1) Describe three reasons why compensatory mortality is such a controversial topic in conservation biology (2 points each)

- **Cannot address all species (focuses on turtles / seabirds) and risks**

- **Focuses on a portion of the life of the protected species that may / may not the one affected by high mortality**

- **Leslie models suggest that juvenile survivorship is not very "flexible", so we need to achieve large reductions in mortality to increase Lambda**

- **Difficult to match the cost and the benefits spatially (colonies, sites) and at the population level (sex, age of bycatch)**

- **The investment we make at colonies (e.g., higher young survivorship) is diluted by the long lag until these animals reach maturity**

- **Without proper demographic data at colonies / bycatch, it is difficult to quantify the costs / benefits (Lambda versus individuals)**

- **Economic optimization can be risky business if replacement is not fully achieved (think of functional roles, not just numbers of animals)**

- **Who pays for mitigation and monitoring? (consumers, industry, govt)**

- **Unexpected by-products (consider bycatch of other species)**

2) You have been monitoring a high seas fishery and have 10 years of data for the catches and the fishing effort. A colleague involved in tagging of these fish gives you fishery-independent abundance data for this same stock - column labeled *Abundance (tagging)*

Year	1	2	3	4	5	6	7	8
Fish catch (number)	10	10	20	20	10	10	10	0
Effort (hooks)	5	5	10	10	5	5	10	20
Abundance (tagging)	200	200	200	150	100	50	10	0

What metric would you use to quantify trends in this fish stock?

Define metric (1 point): **Catch-per-unit-of-effort (CPUE)**

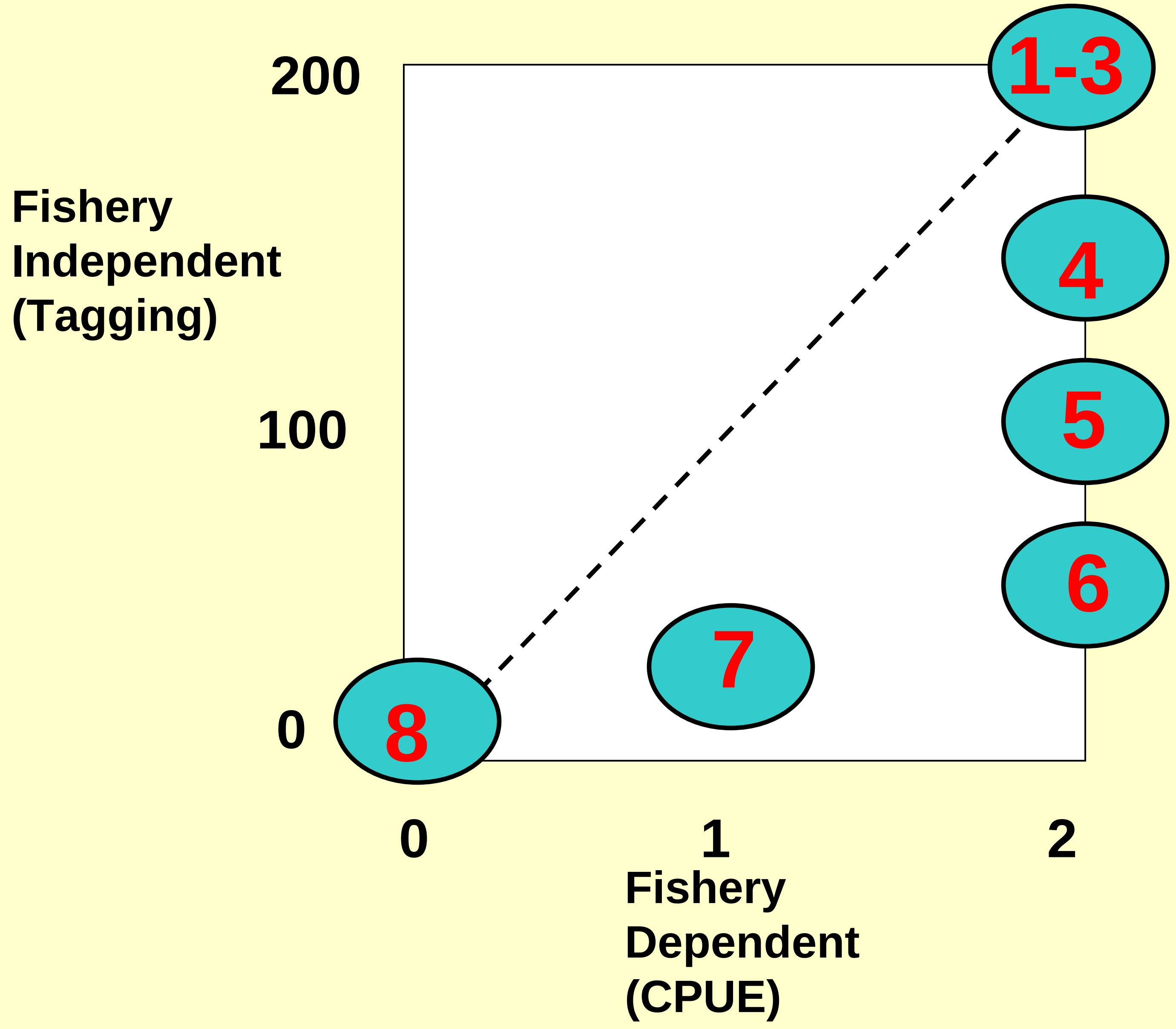
(number fish / number of hooks)

Calculate metric (0.25 point each):

Year	1	2	3	4	5	6	7	8
CPUE	2	2	2	2	2	2	1	0

When do you detect a 50% change in fishery-dependent fish abundance? **year 7 (from CPUE of 2 to 1)**

When do you detect a 50% change in fishery-independent fish abundance? **year 5 (from pop. size of 200 to 100)**


200
100
0
Fishery
Independent
(Tagging)
1-3
4
5
6
7
8
0
1
2
Fishery
Dependent
(CPUE)

What ecological traits would lead to these different trends in abundance? Do you remember the specific example we discussed in class **(2 point)**?

Any fish species that lives in dense schools and are very aggregated in small habitats. As their population abundance declines, the CPUE does not drop concurrently because the fishers still can target dense schools. Anchovies in CA and Anchoveta in Peru during El Niño are the prime examples of this problem.

Describe how your metric of fishery-dependent fish abundance relates to catchability – show the formula **(3 point)** (**Hint:** list the three factors that determine the catch of a given fish species). Describe two factors that influence the catchability of a given species in a given fishery **(1 point each)**

Catch = Biomass * Effort * Catchability

CPUE = Biomass * Catchability

(Catchability Factors: Fish + Fishery)

3) Describe what “fishing down the marine food-webs” refers to (Hint: draw a diagram if necessary) (2 points)?

The mean trophic level of the species groups reported in Food and Agricultural Organization global fisheries statistics declined from 1950 to 1994.

This reflects a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish.

This effect, also found to be occurring in inland fisheries, is most pronounced in the Northern Hemisphere.

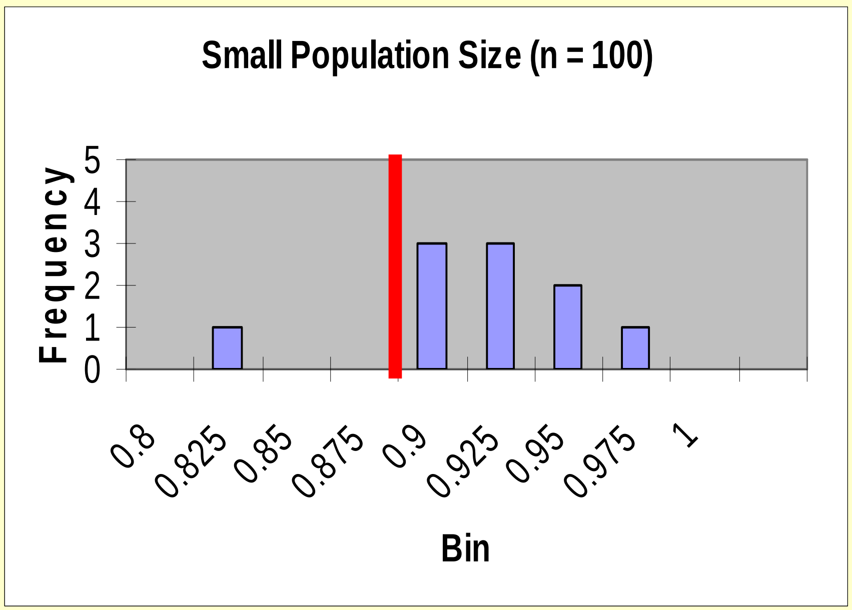
Fishing down food webs (that is, at lower trophic levels) leads at first to increasing catches, then to a phase transition associated with stagnating or declining catches.

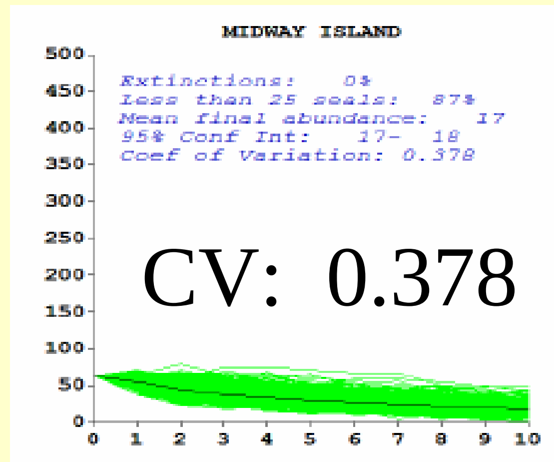
These results indicate that present exploitation patterns are unsustainable. (Pauly et al. 1998)

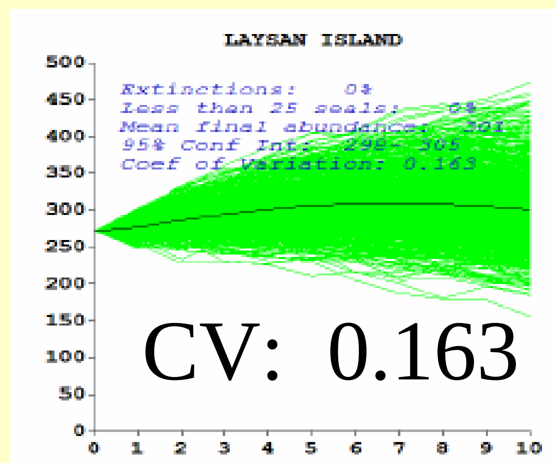
Under the fishing down the marine food web scenario, what changes would you expect in the following metrics of fish population structure? (for each metric, check the box) (1/2 point each)

Metric	Increase	Cannot Predict	Decline
Trophic level of the global fish catches			X
Total global fish catches			X
Proportion of mature fish – target species			X
Bycatch rates (bycatch per unit of effort)		X	
Abundance of top predators– target species			X
Abundance of top predators– nontarget species		X	
Size at maturity – target species			X
Size at maturity – nontarget species		X	
Length of global marine food chains			X
Survivorship of commercially-valuable sharks			X

4) Describe how demographic stochasticity is expected to increase the risk of extinction for the Hawaiian monk seal. Illustrate your explanation with a figure, showing the expected frequency distributions of adult survivorship rates for two model populations (A: 10,000 seals; B: 100 seals). Which of these model populations should have the highest CV of adult survivorship? (3 points)

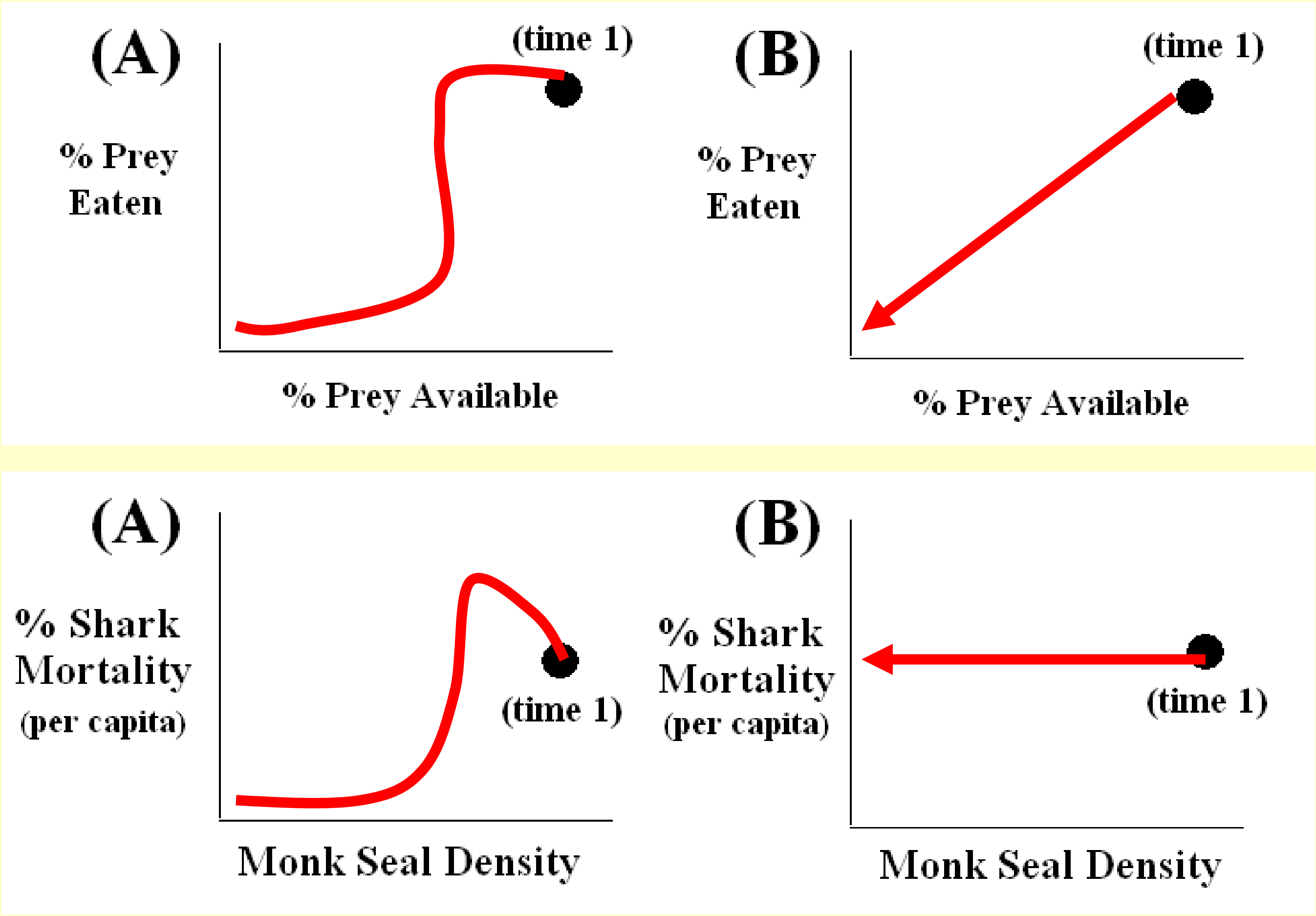






Galapagos sharks eat seal monk pups, and in doing so decrease juvenile survivorship from high to low levels. Consider two scenarios where sharks are generalist predators with:

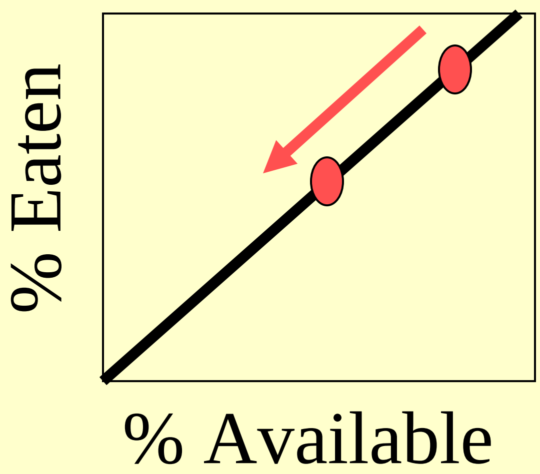
(A) selective predation for seals (B) unselective predation

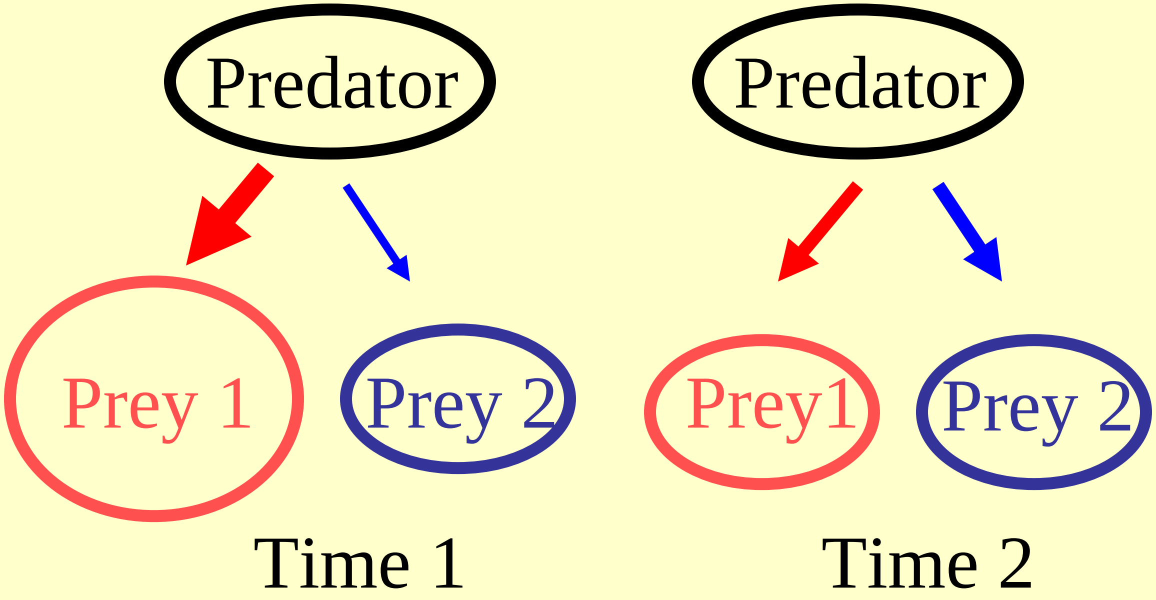


What is the name of the predator behavior responsible for the difference in these curves? **SWITCHING**

Does Predation Promote Prey Coexistence?

- Mechanism: Generalist predator, unselective predation

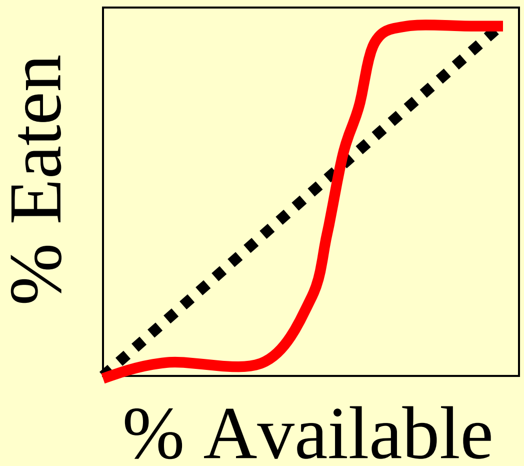


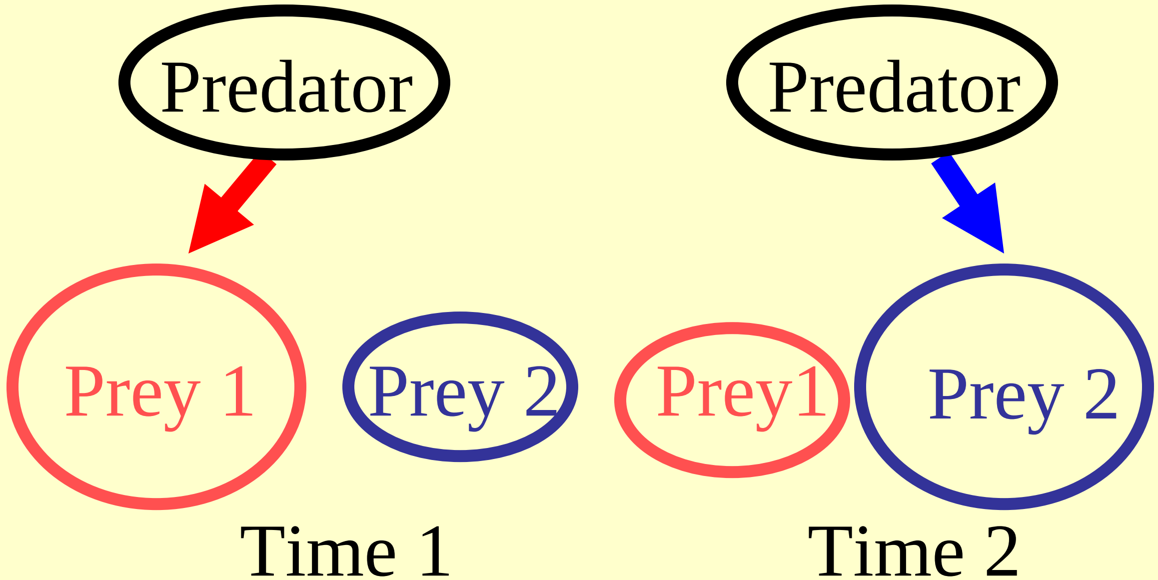


Does Predation Promote Prey Coexistence?

- Mechanism: Generalist predator, selective predation

(Townsend et al., 1986)





5) CNN asks you to comment on the following statement "Background (average) resources (prey densities) in pelagic systems are often too low to sustain predators. How do the birds and whales make a living?". Tell them about two strategies marine vertebrates use to cope with this problem, and provide an example for each one (4 points)

Marine predators exploit the patchiness of their resources in 2 ways:

1) **Forage on prey resources aggregated into dense packages by oceanographic processes (e.g., convergences at fronts / eddies)**
2) **Locate and exploit ephemeral (short-lived) prey patches (e.g., mahi-mahi feeding on fish aggregated at floating debris, seabirds foraging on forage fish brought up towards the surface by sub-surface predators, whale sharks feeding on coral spawning)**

To achieve 1 and 2 above, marine predators need to cover large expanses of the ocean and be capable of finding productive oceanic habitats and of locating prey patches

6) Seals and whales are marine mammals with very different body sizes. Yet, they have similar adaptations to cope with life in the marine environment. List three common adaptations they have to cope with heat loss to the surrounding water (1 point each): List an additional behavior that sea lions / fur seals use to keep warm at-sea (1 point)?

*** Morphological / Physiological adaptations:**

- **Fusiform (torpedo-shaped) body form with small appendanges**
- **Insulation in the form of a thick blubber layer**
- **Ability to regulate blood flow via shunting**
- **Counter-current heat exchange maintains core body temperature**

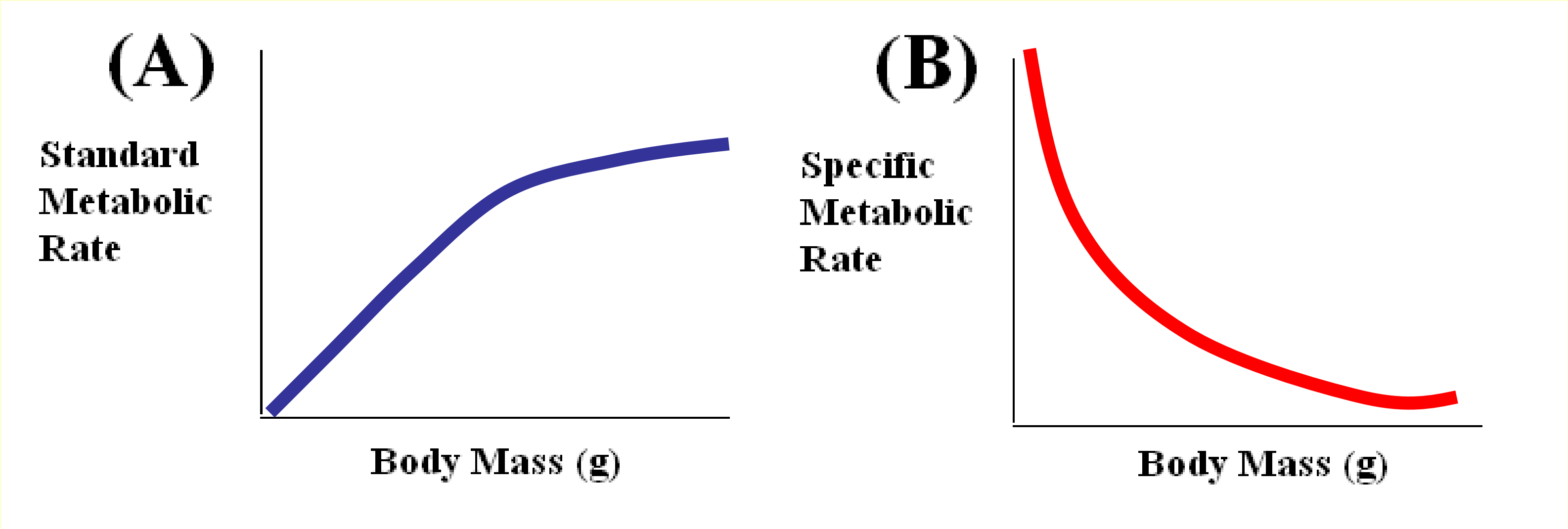
*** Behavioral adaptations:**

- **Basking (flippers in the air) -> to stay warm**
- **Diving to depth -> to cool off**

Assuming marine mammals are subject to Kleiber's law, fill in the following three curves (1 point each for curve and for units / slope):

Kleiber's law describes how MR varies for animals of different size.

$MR = C * Mass^{a}$ $\ln(MR) = \ln(C) + a * \ln(Mass)$ $a = 3/4$

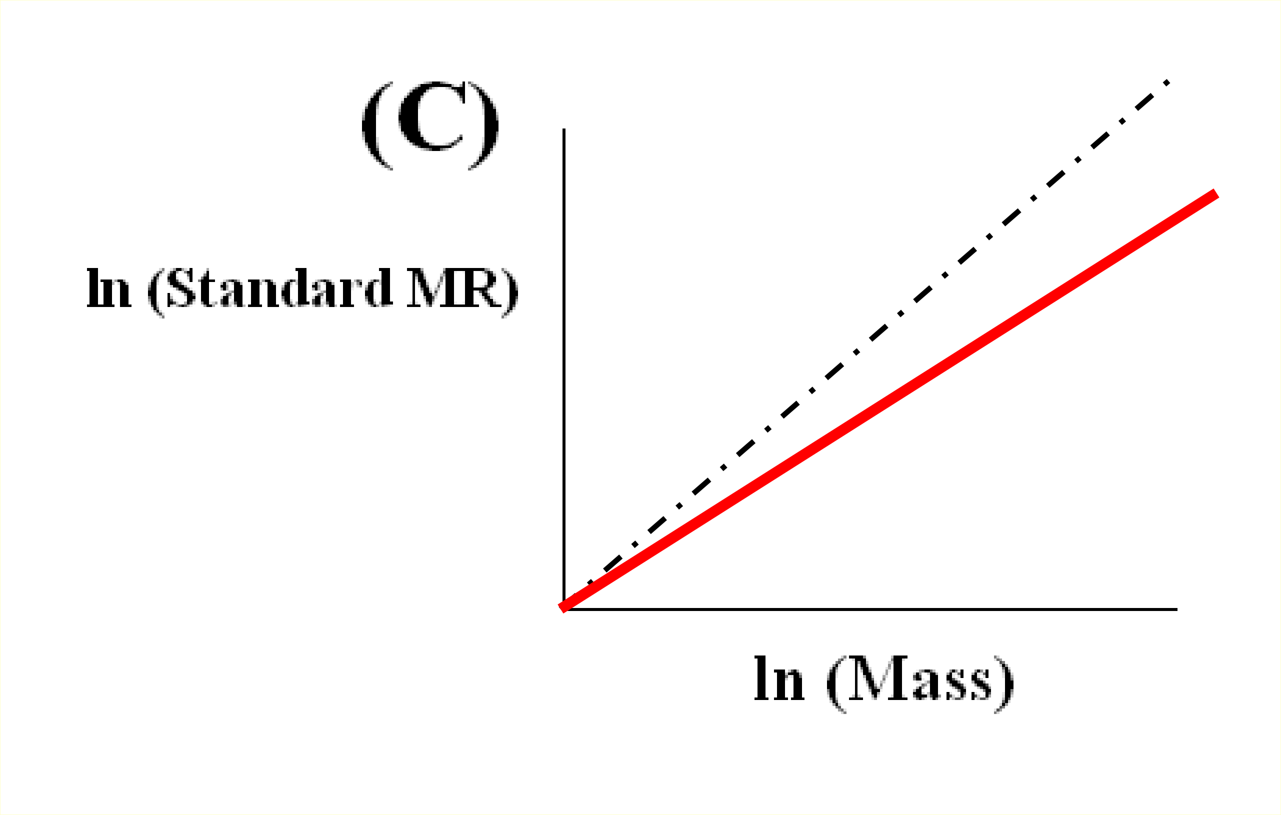


St MR units: $g\ O_2\ hr^{-1}$

Sp MR units: $g\ O_2\ g^{-1}\ hr^{-1}$

(NOTE: For C, show the 1:1 line) and report the slope of the curve

Slope: 3 / 4



ln (MR) = a * ln (Mass)

Following the example above, describe how oxygen stores and fat stores vary across pinniped species of different body size.

For each example, explain the significance of these adaptations and report the qualitative value (> 1, < 1, cannot tell) of the slope in the following equation: (ln (stores) = slope * ln (mass)). (1 point each)

Oxygen stores:

- ecological importance: larger stores allow for deeper and longer dives

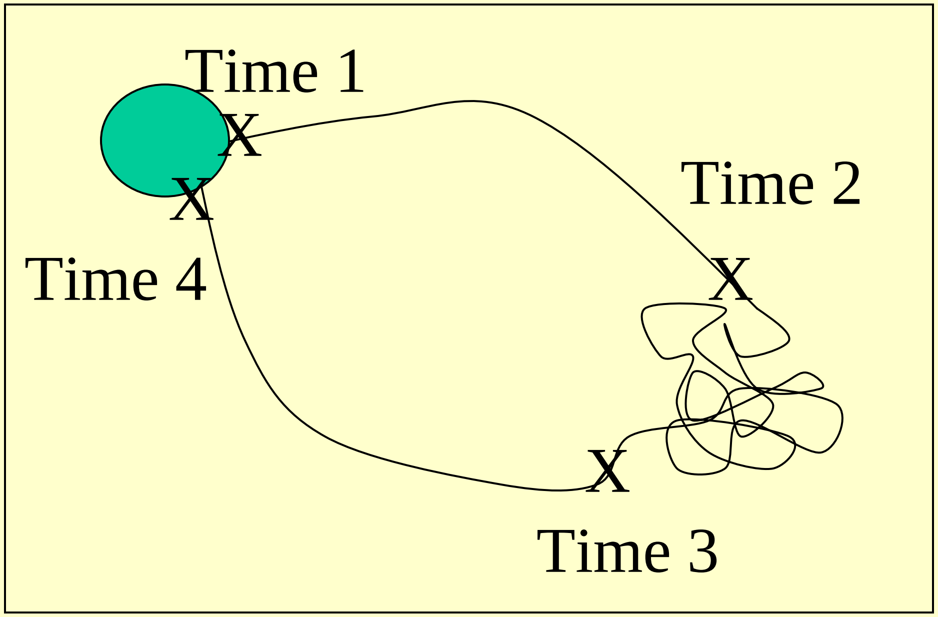
- slope of allometric equation: > 1

Fat stores:

- ecological importance: allows for longer fasting during critical times like migration, molting, breeding

- slope of allometric equation: > 1

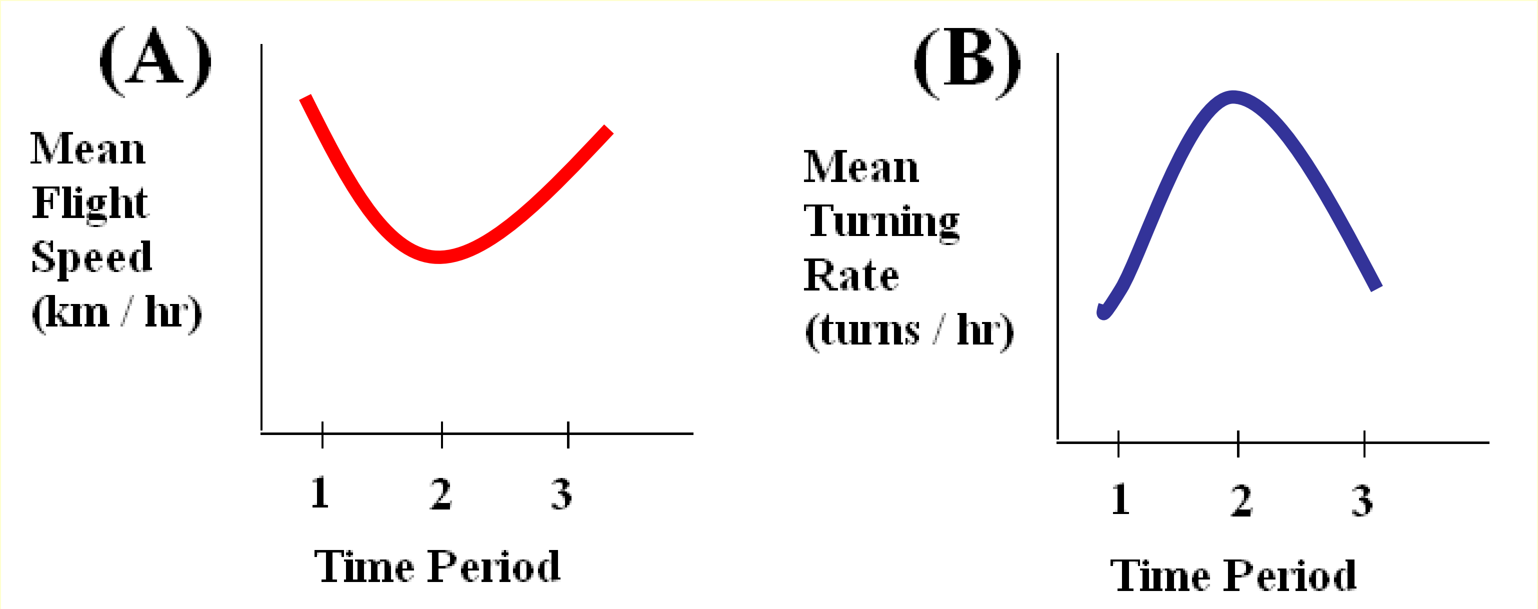
7) You have been tracking albatross from a breeding colony. This map shows one of the bird's travels. The four points along its path are separated by the same amount of time. Consider 3 periods (#1: time1 – time2; #2: time2 – time3; #3: time3 – time4).



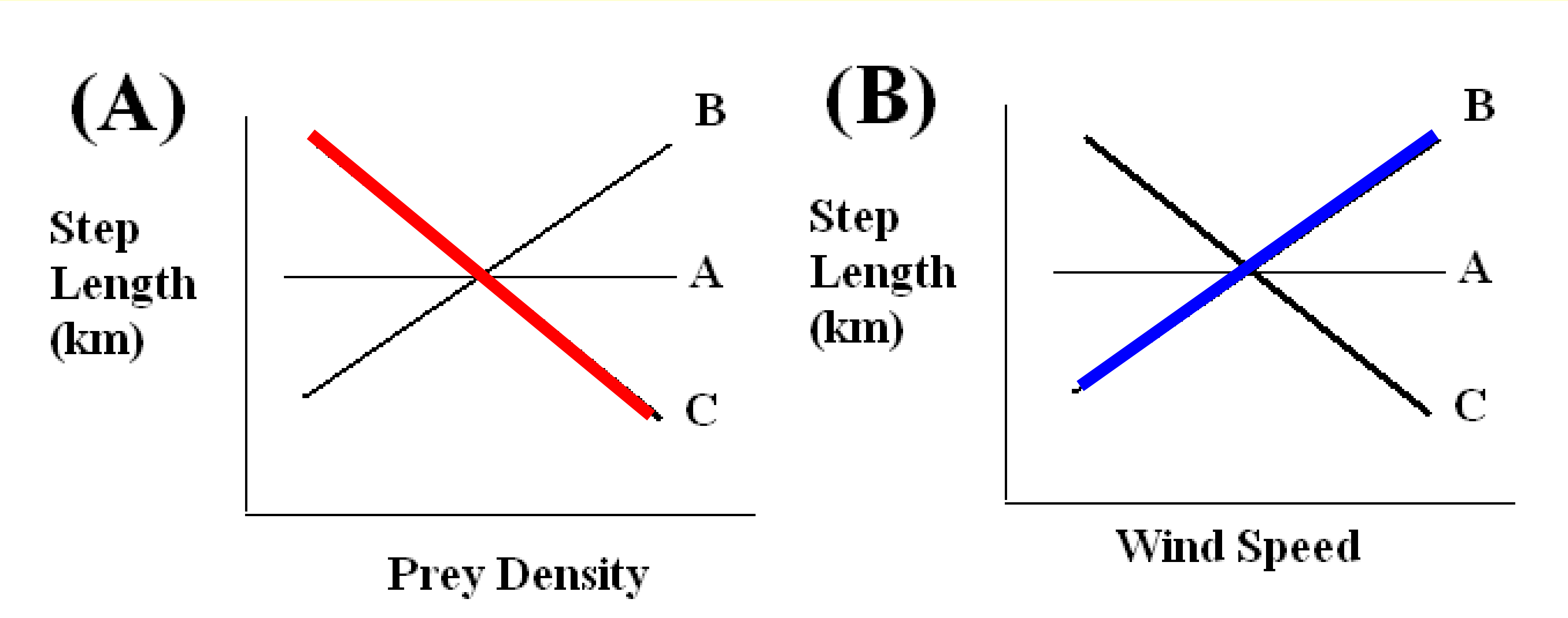
What do you think this albatross is doing in each time period?

Period1: **Commuting**
Period2: **Foraging**
Period3: **Commuting**

Draw box plots to show the following relationships for your tracked bird



The albatross path can be broken into small straight sections (or steps). If the albatross are engaging in area restricted searching behavior and use the wind to transit to their foraging grounds, which of these curves are correct.



Describe three mechanisms these albatross may be using to locate their prey? (see hints) (1 point each)

Social mechanism: **Finding other foraging birds (sitting on the water and feeding) is indicative of prey patches**

Oceanographic mechanism:

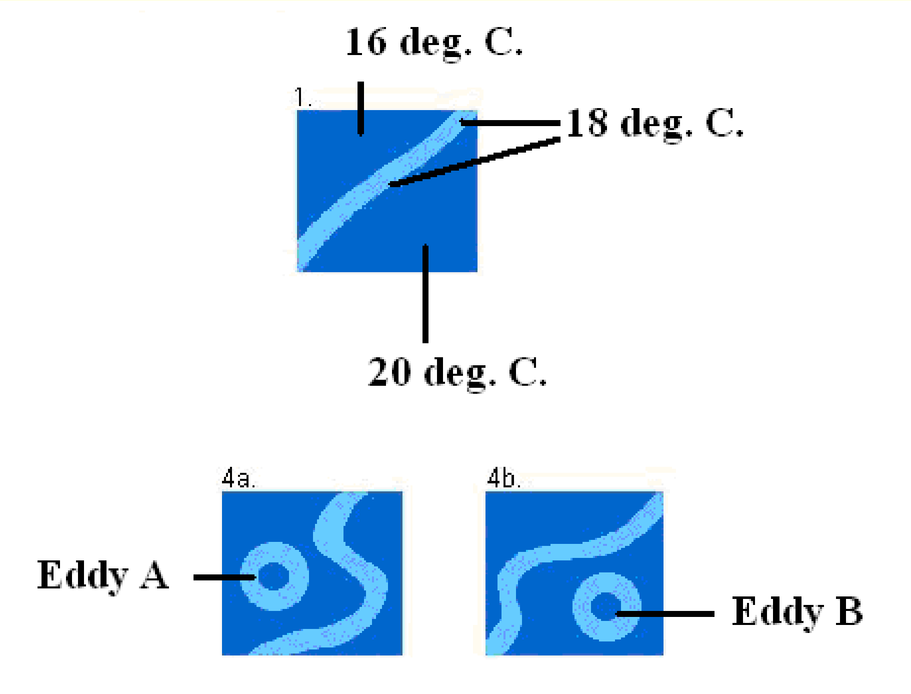
Finding fronts (e.g., different color waters) and convergence zones (e.g., foam lines)

Can you think of another?:

Memory: Remembering the general areas where you found food on previous years / foraging trips

Other cues: such as predators (e.g., tuna schools) and people (e.g., fishing boats)

8) In the SST maps provided below, you see the formation of two northern hemisphere eddies (A, B). For each multiple choice below, circle the correct options:



Eddy A: Warm - core

Eddy B: Cold - core

Eddy A: Anti- cyclonic

Edge upwelling

Eddy B: Cyclonic

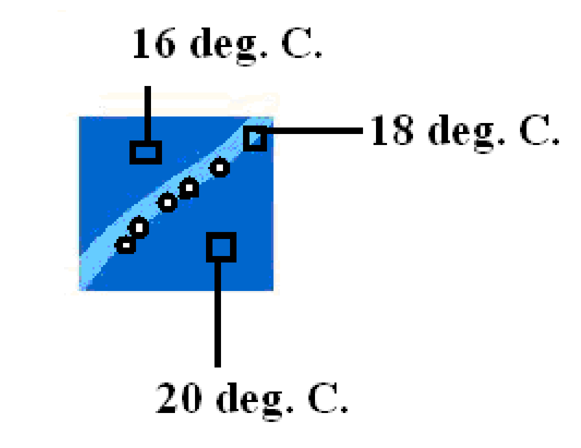
Center upwelling

Another albatross forages on buoyant zooplankton prey that become concentrated at convergence zones. For panels 4a and 4b, circle where you would expect to find these albatross foraging

Eddy A: Center

Eddy B: Edge

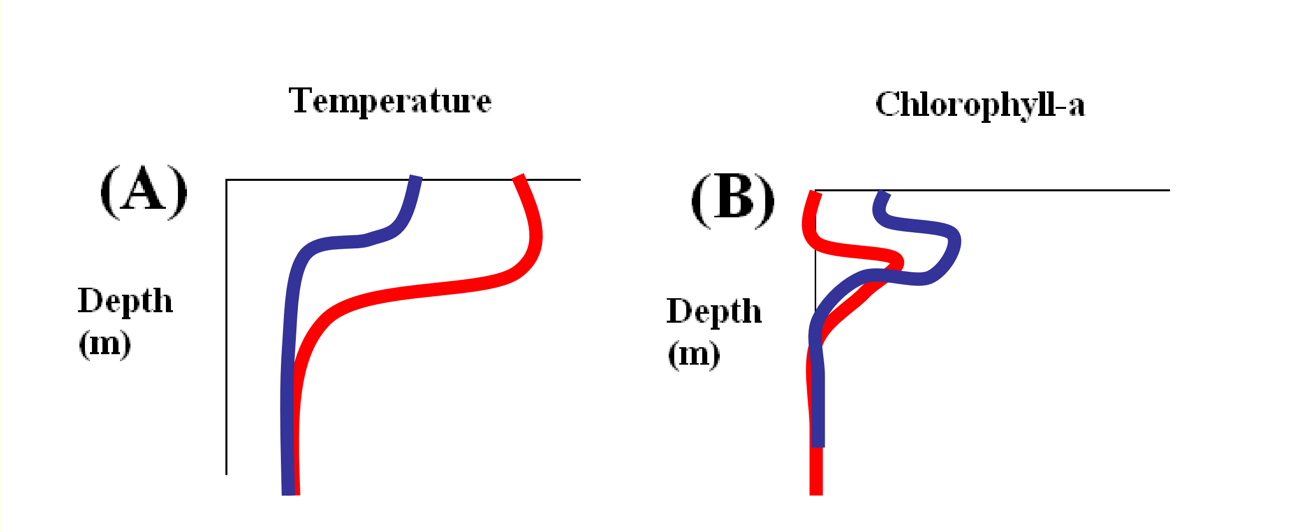
9) During a vessel-based survey, you documented large numbers of loggerhead turtles (circles on the map) travelling along the North Pacific Chlorophyll Transition front (defined by 18 deg. C. SST band). You sampled water temperature, chlorophyll-a concentration and plankton / neuston / pleuston at three stations (boxes on the map). Draw two vertical sections of temperature and chl-a for the subtropical and the subarctic stations (Hint: 2 lines per plot). Label the thermocline and the chl-maximum



Subarctic: 16 °C

Frontal: 18 °C

Subtropical: 20 °C



Where would you anticipate to find the highest densities of the following organisms (check the boxes with the correct answers) ? Justify your answers? (8 points total)

Albacore tuna

Why?

Subtropical side of the front (south of the front) because they are visual predators and forage in clear (low Chl-a) water in areas where food concentrates

Velella velella

Why?

By-the-wind-sailors are weakly-swimming pleuston and concentrate at fronts and convergence zones (* Polovina's paper mentions its loggerhead food)

Olive ridley turtles (eat pyrosomes at deep / strong thermoclines)

Why do pyrosomes aggregate at thermoclines?

Subtropical water, where the deep and strong thermocline will concentrate their weakly-swimming (sinking) gelatinous zooplankton prey

Cosmopolitan whale species

Why?

Cosmopilitan species occur everywhere in the ocean – on either side of the fronts

10) Tuna are harvested using purse seines that target dolphin schools, tuna schools, and floating logs. Each fishing method has different levels of bycatch (see table). Devise two "ecological indices" of bycatch to rate these fishing practices, based on the effects on target (tuna) and non-target species? Explain your rationale for selecting the most ecologically-sensitive fishing practice (2 points each)

Per 2,000,000 adult tuna caught	School sets	Log sets	Dolphin sets
Dolphins	10	50	5,000
Immature tunas	5,000	1,000,000	500
Sharks	20,000	100,000	2,500

Tuna metric:

Adult tuna – good

Immature tuna - bad

→ **% immature tuna caught**

Non-target species metric:

Adult tuna – good

Dolphins / Sharks - bad

→ **# (Dolphins / Sharks) per adult tuna**

	School sets	Log sets	Dolphin sets
% Immature Tuna	0.0025	**0.5**	**0.00025**
# Dolphins / Adult Tuna	0.00005	**0.000025**	**0.0025**
# Sharks / Adult Tuna	**0.01**	0.05	**0.00125**

	School sets	Log sets	Dolphin sets
Dolphins	10	50	5,000
Sharks	20,000	100,000	2,500
Dolphin / Shark	**0.0005**	**0.0005**	**2**

-Why are “dolphin sets” taking so few immature tuna? (Hint: explain how the purse seining fishing practice works) (2 points)

Dolphin sets involve pursuit with speed boats. Smaller tuna and slow fish species cannot keep up and are separated from the dolphins and large tunas, before they are circled by the purse seine

-Why are “log sets” taking so many immature tuna? (Hint: explain the role of logs in an epipelagic tropical ocean) (2 points)

Small fish seeking shelter from visual predators in an environment without cover aggregate at logs and other floating objects at-sea

-List one morphological and one behavioral adaptation that epipelagic animals use to deal with predation risk (2 points)

- Morphological: transparency, scales, large eyes, small-size
- Behavioral: vertical migration, jump through surface, seek cover

- What is your favorite marine vertebrate and state why? (2 point) ?