

- 1) You have compiled these data on the incidental catch of different types of purse seine tuna sets. Gauge the “ecosystem-level” effect of these three different fishery practices on the following: (i) dolphins, (ii) turtles and (iii) the target yellowfin tuna population. You do not have tuna catch data for adult yellowfin per 10,000 sets, so you assume it is equal across the three practices: “tuna school”, “log” and “dolphin” sets. (+0.25 each)

<u>Mean Rate (Per 10,000 sets)</u>	<u>School sets</u>	<u>Log sets</u>	<u>Dolphin sets</u>
Dolphins	8	31	4,500
Immature yellowfin	5,320,000	128,700,000	833,000
Sea turtles	471	617	143

The best fishing practice for dolphin conservation is **school sets** because: **it yields the minimum rate of dolphin bycatch (8 per 10,000 sets) versus the other methods (31 log sets and 4,500 for dolphin sets). Basically, “school” sets target tuna not associated with dolphins.**

The best fishing practice for yellowfin conservation is **dolphin sets** because: **it yields the lowest catch of juvenile (immature) yellowfin tuna of the three fishery practices considered. This is due to the association of dolphins with large (mature) tuna, and due to the separation of adult and juvenile tuna during the ‘chase’ of the dolphin school.**

The best fishing practice for seaturtle conservation is **dolphin sets** because: **it yields the fewest turtles (143) per 10,000 sets, likely because turtles are not associated with dolphin schools or cannot swim fast enough to keep up with the dolphins during the “chase” period.**

- 1) Your fishery colleagues just sent you the adult yellowfin tuna catch data listed below, for these three fishing practices. Would you change your recommendations? (+0.25 each)

<u>Mean Rate (Per 10,000 sets)</u>	<u>School sets</u>	<u>Log sets</u>	<u>Dolphin sets</u>
Adult Yellowfin Tuna (tons)	80	310	45,000

The best fishing practice for dolphin conservation is **school sets & log sets & dolphin sets** because: **all of these practices yield 0.1 dolphins for each ton of tuna caught. Decision changed.**

The best fishing practice for yellowfin conservation is **dolphin sets** because: **the rate of bycatch is 18.5 individuals per ton of tuna caught, compared with 66500**

(for school sets) and 415616 (for log sets). Decision does not change.

The best fishing practice for seaturtle conservation is **dolphin sets** because: **only ~ 0.003 sea turtles are caught per ton of captured tuna, compared with ~2 (for log sets) and ~6 (for school sets). Decision does not change.**

- 2) The results of sections 1 and 2 above change drastically depending on whether we include the catch levels of the target into the decision-making process, or whether we only consider the bycatch rates. In the next example, you will use data on the at-sea distribution of an albatross species (males / females separately) in relation to longline fishing effort and catches of swordfish and big-eye tuna (the two target species). These data are included in the excel file (“fisheries overlap.xls”).

First of all, figure out which cells you would close to fishing with an MPA designed to protect those areas where the birds are spending their time at sea (Hint: Assume that time at sea is proportional to the risk of getting hooked). Prioritize the cells, from the most valuable (the first one you would protect) to the least valuable (the last one you would protect), until all of the albatross habitat (“time at sea”) is in the MPA.

For both sexes (males / females) create a plot that shows how the cumulative proportion of their habitat is encompassed in the MPA, as its size increases (Hint: Express the area of the MPA as the number of 5 X 5 cells it encompasses). (+1 each). Which sex would be easier to protect completely with an MPA? Explain your answer. (+0.5)

**Males should be easier to protect because their distribution is more restricted. For example, their at-sea range is smaller (25 cells versus 48 cells for females) and they are more concentrated (18 cells encompass 95% of their time at sea) than for females (31 cells encompass 95% of their time at sea).**

**Table 1. Ranking grid cells on the basis of male albatross use, from the most to the least used cells. Twenty five cells encompass the male albatross at-sea range.**

<b>Cell_ID</b>	<b>Time_At_Sea(%)</b>	<b>Cumm_Time(%)</b>
84	27.67	27.67
66	10.11	37.78
85	7.32	45.10
4	5.83	50.93
75	5.33	56.27
83	4.47	60.73
24	3.97	64.70

39	3.97	68.67
76	3.35	72.02
48	3.29	75.31
13	2.92	78.23
144	2.79	81.02
32	2.73	83.75
46	2.73	86.48
14	2.61	89.08
67	2.42	91.50
74	2.36	93.86
65	1.80	95.66
57	1.43	97.08
55	0.93	98.01
40	0.74	98.76
5	0.68	99.44
23	0.25	99.69
49	0.19	99.88
47	0.12	100.00

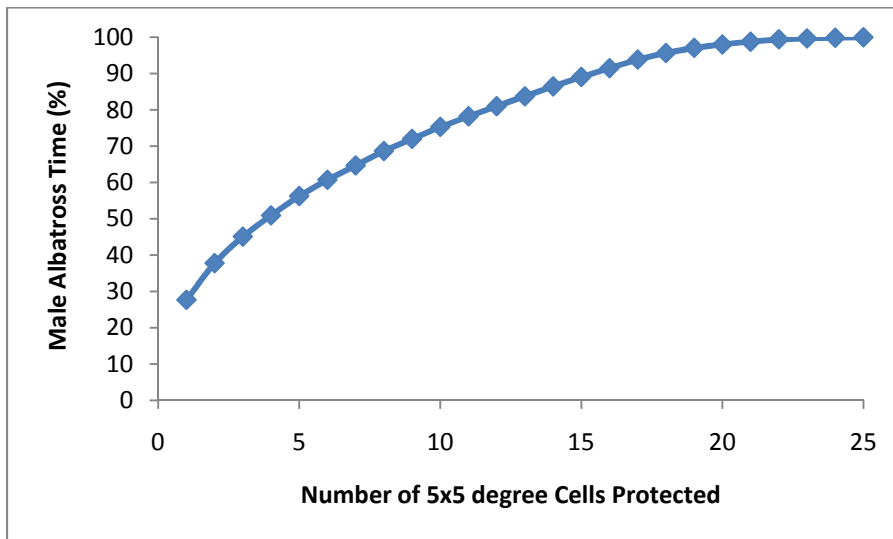


Figure 1. Proportion of male albatross time at-sea encompassed by a MPA of increasing area.

Table 2. Ranking grid cells on the basis of female albatross use, from the most to the least used cells. Forty-eight cells encompass the female albatross at-sea range.

Cell_ID	Time_At_Sea(%)	Cumm_Time(%)
85	11.58	11.58
76	9.80	21.39
84	9.67	31.05
66	6.60	37.65
75	5.56	43.21
57	4.71	47.92
47	4.35	52.27
5	4.18	56.44
3	3.56	60.01
144	3.26	63.27
74	2.77	66.03
48	2.47	68.51
4	2.29	70.79
13	1.94	72.74
12	1.86	74.60
67	1.81	76.41
39	1.73	78.14
65	1.73	79.86
143	1.65	81.51
40	1.57	83.08
33	1.54	84.63
6	1.46	86.09
83	1.34	87.43
49	1.25	88.68
55	1.17	89.85
15	1.14	91.00
64	1.10	92.10
73	1.01	93.11
32	1.00	94.11
56	0.85	94.96
38	0.82	95.78
22	0.76	96.54
54	0.63	97.17
14	0.51	97.67
46	0.51	98.18
68	0.45	98.63
24	0.27	98.90
23	0.19	99.08
45	0.17	99.26
72	0.17	99.43

16	0.12	99.55
58	0.09	99.64
77	0.09	99.73
21	0.08	99.81
31	0.07	99.88
25	0.05	99.93
92	0.04	99.97
91	0.03	100.00

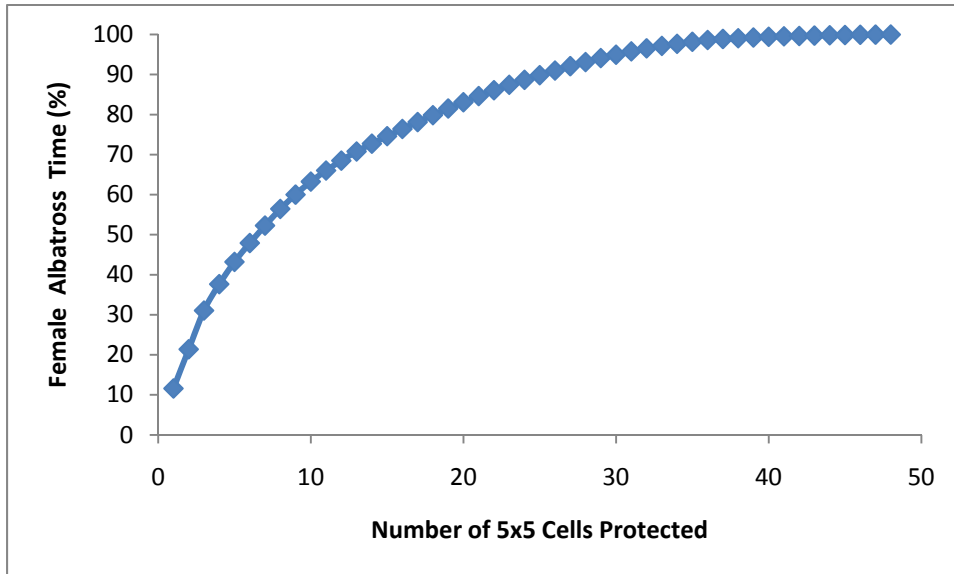


Figure 2. Proportion of female albatross time at-sea encompassed by a MPA of increasing area.

Next, you will assess the cost to the fishery that the MPA would represent. Think of what metric you could devise to gauge the loss of catch for boats targeting swordfish and for boats targeting big-eye tuna. (Hint: The overall catches of tuna and swordfish are very different... and we are looking for a way to make the fishing losses comparable).

To compare the catches of the tuna and the swordfish fisheries, I would calculate the proportions of the total, for each grid cell. This approach allows us to compare the albatross time at sea with these relative metrics of fishing catches.

For each sex, make two plots that show the “cost” of establishing this growing MPA for the boats targeting swordfish or big-eye tuna that you calculated above (+0.5 each). If your MPA seeks to protect the entire male / female albatross time, which fishery would be hit the hardest? Please provide two separate answers (for males / females) and explain your rationale (+0.25 each).

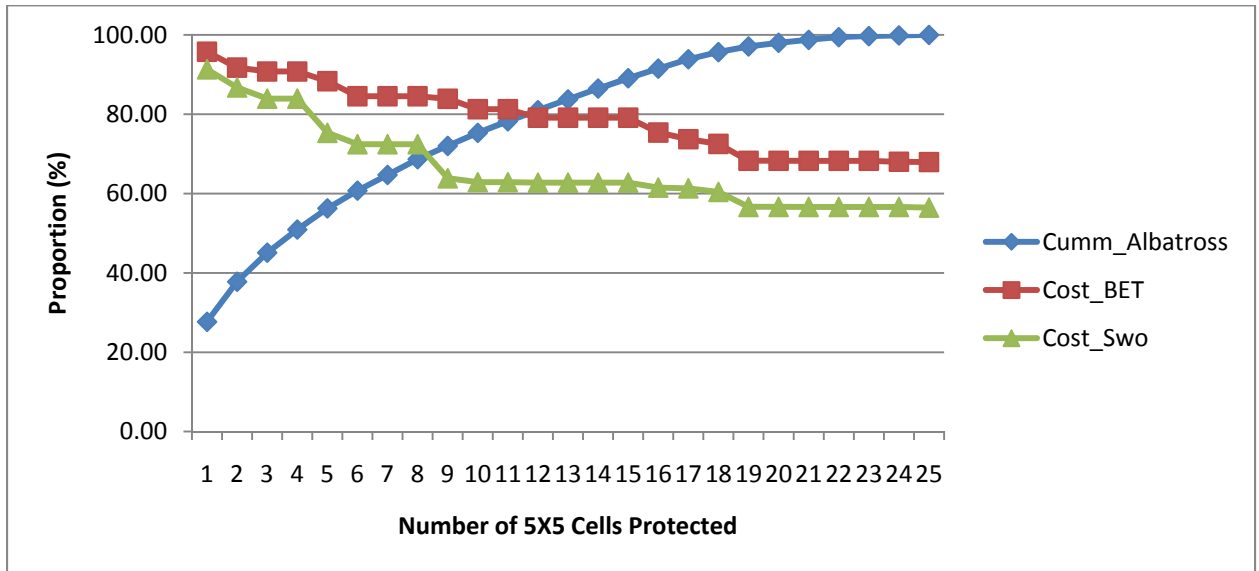


Figure 3. Fishery costs of protecting male albatross, expressed as the proportion of the total tuna and swordfish catch lost due to creation of an MPA.

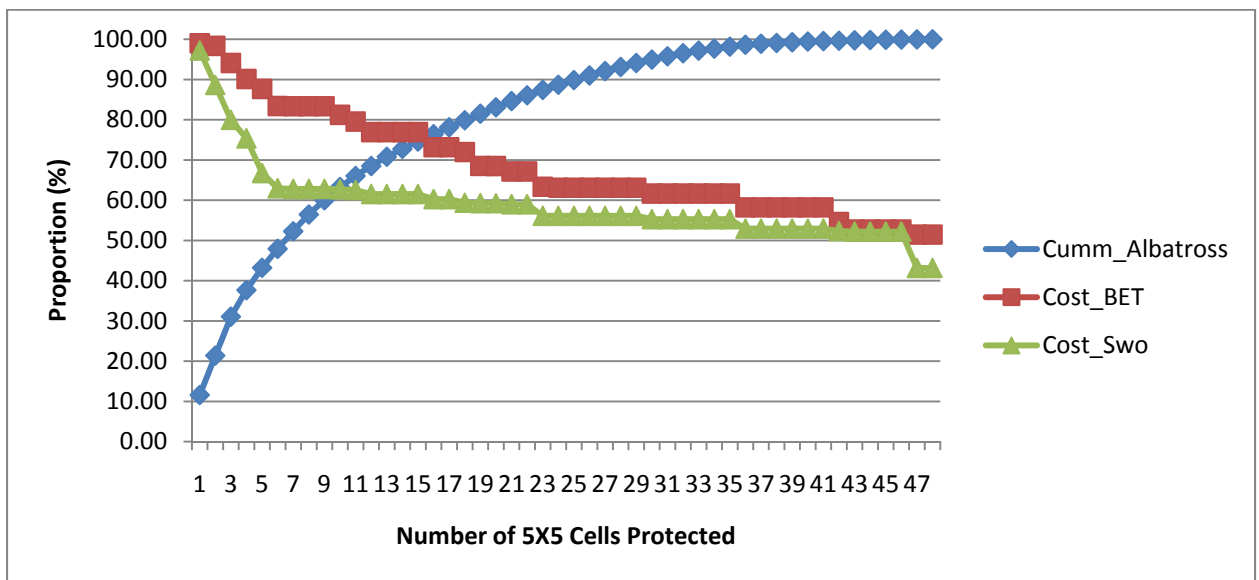


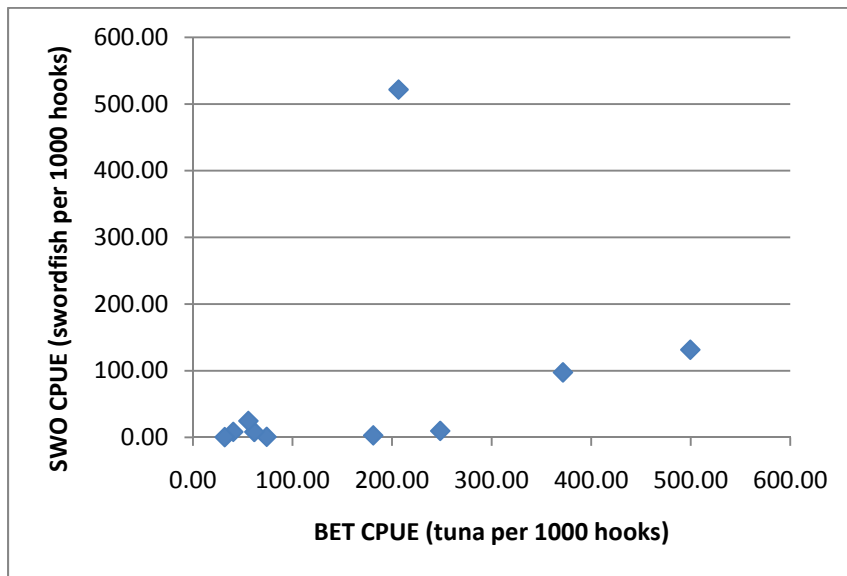
Figure 4. Fishery costs of protecting female albatross, expressed as the proportion of the total tuna and swordfish catch lost due to creation of an MPA. The swordfish boats incur a higher cost, for all levels of protection considered.

- 3) Extra-Credit (+0.5): Finally, imagine you want to identify the best 10-grid-cell fishing area for swordfish and big-eye tuna, designed to give fishers the most efficient (high CPUE) fishing grounds. Sort the cells from most (high CPUE) to less (low CPUE) for

big-eye tuna and swordfish separately, and report the “best” area for each target fishery. Could one reserve encompass both the swordfish and tuna fishing area, or would two reserves be needed? (Hint perform two correlations using “correl” formula in excel to determine whether the tuna / swordfish catches in these two sets of 10 best cells are positively / negatively correlated).

Top 10 cells with the highest tuna catch efficiency: CPUE expressed as the number of tunas and swordfish caught per 1000 hooks. The correlation is low (0.313), indicating that these two species live in different grid cells. Thus, we would likely need two MPAs for tuna / swordfish.

cell_ID	Bet_CPUE	Swo_CPUE
83	499.63	131.36
65	371.69	97.42
74	248.44	9.61
92	206.56	521.79
144	181.12	2.90
143	74.09	0.72
48	61.64	8.14
131	55.68	24.60
56	40.54	8.16
137	31.92	0.28



Top 10 cells with the highest swordfish catch efficiency: CPUE expressed as the number of tunas and swordfish caught per 1000 hooks. The correlation is low (0.387), indicating that these two species live in different grid cells. Thus, we would likely need two MPAs for tuna / swordfish.

cell_ID	Bet_CPUE	Swo_CPUE
92	206.56	521.7883
83	499.63	131.3629
65	371.69	97.42323
132	0.44	83.19302
94	18.51	49.81409
109	0.88	24.7477
131	55.68	24.60279
102	2.44	14.64139
76	2.99	13.64865
118	20.19	11.93844

