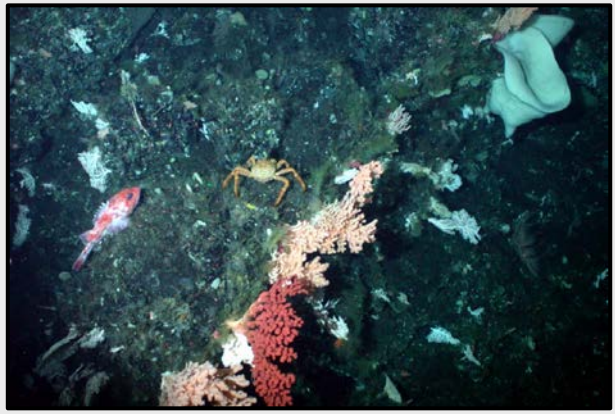
Association of FMP Species with Emergent Epifauna: Case Studies from Alaska

Robert Stone
Alaska Fisheries Science Center

FISH & CORALS

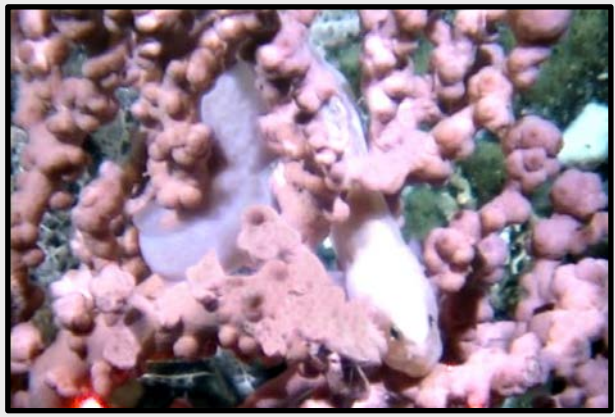


- Alaska has a lot of fish and FMP species.
- Alaska has a lot of corals and sponges.

TYPE & NATURE of ASSOCIATION

- Negative – interactions are detrimental to one/both species
- Neutral – not associated one way or the other
- Positive/Coincidental – no function
- Positive/Facultative – not required but rather contingent
- Positive/Obligatory – absolutely “essential”

QUESTION of SCALE



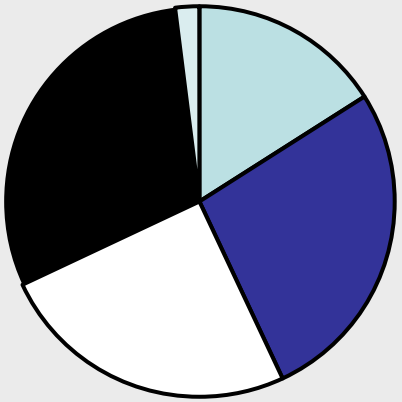
- Large-scale association – kilometers or greater?
- Medium-scale association – 10’s of meters?
- Fine-scale association – < meters?

Function of Association

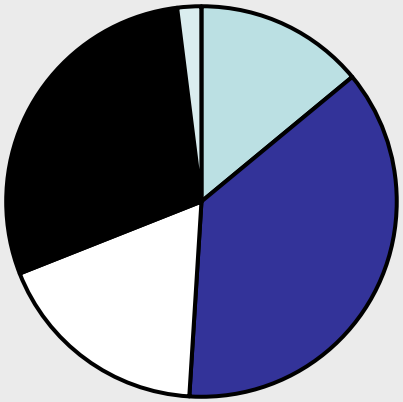
- structural refuge from predation & currents
- focal sites for foraging
- spawning habitat
- others (e.g. antibiotics)

Heifetz, J. 2002. Coral in Alaska: distribution, abundance, and species associations. Hydrobiologia 471:19–28.

Scleractinians

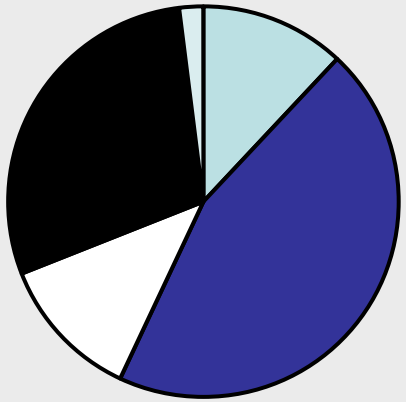


Gorgonians

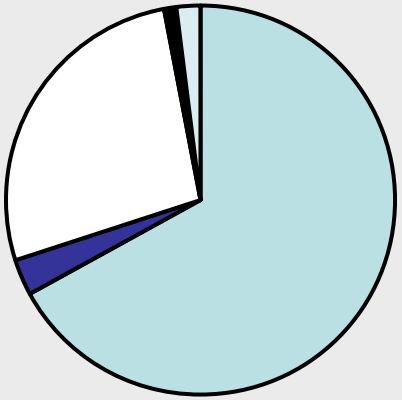


- NMFS research trawl surveys 1975–1998
- 41,462 hauls (corals in 12.7% of hauls)
- Proportions in each figure are the percentages for each fish group of the total fish CPUE.

Hydrocorals



Alcyonaceans



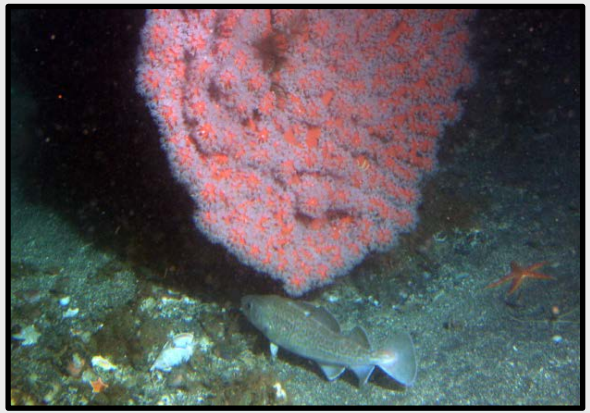
- Flatfish
- Rockfish
- Gadids
- Atka Mackerel
- Others

Stone, R. P. 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species association, and fisheries interactions. Coral Reefs 25:229–238.

- 26,597 m^2 surveyed (25 submersible transects, depth range = 27–363 m)
- 32,687 corals total (1.23 coral colonies per m^{-2})
- 4,428 FMP individuals (19 taxa or life-history stages)

- Fish and crabs were only considered associated with emergent epifauna if they were within one body length of emergent epifauna while at rest, or within 1 m while swimming or hovering above.
- Fish and crab behavior was classified to three categories: (1) resting, including hovering, (2) searching (i.e., slow swimming) and (3) directed movement (i.e., fast swimming).
- Emergent epifauna included corals, sponges, bryozoans, hydroids, and crinoids and the individual epifauna or continuous patch of epifauna did not qualify unless it was of equal size or larger than the fish or invertebrate.

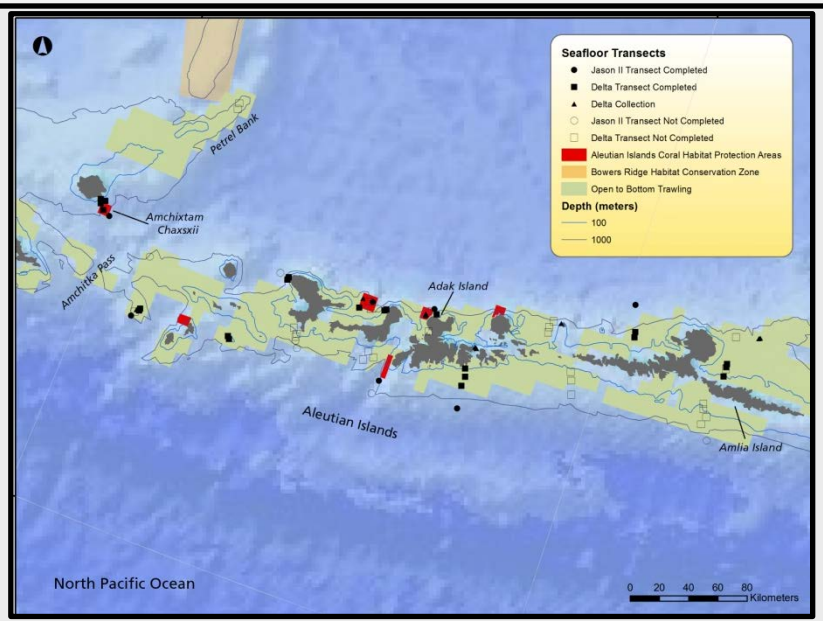
- Overall, **85%** of the individuals enumerated on submersible transects were associated with emergent epifauna.
- All species of rockfish were highly associated with emergent epifauna and ranged from **84%** for ‘‘other’’ rockfish to **98.5%** for sharpchin rockfish. Most juvenile rockfish (**97%)** were associated with emergent epifauna.
- Most juvenile golden king crabs (**96%**) were also highly associated with emergent epifauna and the majority were observed on or within the spongocoel of hexactinellid sponges.
- Flatfish and giant grenadier showed no association with emergent epifauna.
- For all species pooled, **83%** of the individuals displayed resting behavior and **20**% of the individuals were physically in contact with emergent epifauna.

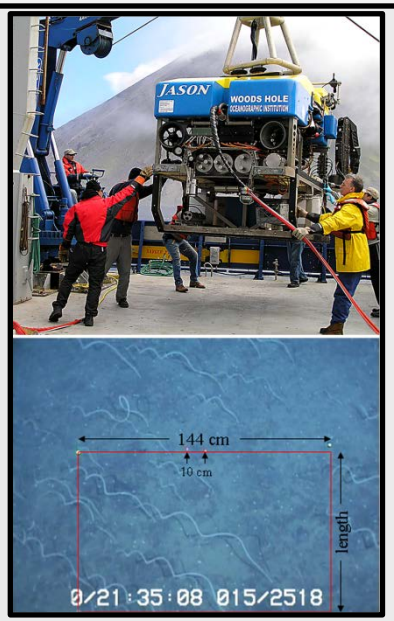


Stone, R. P. 2014. The ecology of deep-sea coral and sponge habitats of the central Aleutian Islands of Alaska. NOAA Professional Paper NMFS 16, 51 p.

- 48,985 m^2 surveyed (22 submersible transects, depth range = 129–2947 m)
- 59,522 corals total (1.22 coral colonies per m^{-2})
- 3,029 FMP individuals (33 taxa or life-history stages)

Method 1 – Fish, crabs, and octopods were considered associated with corals, sponges or "other" emergent epifauna if they were in the same sampled video frame (mean frame area = 1.5 m^2).





Method 1

Taxon	%-Coral	%-Sponge	%-Other
Rockfish (juveniles)	97	100	70
Grenadiers	32	23	11
Pacific Ocean Perch	59	89	86
Sculpins	41	59	62
Northern Rockfish	90	97	91
Blackspotted Rockfish	74	90	84
Shortspine Thornyhead	67	75	48
Snailfishes	36	50	50
Verrill's *Paralomis* crab	57	46	18
Octopods	40	54	44
Pleuronectids	32	38	38
Southern Tanner crab	27	14	22
Atka Mackerel	88	96	77
Golden king crab	60	93	70
Spiny *Paralomis* crab	22	8	8
Skates	16	32	28
Light Dusky Rockfish	78	100	100
Sharpchin Rockfish	100	100	92
All taxa	**63**	**69**	**55**

Method 2 (Odds-Ratios) – Examined fish distribution relative to all available habitats following Auster (2005). An individual is assumed to be actively associating with corals if it is found more frequently in frames with corals than would be expected given the number of frames with corals present.

Definition of the odds of event *A* occurring: odds $(A) = P(A)/(1-P(A))$, where $P(A)$ is the probability of the event occurring.

Definition of odds-ratio: OR = odds $(S|E)$/odds $(S|\bar{E})$, where E is the event that an emergent epifauna group is present, $\bar{E}$ is the complementary event, and S is the event that a particular species is present in the frame.

	# frames w/o juv. rockfish	# frames w/ juv. rockfish
# frames w/o coral	6049	20
# frames w/ coral	4267	369

The estimate of the odds-ratio is calculated as:

$$\widehat{OR} = \frac{(369)(6049)}{(4267)(20)} = \mathbf{26.2}$$

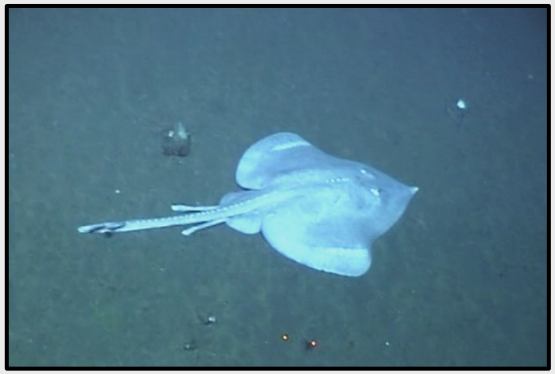
95% CI = 17.5–44.8 *

Method 2

Taxon	Odds ratio	95% CI
Rockfish (juveniles)	26.2	17.6–45.2*
Grenadiers	1.2	1.0–1.4
Pacific Ocean Perch	2.1	1.6–2.7*
Sculpins	1.3	0.9–1.7
Northern Rockfish	10.4	6.1–22.6*
Blackspotted Rockfish	3.5	2.3–5.8*
Shortspine Thornyhead	2.1	1.4–3.5*
Snailfishes	1.3	0.7–2.3
Verrill's *Paralomis* crab	2.7	1.6–4.8*
Octopods	1.4	0.8–2.5
Pleuronectids	0.6	0.3–1.0
Southern Tanner crab	0.8	0.4–1.4
Atka Mackerel	8.4	4.0–29.1*
Golden king crab	1.3	0.7–2.7
Spiny *Paralomis* crab	1.0	0.4–2.0
Skates	0.4	0.1–1.0
Light Dusky Rockfish	4.2	1.6–23.5*
Sharpchin Rockfish	188.4	14.8–296.3*

Method 2

Taxon	Corals	Sponges	Other	Any
Rockfish (juveniles)	+	+	+	+
Grenadiers	**0**	+	**0**	+
Pacific Ocean Perch	+	+	+	+
Sculpins	**0**	+	+	+
Northern Rockfish	+	+	+	+
Blackspotted Rockfish	+	+	+	+
Shortspine Thornyhead	+	+	**0**	+
Snailfishes	**0**	+	+	+
Verrill's *Paralomis* crab	+	+	+	+
Octopods	**0**	+	+	**0**
Pleuronectids	**0**	-	-	-
Southern Tanner crab	**0**	-	**0**	**0**
Atka Mackerel	+	+	+	+
Golden king crab	**0**	+	**0**	+
Spiny *Paralomis* crab	**0**	**0**	**0**	**0**
Skates	**0**	**0**	**0**	**0**
Light Dusky Rockfish	+	+	+	+
Sharpchin Rockfish	+	+	+	+



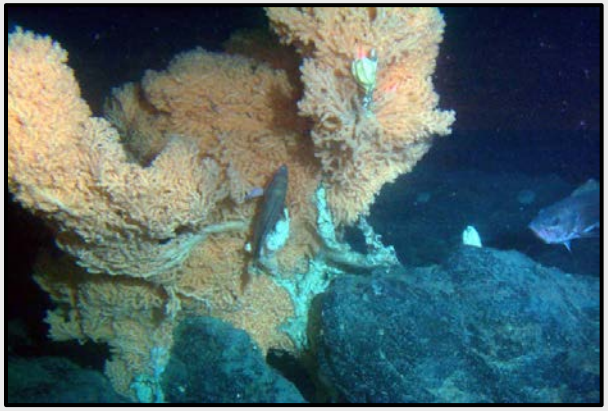
Stone, R. P., M. M. Masuda, and J. F. Karinen. In review. Assessing the ecological value of red tree coral thickets in the eastern Gulf of Alaska. ICES Journal of Marine Science.

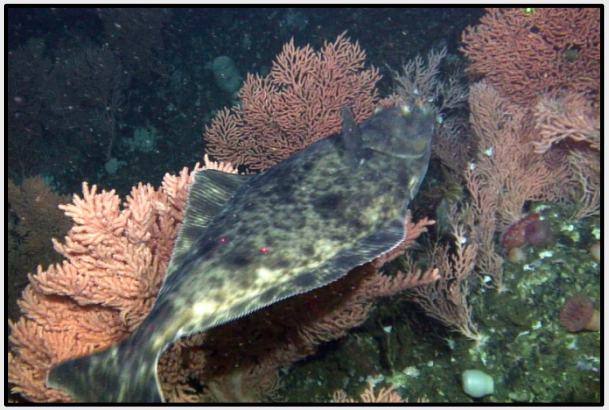
- 26,356 m^2 surveyed (19 submersible transects at two sites, depth range = 69–306 m)
- 49,476 corals total (0.36–3.55 coral colonies per m^{-2}); 5,112 RTC
- 7,456 FMP individuals (29 taxa or life-history stages)

- Method 1 – Fish and crabs were considered associated with red tree coral (RTC) habitat if they were found more frequently than not in the same sampled video frames designated as RTC habitat.
- A frame is designated as RTC Habitat if a RTC colony was within a 10-m radius of the center of that frame.

Method 1 - % Association w/ RTC Habitat

Taxon	Site 1	Site 2
Rockfish (juveniles)	76	45
Rockfish (YOY)	35	0
Sharpchin Rockfish	61	50
Pacific Ocean Perch	16	15
Harlequin Rockfish	63	49
Rosethorn Rockfish	33	35
Rosethorn Rockfish (juv)	41	47
Silvergray Rockfish	84	83
Yelloweye Rockfish	76	33
Yelloweye Rockfish (juv)	82	8
Redstripe Rockfish	16	0
Redbanded Rockfish	92	69
Shortspine Thornyhead	0	15
Shortspine Thornyhead (juv)	0	4
Pacific Halibut	6	8
Pleuronectidae	2	0
Lingcod	63	1
Brown box crab	62	26
All taxa	**62**	**33**





Method 2 (logistic regression with scaled binomial variance) – Modeled the proportion of frames with juvenile and sharpchin rockfish as a function of habitat types: no bedrock or bedrock with or without emergent epifauna (red tree coral habitat and large sponges).

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \sum_{i=1}^{4} \beta_i X_i + \beta_5 X_5 + \sum_{j=1}^{4} \beta_{j+5} X_j X_5,$$

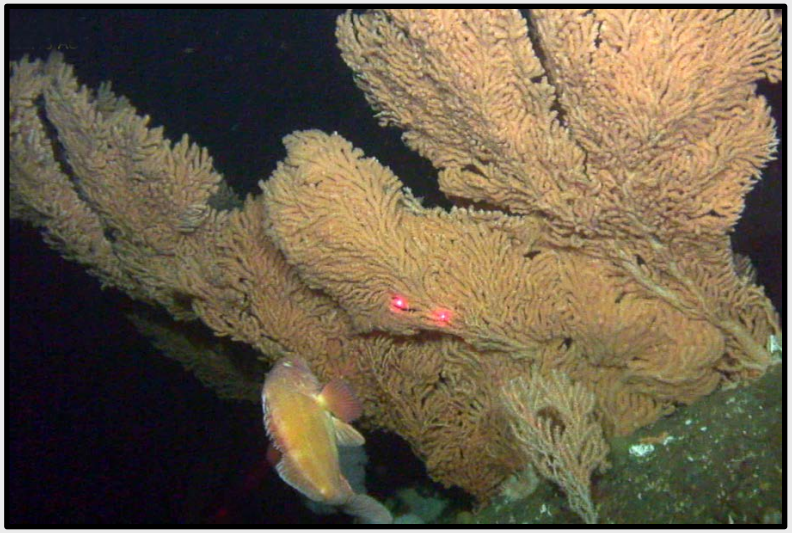
where π is the proportion of frames with taxa present;

βs are the regression coefficients;

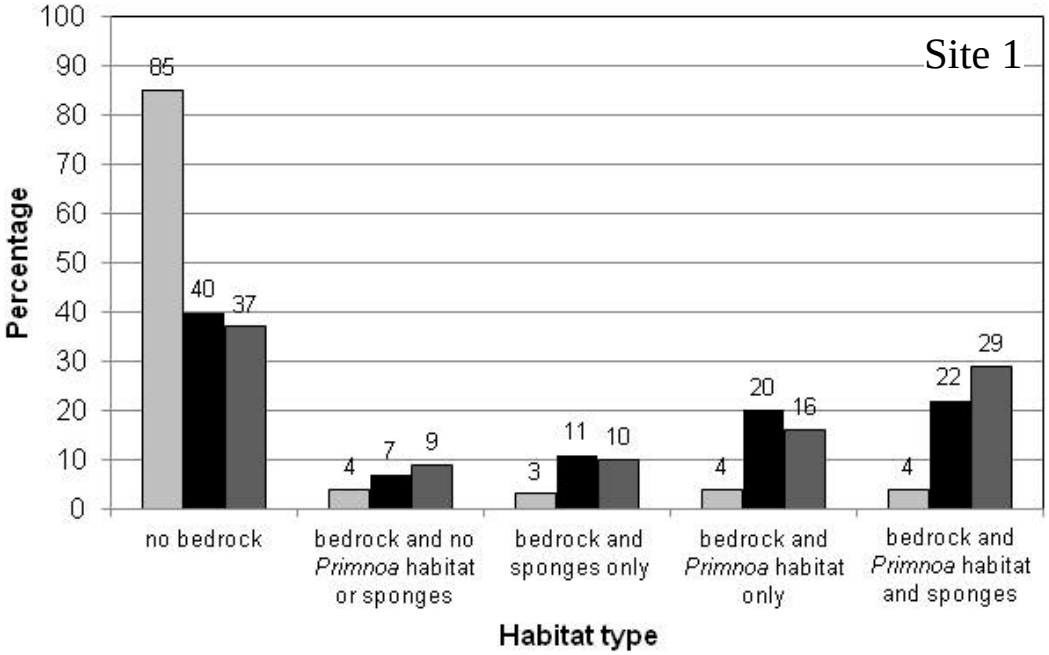
$X_{1\text{-}4}$ = indicator variables for habitat type; and

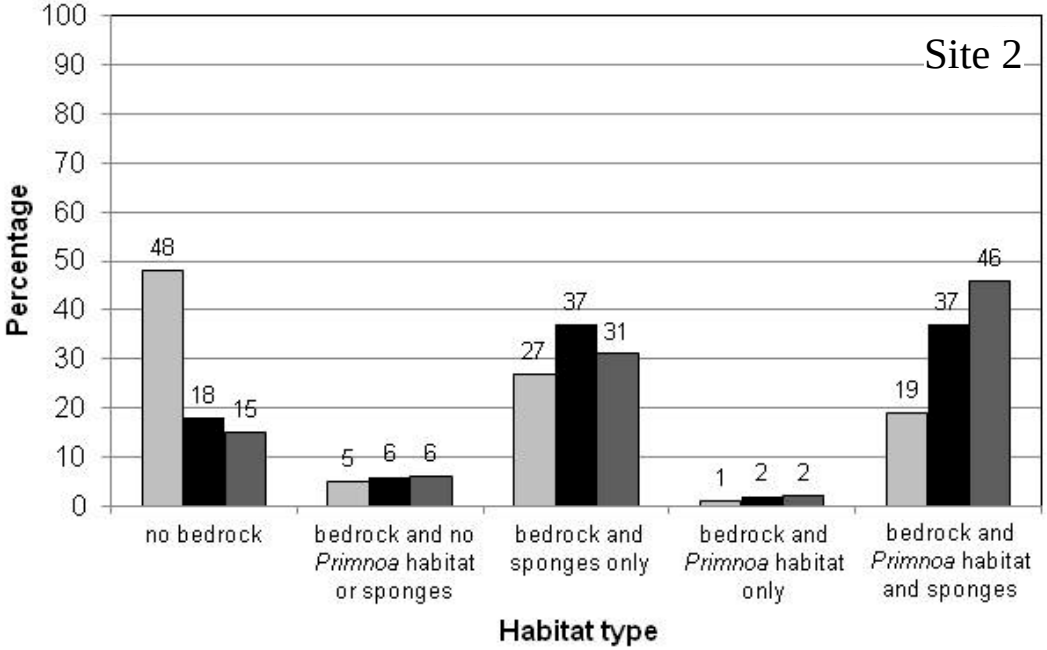
X_5 = indicator variable for fish species.

Given our coding, the intercept corresponds to the comparative baseline category of no bedrock and sharpchin rockfish present.



Habitat	Site	
	1	2
	Odds ratio	Odds ratio
no bedrock		
juvenile rockfish	0.08 (0.06–0.10)*	0.09 (0.08–0.10)*
sharpchin rockfish	0.008 (0.005–0.014)*	0.043 (0.038–0.049)*
bedrock		
no red tree coral habitat or sponges	5.6 (2.6–12.1)*	4.1 (3.2–5.2)*
sponges only	13.9 (6.7–28.6)*	5.5 (4.8–6.4)*
red tree coral habitat only	20.8 (11.2–38.8)*	7.9 (5.1–12.5)*
red tree coral habitat and sponges	43.0 (21.9–84.6)*	10.4 (9.0–12.0)*



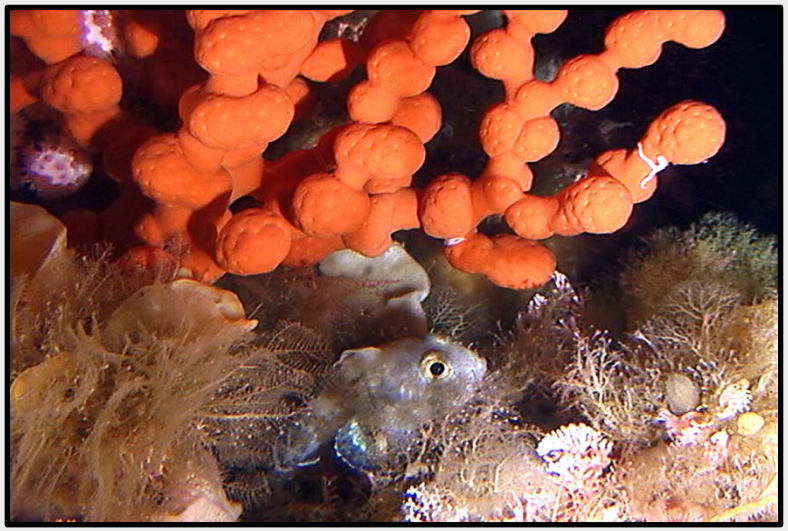


% frames sampled

% frames w/ juvenile rockfish

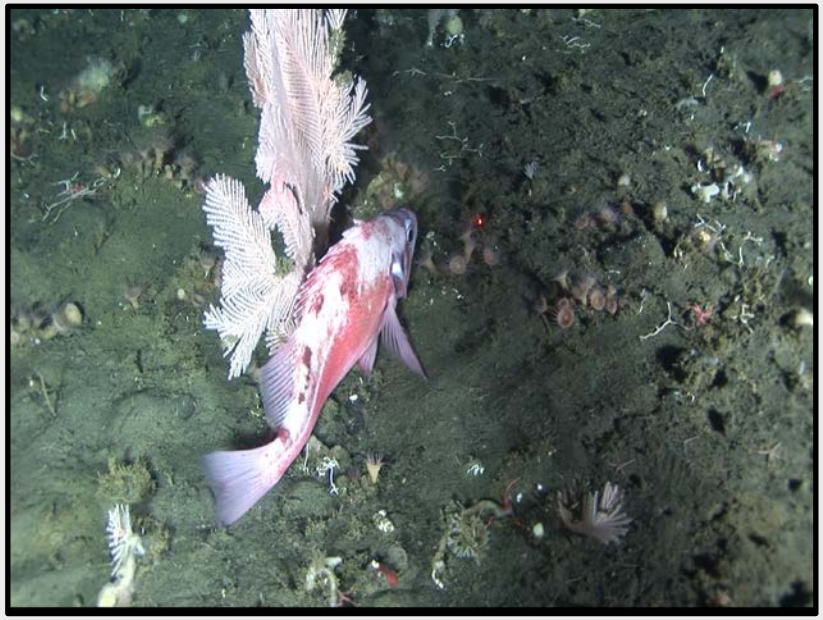
% frames w/ sharpchin rockfish

CONCLUSIONS



- Many FMP species in Alaska are highly associated with corals, sponges, and other emergent epifauna, particularly juveniles of rockfish and lithodid crabs.
- Some evidence that the degree of association between fishes and corals may depend on the density and behavior of fishes and the density and physical structure of the corals – all of which may vary from region to region.
- Few deepwater fish and crab species (depths >1000 m) appear to actively associate with emergent epifauna.
- In some Alaskan habitats, bedrock with and without corals and sponges are **not** functionally equivalent habitats.

OTHER CONSIDERATIONS



- Do fish and crabs use as refuge structures smaller than themselves?

- Very important to study the behavior of the animals – the nature and function of association may be revealed. Behavior can only be studied with “eyes” on the seafloor.

- Very important to look at different life-history stages, if possible.

- Burdon of proof.