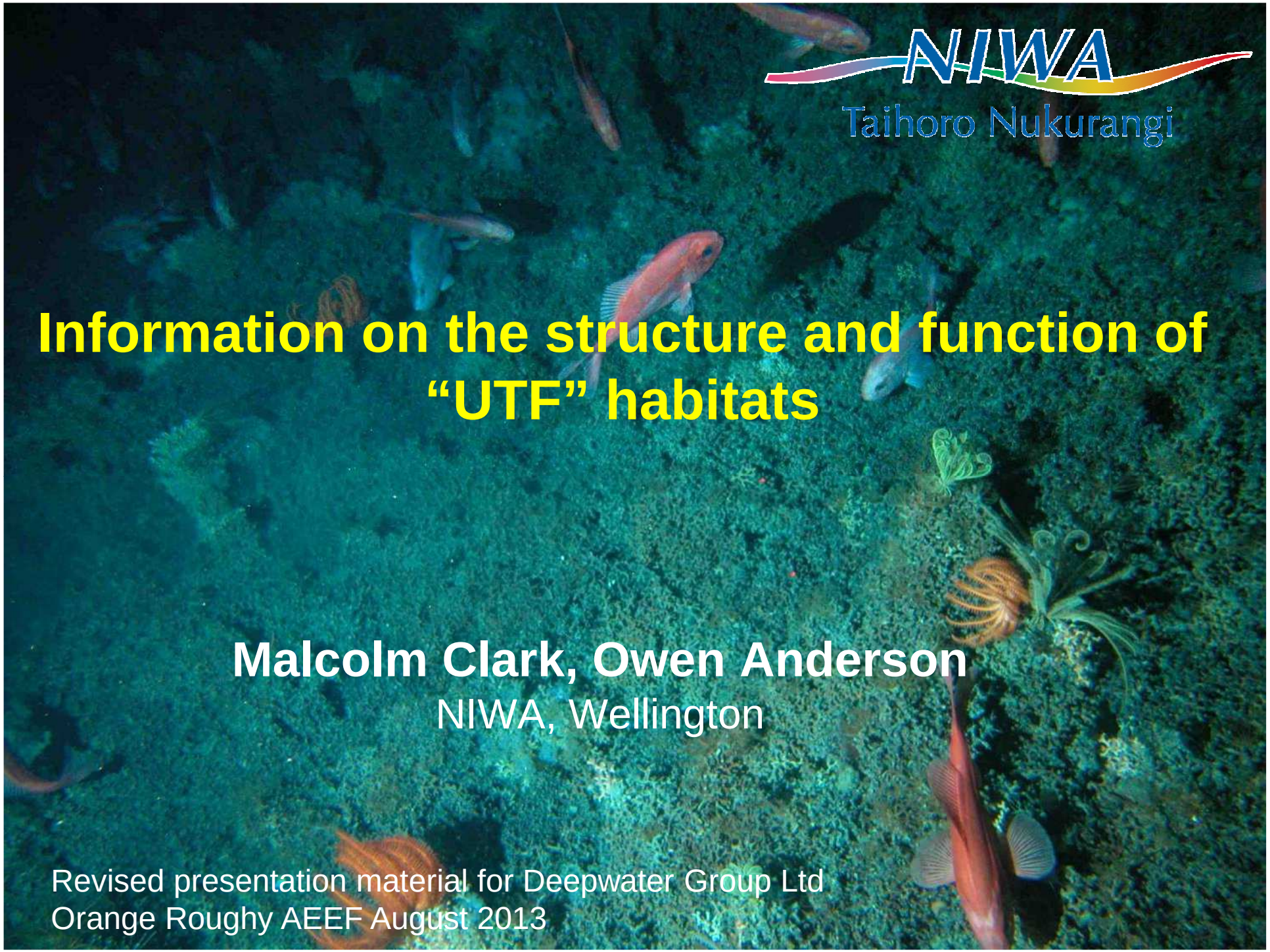

Information on the structure and function of "UTF" habitats

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Revised presentation material for Deepwater Group Ltd
Orange Roughy AEEF August 2013

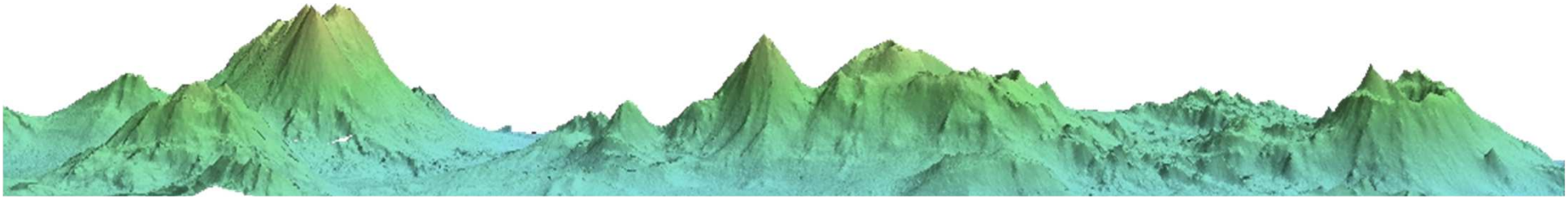
Presentation content

- Metrics and information on “UTFs” in ORH3B (NWCR, ESCR), ORH2A-2B-3A (MEC) and ORH7A (includes Westpac Bank region)
  - UTF features, based on NIWAs “seamount database”
  - Catch-effort data from MPI (Fisheries)
  - Coral data from various NIWA sources
- Summary of structure and function of benthic habitats on “UTFs”
  - largely a general description about UTF communities
  - Links to information presented on protected coral species
- Information on changes in benthic fauna on Morgue in the Graveyard Hills complex.
  - Based on 2001, 2006, 2009 surveys

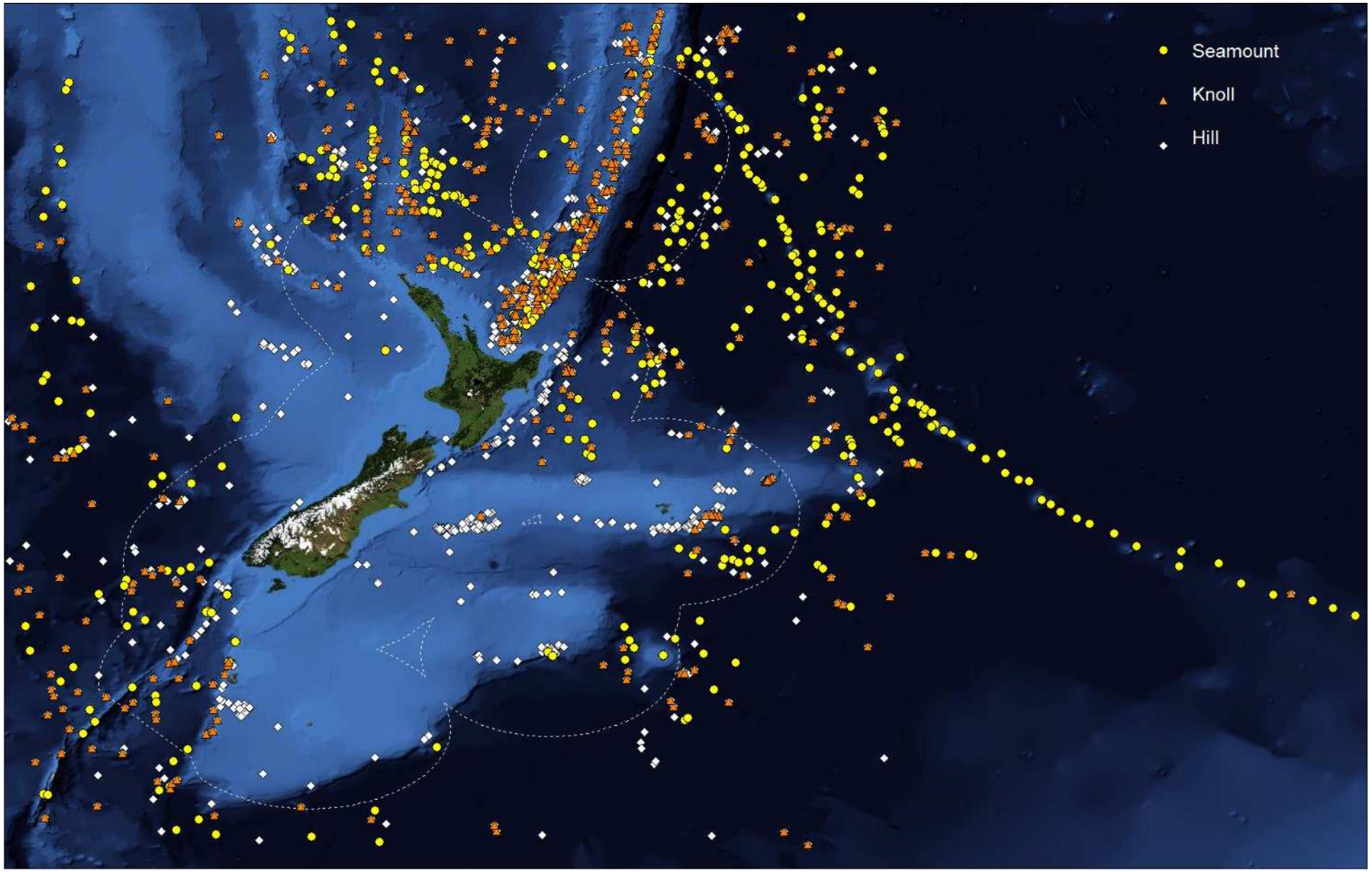
UTF features in NZ region

- Defined as seamounts, hills, knolls
  - not canyons, valleys, ridges, plateaux, banks etc
- NIWA “Seamounts database” holds information on:
  - 1517 features
  - 892 inside the EEZ
  - 625 outside the EEZ

  - Seamounts (>= 1000 m elevation) 409
  - Knolls (500-999 m) 426
  - Hills (100-499 m) 682



Location of seamounts, knolls, hills



Specific QMA UTF metrics

Area	N seamt	<600 m	600–799m	800–1199m	>= 1200m
CHAL	0				
MEC	9	0	0	0	9
NWCR	0				
ESCR	5	0	0	0	5
Area	N knoll	<600 m	600–799m	800–1199m	>= 1200m
CHAL	0				
MEC	13	1	0	0	12
NWCR	0				
ESCR	11	5	3	1	2
Area	N hills	<600 m	600–799m	800–1199m	>= 1200m
CHAL	6	2	1	3	0
MEC	31	5	8	3	15
NWCR	27	0	2	22	3
ESCR	135	44	46	41	4

Note: Depth is summit depth. Main fishing range for ORH is on hills and knolls with summit depths 600-1199 m (hence highlighted).

QMA UTF summaries (summit depth 600-1199 m)

Fishery			Summit (m)	Elevation (m)	Area (km2)	Slope (degree)
CHAL	Hills	Mean	841	146	2.5	9.6
		Range	790-933	117-190	2.0-3.0	7-13
MEC	Hills	Mean	768	235	25	9.4
		Range	663-950	100-367	2-106	2-21
NWCR	Hills	Mean	981	208	1.4	18.2
		Range	748-1178	100-405	0.4-4.1	11-30
ESCR	Knolls	Mean	755	590	6.3	27
		Range	643-881	510-625	1-13	16-42
	Hills	Mean	806	267	3.5	19
		Range	600-1140	100-490	0.3-96	4-43

Knoll and hill characteristics vary between fishing areas, most features small in both elevation and size (<10km2 basal area), and moderate slope.

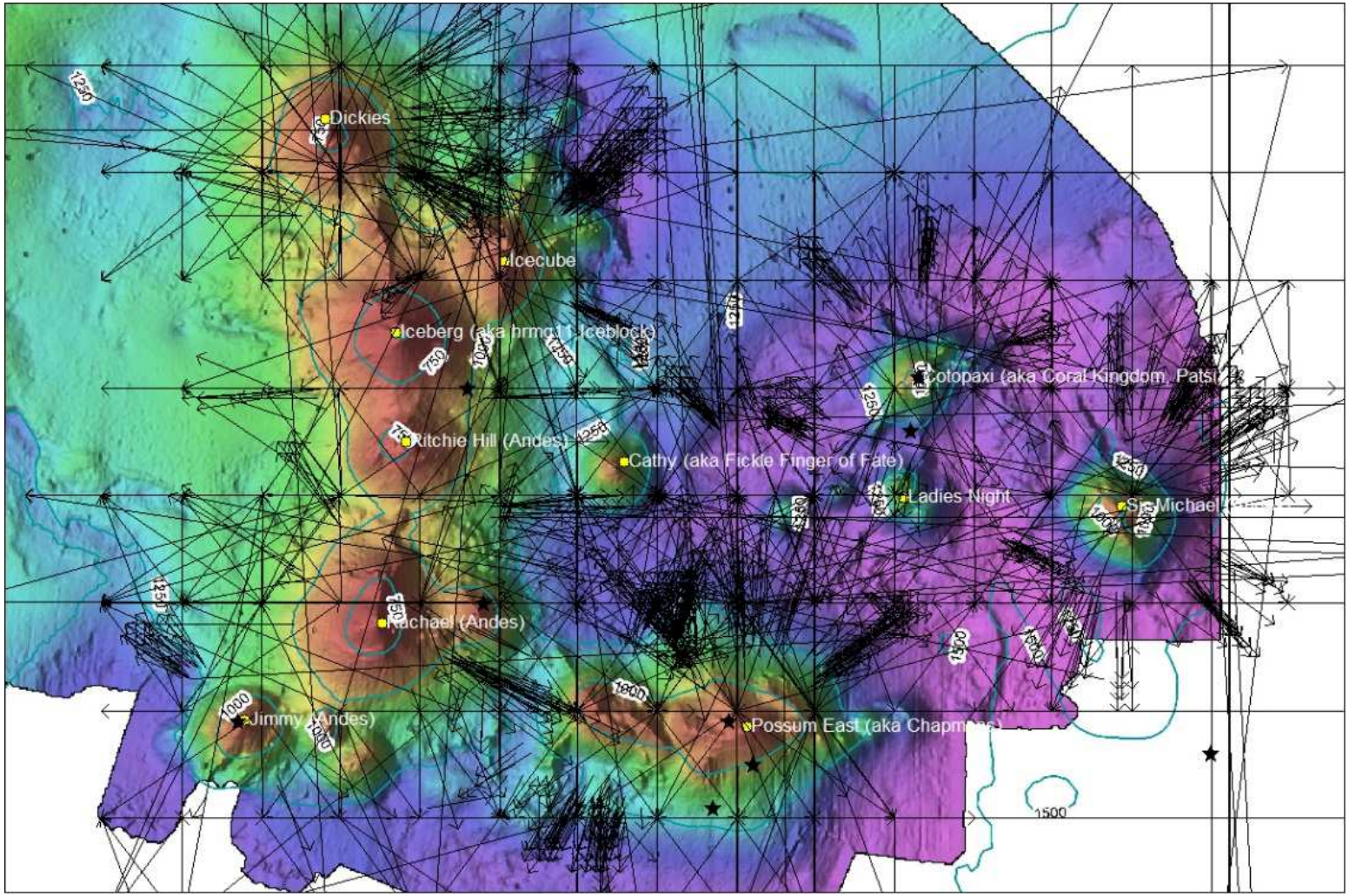
Catch data

- Data assimilated from various sources to include as much of the historical ORH fishery as possible.

- The distance to the summit point of the nearest UTF was calculated for the start position of each record, using a subset of the seamounts in the “Seamounts” database. The subset included all UTFs with summit depth between 400 and 1500m.
- Records were assigned to the nearest UTF if the trawl start position was <= 2 n.miles from the location of the peak, if the trawl was <= 30 minutes in duration, and if trawl start depth <UTF base depth.
- Note: start depth was not compared with summit depth, because of variable landing depth depending on UTF terrain (e.g., rugged on summit, or upper flanks)
- Note the data are only TCEPR, so missing CELR where no position (mainly affects 1980s-early 1990s fisheries).

UTF assignment is tricky

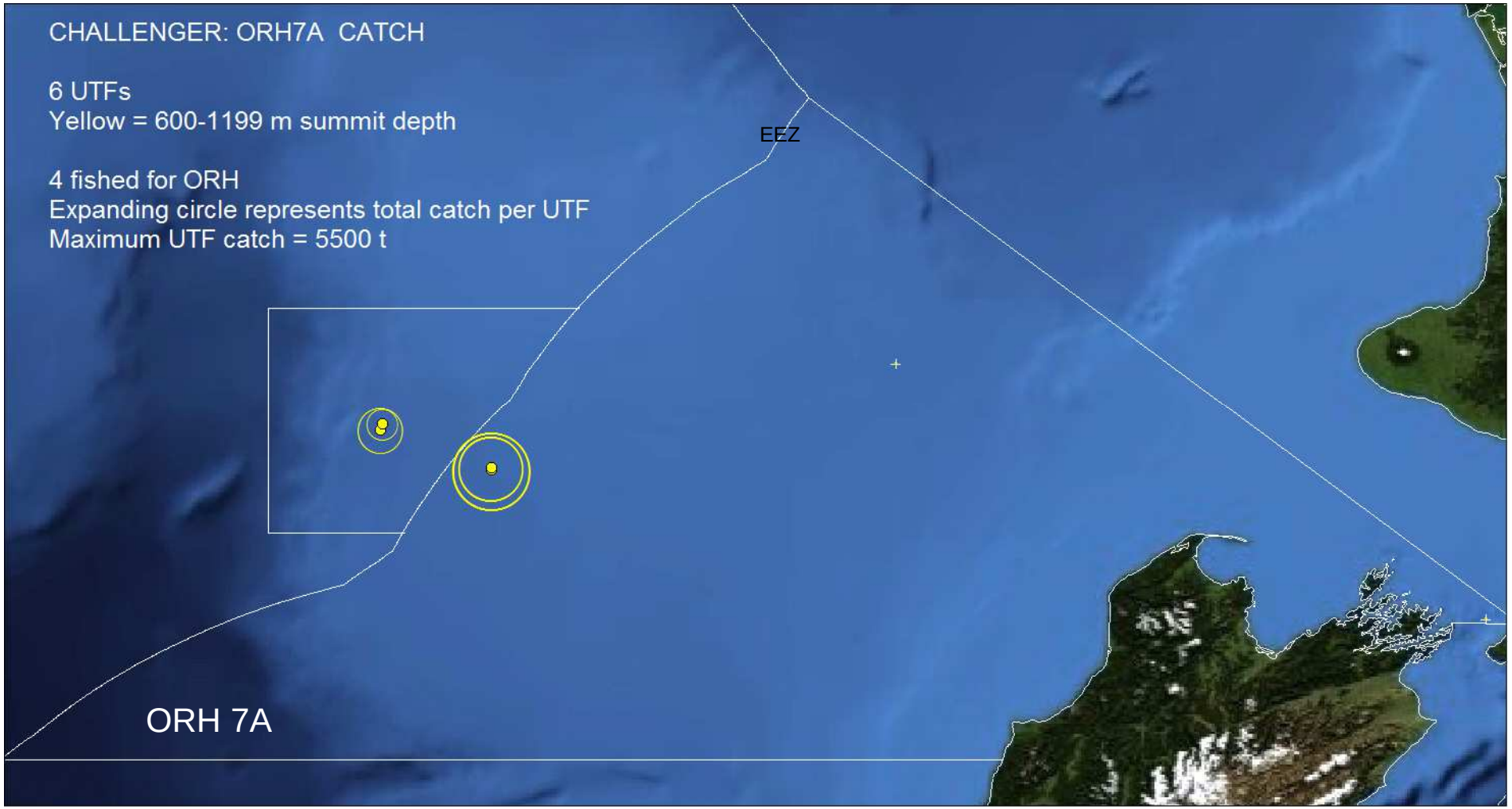
- Small features, often close together, 1 n.mile precision of most TCEPR records, vessel position recorded.
- Most OK, but some mis-assignment in UTF clusters (e.g., Andes)



UTF catch summaries

- The following slides show the 4 fishery areas
- For each, all UTFs are plotted
- The UTFs with summit depths between 600 and 1199 m are highlighted in yellow
- The total historical catch of ORH on each UTF is displayed as an expanding symbol plot
- These figures serve to show the varying relative importance of the UTFs for orange roughy fisheries
- Full catch data are available, but not presented here

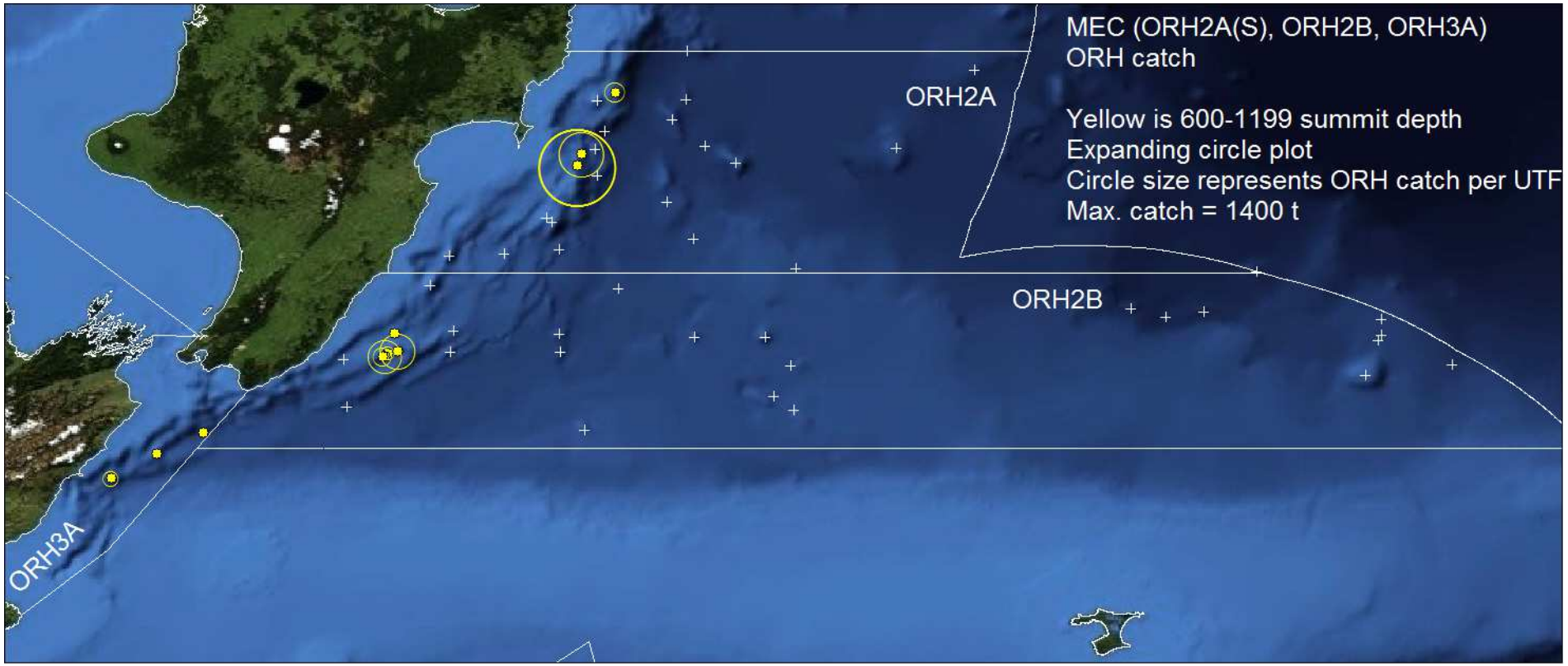
CHAL UTF catch



Total catch of ORH off UTFs estimated at 12,800 t

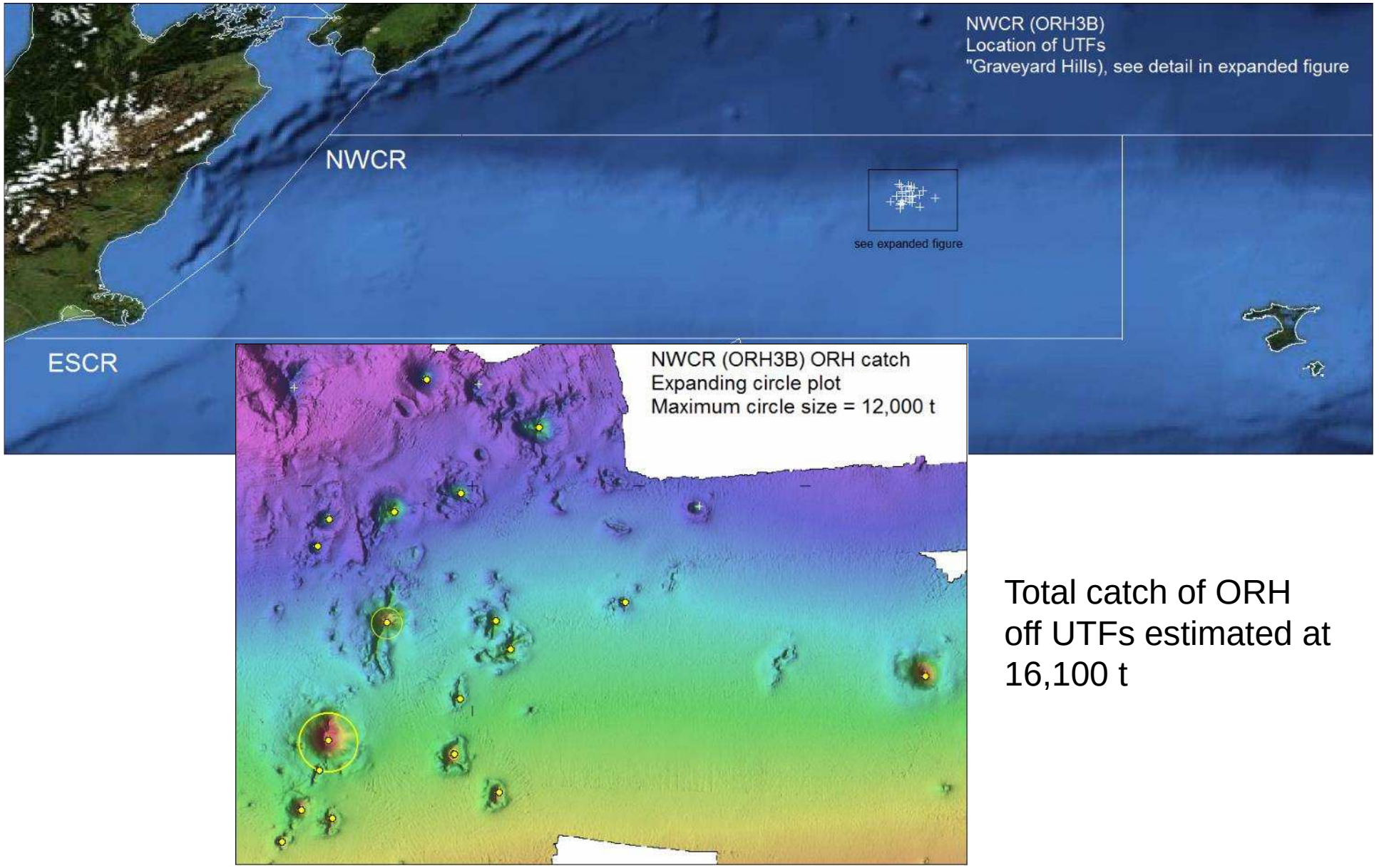
Note the extension of the EEZ is recognition of a straddling stock of ORH

MEC UTF catch



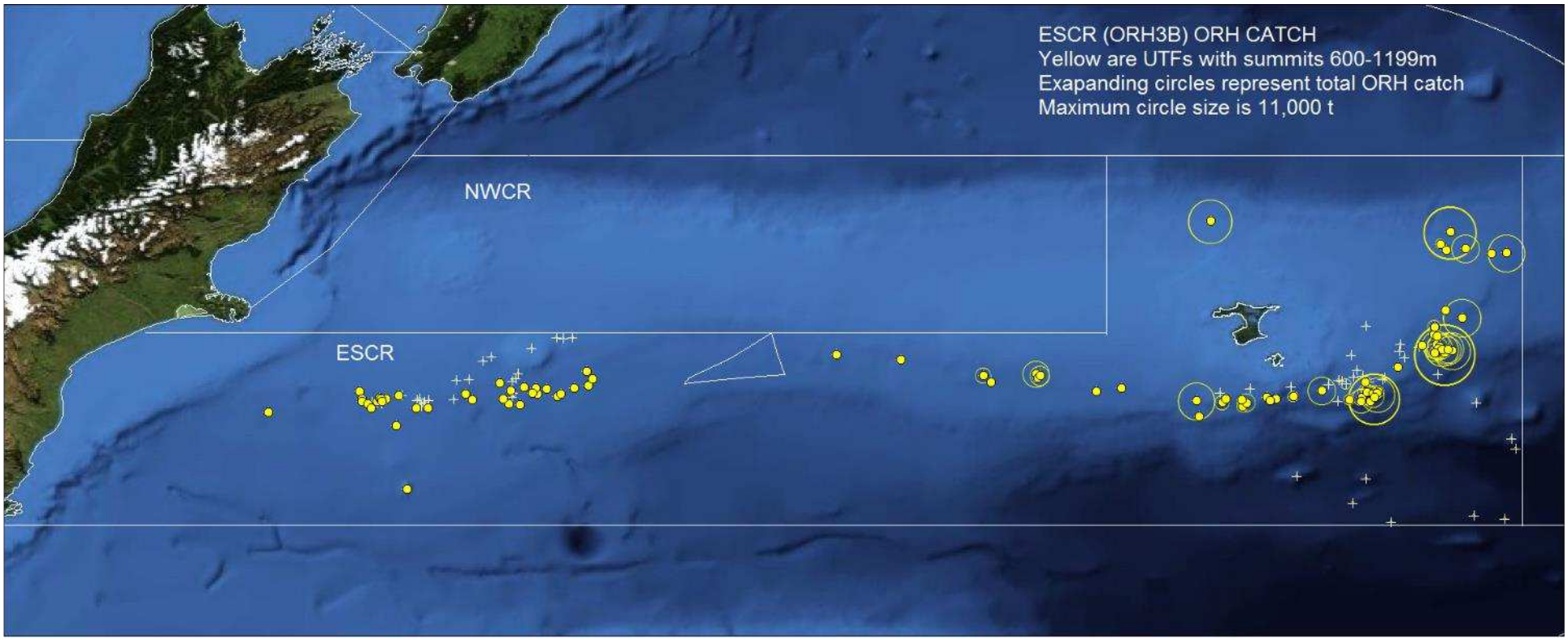
Total ORH catch off UTFs estimated at 3,000 t (known to be low)

NWCR UTF catch



Total catch of ORH off UTFs estimated at 16,100 t

ESCR UTF catch



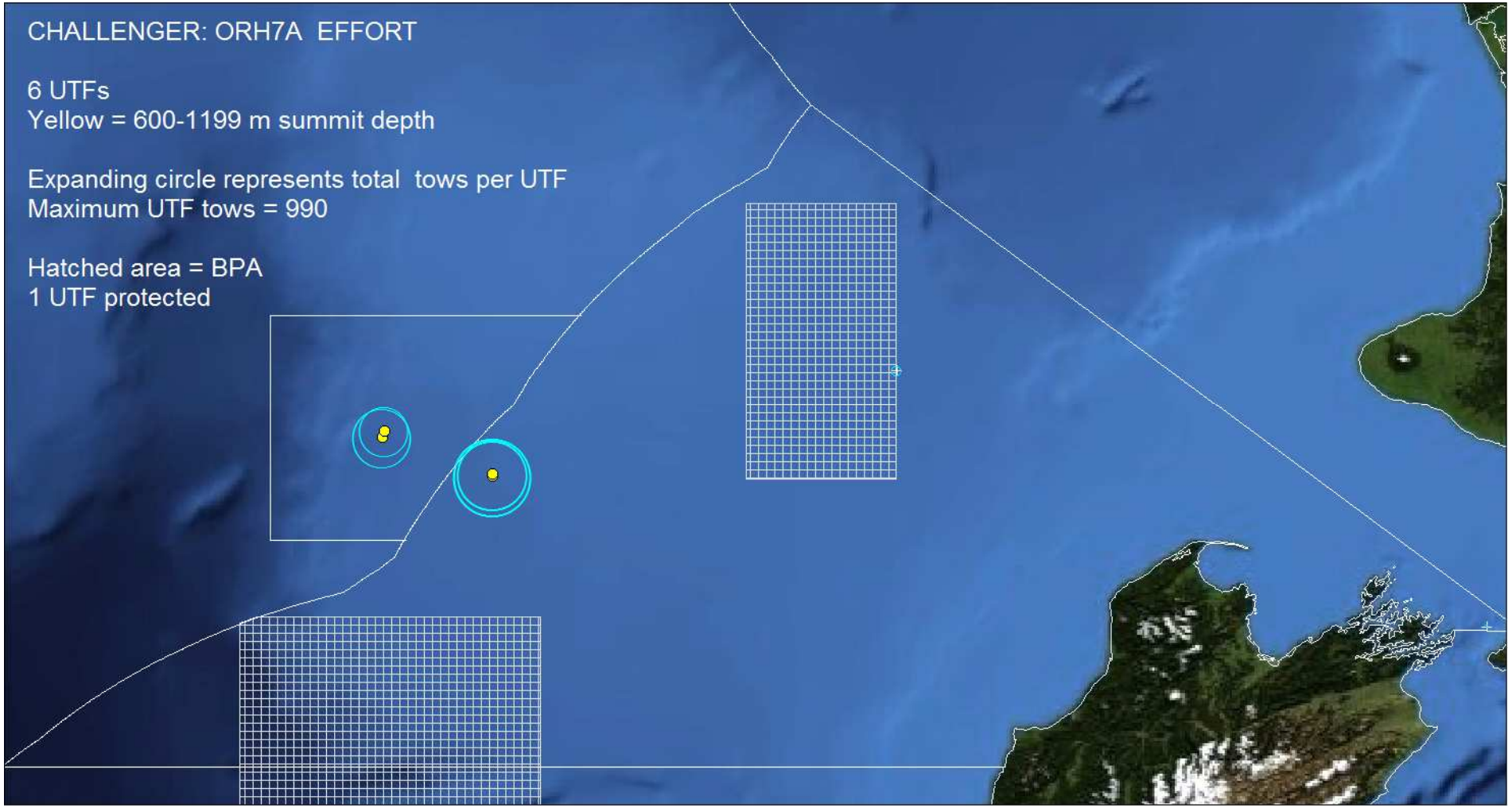
Total catch of ORH from UTFs estimated at 96, 800 t

UTF effort summaries

- The following slides summarise effort data (bottom trawling) for the 4 fishery areas
- A tow is one where ORH was the reported target species, or ORH was recorded in the catch
- Each area is summarised separately
- Tables are given which show the total number of trawls on each feature by year, where summit depth is 600-1199m, and years are 1990 onwards (when tow data are more reliable)
- Plots are made showing all UTFs
- The UTFs with summit depths between 600 and 1199 m are highlighted in yellow
- The total number of trawls on each UTF is displayed as an expanding symbol plot
- These figures serve to show the relative effort on UTFs in orange roughy fisheries
- Information also given on protected status of UTFs in each area

CHAL effort (number of tows)

UTF RegNo	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
578	58	18	85	45	26	26	30	19	11	15	1	0	0	0	0	8	8	0	0	9	2	8	15
579	79	30	60	68	56	41	21	27	16	21	3	0	0	0	0	6	7	0	0	2	0	7	7
581	27	1	0	71	48	8	45	40	35	41	4	0	0	0	0	24	6	0	0	2	6	0	0
582	34	4	2	40	16	22	22	49	13	13	2	0	0	0	0	4	6	0	0	4	3	1	7

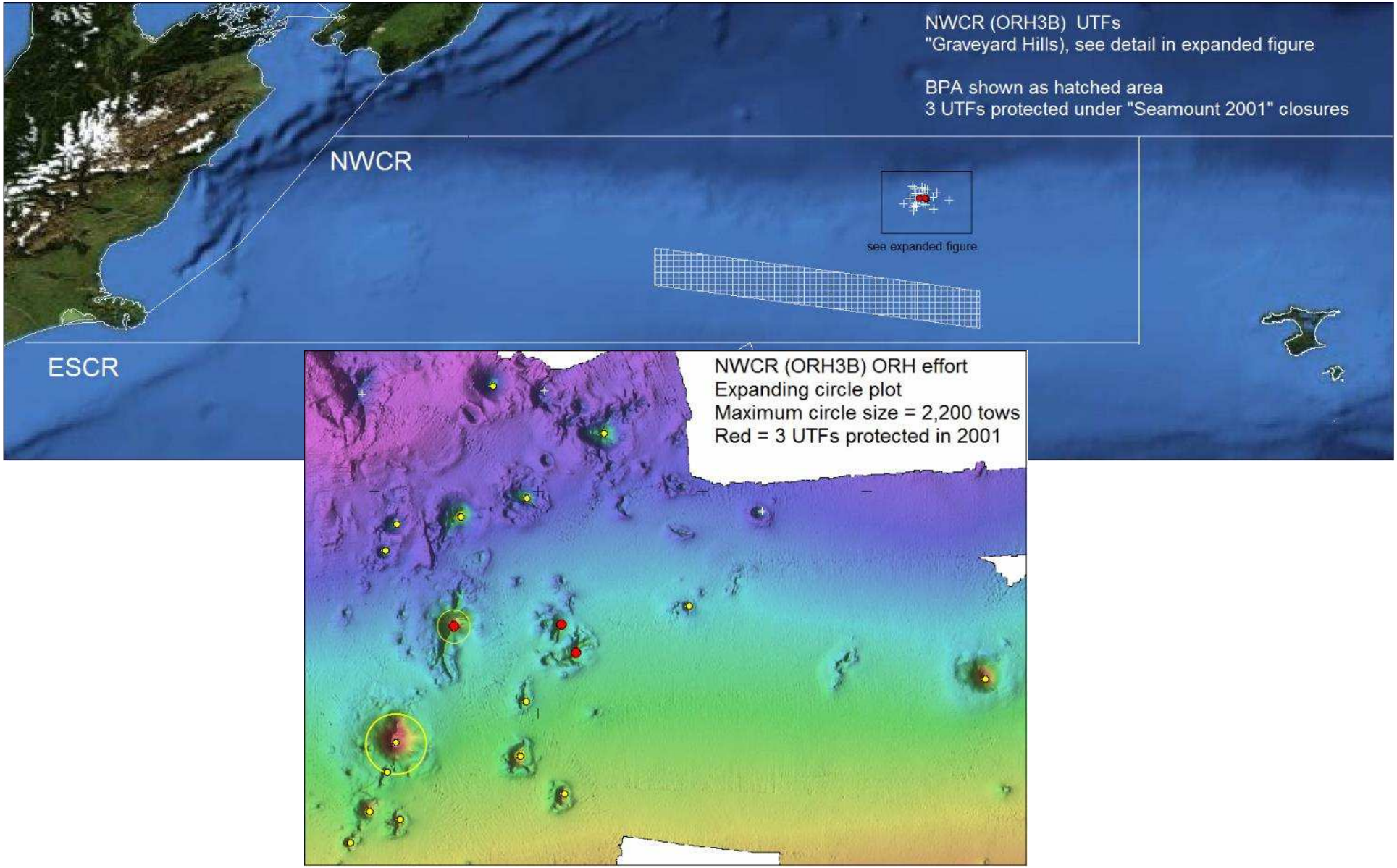


NWCR effort (number of tows)

UTF RegNo	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
583	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	5	12	4	10	0	0
584	0	0	1	0	0	2	1	0	3	4	15	21	0	0	0	0	1	1	6	5	6	0	0
585	0	0	3	35	114	132	133	92	87	40	48	46	1	3	3	0	1	1	10	7	0	0	3
586	0	0	20	130	175	173	171	97	156	68	120	140	120	156	77	138	124	60	120	50	73	4	3
587	0	0	0	5	20	8	6	3	6	4	5	10	6	5	3	4	6	0	7	6	0	1	0
588	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	2	0	0
589	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0
591	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
592	0	0	0	0	5	0	1	1	11	3	8	9	6	5	3	6	10	0	3	0	1	0	0
593	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	4	5	2	2	0	0
594	0	0	0	0	0	0	0	0	9	4	6	11	2	2	0	1	2	0	2	1	0	0	0
595	0	0	0	14	0	0	0	0	0	1	0	0	0	9	1	0	0	0	1	0	0	0	0
596	0	0	0	1	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
597	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
598	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	2	7	0	0
599	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0
602	0	0	0	0	0	7	3	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
603	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0

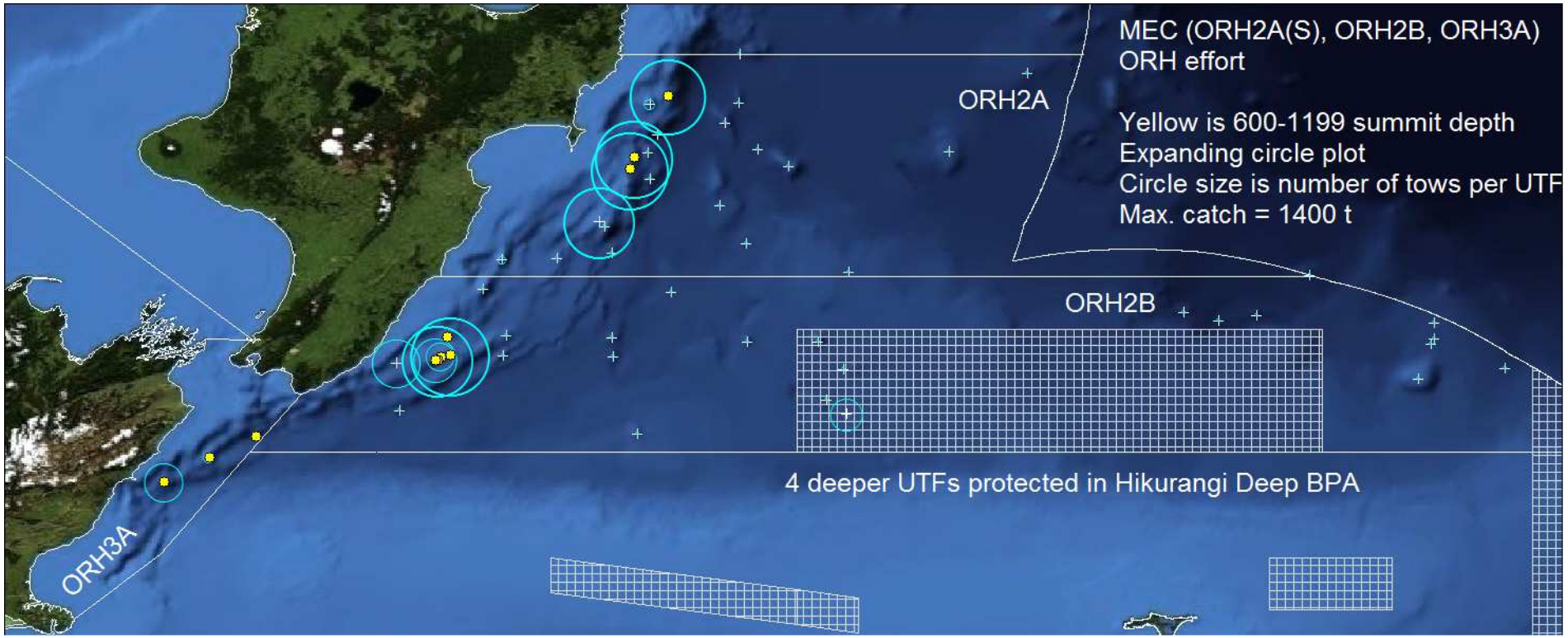
Most effort on two hills
Many with only a few tows

NWCR effort (2)



MEC effort (number of tows)

UTF RegNo	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
308	0	3	0	18	2	1	3	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0
542	4	3	6	9	18	6	16	7	0	0	6	10	5	6	4	5	5	19	11	4	4	10	5
574	14	7	35	8	6	14	1	14	15	14	6	8	0	2	4	0	2	0	0	0	0	0	1
575	8	7	18	39	15	30	2	1	2	12	8	5	1	2	1	10	0	0	4	2	2	1	1
760	2	13	39	30	4	7	15	0	4	1	0	0	0	0	1	0	1	1	2	0	0	0	1
763	0	2	24	24	48	8	5	2	2	2	2	1	0	6	4	4	9	5	2	2	1	3	1
764	0	1	7	1	15	4	1	0	5	1	3	1	4	0	0	1	2	2	1	1	2	6	2
766	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
767	1	2	2	4	13	5	1	2	0	1	2	0	0	0	1	1	3	3	3	2	1	0	0



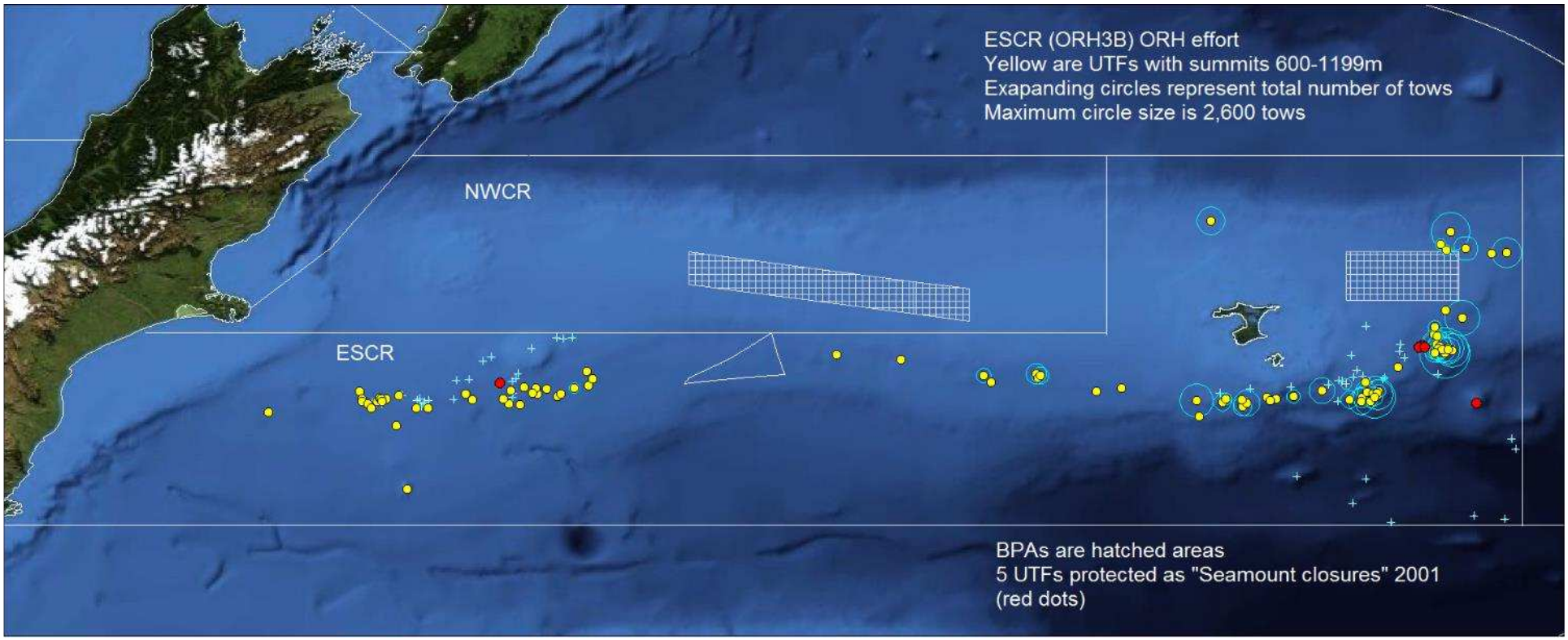
ESCR effort 1 (number of tows)

UTF RegNo	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
608	0	15	2	0	0	15	25	55	51	64	59	69	69	85	73	69	54	32	46	35	62	15	6
610	0	338	157	36	57	139	54	43	55	111	87	84	71	53	68	48	37	63	24	59	39	10	12
611	0	54	21	31	42	76	31	38	29	60	42	39	27	31	34	19	17	55	22	26	13	5	6
612	0	193	34	13	15	105	45	53	47	72	61	49	58	28	44	39	47	48	12	61	20	11	7
613	0	4	8	3	1	9	0	10	13	24	7	6	7	1	7	3	1	8	8	6	4	0	4
614	8	21	20	0	2	20	5	13	11	24	5	6	5	4	8	1	2	7	4	6	1	2	0
615	10	1	205	122	158	173	94	82	131	140	84	77	164	180	143	113	126	128	109	109	89	40	48
616	0	9	162	57	98	94	59	38	50	61	65	44	41	61	70	60	64	47	27	16	12	4	8
617	0	0	184	39	77	69	58	24	45	57	61	55	65	87	77	50	60	104	45	66	29	15	8
618	0	0	1	2	123	102	60	30	106	69	50	49	46	83	71	51	61	46	42	35	16	7	19
619	0	0	3	2	4	1	5	1	18	39	51	40	30	107	66	28	57	68	85	27	34	15	17
620	0	0	4	1	0	1	0	3	11	0	91	28	52	96	72	74	117	42	15	21	15	12	11
621	0	0	38	84	83	75	9	14	31	24	64	28	74	69	40	56	32	16	17	4	13	6	6
624	0	0	0	0	1	0	0	0	6	1	3	0	2	0	1	3	4	0	1	1	0	0	0
625	0	0	0	0	0	1	0	0	7	2	1	0	0	0	0	0	0	0	0	0	0	0	0
628	0	0	159	49	81	120	73	47	99	87	53	48	62	88	58	43	42	70	21	50	28	18	16
629	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	1	1	0	0
630	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	44	66	28	9	2	13
631	0	0	1	0	1	0	0	1	8	0	3	42	40	108	67	37	69	48	7	9	9	3	3
632	45	50	4	52	52	6	4	2	14	14	1	6	1	4	47	23	38	9	45	20	6	4	2
633	11	95	24	126	186	49	24	20	50	36	24	22	32	37	30	54	35	49	42	46	31	9	19
634	1	0	3	28	13	16	5	3	14	7	14	21	16	9	12	4	9	10	12	10	3	2	0
635	77	16	15	59	49	16	11	21	18	14	13	18	17	25	16	21	23	17	10	22	2	1	11
636	38	8	22	68	49	15	11	20	13	11	9	22	34	26	21	11	21	27	17	20	4	3	2
637	11	1	1	24	74	51	19	13	34	13	6	8	9	6	5	17	43	36	14	24	8	8	3
639	0	2	0	7	9	10	3	3	2	7	5	27	16	23	26	34	20	18	11	22	1	1	0
640	147	83	19	54	104	62	20	26	14	25	15	25	11	18	38	18	19	8	12	13	7	9	4
642	15	27	0	64	12	2	3	2	5	3	0	2	2	7	9	10	26	12	25	12	4	2	2
647	0	2	0	20	32	13	3	4	3	5	10	9	3	5	9	8	8	22	8	10	1	2	1

ESCR effort 2 (number of tows)

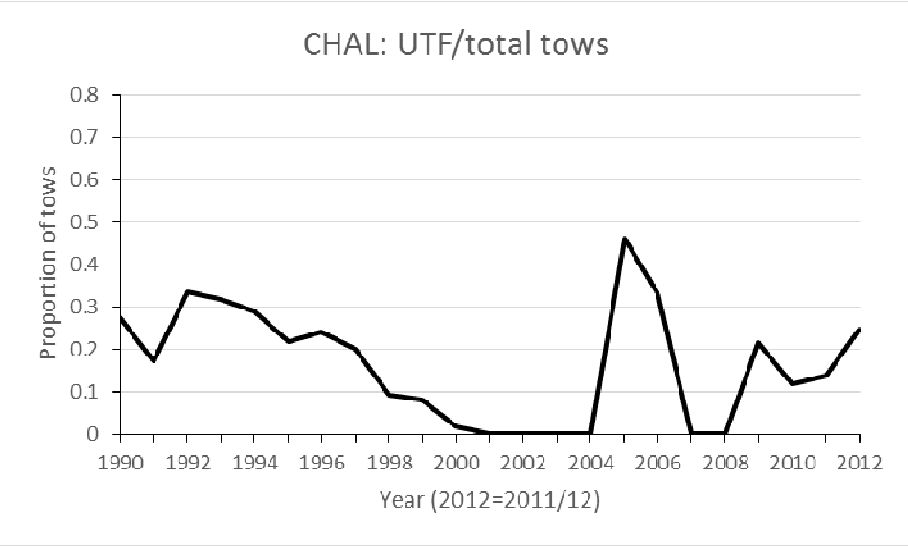
UTF RegNo	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
648	70	136	44	191	194	68	50	42	123	82	26	62	71	85	99	74	61	78	108	108	44	29	21
651	21	14	4	5	11	9	10	6	3	2	6	1	0	1	3	1	2	5	6	3	5	1	1
652	10	8	7	6	13	2	9	21	6	0	0	2	1	2	19	15	12	22	18	22	5	10	10
654	3	2	8	6	8	5	2	1	1	3	3	3	1	2	1	1	0	1	2	1	0	0	0
657	84	13	22	32	94	82	34	23	57	32	28	38	36	25	58	61	33	53	47	27	23	15	10
658	19	0	1	10	25	13	1	27	51	52	7	27	17	21	19	15	22	25	32	8	8	3	2
659	62	27	54	26	48	49	20	2	20	18	10	16	11	7	11	15	17	9	6	13	3	7	3
661	81	43	57	37	100	68	26	14	23	18	34	31	18	19	19	22	34	24	11	17	13	9	8
663	0	0	0	1	5	0	0	0	1	1	0	5	0	0	1	0	0	0	0	0	0	0	0
664	50	21	9	9	36	12	12	5	5	11	6	6	4	4	12	5	11	5	6	3	2	2	2
665	0	0	0	0	4	42	8	0	13	8	1	1	7	6	1	3	6	0	2	1	0	4	1
666	4	0	1	8	25	12	9	5	36	15	17	7	9	5	8	1	6	3	1	1	1	1	1
667	1	0	1	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
669	3	2	0	0	3	3	1	0	0	3	0	0	1	0	0	0	0	0	2	0	1	0	1
677	0	0	3	14	22	11	5	5	8	5	2	9	7	3	3	4	0	2	4	1	6	0	3
680	0	0	9	6	24	4	3	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
682	5	0	0	0	2	1	1	1	2	4	1	0	0	0	2	0	0	2	0	1	0	0	0
692	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
695	0	0	1	5	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
799	0	1	0	0	1	5	2	0	0	1	3	2	0	0	0	0	0	0	0	0	1	0	1
800	0	0	0	0	4	4	0	0	2	3	0	1	1	2	0	0	0	0	1	1	3	0	1
801	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
802	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
806	5	5	2	2	5	5	4	0	2	0	2	1	0	2	2	5	1	2	2	4	2	3	1
807	20	1	4	33	5	8	6	2	3	6	3	0	0	9	2	0	5	6	3	36	88	6	16
808	1	1	0	0	3	14	3	9	11	11	7	5	2	0	2	1	3	0	1	1	1	0	0
809	0	0	0	1	0	2	0	0	17	9	3	4	8	1	36	21	12	4	3	0	0	0	0
813	0	2	80	32	34	30	55	13	20	25	32	14	24	50	38	32	85	53	21	16	12	15	13
814	0	0	1	0	3	2	5	0	40	5	16	4	5	27	14	7	23	7	10	1	3	2	3

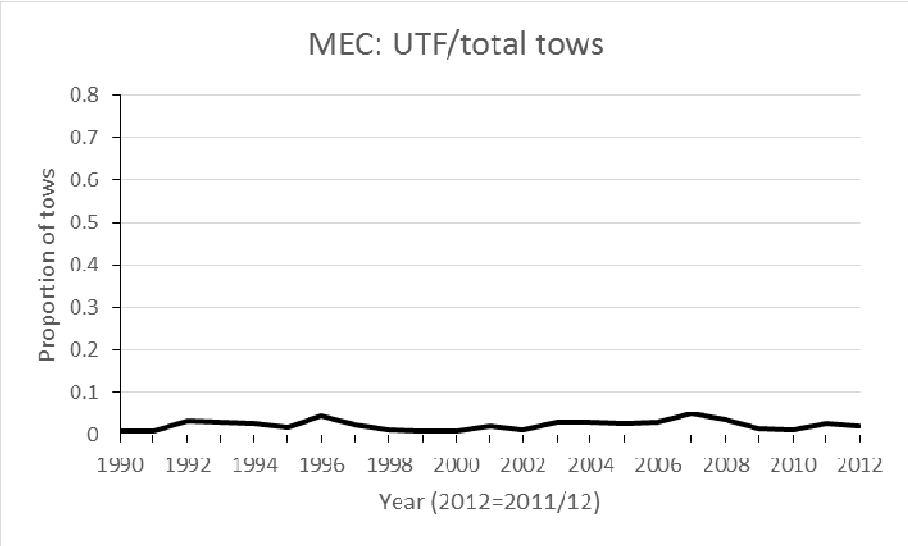
ESCR effort (3)

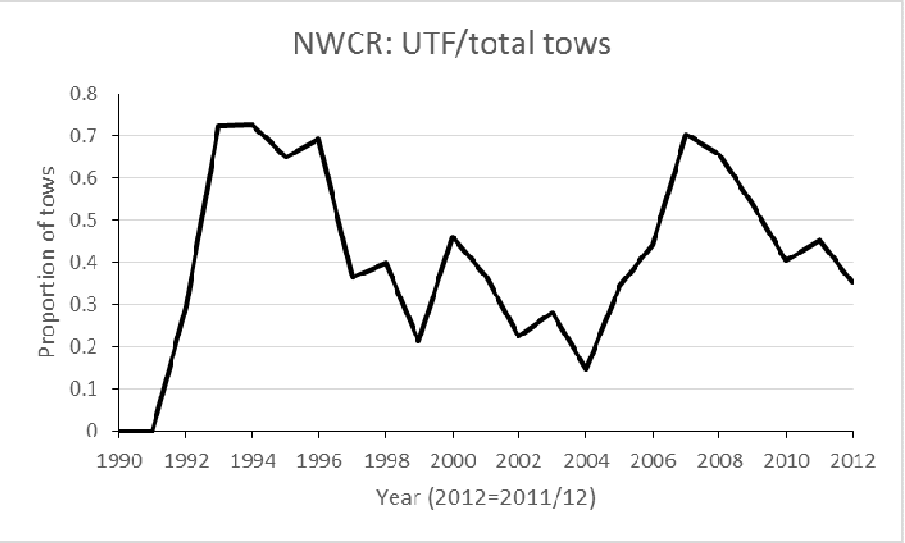


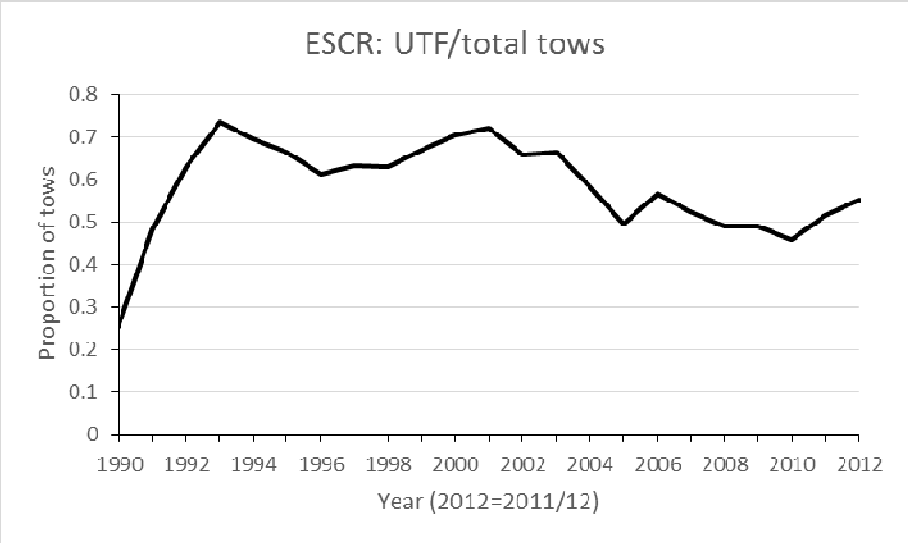
Most ORH effort is on the hills on the eastern side of the Chatham Rise, with small catches occurring in the oreo fisheries to the west.

Relative effort on UTFs







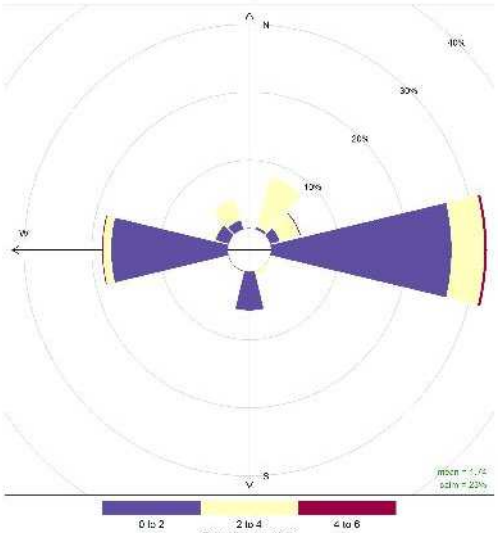


Graphs show proportion of tows on UTFs (with 600-1199m summit depths) against the total number of tows in the fishery areas (so including the slope)

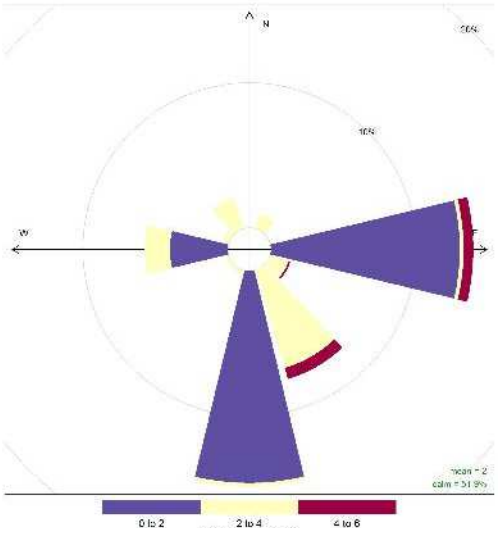
Trawling within a UTF

- As seen with an earlier slide on trawl assignment to UTFs, there are issues with the underlying effort data that limit the ability to accurately plot trawl tracks on a UTF
- Where a UTF is reasonably large (several km2), and tows are relatively long (about 1 n.mile or more (>15 minutes towing)), then start-finish is informative
- In the following slides we show such data for a number of UTFs in the 4 fishery areas. We use a “weather vane approach) which plots tow direction by sector (the number is proportional to length of vane, and tow distance is colour-coded) [note “calm” is the proportion of zero distance tows]
- More work is required, but this preliminary analysis demonstrates the variability in tow lines and trawl duration between UTFs.

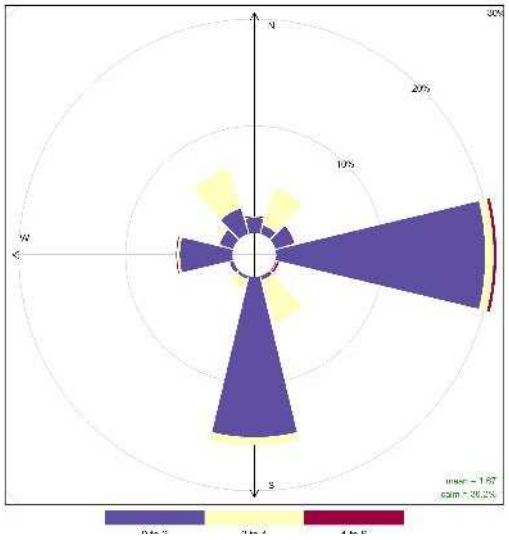
Graveyard



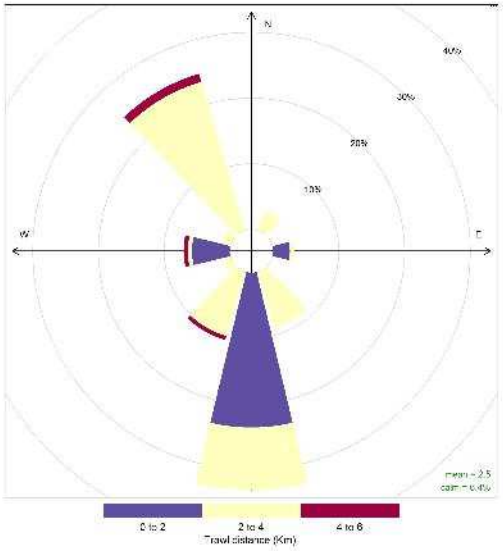
Morgue



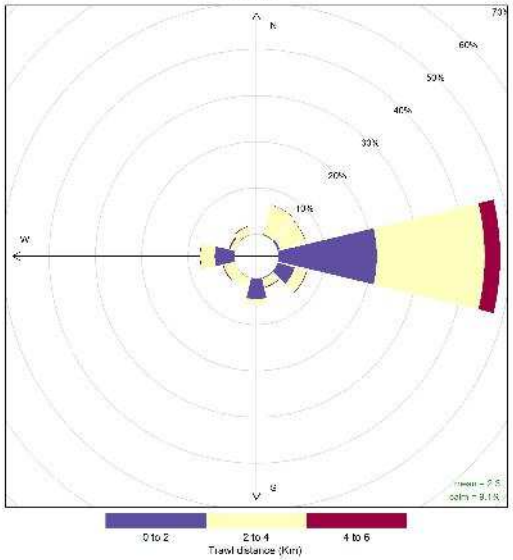
Cotopaxi



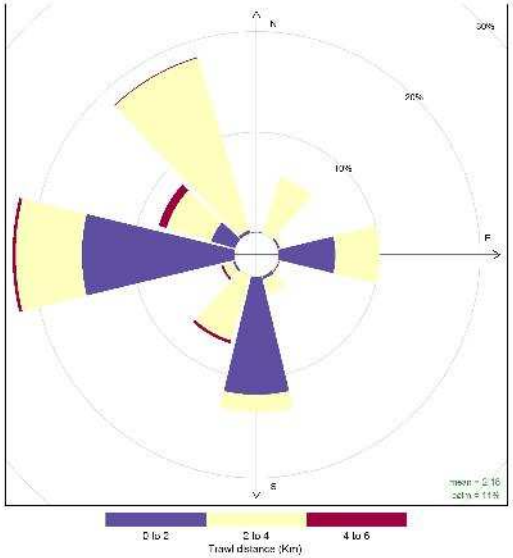
North Hill



Dickies



Hegerville



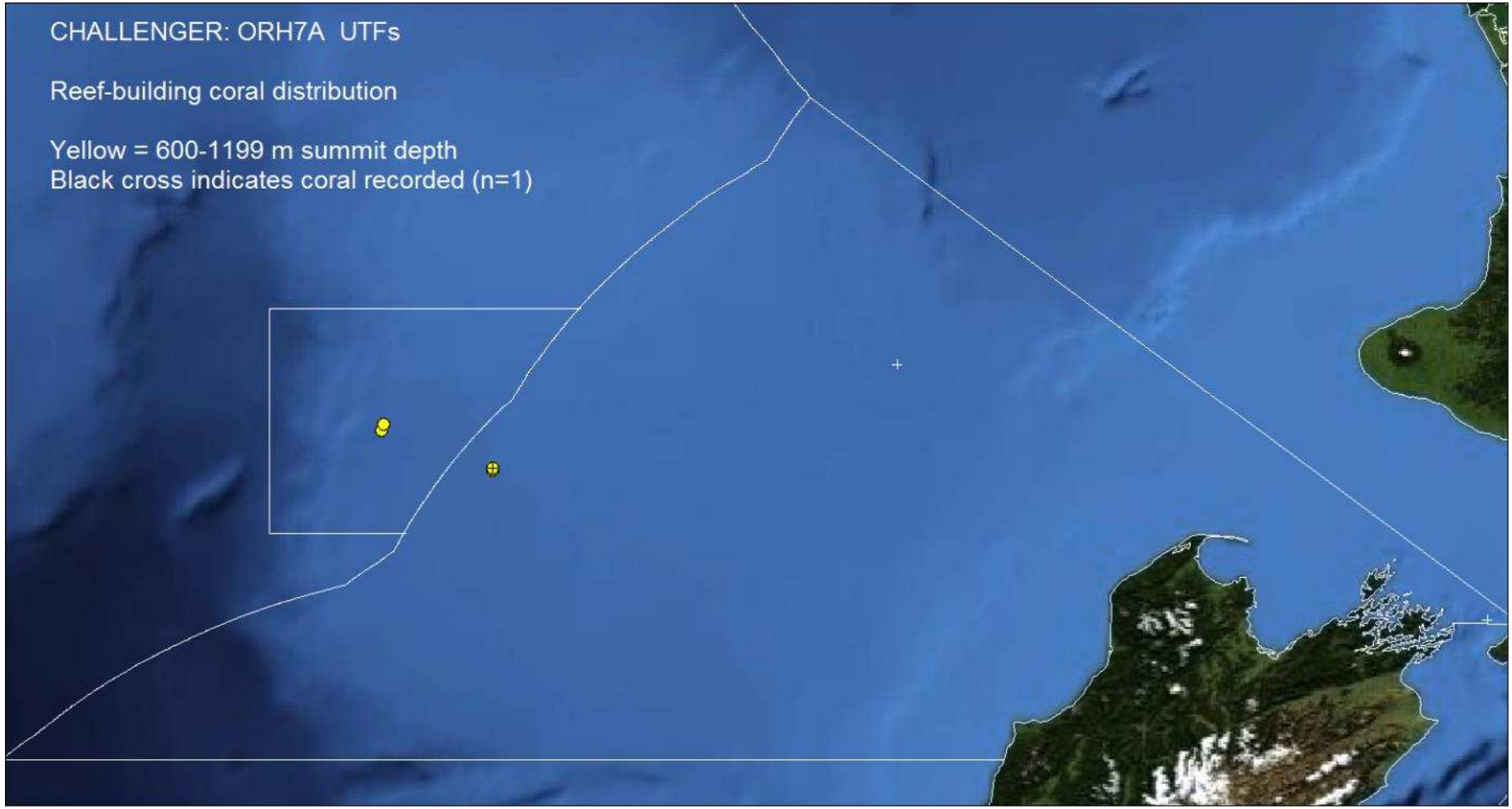
Stony coral benthic habitat on UTFs

- Reef-building stony corals (O. Scleractinia) are the main habitat-forming taxa on UTFs
- 4 principal species of relevance to ORH fisheries (in the appropriate depth range –see Corals presentation)
  - *Solenosmilia variabilis*
  - *Madrepora oculata*
  - *Enallopsammia rostrata*
  - *Goniocorella dumosa*

Distribution of stony corals on UTFs

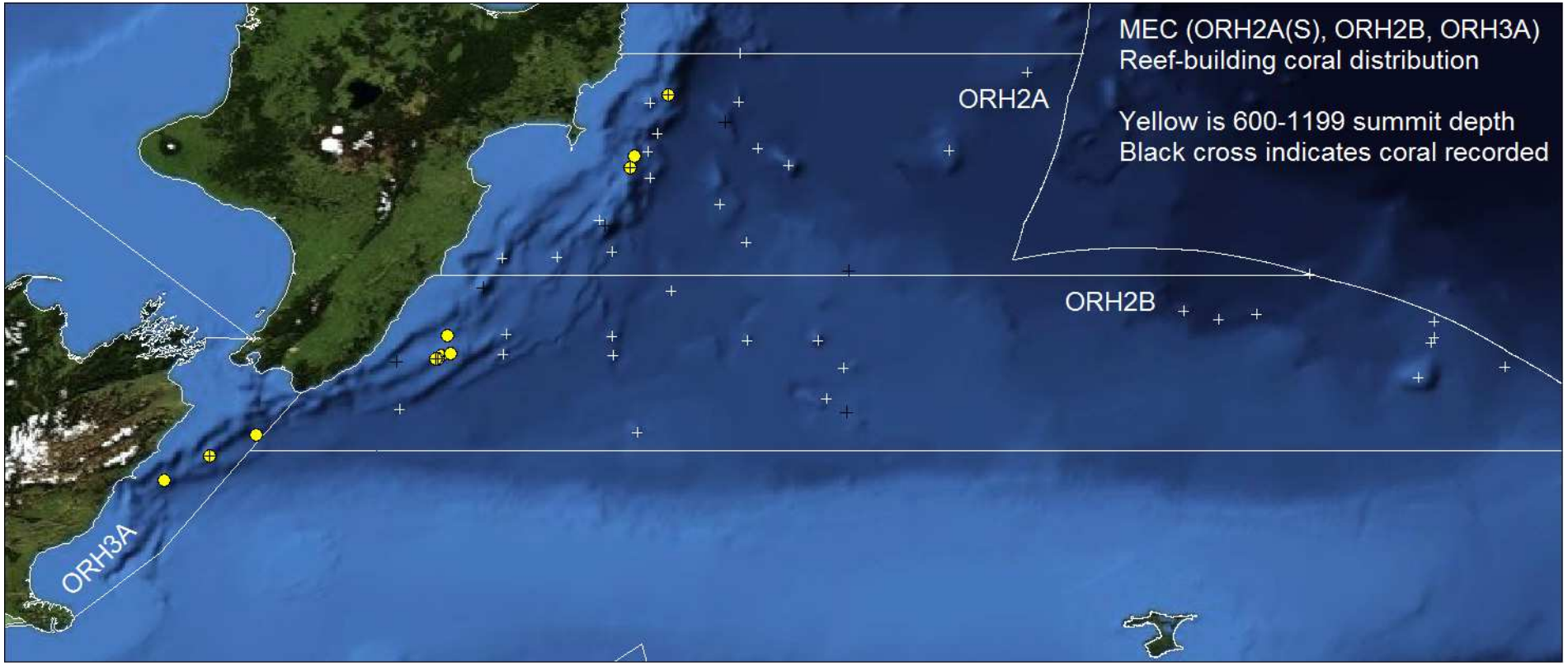
- Links with distributional data in Corals presentation
- Point sample distribution and depth of the 4 reef-building species were compared with location and depth of UTFs
- The following plots show the distribution of UTFs in the 4 fishery areas, and those with records of the 4 species
- Note that coverage is incomplete, and many UTFs have not been sampled.

CHAL (ORH 7A) UTF corals



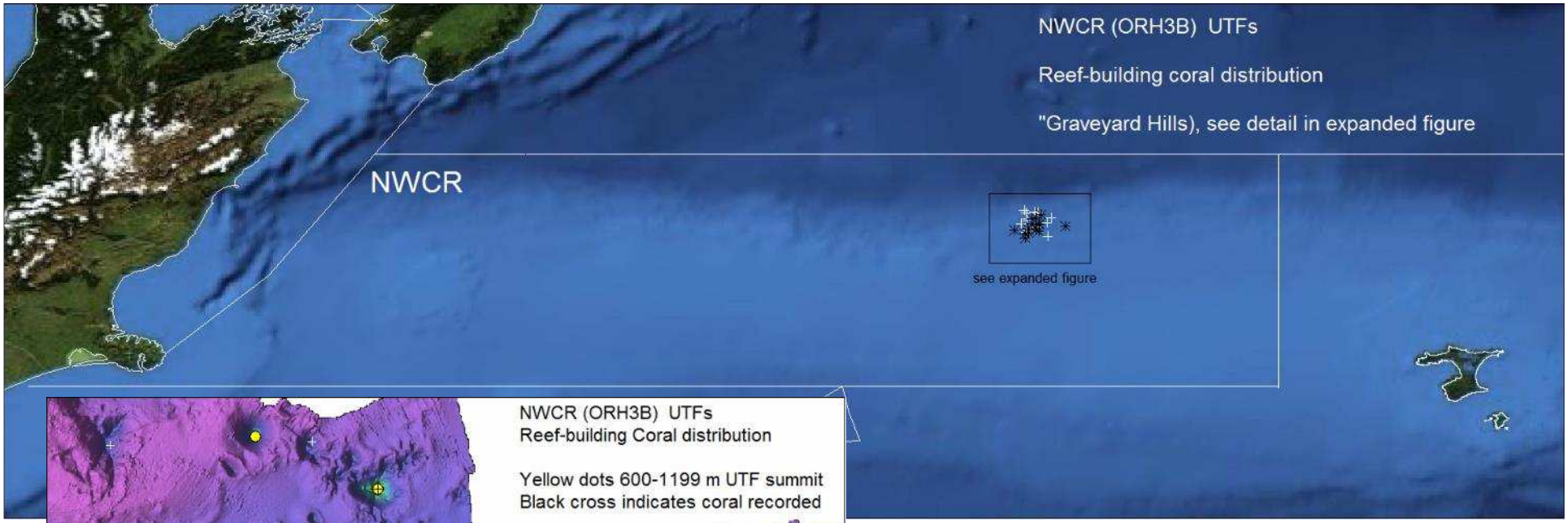
CHAL	<600m	600-1199m	>=1200m
No. UTFs	2	4	0
No. coral	0	1	

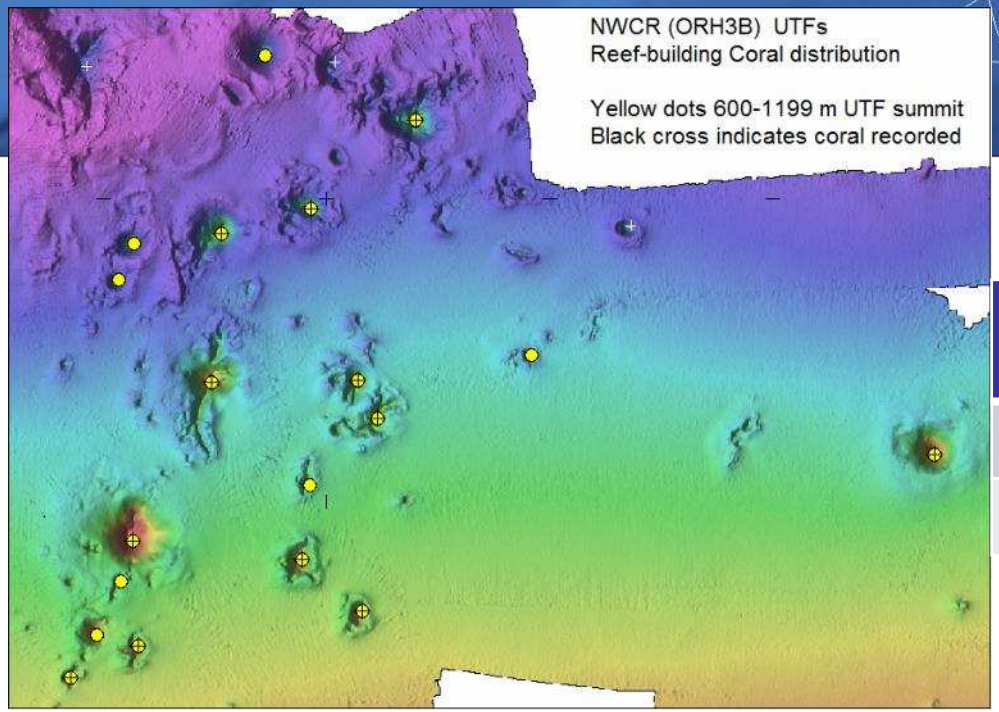
MEC UTF corals



MEC	<600m	600-1199m	>=1200m
No. UTFs	6	11	36
No. coral	3	5	3

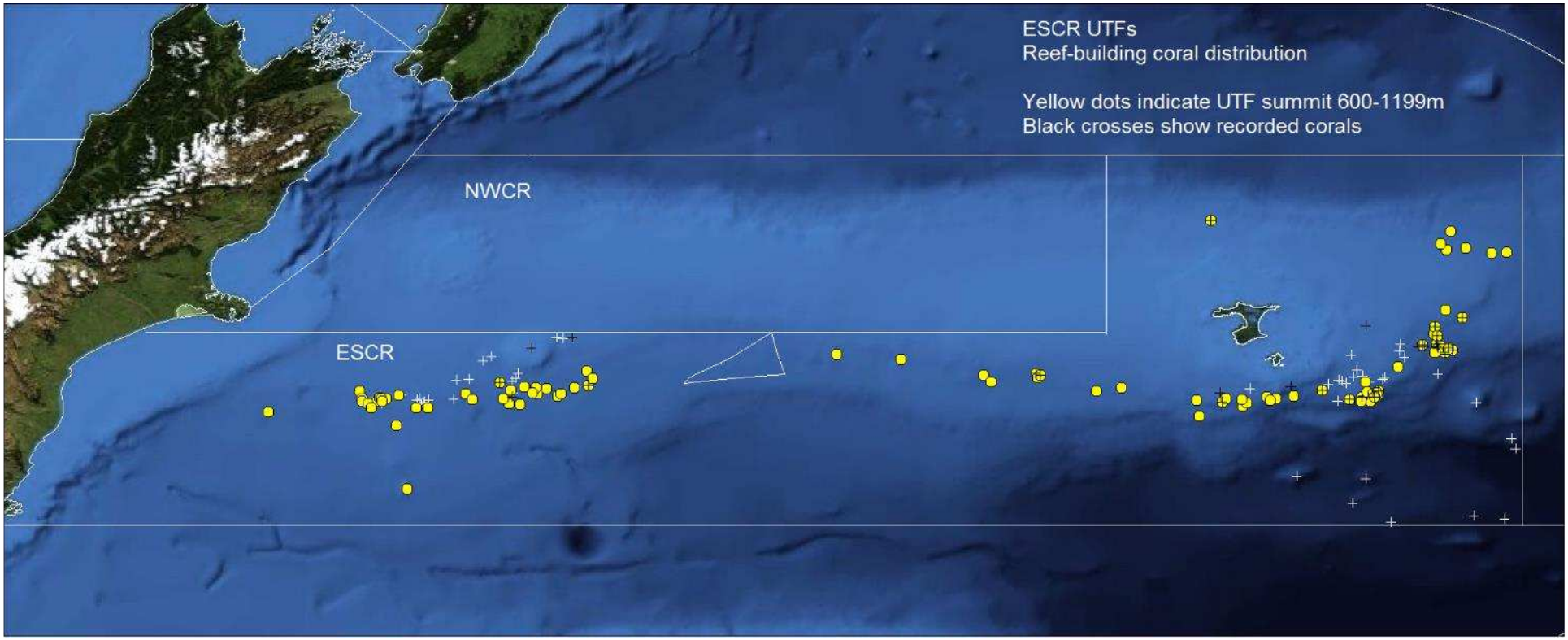
NWCR –Graveyard hill corals





NWCR	<600m	600-1199m	>=1200m
No. UTFs	0	24	3
No. coral		14	0

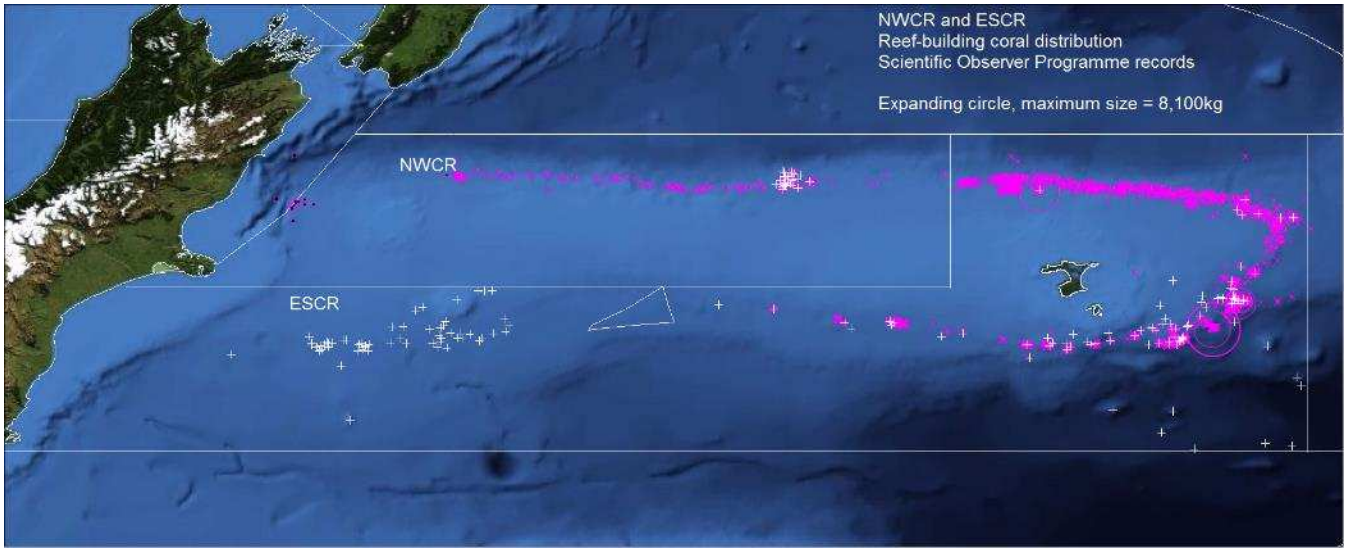
ESCR UTF corals



ESCR	<600m	600-1199m	>=1200m
No. UTFs	49	91	11
No. coral	9	22	0

Stony coral habitat “catch”

- Data analysed from Scientific Observer Programme records between 2007/08 and 2009/10 years (Tracey et al. 2011)
- 5926 ORH-target trawls observed
- Divided by Fishery Area
  - CHAL: 151 tows, 0 catch
  - MEC: 86 tows, 0 catch
  - NWCR: 318 tows, 26 with reef-building corals, 0 UTFs with catch.
  - ESCR: 2658 tows, 155 with reef-building corals, 3 UTFs with catch
- More detail given in Revised coral presentation



Objective 2: Structure and Function

- Role of UTFs summarised in Pitcher et al. (2007), Clark et al. (2010) and Rowden et al. (2010)
- Important as **benthic habitat** for fishes
  - Many fish are associated with UTFs
    - Either enhanced numbers or biomass (UTF preference)
    - Or similar to slope (more generalised association with deep-sea habitats)
  - Clear role for ORH spawning
  - Feeding very important
  - Nursery grounds not known
- Important as **benthic habitat** for invertebrates
  - Wide depth range offered by UTF elevation
  - Hard surfaces for attachment of sessile animals
  - Current flow enhanced increasing food supply
  - Regular input of food from DSL migrations
  - Variable substrate suitable for a wide range of biodiversity

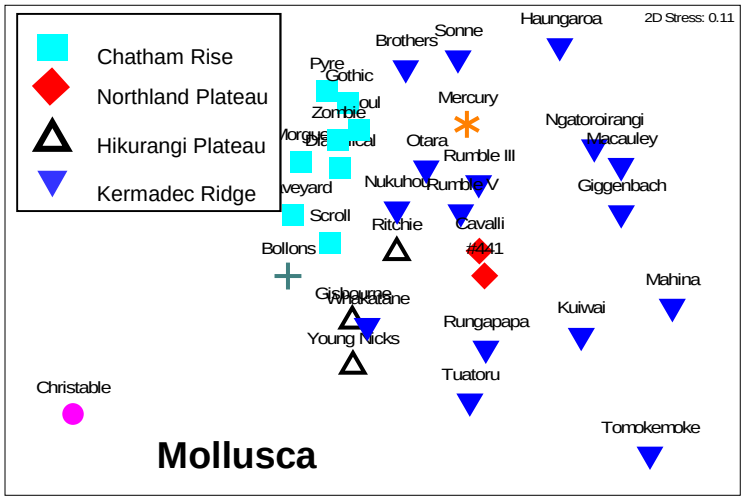
The importance of UTFs

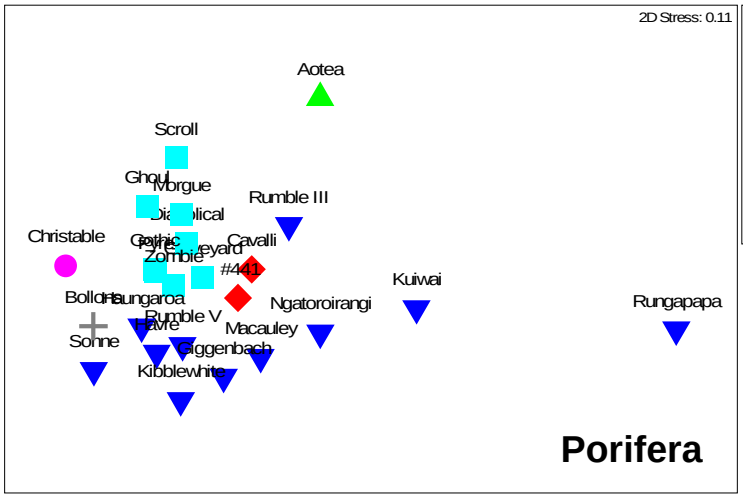
- There are many “paradigms” about seamounts, knolls and hills that characterise them as:
  - Unique-having high levels of endemism
  - Diverse-being hot spots of biodiversity
  - Productive-having enhanced production and biomass
- Often, these findings have been driven by limited sampling
- Some are true for some UTFs, some are not
- Typically difficult to generalise the ecological characteristics of UTFs
- Next few slides deal with some NZ-Australian studies

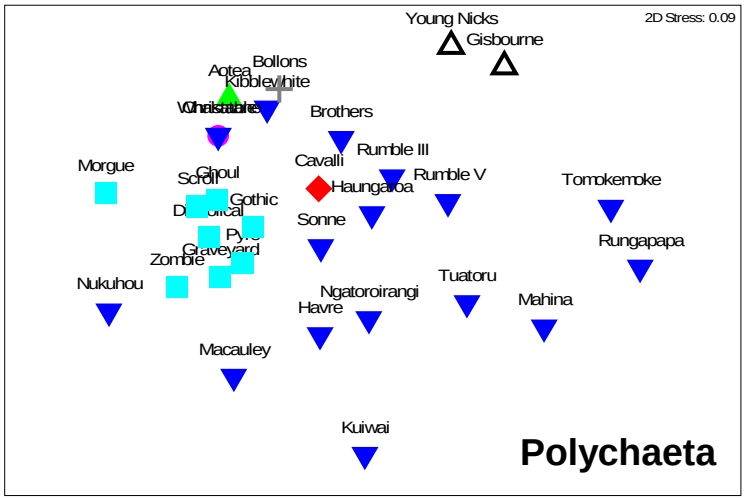
Endemism

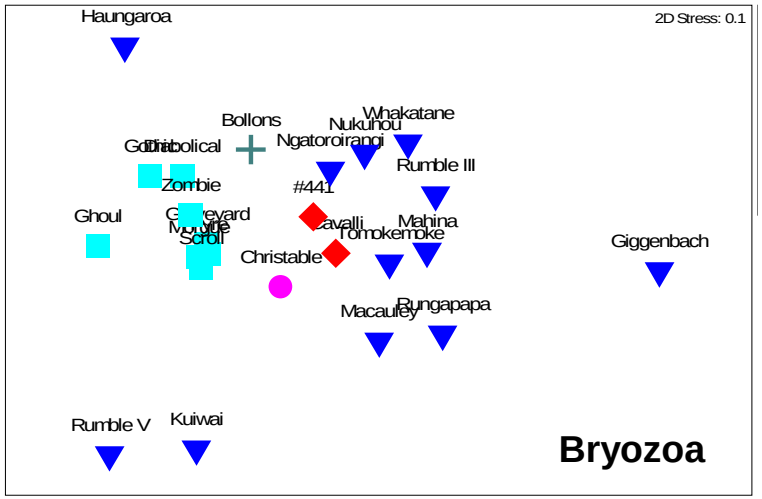
- A difficult ecological aspect to address
- Some UTFs do appear to be unique in having very specific physical characteristics (e.g., isolation, hydrothermal venting, very shallow, very deep etc)
- More sampling generally tends to reduce the numbers of “unique” species
- Typically in NIWA surveys, we find 5-10% of benthic invertebrates are new to science or new records for the NZ region
- Recent reviews tend to suggest UTF endemism at levels of 10-20% on a ”regional” scale

Some NIWA assemblage results









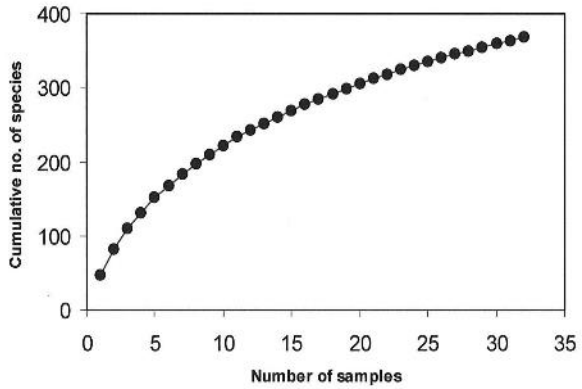
Benthic invertebrate assemblages show different patterns-some UTFs close together (indicating faunal similarity) for some taxa, others distant

Macro-invertebrate biodiversity patterns

- Comparing biodiversity of New Zealand UTF assemblages to those from slope habitats elsewhere in region again show variable patterns by taxa

	Porifera	Bryozoa	Mollusca	Polychaeta
# taxa in region	763	1166	4515	873
# taxa on seamounts	181	370	225	113
# taxa on only seamounts to date	154	193	~173	~91
'**apparent seamount endemism**'	**20%**	**17%**	**~4%**	**~10%**

- However, level of 'apparent endemism' is potentially high because of various sampling artefacts:
- Diversity increases with sampling effort, so rare species can be hard to sample
- Studies comparing different habitats are increasing, so the regional species "pool" increases



‘Distinct’ communities idea decreasing

- UTF communities often contain species found elsewhere

Marine Ecology. ISSN 0173-9565

ORIGINAL ARTICLE

Squat lobster assemblages on seamounts differ from some, but not all, deep-sea habitats of comparable depth

Ashley A. Rowden[1], Kareen E. Schnabel[1], Thomas A. Schlacher[2], Enrique Macpherson[3], Shane T. Ahyong[1] & Bertrand Richer de Forges[4]

1 National Institute of Water & Atmospheric Research, Wellington, New Zealand
2 Faculty of Science, Health & Education, The University of the Sunshine Coast, Maroochydore DC, Queensland, Australia
3 Centro de Estudios Avanzados de Blanes (CSIC), C. acc. Cala Sant Francesc, Blanes, Girona, Spain
4 Systématique, Adaptation et Evolution, UMR7138UPMC-IRD-MNHN-CNRS (URIRD148), Institut de Recherche pourle Dévelopement, Nouméa Cedex, Nouvelle-Calédonie

But, despite similar species lists (composition) species attain different biomass/abundance on UTFs changing the **structure** of communities

The figure to the right shows a similar species mix in the canyon and seamount, but very different rank abundances

McClain et al (2009)
Plos ONE, Vol 4, e4141

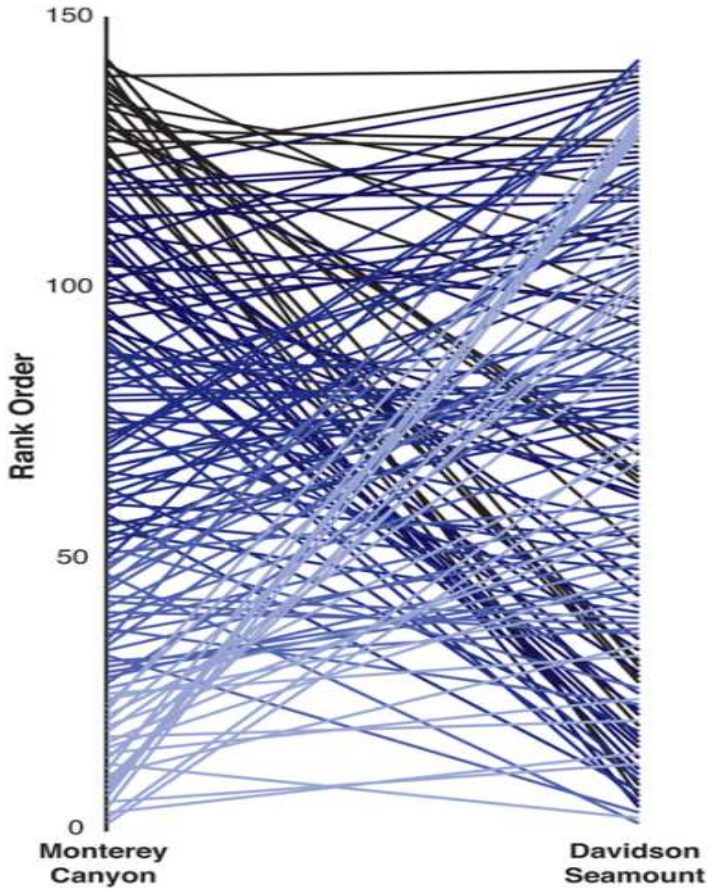
Marine Ecology. ISSN 0173-9565

ORIGINAL ARTICLE

Mounting evidence: near-slope seamounts are faunally indistinct from an adjacent bank

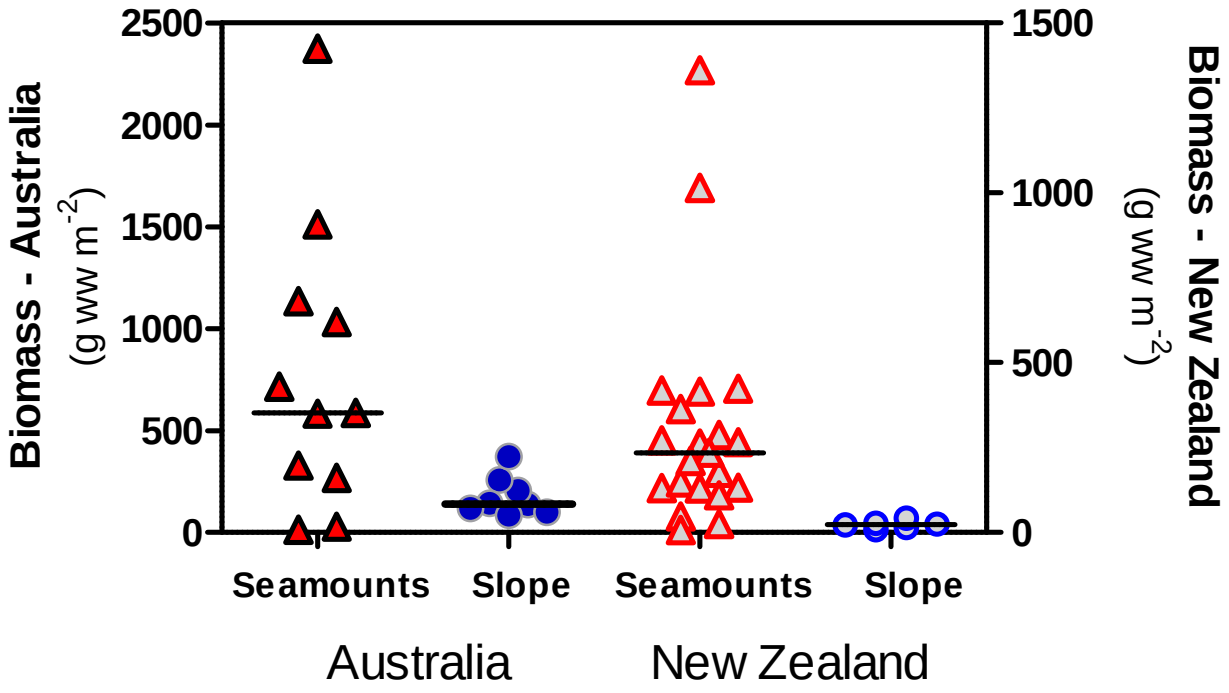
Kerry L. Howell, Sophie L. Mowles & Andrew Foggo

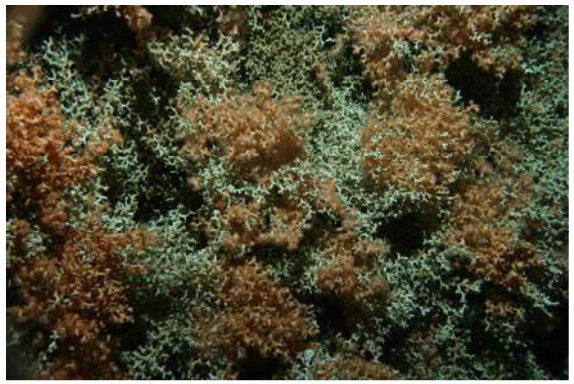
Marine Biology and Ecology Research Centre, Marine Institute, University of Plymouth, Plymouth, UK



High ‘biomass’ associated with UTFs

- Well known for pelagic fish and demersal species such as ORH
- Single study only for benthos, comparing 20 SW Pacific UTFs (mainly hills) with adjacent slope
- Overall biomass of benthic communities was 4 times that of slope
- Stony corals were the main driver (29 times higher)





Rowden et al (2010)
Marine Ecology, Vol 31

Resilience

- Community/species Resilience
  - Depends on size and form
  - Clark et al. (2010) included the table below, illustrating some species can withstand bottom trawling (within limits)

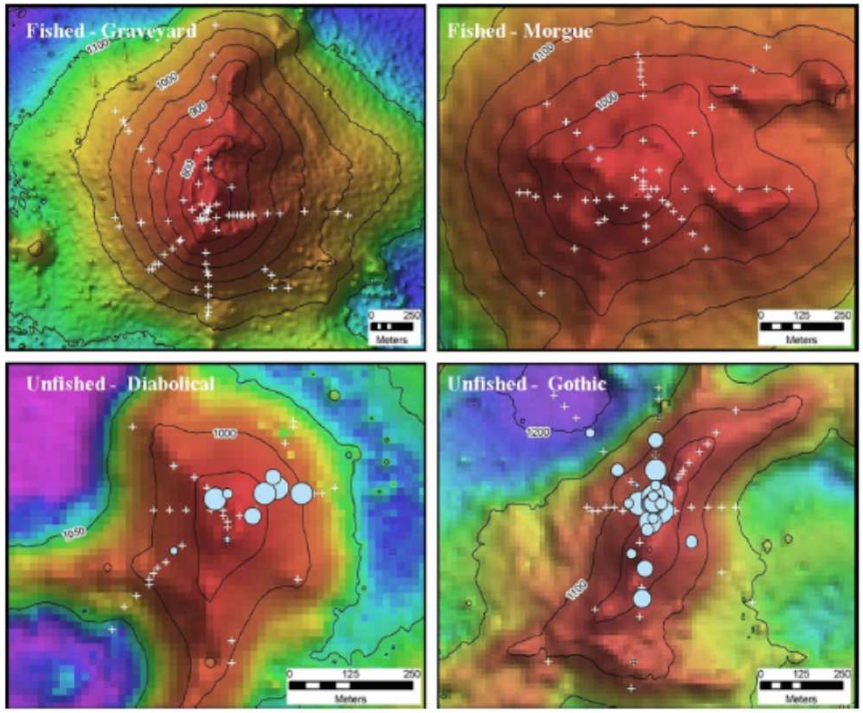
Table 2 Examples of megabenthic taxa on seamounts that appear more resilient to trawling impacts

Taxon	Ecological traits and observations
Hydrocorals: *Stylaster* sp.[a] *Calyptopora reticulata*[b] *Lepidotheca fascicularis*[b]	Small size (≲100 mm height)[a,b]; many (most) species brood with possibly continuous or protracted spawning; possibly short-lived larvae; most slow growing [d], but some (emergent) species fast growing[e]; ubiquitous in survey areas[a,b]
Gold corals: *Chrysogorgia* spp.[a,f]	Small size (≲200 mm height), compact (bottle-brush), and flexible[c]
Chrysogordidae (undescribed species)[a]	Small size (≲300 mm height), whiplike, robustly stiff but flexible[c]; abundant on heavily fished seamount in 1997 and 2007 surveys[c]
Bryozoan: *Lagenipora* sp.[b]	Small encruster considered opportunistic in disturbed environments[b]
Anemone: ?Actinernidae[c]	Anemones have capacity for local-scale mass colonization by larvae or brooded juveniles; not colony forming but have propensity for clustered distributions in shallow water[f]; on a single heavily trawled seamount, uncommon in 1993 but highly abundant in 2008[c]

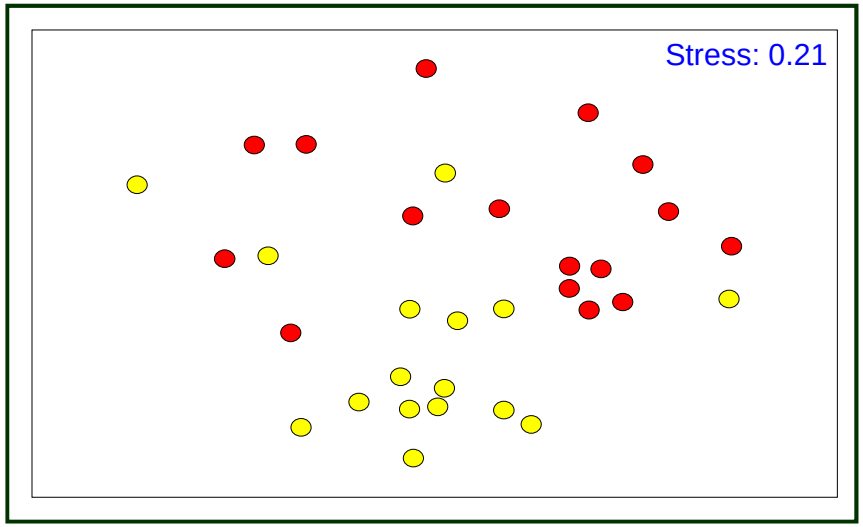
Vulnerability of stony corals

- Clark et al. (2010)
  - Some taxa highly vulnerable (e.g., stony corals)
  - Koslow et al (2001), Clark & Rowden (2009) comparing fished and unfished UTFs
  - Both studies found a strong relationship between the extent of bottom trawling and extent of cover of biogenic habitat (stony coral reef)
  - Also difference in benthic community composition between fished and unfished
  - Not necessarily cause and effect, but strong inferences that trawling is contributing factor
  - Stony coral structure is very fragile and fragments with contact

Graveyard hills, 2001

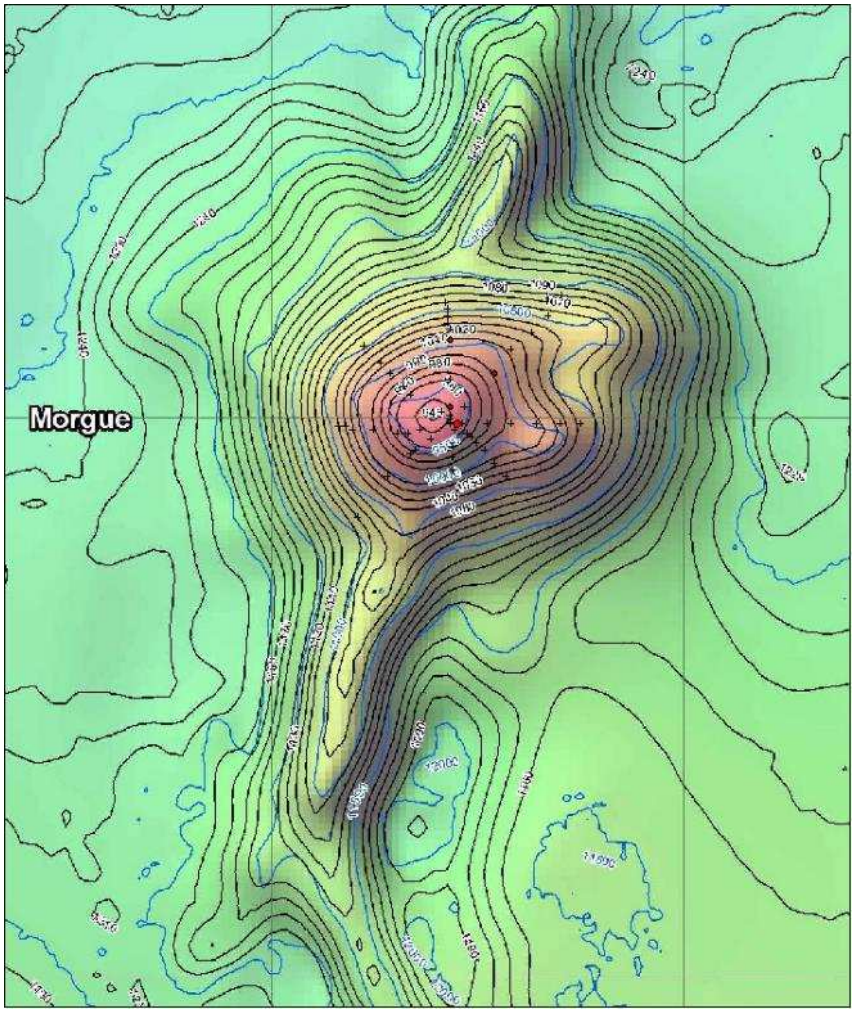


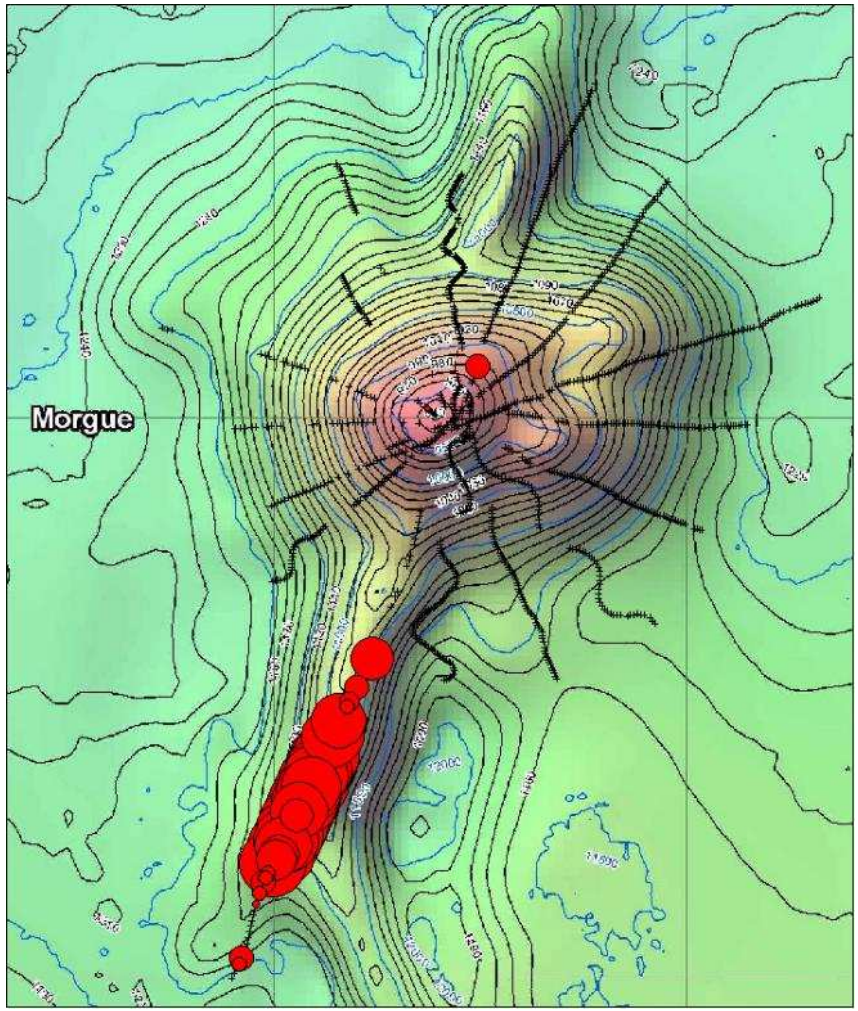
Percentage cover of still images by intact stony coral matrix
Fished: 4% of image area
Unfished: 25% of image area



MDS plot of community assemblage composition (p/a) in epibenthic sled catches between fished (red) and unfished (yellow)
SIMPER: 75% dissimilar. 3 discriminatory species identified (e.g. stylasterid corals) more common on fished hills

Morgue analyses, 2001 compared with 2006

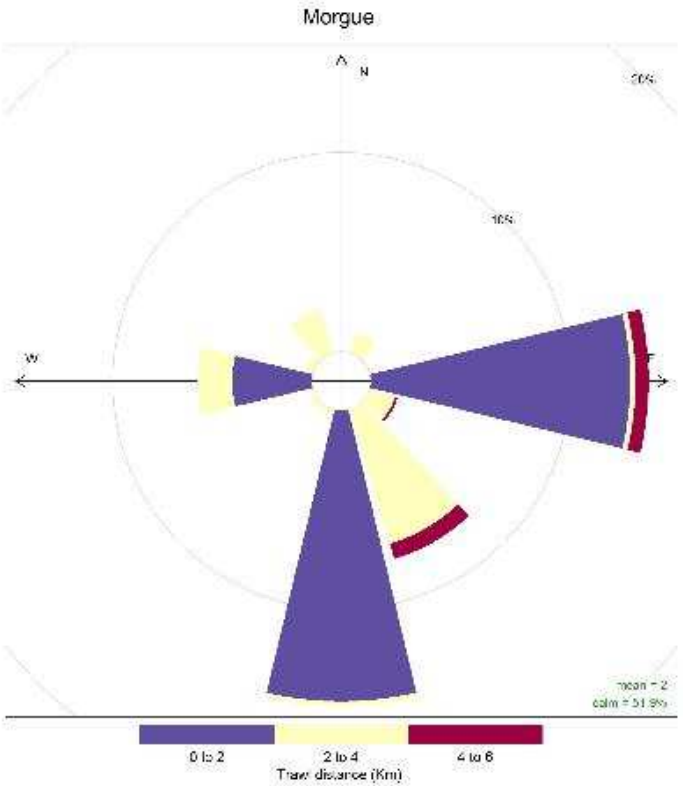




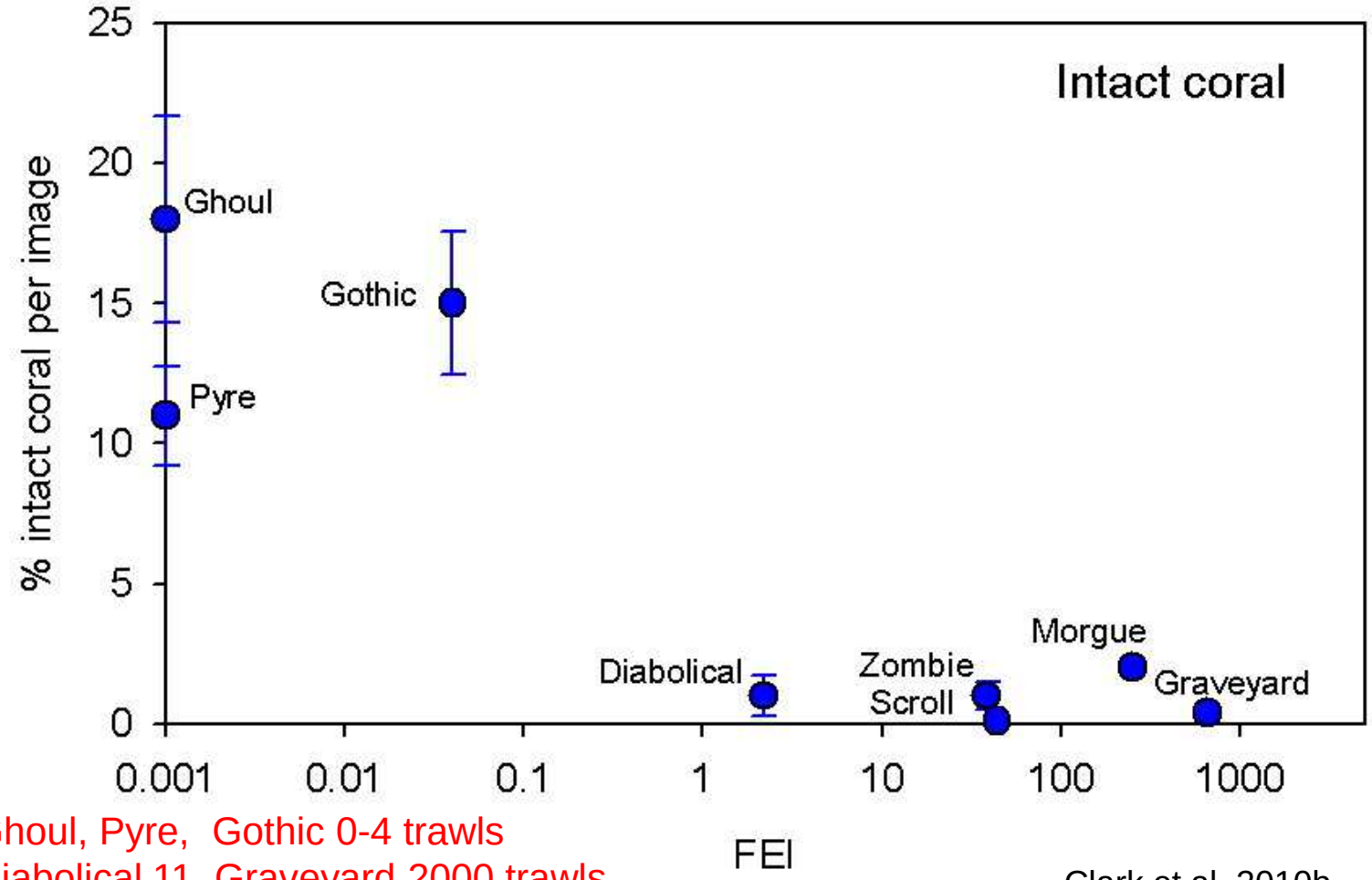
2001 survey, no coral found, but 2006 dense intact coral surveyed on SW ridge line. Confirms Morgue is suitable habitat. No corals seen on Graveyard.

Morgue trawling

- The image isn’t very easy to see with the cream colour, but some observations on trawling:
- Short trawls common generally to the east and south. Some longer tows in other sectors, except north and southwest
- Agrees with topography in terms of avoiding the ridges to the NE and SW



Coral cover versus fishing effort

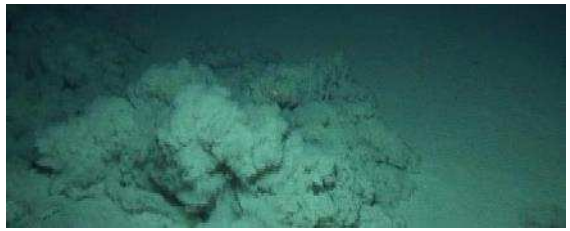


Ghoul, Pyre, Gothic 0-4 trawls
Diabolical 11, Graveyard 2000 trawls

Clark et al. 2010b

Effects of trawling

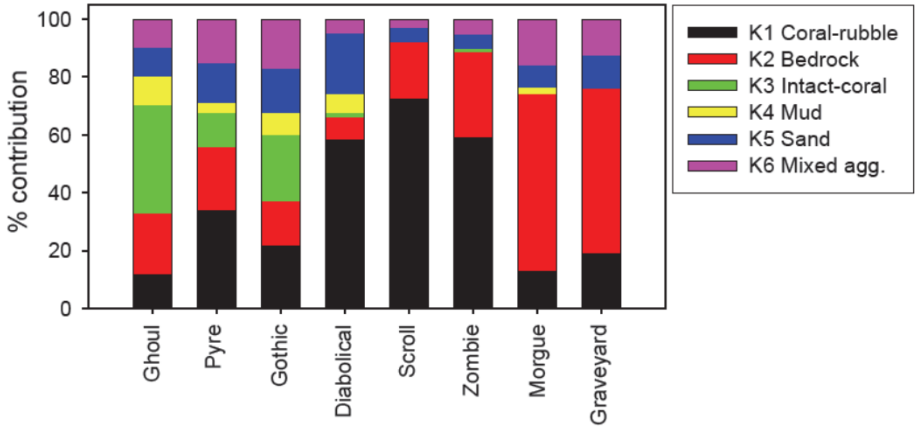
- Direct physical impact is clear
- Less easy to evaluate are the indirect effects, such as:
  - Sedimentation cloud
  - Sediment/substrate reworking
  - Chemical changes
  - Water quality etc



- UTFs are often thought as rocky and always hard substrate.
- But can be highly patchy

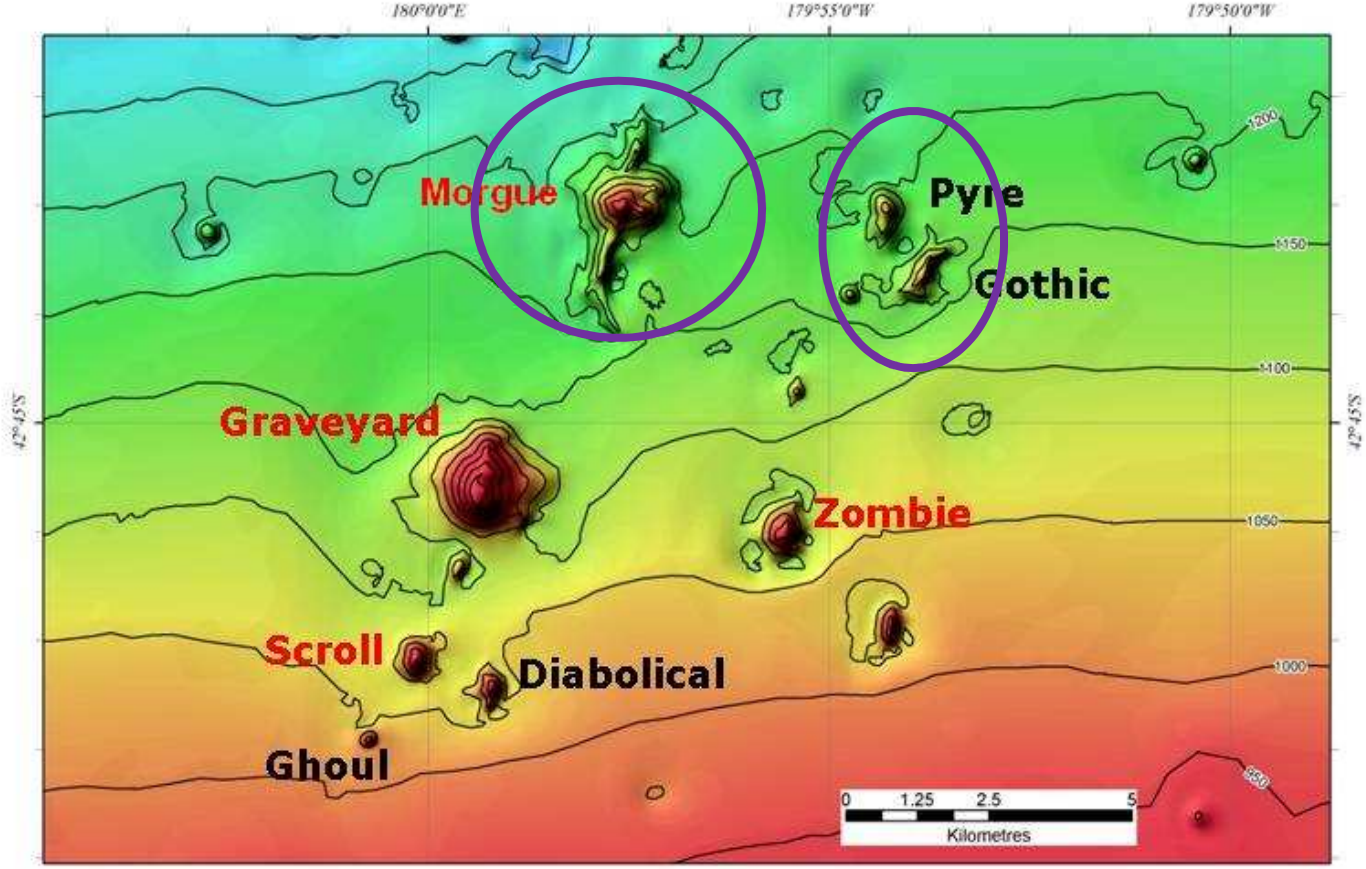
e.g., mud, sand, gravel

Refer K-means substrate



Clark et al. 2010b

Objective 3: Graveyard seamounts

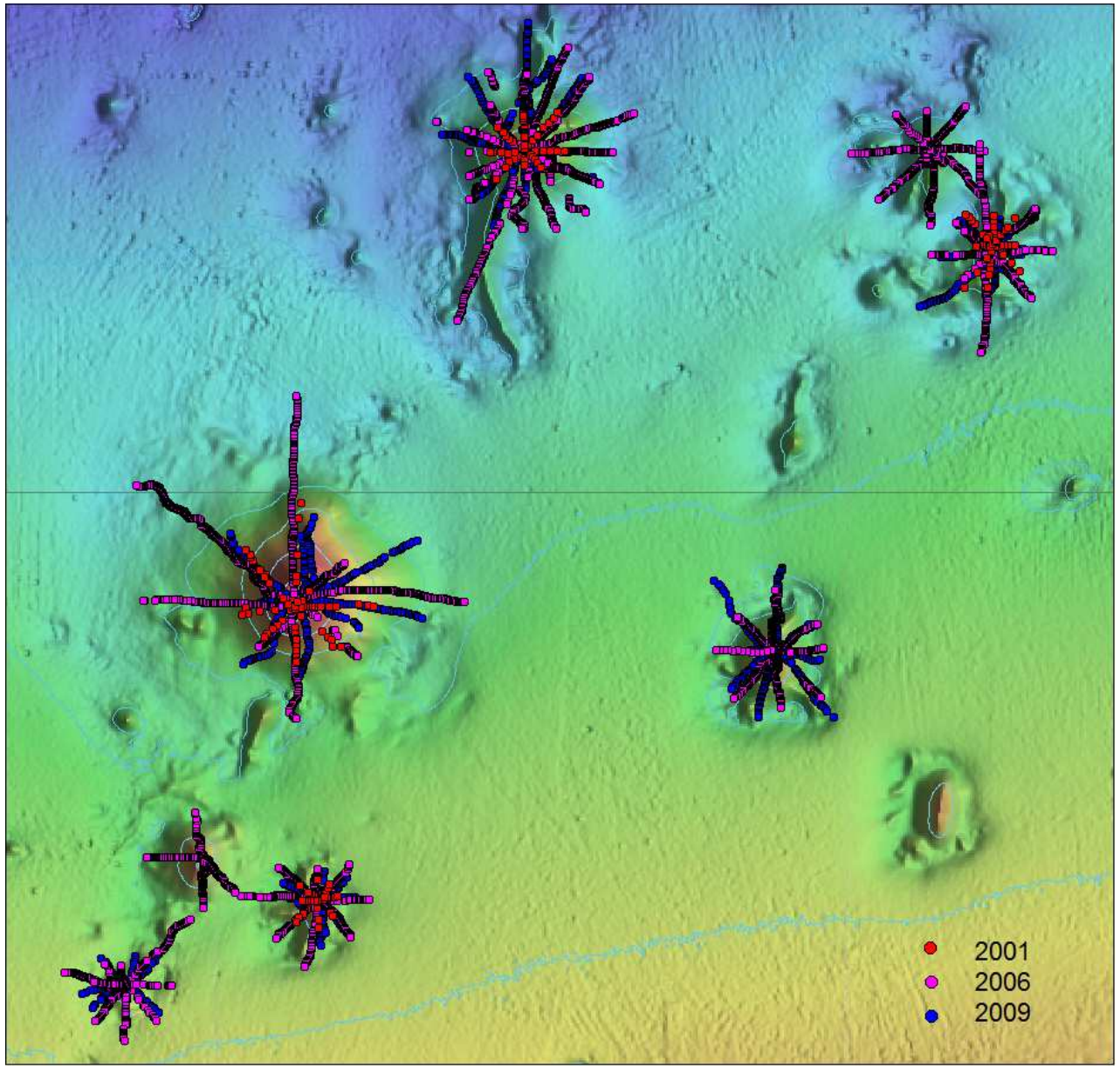


Fished (red) and unfished (black) seamounts, plus gradient in fishing pressure

In 2001 Morgue, Pyre & Gothic were protected

So have fished-fished, fished-closed, unfished-unfished

Surveys

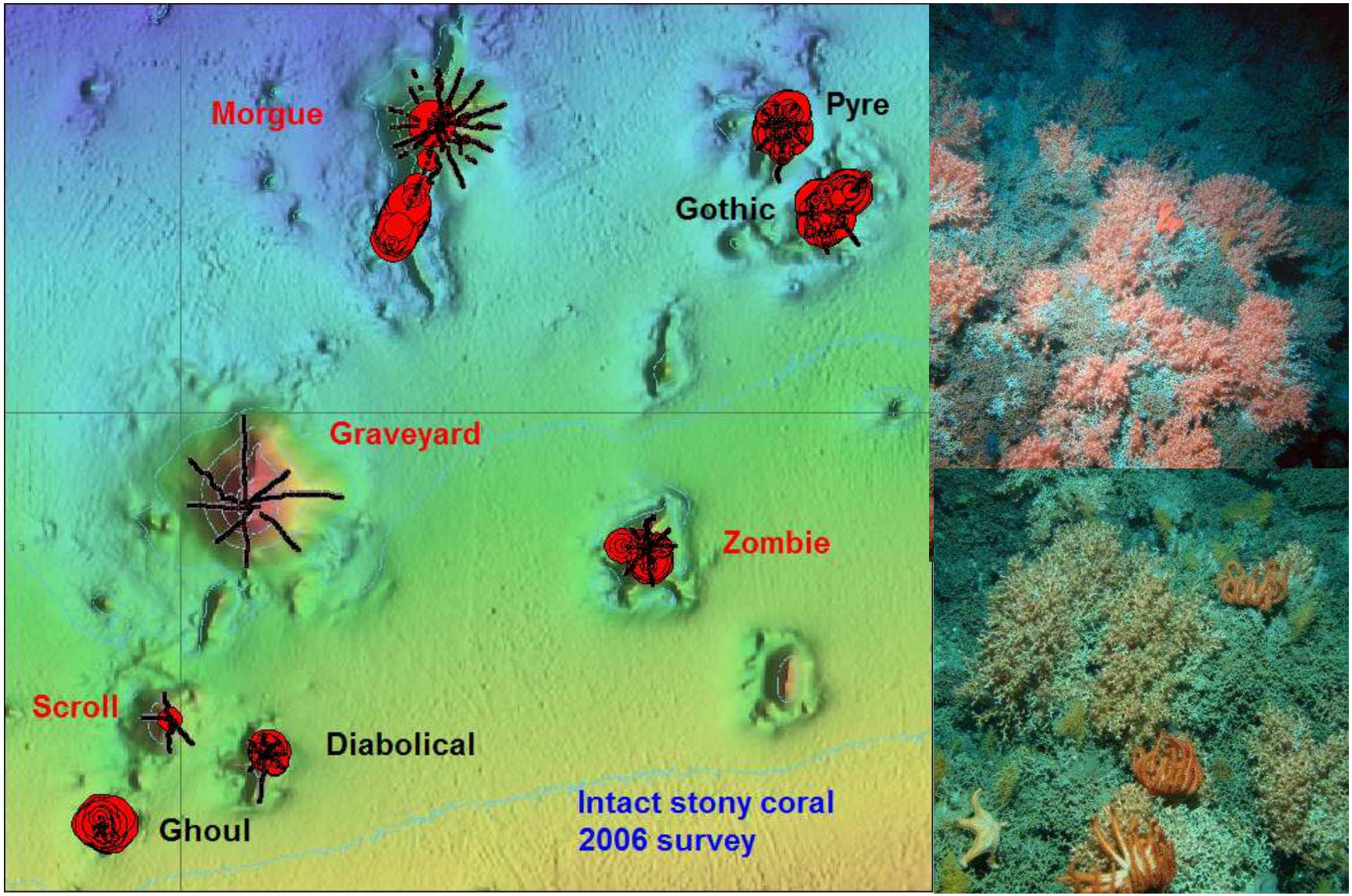


No. stills

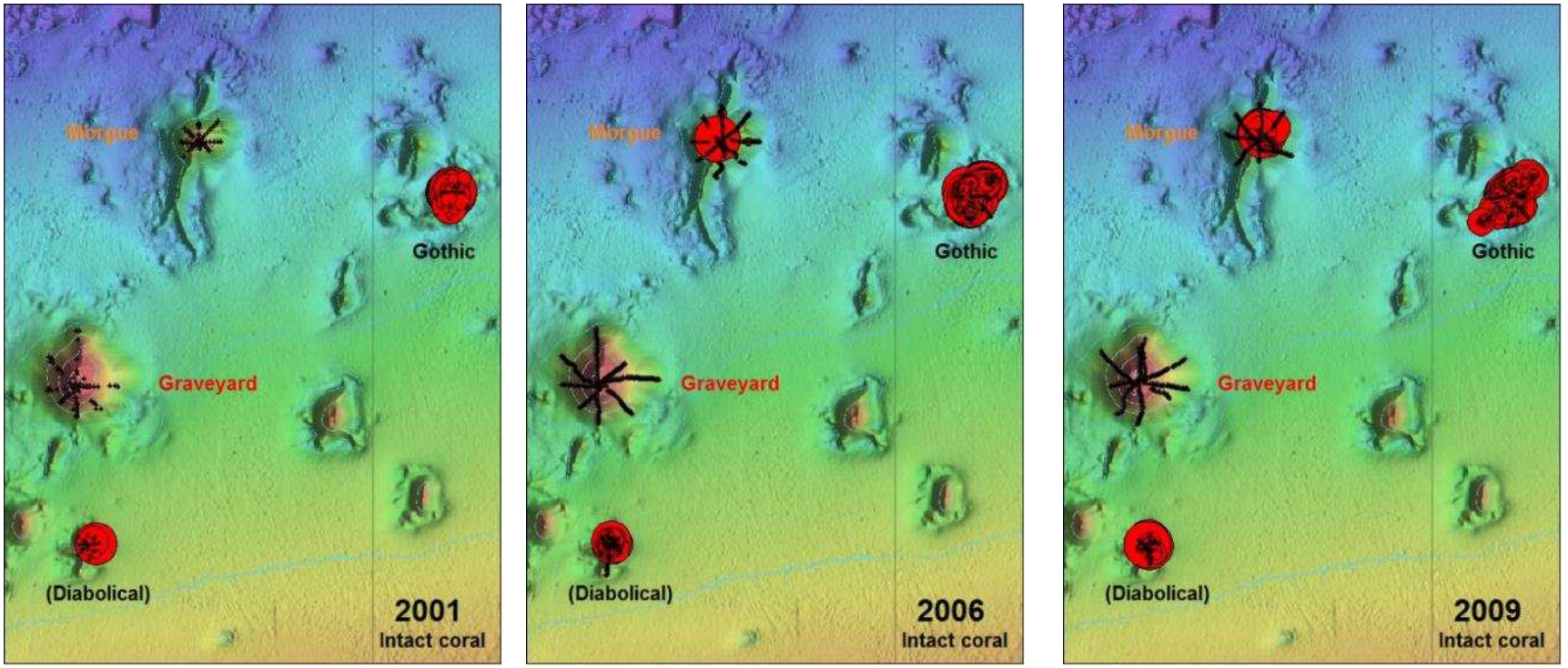
2001: 225
2006: 2635
2009: 1544

2001 less frequent images, and lower image resolution

These are stony-coral dominated communities



Temporal changes: Intact coral



Stony coral matrix: Changes difficult to discern from sampling distribution. 2001 poorer coverage.

<u>Overall, No strong changes</u>

Graveyard (fished), no coral; Diabolical (lightly fished) and Morgue (unfished since 2001), small patches; Gothic (unfished), extensive cover

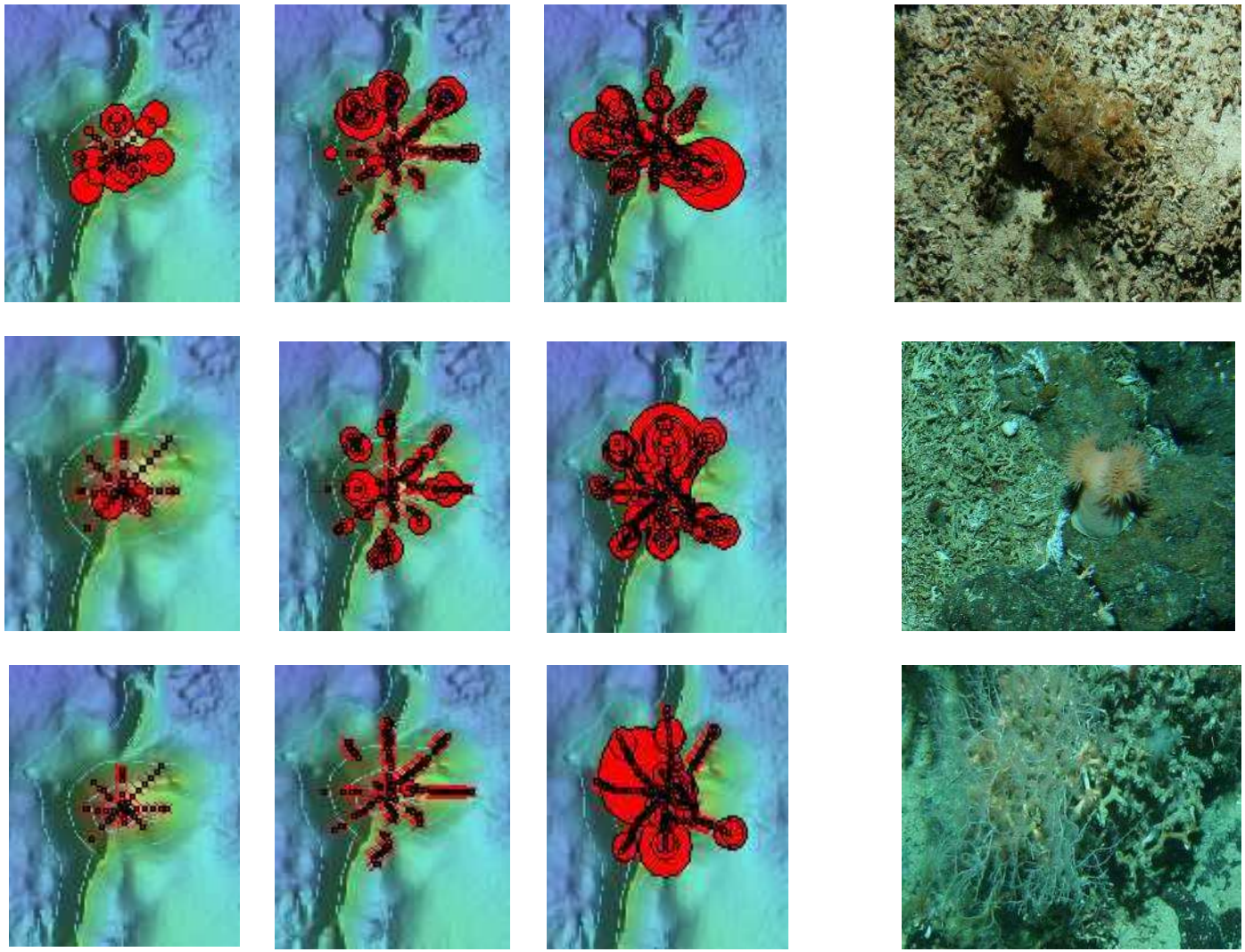
Note: SW sector of Morgue removed to be comparable with 2001

Morgue: temporal changes

Crinoids

Anemones

Hydroids



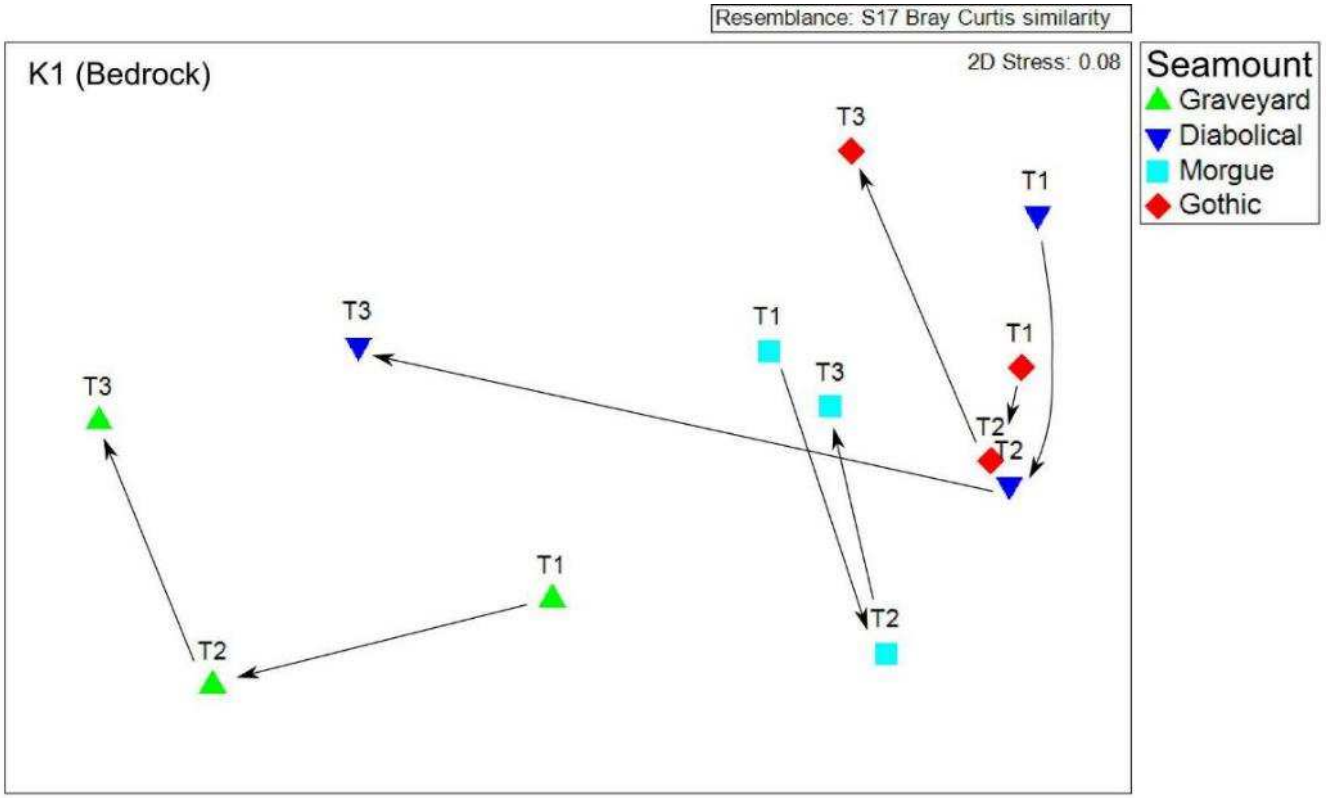
2001 2006 2009

Community change: what might we expect?

- GRAVEYARD: Fished continuously, expect very different from unfished, and show no change
- GOTHIC: Unfished, protected, expect no change, very different from fished
- MORGUE: Fished, and then protected. Expect similar to Graveyard at start, and move towards Gothic state
- DIABOLICAL: Unfished early on, increased fishing over time. Expect similar to Gothic at start, move towards Graveyard over time

State	Time 1	Time 2	Time 3
Fished-fished	Same modified state	Same modified state	Same modified state
Fished-unfished	Modified state	Move away from modified state	Move towards virgin state
Unfished-unfished	Same virgin state	Same virgin state	Same virgin state

MDS plot 1-bedrock



- Multivariate analyses: MDS plot, closer together the points, the more similar the communities
- GOTHIC similar “location” on RHS of plot, GRAVEYARD also similar on LHS
- MORGUE is fairly consistent, in middle area but tending to RHS
- DIABOLICAL similar T1-T2, then large shift towards Graveyard
- This general pattern fits the expected direction of changes

Preliminary conclusions

- The time series analyses are “work in progress”
- Camera resolution is a problem, and we are currently re-examining some taxa where comparability is better, and re-analyzing substrate composition
- Indicates changes in deep seamount benthic communities can occur over relatively short time periods. Changes are consistent with expectations of responses to fishing/closure (at least with rock substrate-less clear with other substrate types)
- No evidence of “Recovery” of stony corals. This is likely to be very slow-decadal time scales at least. Similar result to that of Williams et al. (2010)

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