MODELING KRILL HABITAT IN THE NORTHERN-CENTRAL CALIFORNIA CURRENT SYSTEM

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EUPHAUSIID CRUSTACEANS FOCAL POINT FOR *FUTURE* AND *EBM*?

- EUPHAUSIACEA: ~86 SPECIES DISTRIBUTED IN THE WORLD S OCEANS.

- SPATIAL ECOLOGY (PATCH DYNAMICS): DENSE, PERSISTENT AGGREGATIONS PLAY KEY ROLE IN TROPHIC DYNAMICS/ENERGY FLOW.

- HUMAN USE: INCREASING, LEADING TO POTENTIAL CONFLICT WITH NEEDS OF EUPHAUSIID PREDATORS (LINKAGES THROUGHOUT FOOD WEB)

- CLIMATE CHANGE: RESPONSE UNKNOWN (+, -), PROBABLY (-)

- --- WARRANTS MULTISPECIES, ECOSYSTEM-BASED APPROACH TO SCIENCE AND MANAGEMENT

TALK OUTLINE

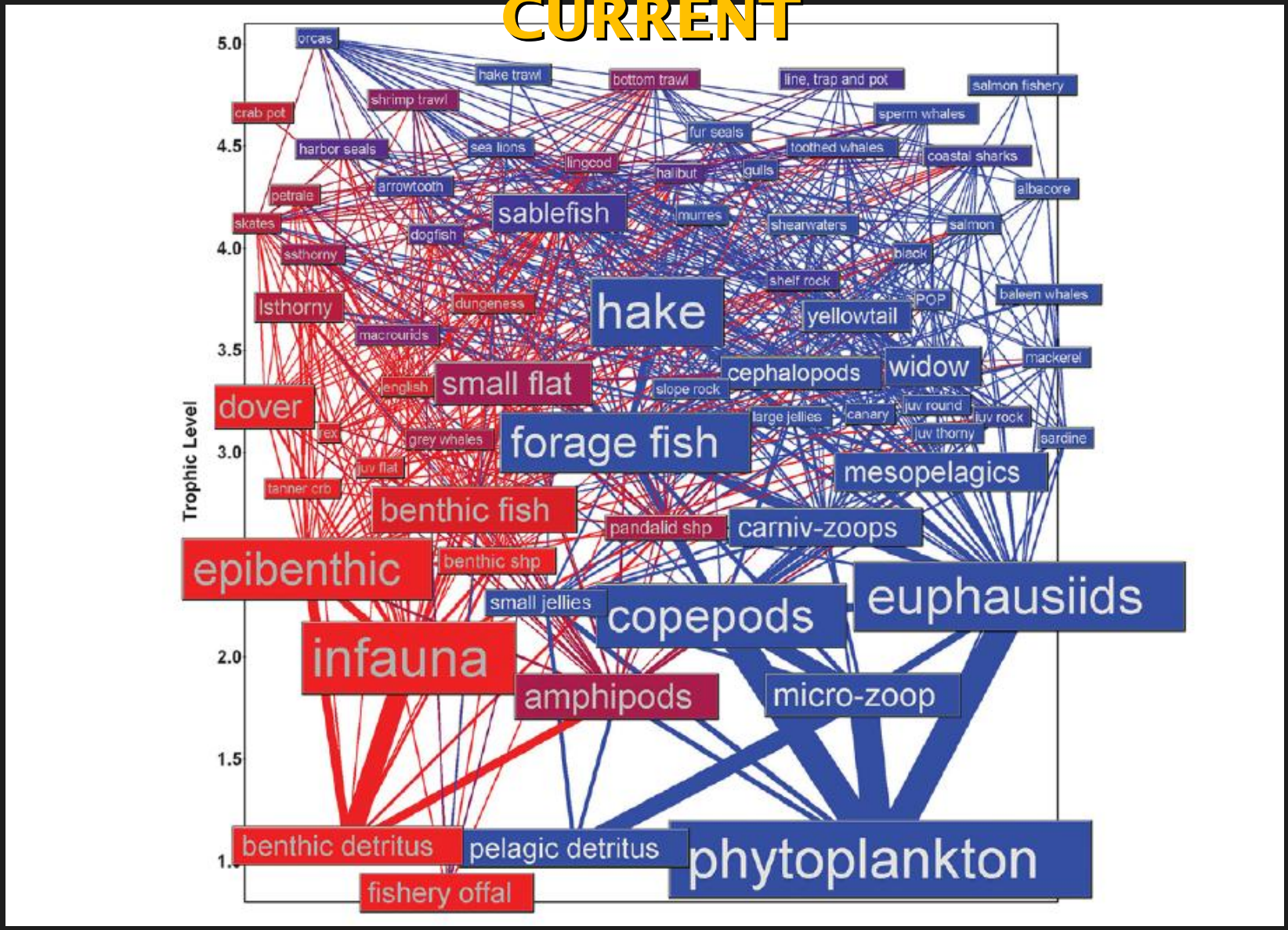
1. Importance of euphausiid crustaceans ("krill") in food web & predator-prey relationships in the CA Current.

2. Krill Habitat Suitability Modeling (Patch Dynamics)

    a. Based on acoustic surveys – where are the patches? (what is the acoustics sampling?)
    b. Link bathymetric data with acoustically-derived maps of krill patches
    c. What can we predict from these habitat associations?

3. Application(s) in ecosystem science and management: maps and marine spatial marine planning (MSP).

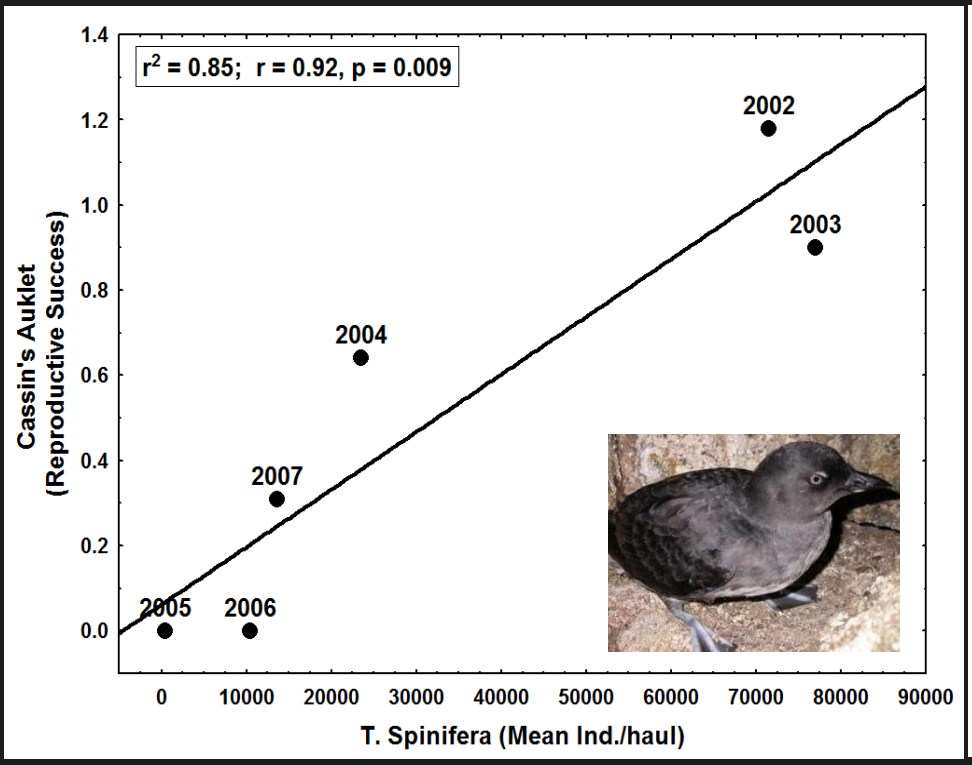
EUPHAUSIID FOOD WEB OF NORTHERN CA CURRENT

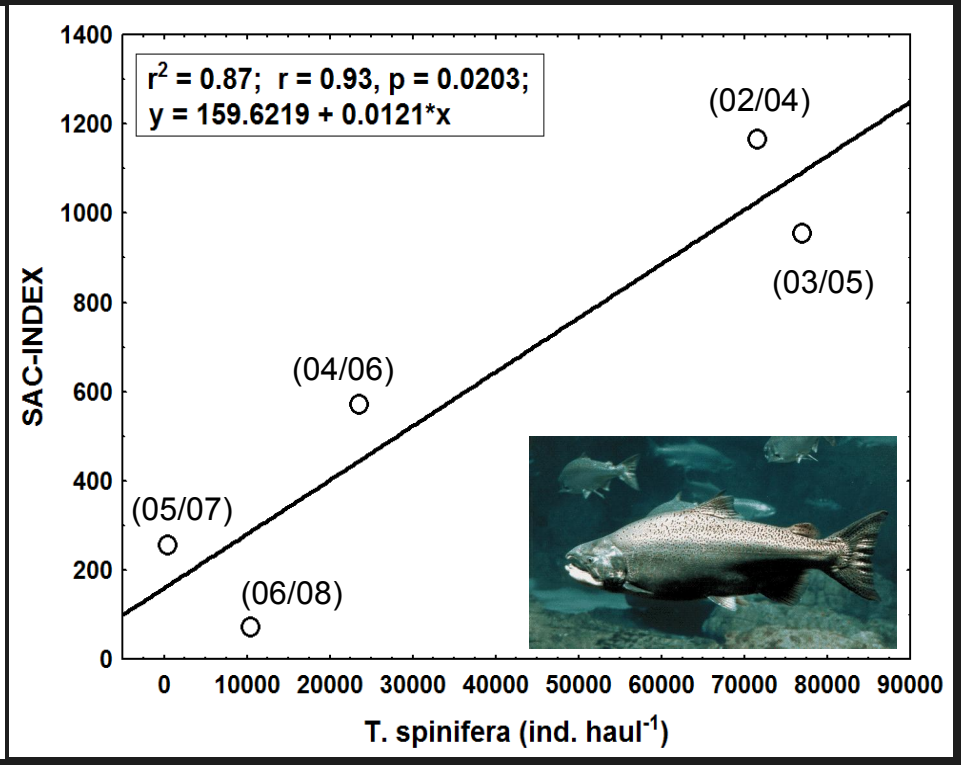


Field et al. 2006 PiO


PLANKTIVOROUS PREDATORS
BLUE WHALE
HUMPBACK WHALE
SPLITNOSE ROCKFISH
PACIFIC HAKE
COHO SALMON
*CHINOOK SALMON
*CASSIN S AUKLET
SOOTY SHEARWATER

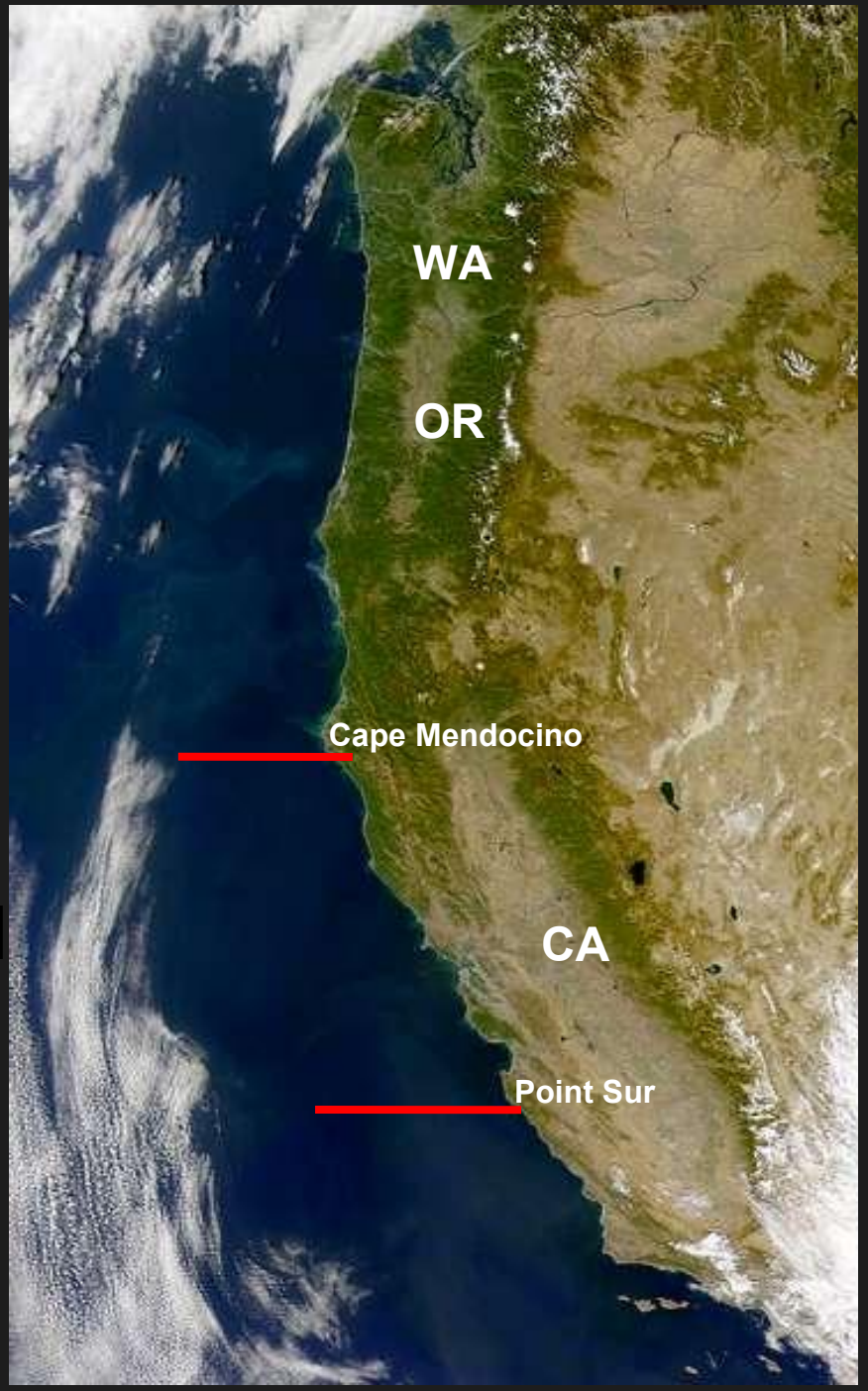
➢ ...LOCATION OF KRILL PATCHES PREDICTIVE OF SEABIRD PRODUCTIVITY AND SALMON SURVIVAL/RETURNS, 2002-2008





(6 stations in Gulf of Farallones; 0 lag for seabird; 2.5y lag for salmon)

STUDY REGION



Imagery courtesy C. Harvey – NOAA/NMFS

Acoustic Survey

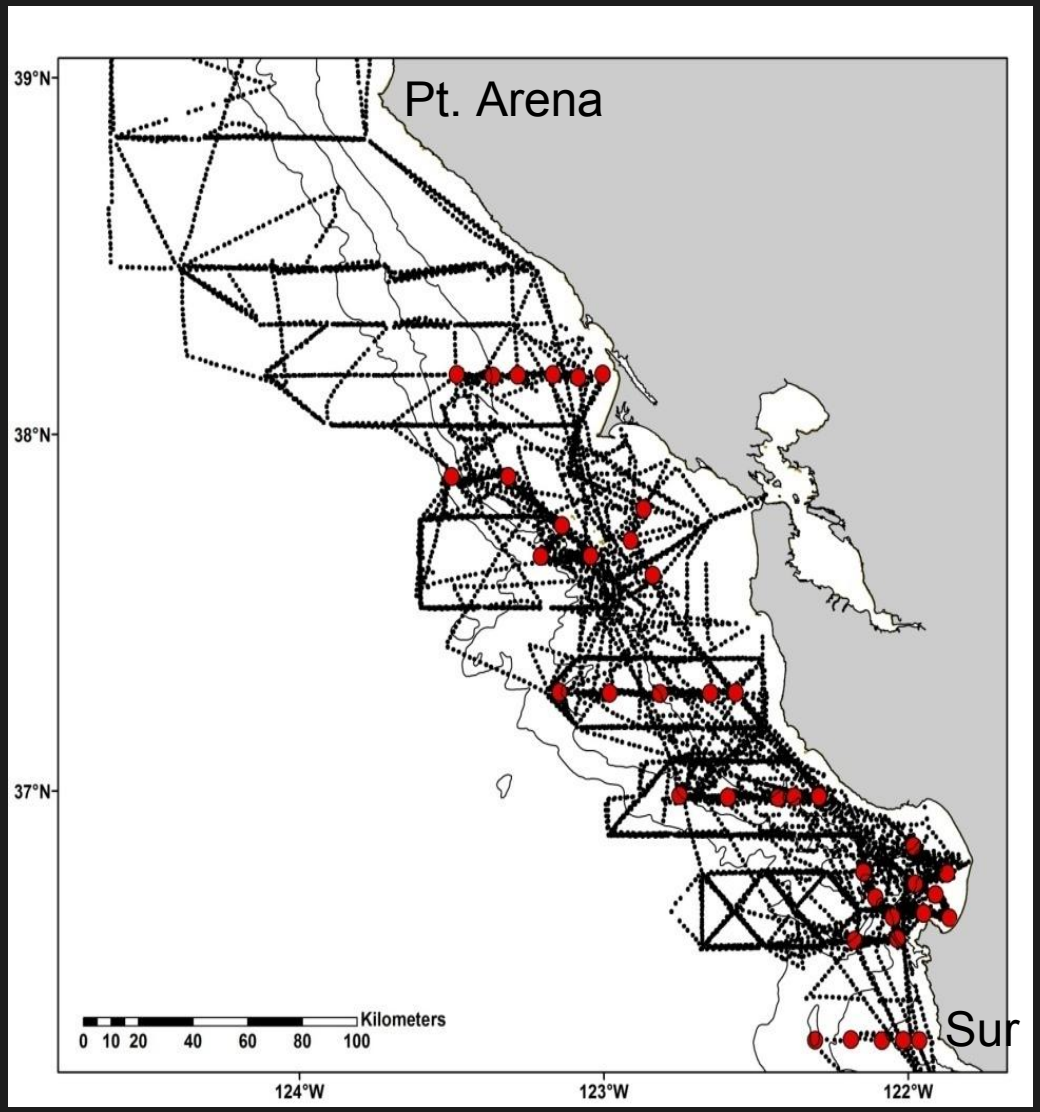
- NMFS Juvenile Rockfish Survey (S. Ralston and J.C. Field, co-PI)

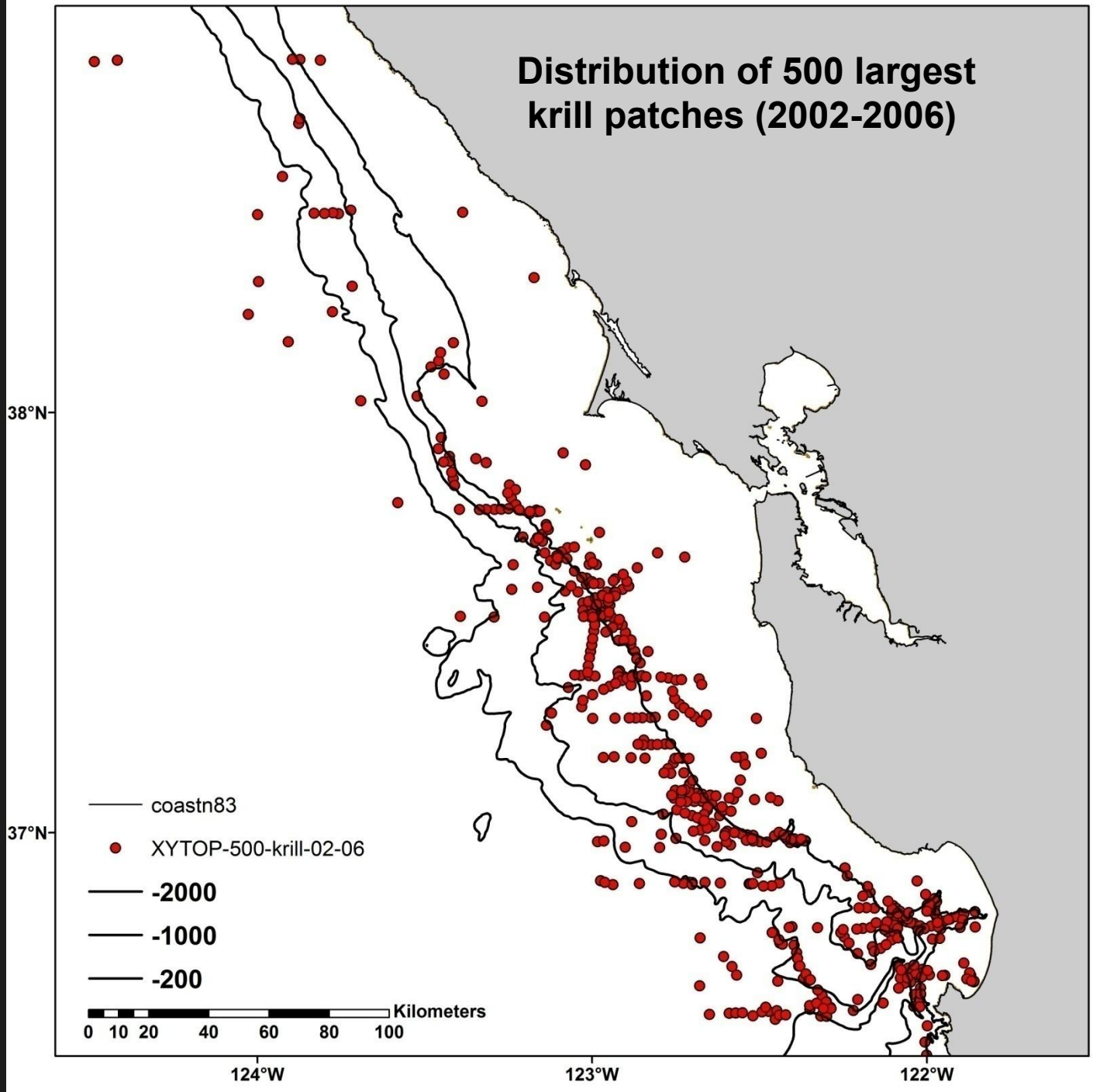
  - EK500 (38, 120, 200 kHz)
  - Data processed using Echoview
  - Three frequency delineation model using size of *E. pacifica* target strength model; integrated to 400m

  - Result: Nautical Area Scattering Coefficient (NASC) per nni.; NASC proportional to biomass

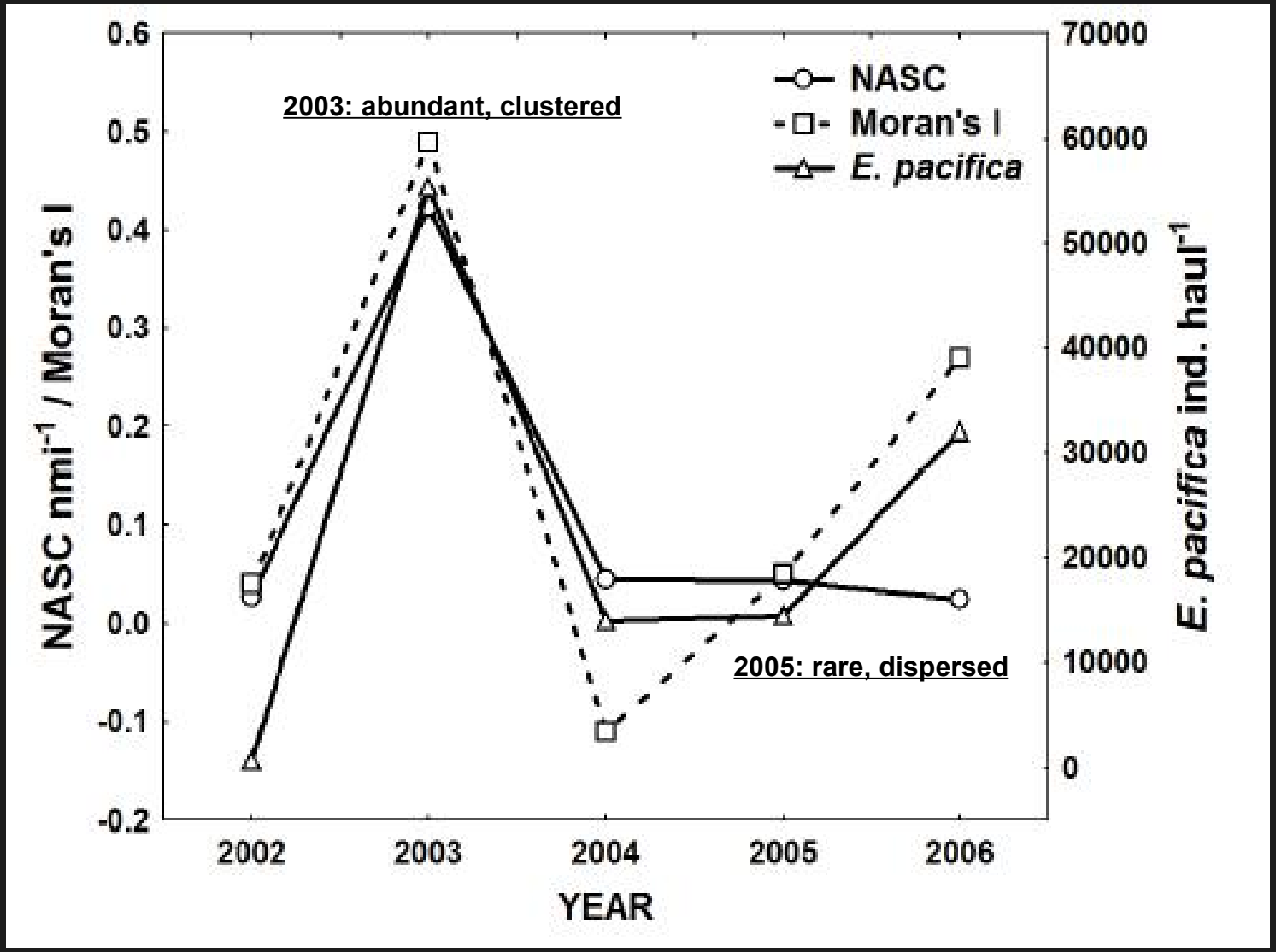
Acoustic Tracklines (n=~8,900 nmi) and Net Sampling sites (n=40)

(~1 May – 15 June, 2002 – 2006)




Distribution of 500 largest krill patches (2002-2006)
38°N
37°N
124°W
123°W
122°W
coastn83
XYTOP-500-krill-02-06
-2000
-1000
-200
Kilometers
0 10 20 40 60 80 100

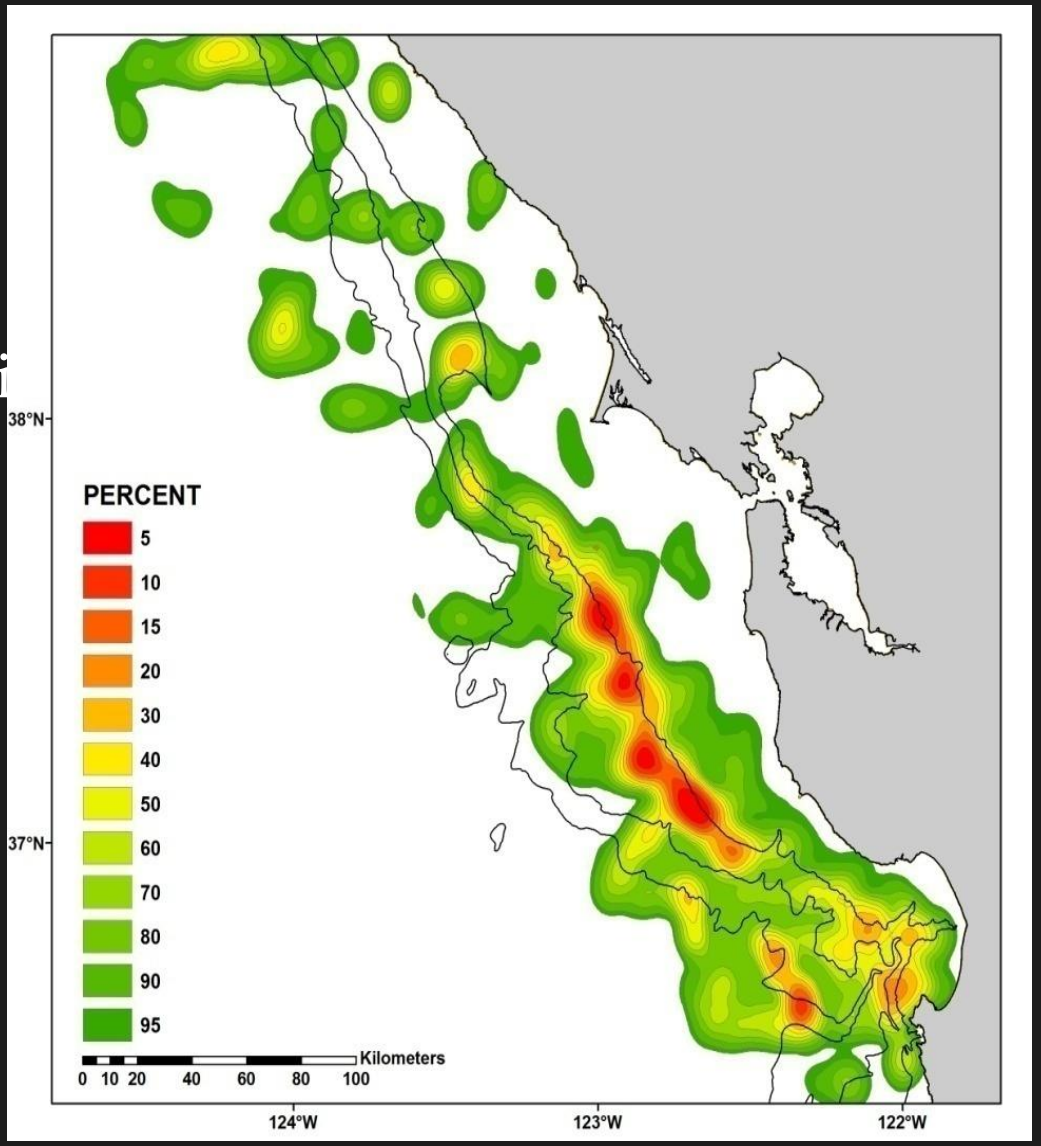
COUSTIC SURVEYS REFLECT *E. PACIFICA* DYNAMI



Santora et al. submitted CJFAS

Krill 'Hotspots'

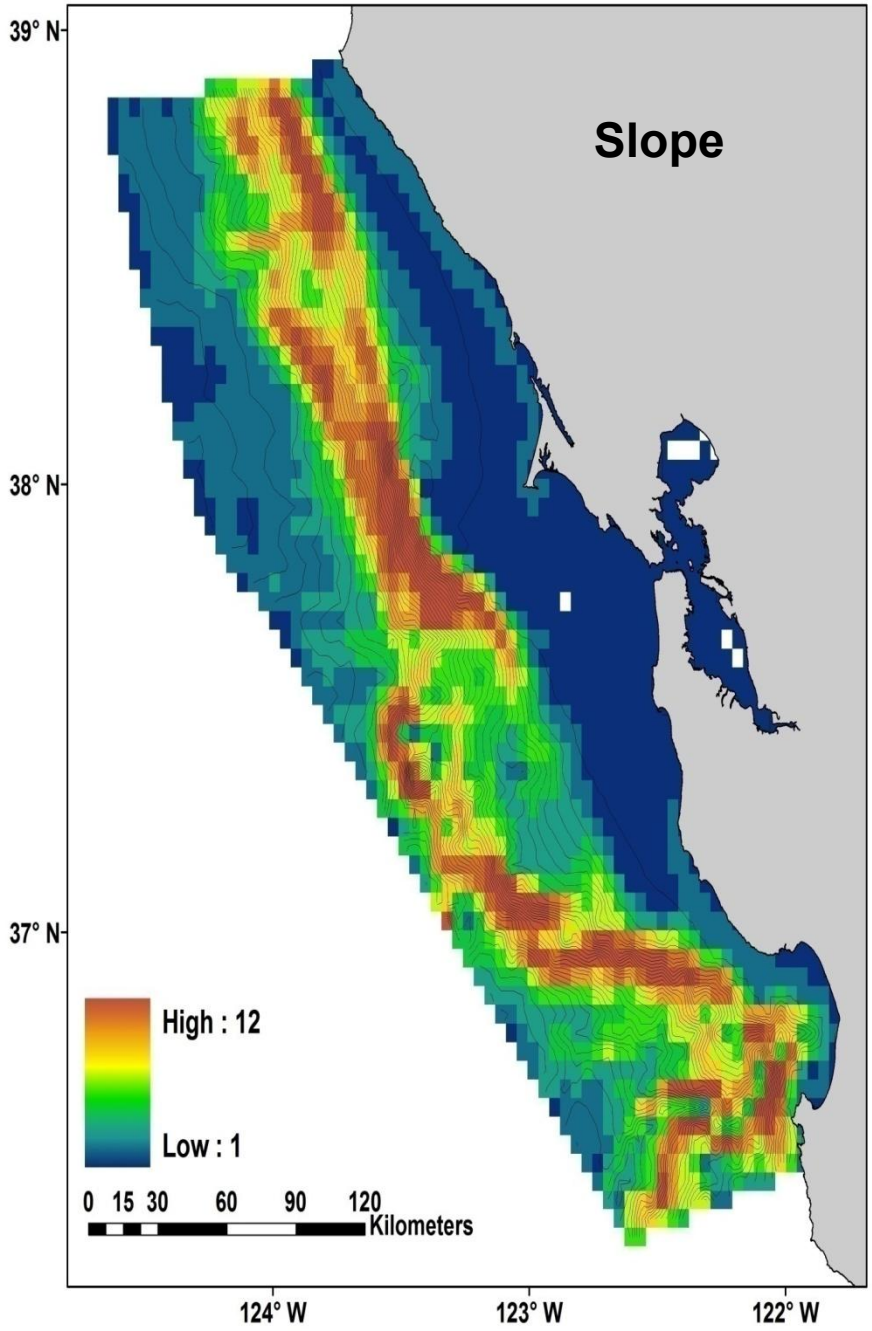
- Approach: Geo-spatial statistical modeling
  - 5 year composite
- Technique: Kernel densi spatial interpolation
  - Inverse Distance Squared
- Result: Utilization distribution
  - Volume contours , percent and spatial extent
  - Assoc. w/ 200-1000m isobaths

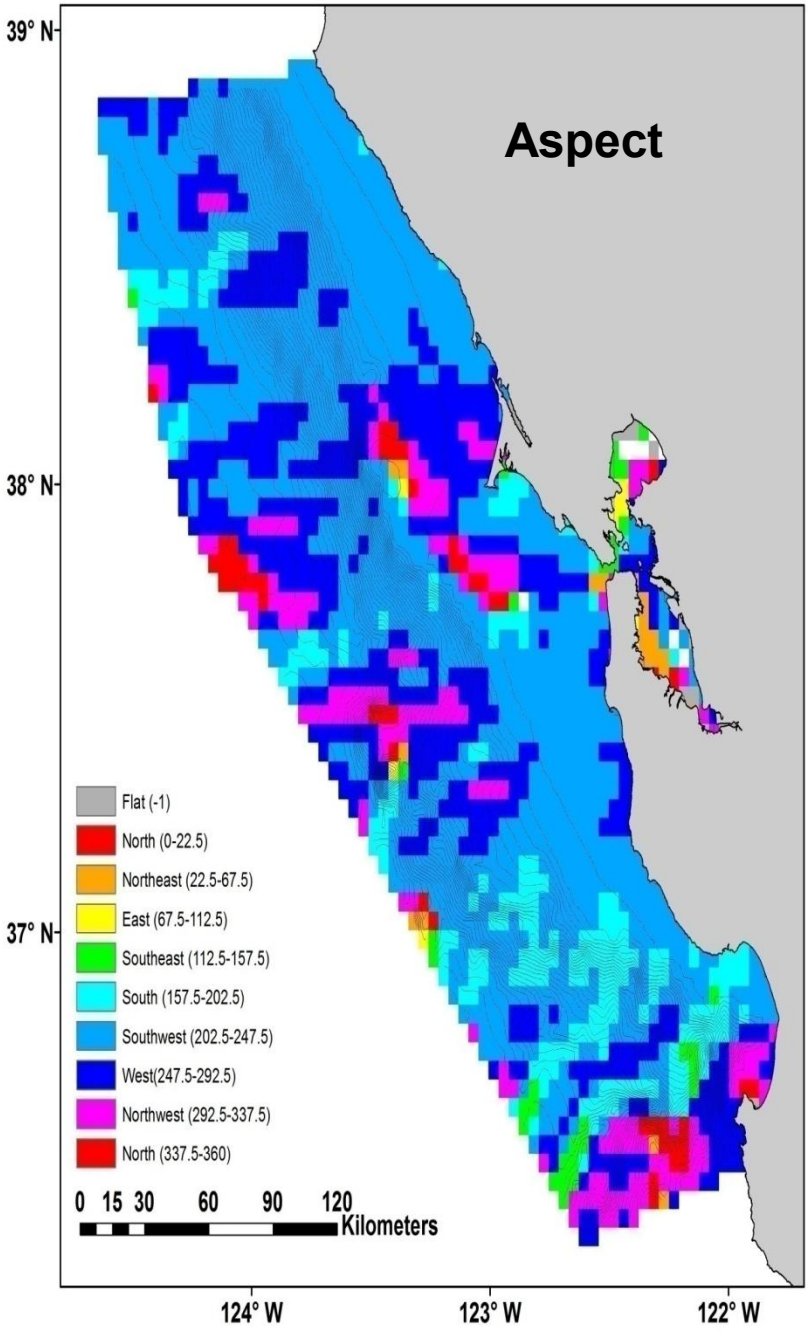


Krill Habitat Modeling

- Presence-Absence (n=8808 nmi. of sampling, 02-06)
- Abundance (n=4054 nmi. of positive)
- Today- Bathymetry: Depth, Slope, Aspect, Curvature
- Model Predictors and Krill Utilization Distribution: Combined into Habitat Suitability Index: each pixel has a ranking...

- Result: GIS-based spatial composite of predicted krill habitat based on bathymetric predictors and measured krill dist'n


Slope
39° N
38° N
37° N
High : 12
Low : 1
0 15 30 60 90 120
Kilometers
124° W
123° W
122° W

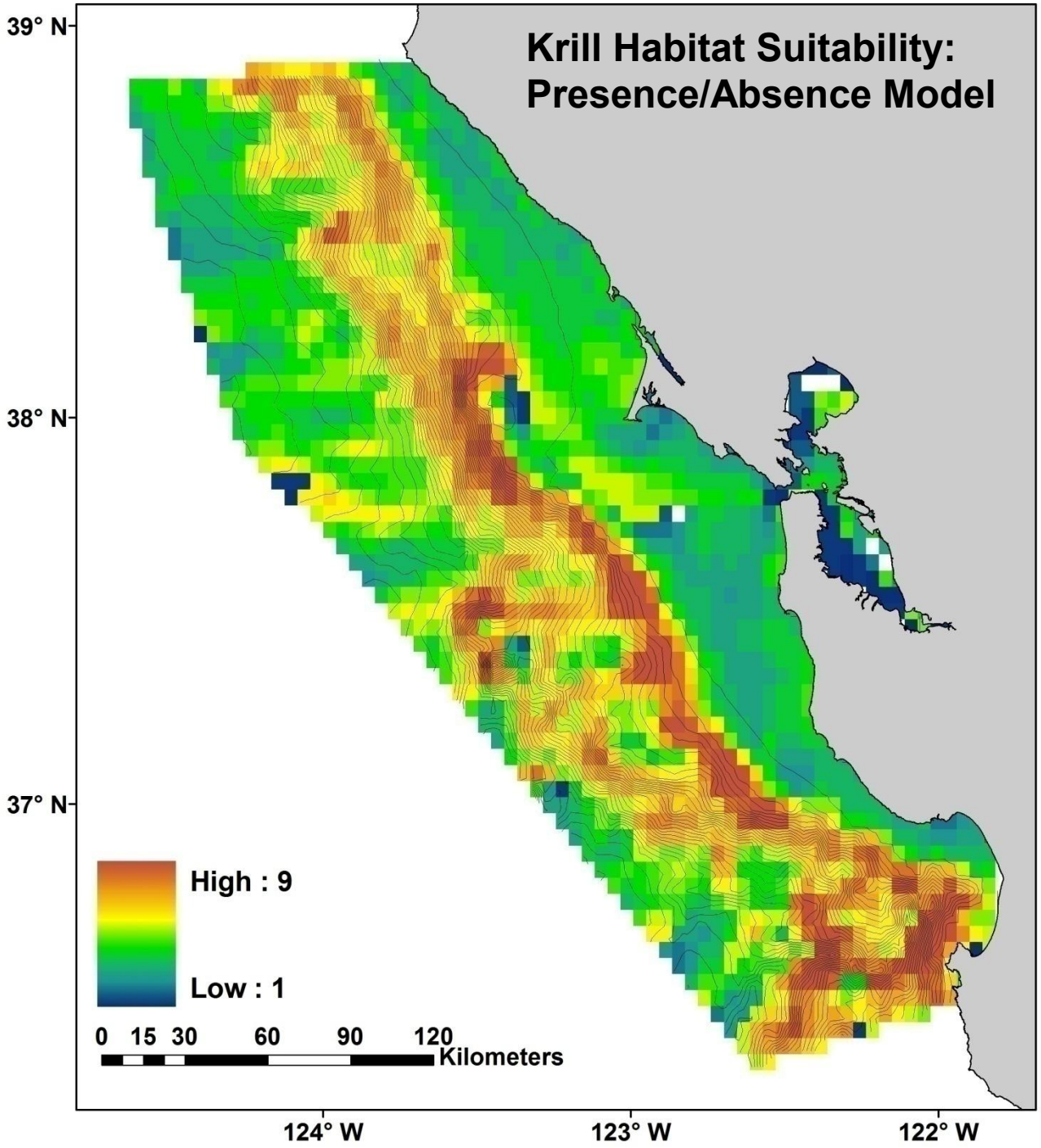

Aspect
39° N
38° N
37° N
Flat (-1)
North (0-22.5)
Northeast (22.5-67.5)
East (67.5-112.5)
Southeast (112.5-157.5)
South (157.5-202.5)
Southwest (202.5-247.5)
West(247.5-292.5)
Northwest (292.5-337.5)
North (337.5-360)
0 15 30 60 90 120
Kilometers
124° W
123° W
122° W

Bathymetric Predictors

GLM: Logit-Binomial, Presence-Absence
Maximum Likelihood Estimation and AIC

Variable	Estimate	SE	Wald Stat.	p
Intercept	1.230773	0.147929	69.22297	0.000000
Depth	-0.000124	0.000029	18.57758	0.000016
Slope	-0.083626	0.008787	90.57952	0.000000
Aspect	0.036968	0.012806	8.33375	0.003892
Curvature	0.052466	0.032683	2.57699	0.108428

Model	Var1	Var2	Var3	Var4	d.f.	AIC
1	Depth	Slope	Aspect	Curvature	4	8779.460
2	Depth	Slope	Aspect		3	8780.037
3	Depth	Slope	Curvature		3	8785.842
4	Depth	Slope			2	8785.905

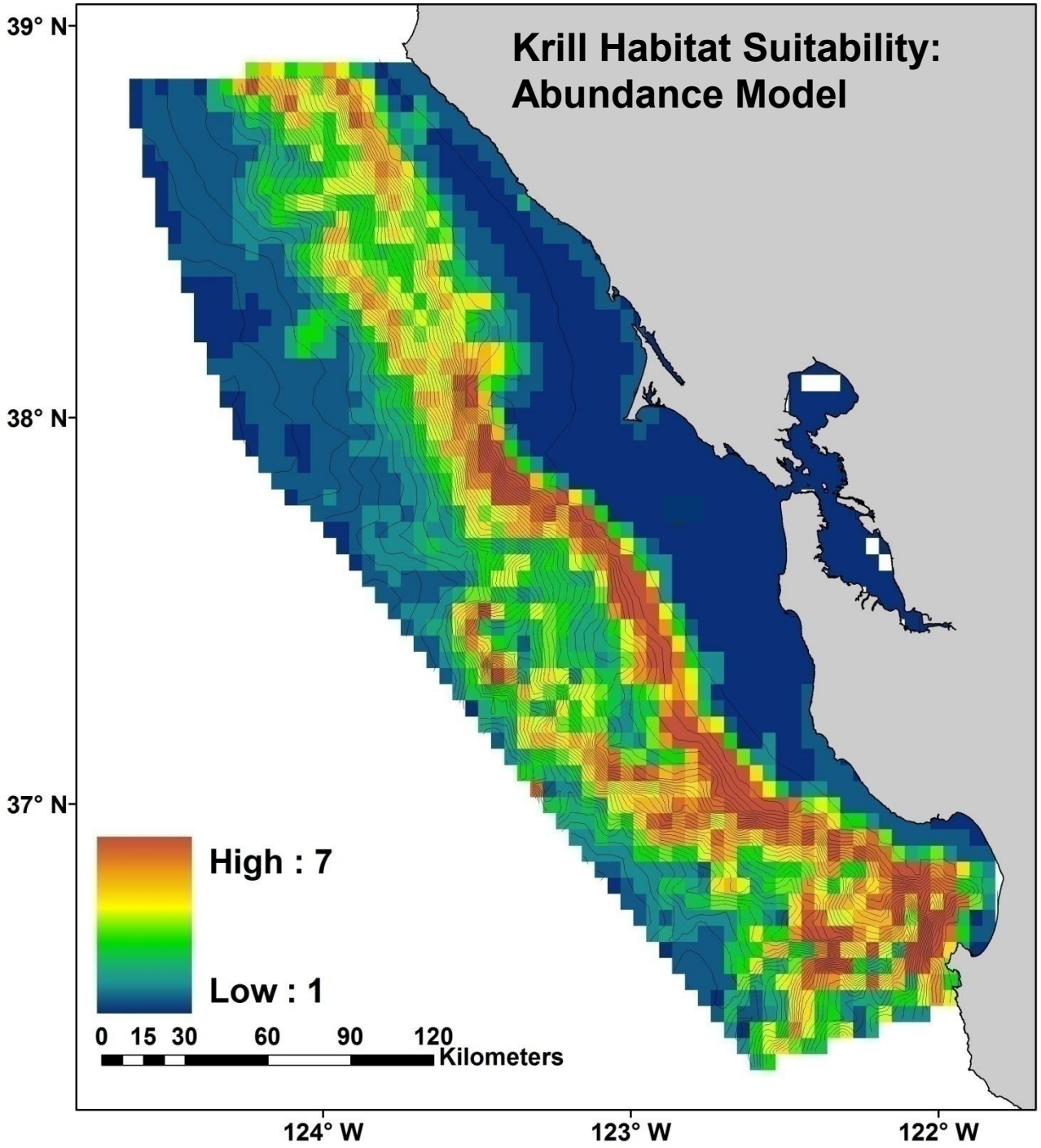

Krill Habitat Suitability:
Presence/Absence Model
39° N
38° N
37° N
124° W
123° W
122° W
High : 9
Low : 1
0 15 30 60 90 120
Kilometers

BATHYMETRIC PREDICTORS

GLM: GAMMA DISTRIBUTION WITH LOG LINK FUNCTION MAXIMUM LIKELIHOOD ESTIMATION AND AIC

Variable	Estimate	SE	Wald Stat.	p
Intercept	5.765	0.142	1651.316	<0.0001
Depth	0.000352	0.00003	191.231	<0.0001
Slope	0.1057	0.0086	150.452	<0.0001
Aspect	-0.0115	0.012	0.911	0.3398
Curvature	-0.0703	0.0312	5.085	0.024

Model	Var1	Var2	Var3	Var4	d.f.	AIC
1	Depth	Slope	Curvature		3	50114.63
2	Depth	Slope	Aspect	Curvature	4	50115.90
3	Depth	Slope			2	50117.26
4	Depth	Slope	Aspect		3	50118.86


Krill Habitat Suitability:
Abundance Model
39° N
38° N
37° N
124° W
123° W
122° W
High : 7
Low : 1
0 15 30 60 90 120
Kilometers

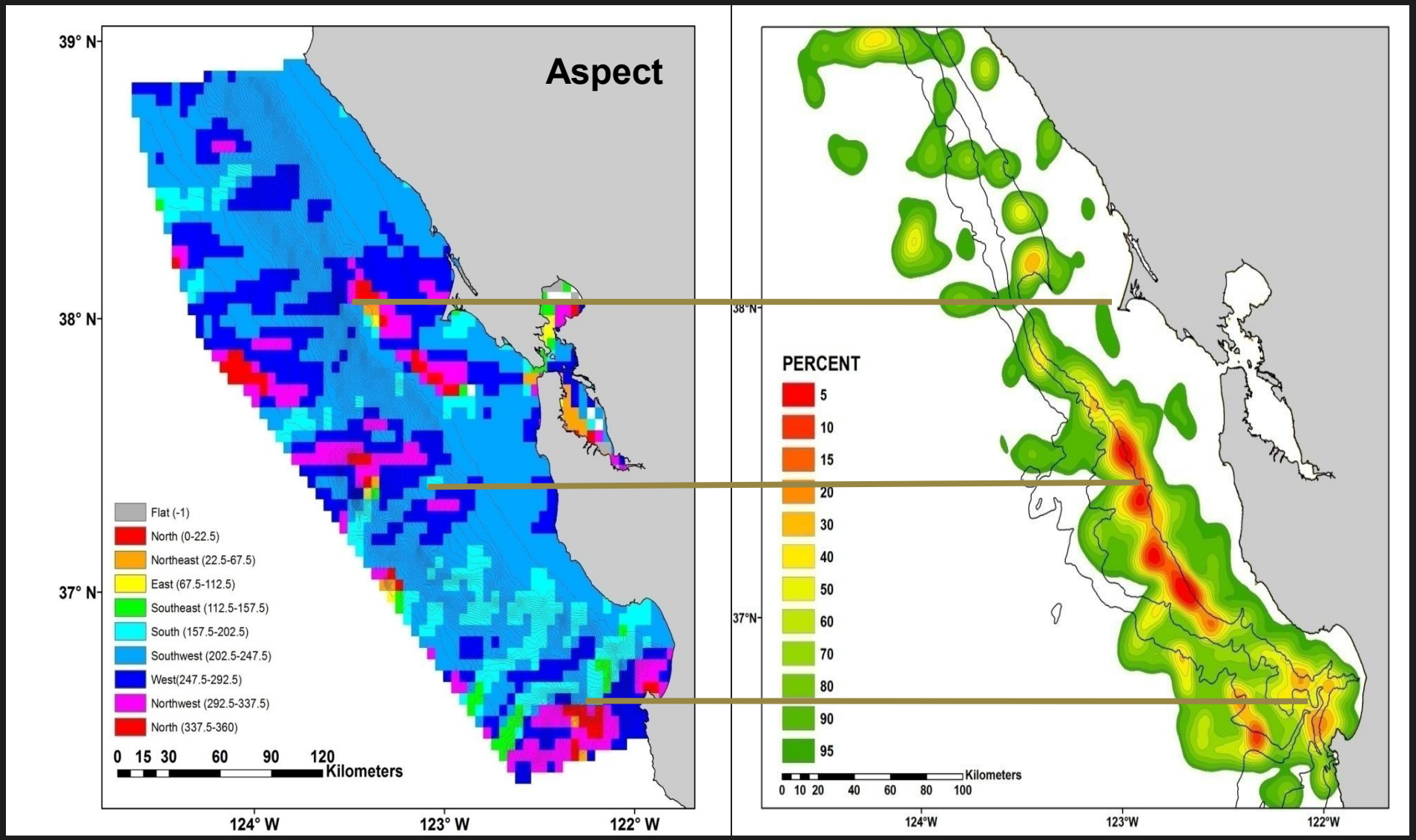
SUMMARY

- H_o: Krill P/A and relative abundance (spatial organization) similar, related to bathymetric characteristics

  Course-scale: Depth, Slope
  Finer-scale: Aspect, Curvature

New Hypothesis: Aspect, Curvature explain the details of krill patch structure in space/time

D KRILL STACK UP AGAINST NORTHWARD-FACING SLOPE



CONCLUSIONS

I. Spatio-temporal ecology key to UTL responses to climate

- Recent changes in spatial structure of euphausiids has contributed to bird productivity and salmon run failures; whale re-distributions; closed fisheries

I. Better understanding of spatial ecology needed to predict ecosystem change and manage ecosystems, holistic perspective

II. Euphausiids are difficult: integrated (net, acoustic and predator-based sampling) approach most effective

III.MSP and forecasting krill-predators (many spp.) dependent on understanding krill habitat suitability...this study a first step


TIME TO EAT:
THANK YOU