytes (stage III and IV)
102568	62.11	27.4	41.49	25	14.2 ± 12.24	11.00 ± 11.82	355 ± 306	275 ± 296
53483	**55.3**	**27.41**	**41.55**	**17**	**48.22 ± 54.83**	**42 ± 48.41**	**820 ± 932**	**714 ± 823**
54027	46.4	25.65	36.35	15	18.5 ± 19.09	18.5 ± 19.09	289 ± 286	255 ± 257

Male reproductive data (E. *rostrata*)

Six male specimens and 67 polyps analysed
Mature spermiaries (stage IV) were observed in all three seasons sampled (April, June, August)

Species	NIC number	Collection date	No. of Polyps analysed	Max M stage
ERO	102631	11 April	12	IV mature
ERO	43171	17 April	9	IV mature
ERO	53486	22 June	6	III maturing
ERO	53719	26 June	11	IV mature
ERO	54169	27 June	8	III maturing
ERO	148159	19 August	13	IV mature
Total polyps			67	

Summary (*E. rostrata*)

Only five female specimens, only three of which provided detailed reproductive data

However, **no evidence of reproductive periodicity/seasonality in *E. rostrata***

- Mature (stage IV) oocytes were present in April and June
- Maximum recorded oocyte size was 1088 µm (similar to Pires et al 2014 (1095 µm))
- Maturing oocytes present in August (* incomplete sample)
- Mature spermiaries present in all samples examined (April, June, August)

Agree with previous work suggesting *E. rostrata* is an aperiodic broadcast spawner (Pires et al (2014, SW Atlantic) and Burgess & Babcock (2005, NZ)

Up to 63 oocytes in half a polyp – estimated **fecundity up to 128 oocytes per polyp** (mean of 25.59 ± 35.34)
Or if only including stage III and up oocytes, max would be 116 oocytes (mean of 21.72 ± 31.51)

Burgess and Babcock (2005): maximum oocyte size of 400 µm (April 2001) & fecundity of 144 ± 96 oocytes/polyp

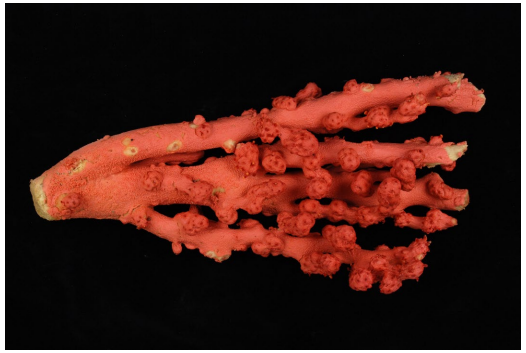
Histology: Scleractinian cup coral and Gorgonian octocorals

Specimens of these protected coral groups are being worked on by a PhD student (Diego Moreno Moran) of our international collaborator (Rhian Waller) at the University of Gothenburg

Diego visited NIWA in December 2023 to select specimens and carry out imaging, 3D scanning and de-calfication of specimens prior to shipping them to Sweden for further analyses

The following specimens are being worked on:
18 specimens of *Desmophyllum dianthus* (Scleractinian cup coral)
14 *Primnoa notialis (*Primnoid*)*
18 *Paragorgia arborea* (Bubblegum coral)

D. dianthus



P. arborea

P. notialis

Histology: Hydrocorals

Methodological trials only

Poor sections from hydrocoral samples due to large amount of hard skeleton

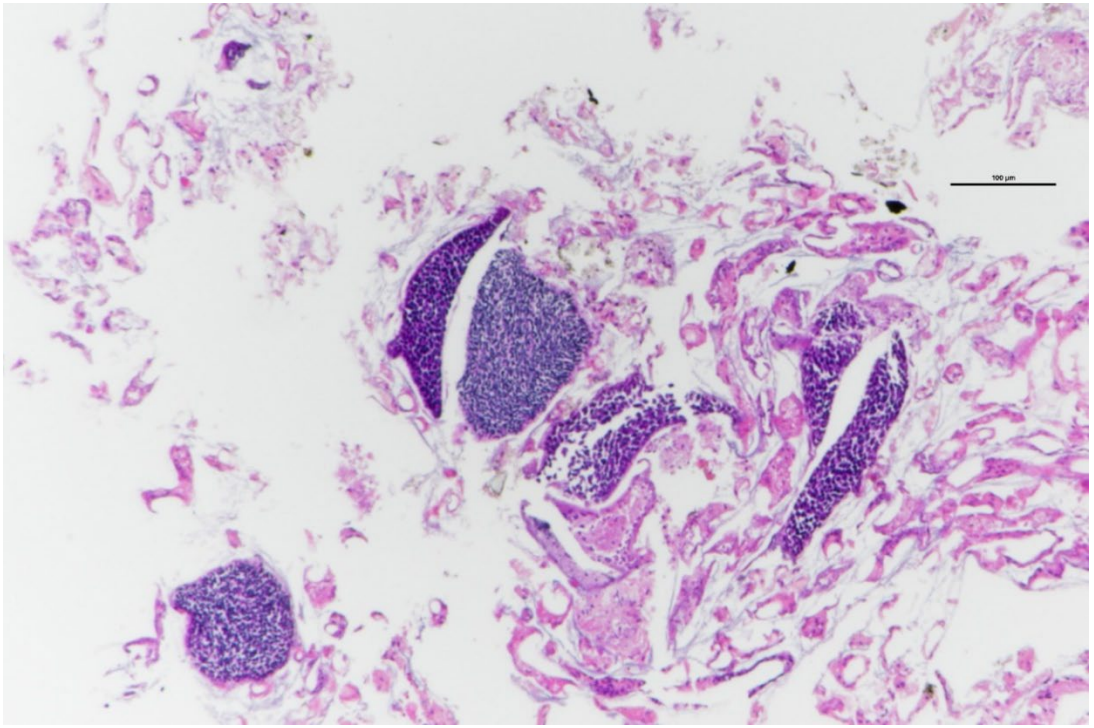
The de-calcification process used for other species is not suitable for hydrocorals

Errina sp. specimen dissolved completely

Stylaster eguchii specimen retained little of its structural integrity. However, some soft tissue remained

Next steps:
Embed the sectioned coral fragments in an agarose gel prior to decalcification

This will help to entrain the small amounts of non-calcified tissue in a matrix helping to prevent it from becoming lost from the cassette during the histological processing



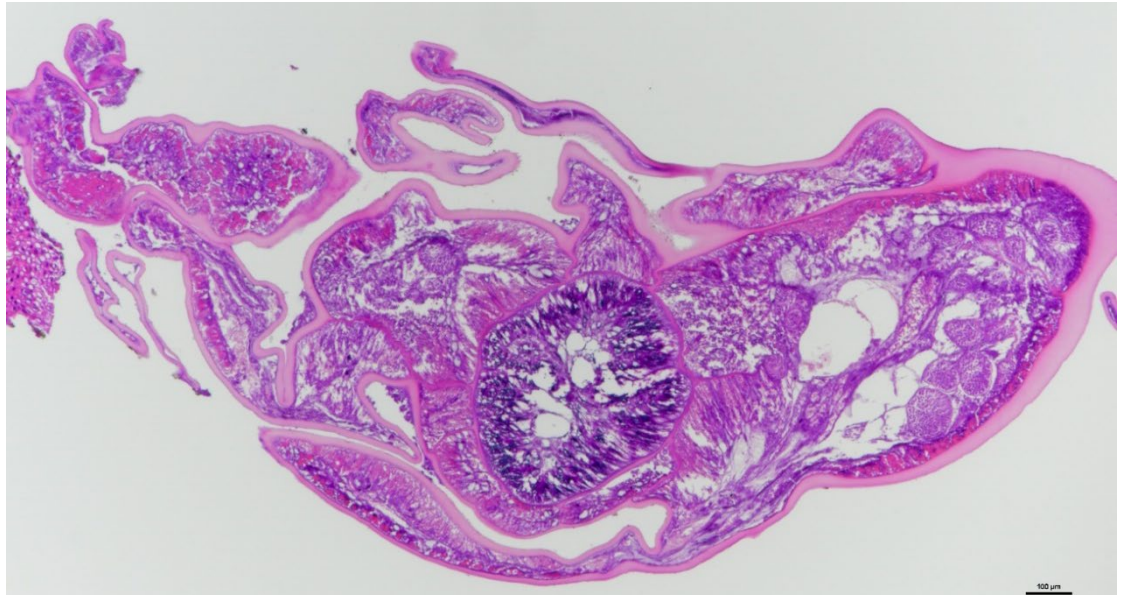
Section through a male ampullae of a *Stylaster eguchii* specimen NIWA91243. Dark purple stained spermiaries containing maturing and mature spermatozoa are evident in the centre and lower left of the section. Ampullae are the reproductive bodies of stylasterid corals, occurring as raised hemispheres on the surface of branches or as spherical inclusions within the branches depending on the species. 140x magnification. Scale bar is 100 µm.

Histology: Black corals

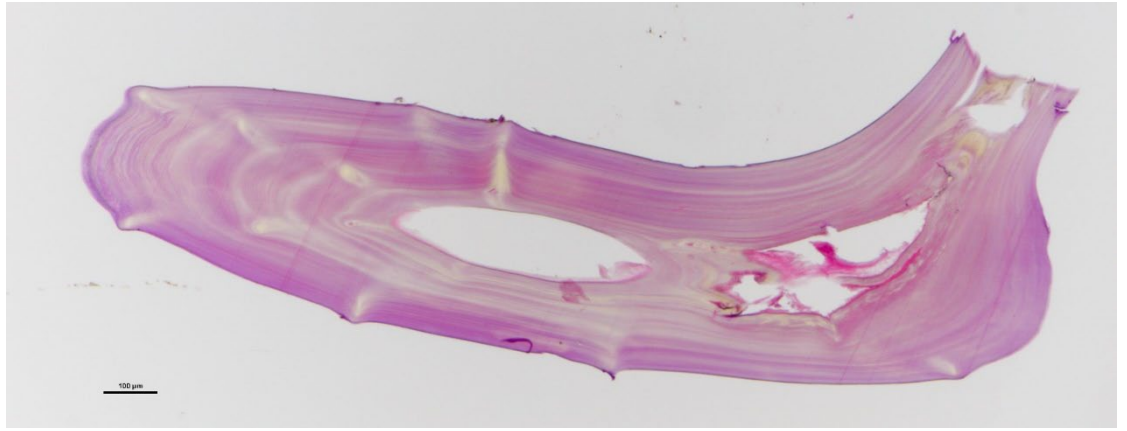
Methodological trials only

Good sections from the black coral trials (*Leiopathes* sp. and *Sibopathes* sp.)

No de-calcification required



Longitudinal section through a terminal polyp of *Leiopathes bullosa* specimen NIWA53045. Specimen is likely a male. 60x magnification. Scale bar is 100 µm.



Longitudinal section through a *Sibopathes* sp. specimen NIWA2071. Specimen comprised skeletal matrix only. 60x magnification. Scale bar is 100 µm

Summary

Branching stony corals
G. dumosa is a brooder
E. rostrata assumed to be a broadcast spawner
No evidence of seasonality for either branching stony coral

E. rostrata and *G. dumosa* have similar maximum diameter of oocytes (1088 vs 1142 µm)
E. rostrata has a lower potential fecundity than *G. dumosa* (172 vs 128 oocytes per polyp)
E. rostrata assumed to be a broadcast spawner and *G. dumosa* is a brooder

Black corals: Methodology trials were successful and we have images of probable male specimen

Hydrocorals: Methodology trials not successful though some success for one specimen. Next steps suggested for future work

Solitary stony corals and Octocorals: Results to come

We have advanced our knowledge of protected deep-sea coral reproduction and filled knowledge gaps (and more results to come..)
This helps us understand population dynamics, connectivity between suitable habitats, vulnerability and/or resilience to physical disturbance such as bottom trawling

Histology work is very useful but more costly/time consuming than initial budget allowed for

Objective 2. Use available life history and reproductive data to inform relative productivity/vulnerability parameters for relevant concurrent and future research

Results from Objective 1 (histological and morphological work) will be used to inform concurrent projects such as INT2022-04 - Risk assessment for protected corals to inform the management and conservation of protected corals

Results will be useful for further reproductive studies

Coral reproduction: next steps

Complete and present results of Diego's work on *D. dianthus*, *P. notialis* and *P. arborea*.

Upcoming NZ Cold Water Coral Biology and Geology voyage with international collaborators (Jan-Feb 2025)

- Live animal experiments – to inform reproductive mode, seasonality and larval behaviour/pelagic larval duration/settlement preferences

Larval dispersal – settlement plate trials being deployed on DART buoys to investigate settlement/dispersal of deep-sea fauna

Further histology work – need for more specimens (e.g., making use of specimens collected/recorded by fisheries observers)

Acknowledgements

We thank the Department of Conservation — Te Papa Atawhai, particularly the CSP programme, for their ongoing support of this research, the Gillies McIndoe Research Institute histology lab team (especially Diane Luey) for processing our coral samples, and Erika Mackay for the illustration of *G. dumosa* life-cycle.

Ngā mihi nui ki a koe

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NIWA
Taihoro Nukurangi

Climate, Freshwater & Ocean Science