Studies on least tern foraging requirements done in support of dredging and maritime construction in Oakland Harbor

Many Thanks to:

Eric Jolliffe

Chris Bandy

Meredith Elliott

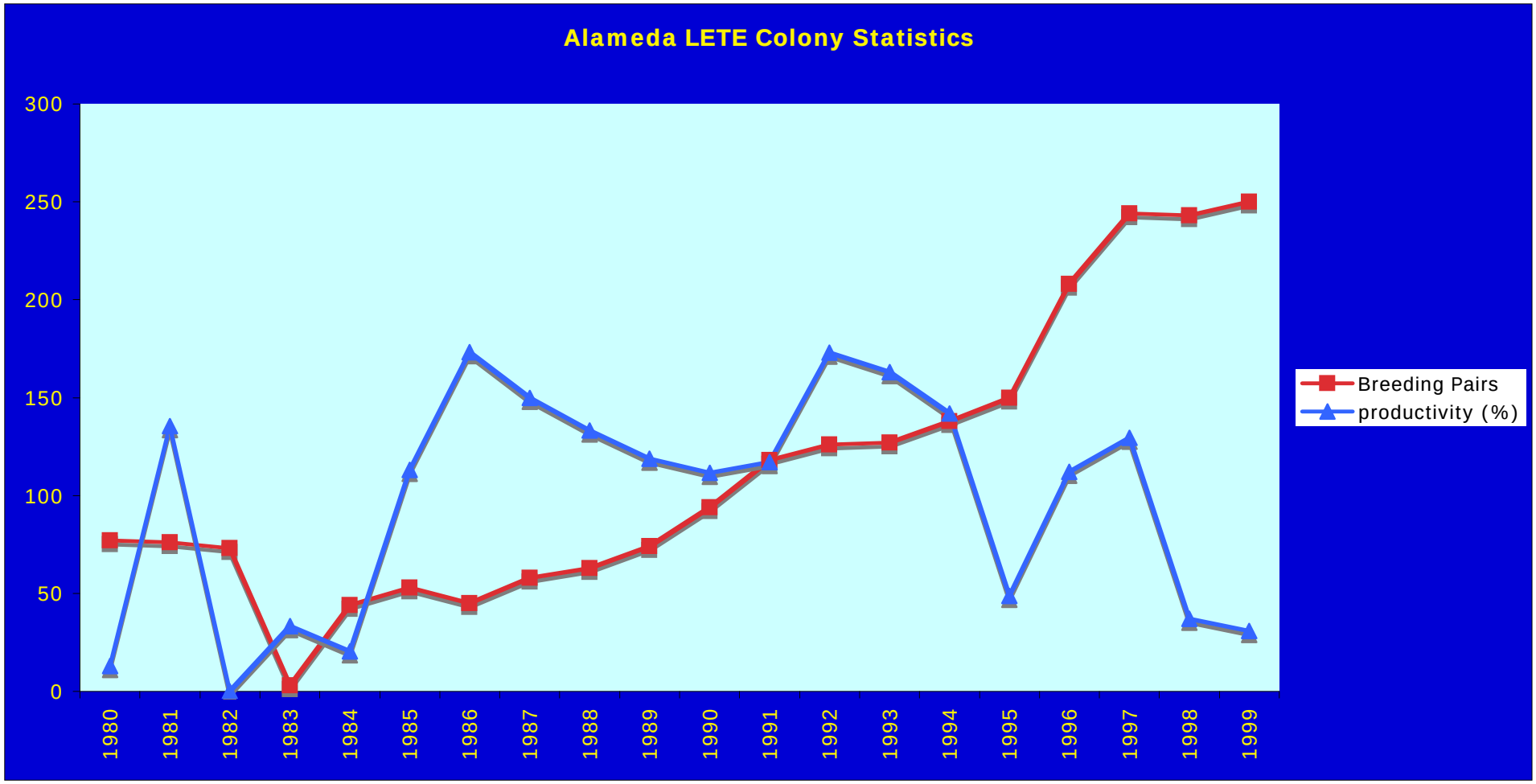
Chris Ehrler

Jody Zaitlin

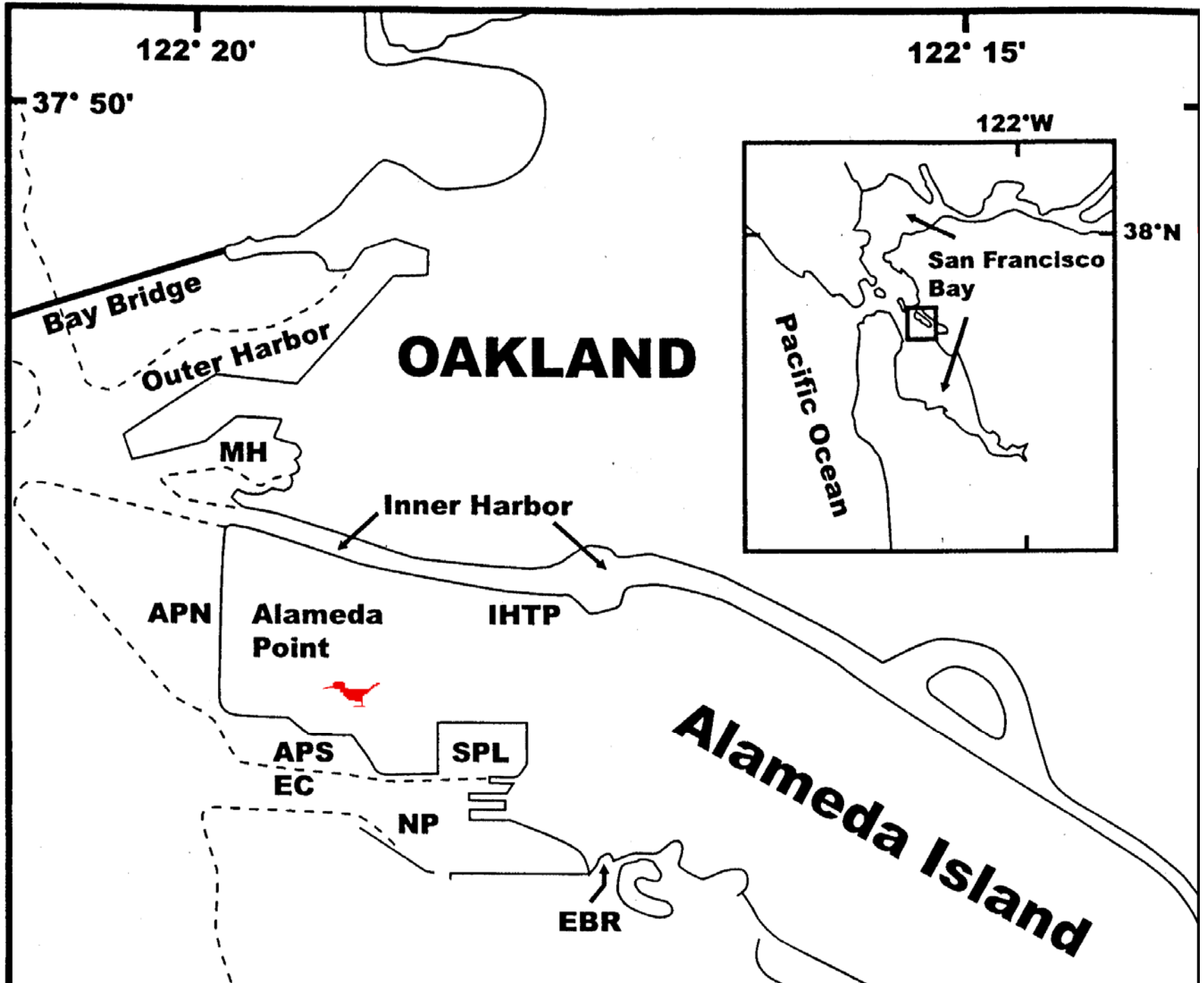
EBRPD

City of Alameda

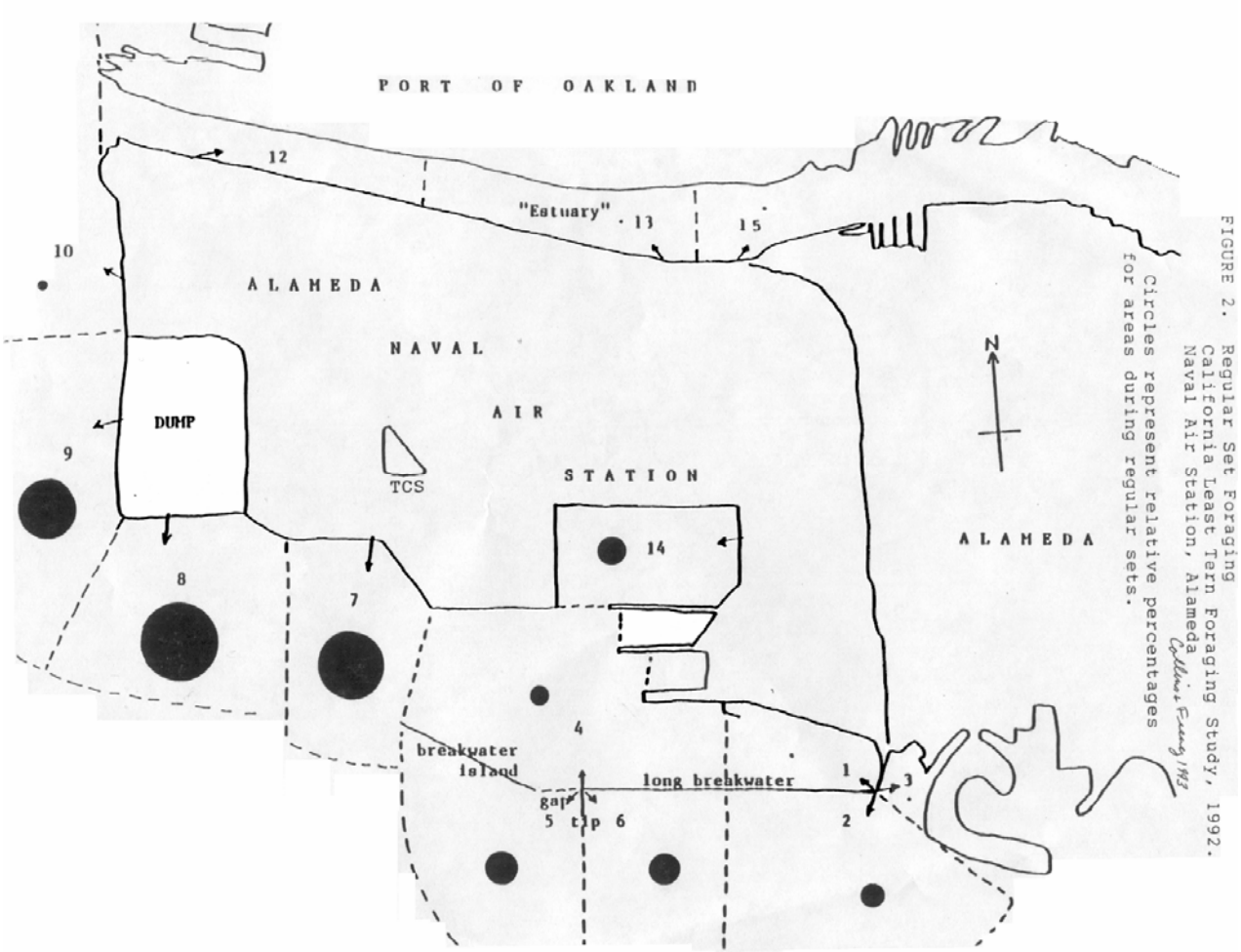
Colony stats



Vicinity

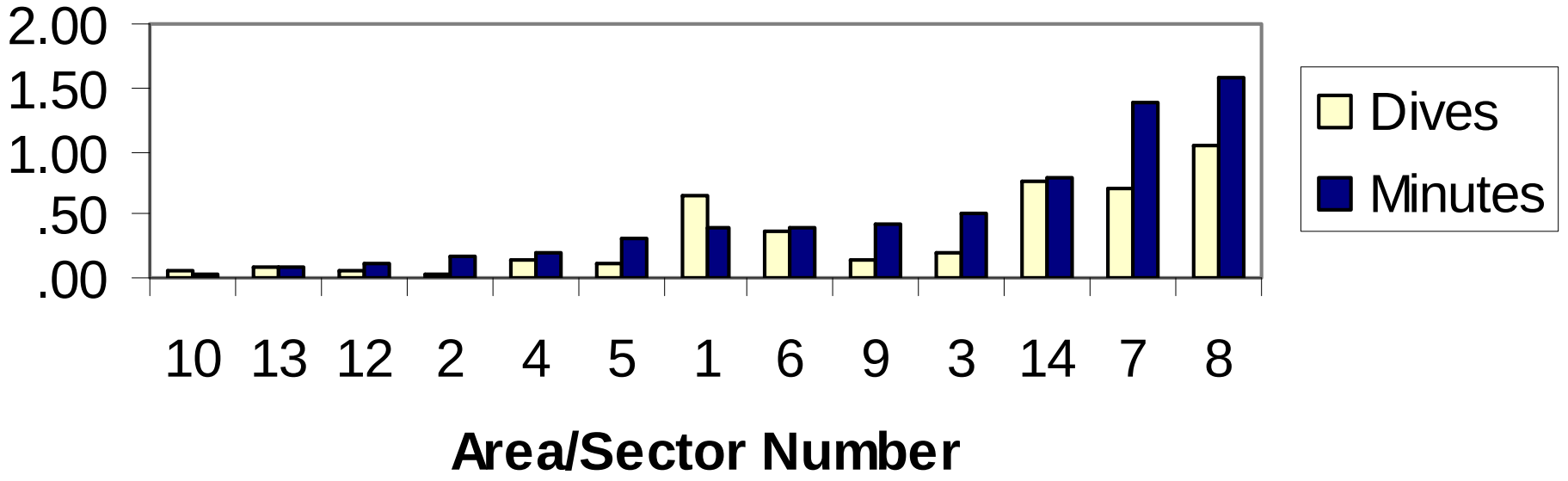

122° 20'
122° 15'
37° 50'
122°W
38°N
San Francisco Bay
Pacific Ocean
Bay Bridge
Outer Harbor
OAKLAND
MH
Inner Harbor
APN
Alameda Point
IHTP
APS
EC
SPL
NP
EBR
Alameda Island

U.S.Navy studies, ~ 20 yrs



Scaled Data

Figure 1. Dives or Bird minutes per ten acres per ten minutes



50' Biological Opinion

called for a study of least tern foraging at paired sites that "strongly show and do not show turbidity, as induced by [the project]."

“Statistical Design”

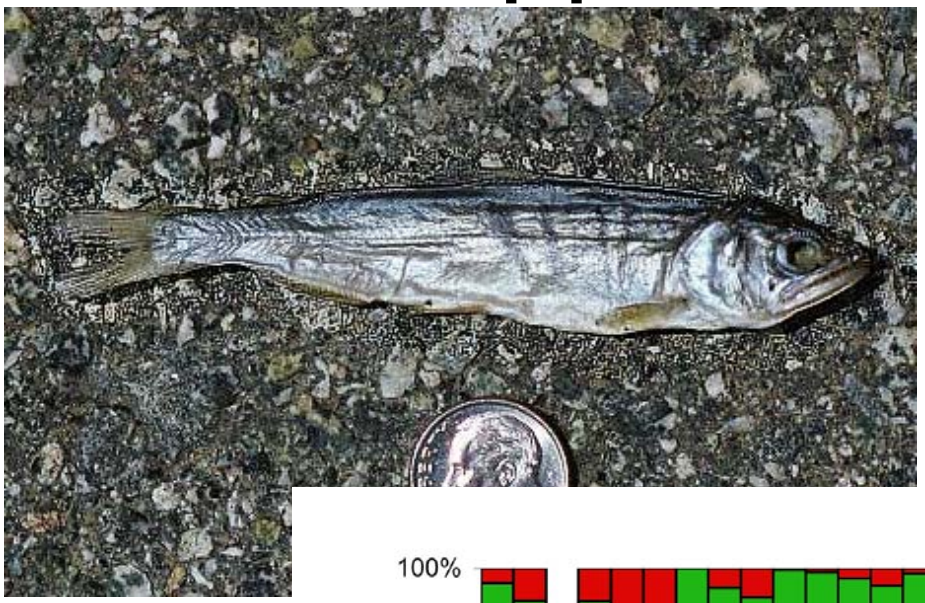
" The analysis of results shall not presume no effect of dredging and test the “alternative” hypothesis of an effect at a 95 percent confidence level; rather the study shall report the statistical confidence level of the no-effect and effect hypotheses given the observed data."

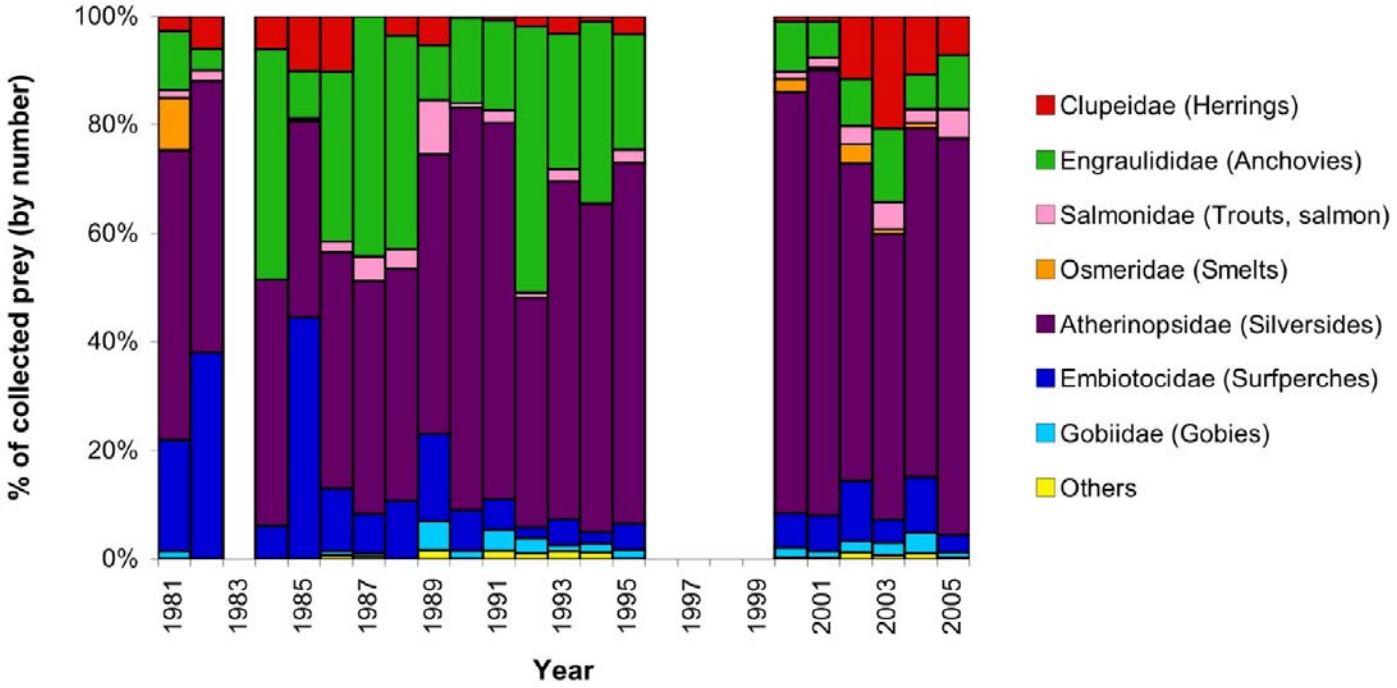
Foraging Baseline

Table 1. Number of least tern dives per 10 minute observation period per sector on 12 dates in 1997(data from Entrix 1997).

Location	Sector	6/4	6/6	6/9	6/11	6/20	6/25	6/30	7/9	7/11	7/14	7/18	7/23	Total dives
south far	1			3	2	28			9		3			45
south far	2		2		2			2						6
south far	3									4				4
south far	5				5			14						19
south far	6			7			1	67		1				76
south near	4			1	22	10				1				34
south near	7		17	14	9		1	22		2	37	2		104
south near	8	2	179	7	1	6	12	5					1	213
south near	14		35	3	1	27	2			21				89
west	9				1	16	30	1						48
west	10					17	3			1				21
Inner Harb.	12	2				1		2		1	1			7
Inner Harb.	13					1	2	4	2	1				10
Inner Harb.	15					2		1	6		3			12
Middle Harb.	16	7						6		1	2			16
Outer Harb.	17						1	14	4					19
Total dives		11	233	35	43	108	52	138	21	33	46	2	1	723

Dropped fish collections





Purpose of Studies

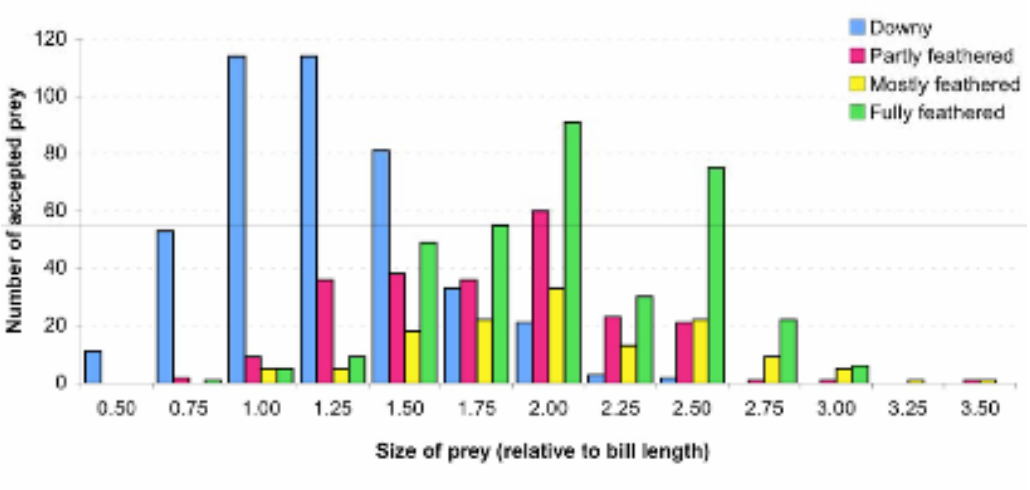
Investigate tern foraging needs

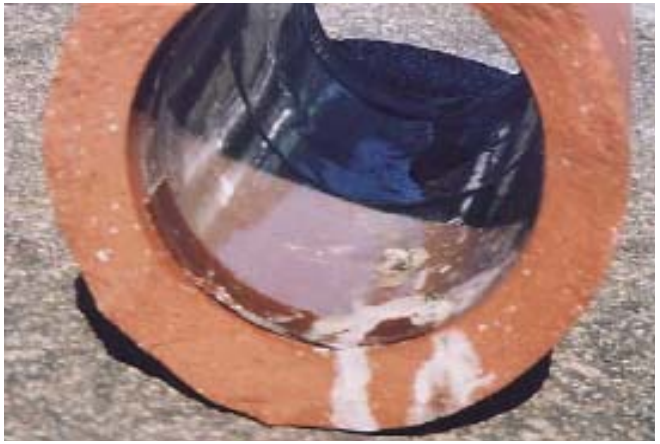
- Species
- Amounts
- Prey distribution
- Prey habitat requirements

Objectives:

- Get out of the office
- Quantify chick provisioning
- Estimate atherinopsid abundance
- Design efficient sampling
- Describe pattern of foraging effort
- Foraging vs. turbidity
    - Monitoring Design for MHEA

Chick Provisioning



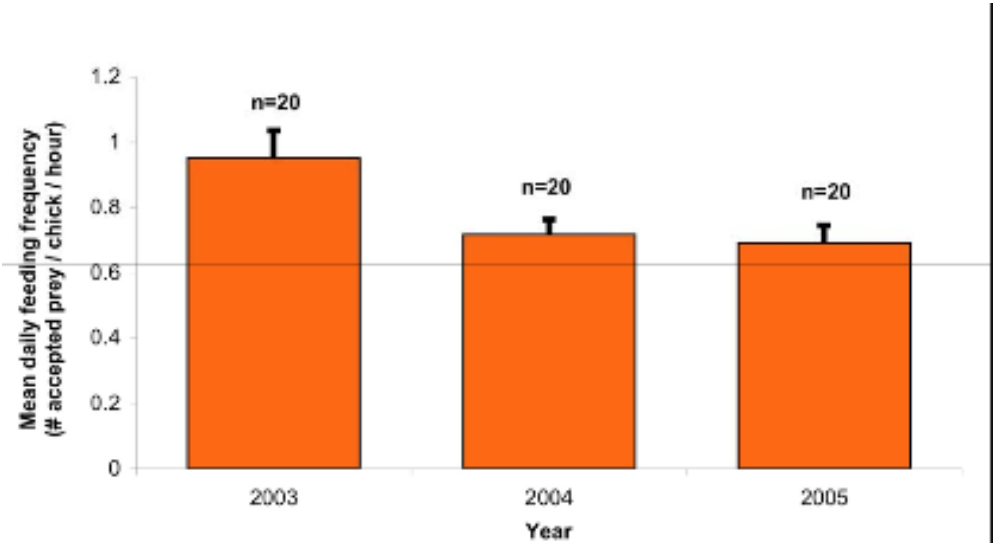


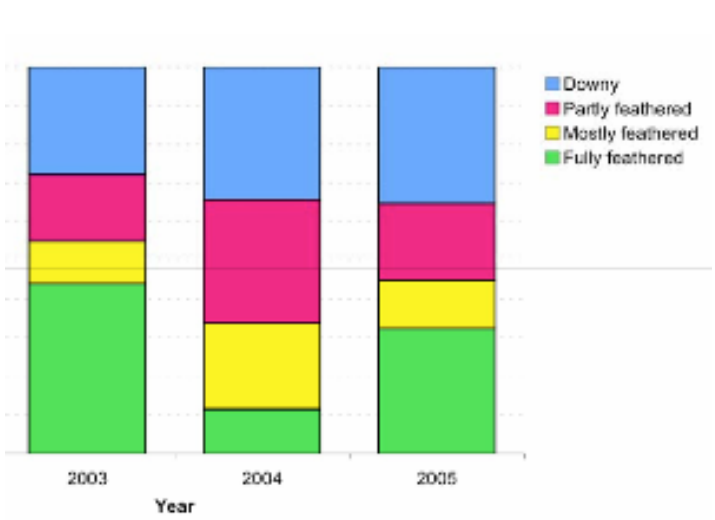
Fish fate	Number of Prey Items	Percent of Prey Items
Accepted by chick	1,468	89.2%
Dropped by chick	64	3.9%
Refused by chick	26	1.6%
Withheld from chick	43	2.6%
Unknown	44	2.7%
Total	**1,645**	**100.00%**

Species composition based on chick fecal sample analyses (all indigestible parts included); Table 30 in the report

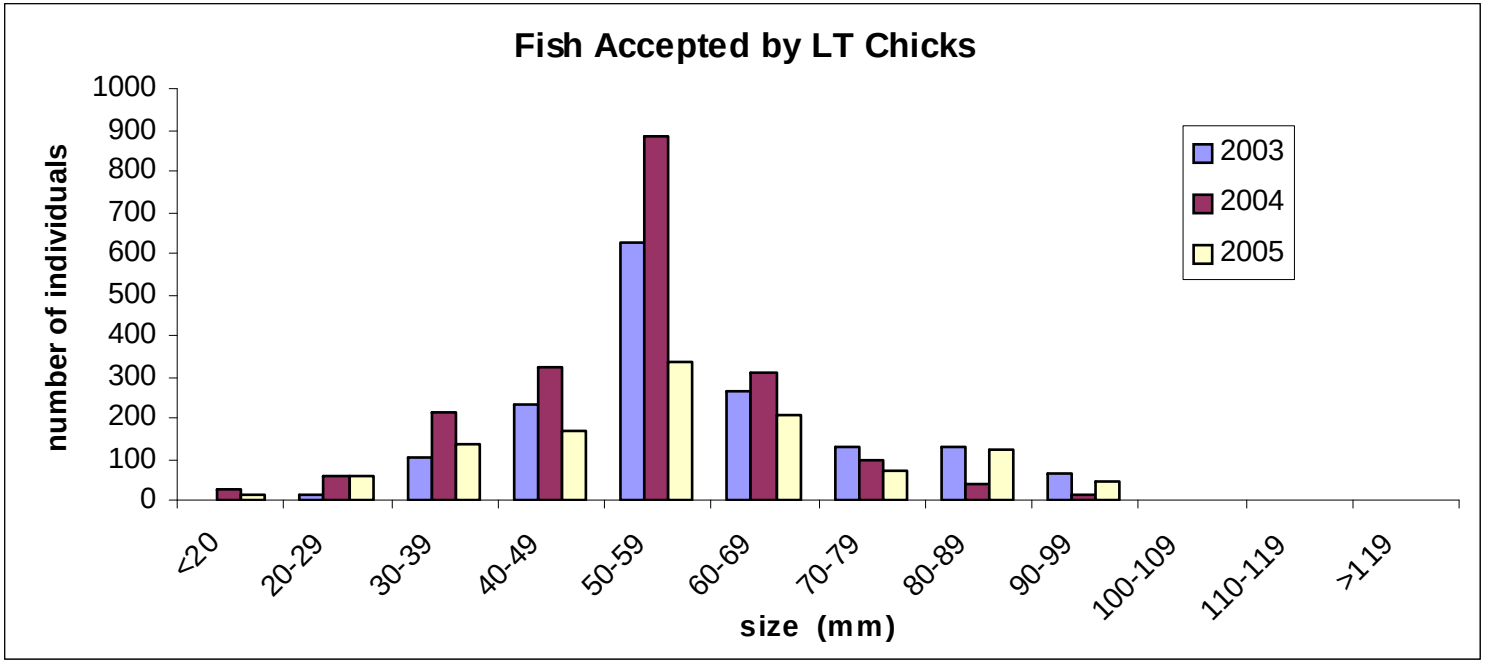
	Year				
Prey Family	2002	2003	2004	TOTAL	% frequency
Clupeidae / Engraulididae	46	56	30	132	52.38
Salmonidae	0	2	1	3	1.19
Atherinopsidae	77	77	85	239	94.84
Syngnathidae	0	1	0	1	0.4
Scorpaenidae	0	0	1	1	0.4
Hexagrammidae	3	0	0	3	1.19
Embiotocidae	2	0	5	7	2.78
Gobiidae	4	0	7	11	4.37
Total # samples analyzed	81	84	87	252	

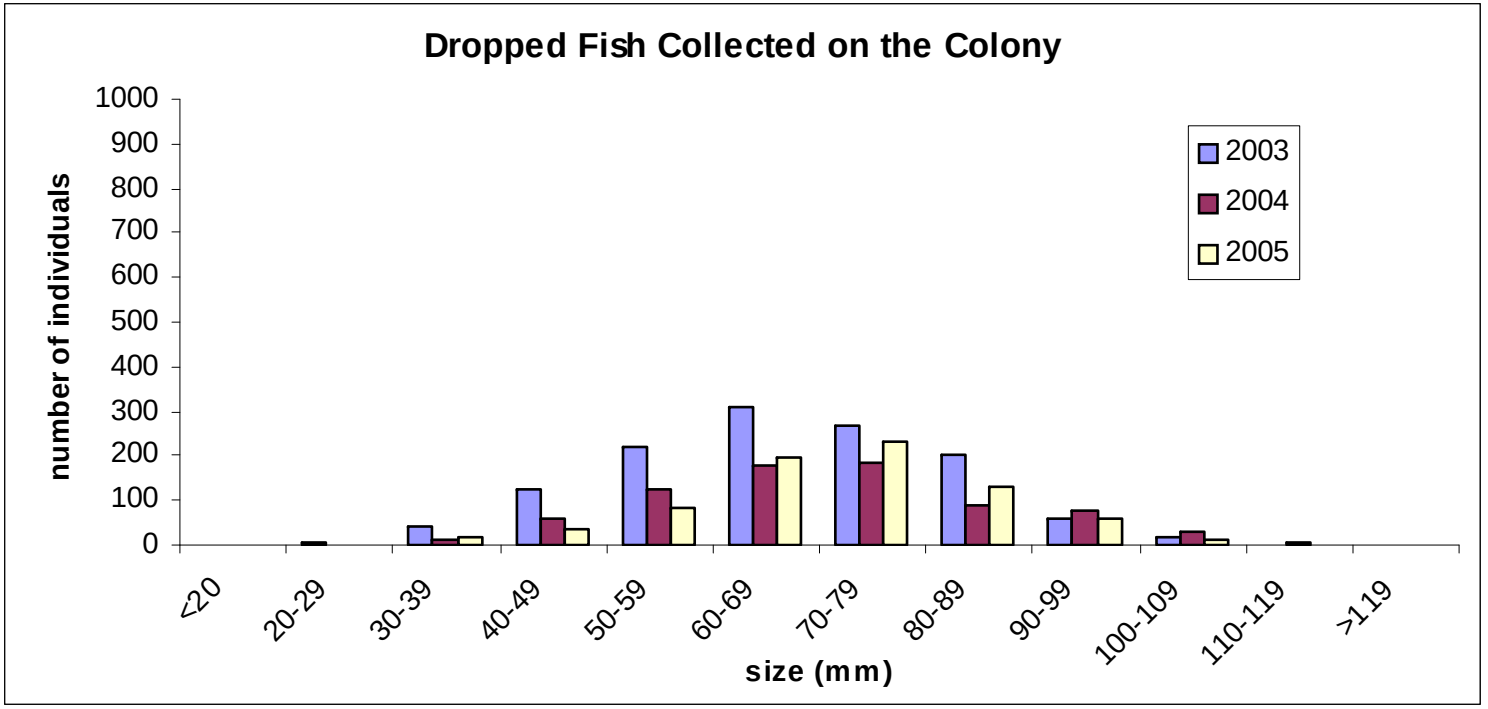
More chick provisioning



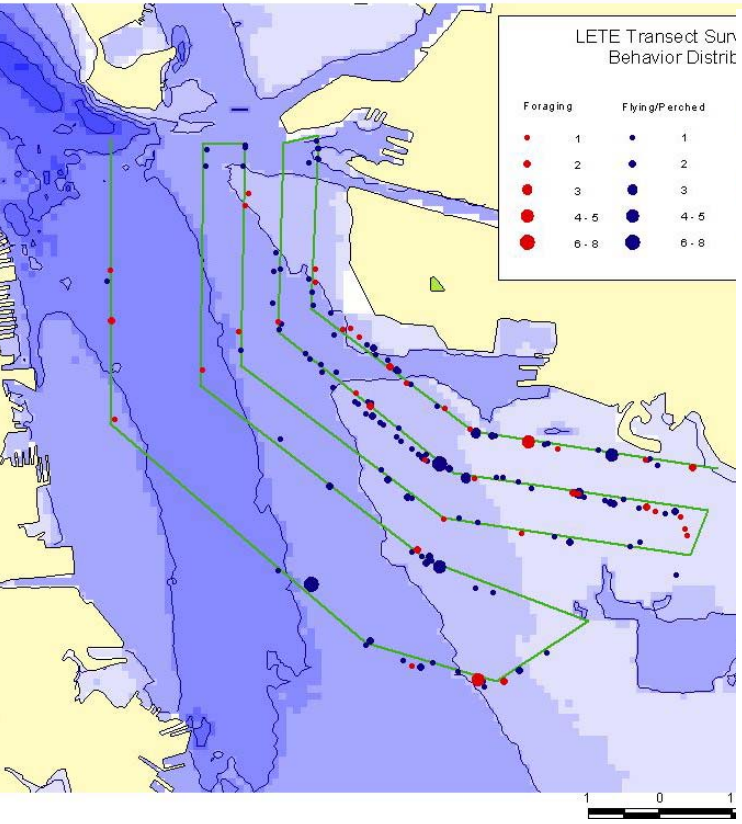


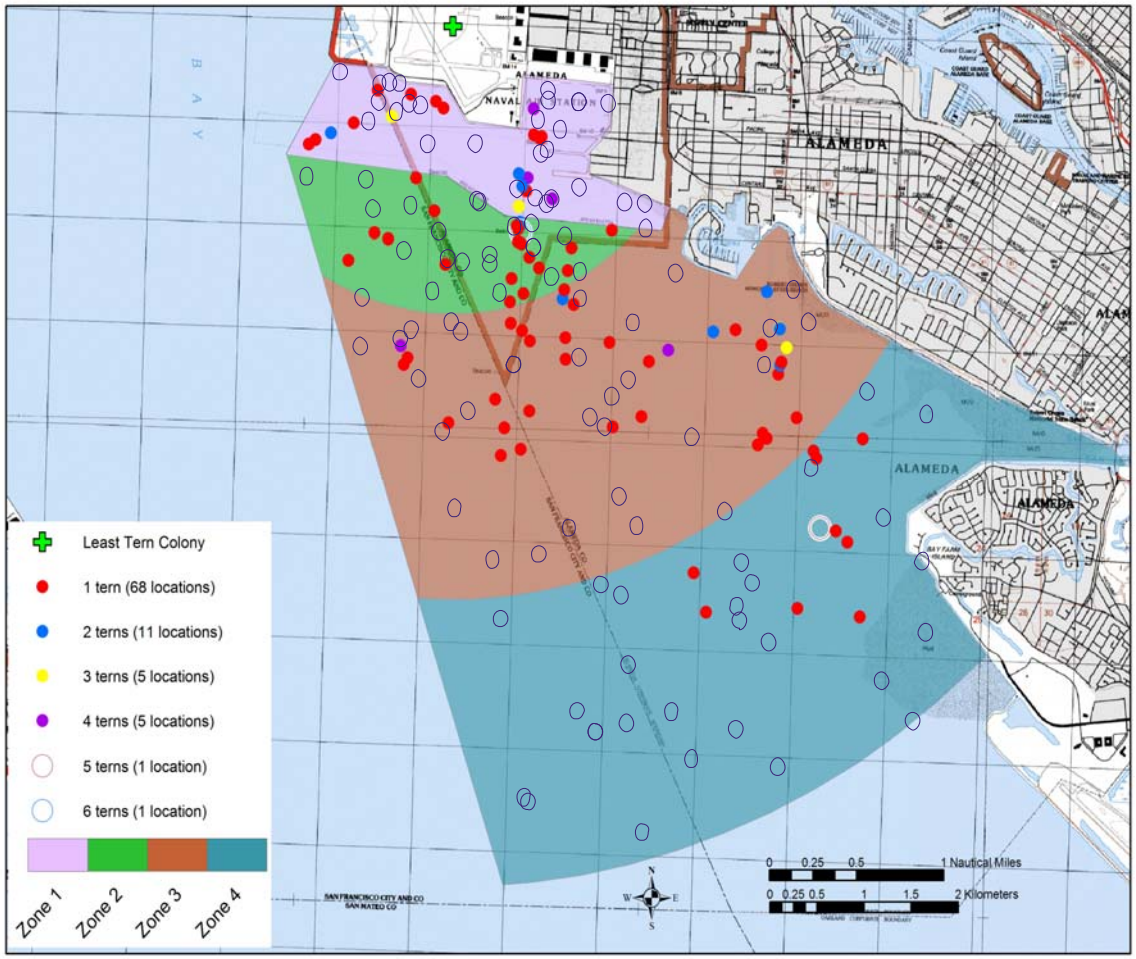
- Most inter-annual variance explained by chick age structure
- 0.7 fish/chick/hr x 14 hr x 400 chicks ≈ 4,000 fish per day
- Biomass estimates ≈ 50 kg/yr (wet)


Fish Accepted by LT Chicks
number of individuals
1000
900
800
700
600
500
400
300
200
100
0
2003
2004
2005
<20
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
100-109
110-119
>119
size (mm)


Dropped Fish Collected on the Colony
number of individuals
1000
900
800
700
600
500
400
300
200
100
0
2003
2004
2005
<20
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
100-109
110-119
>119
size (mm)

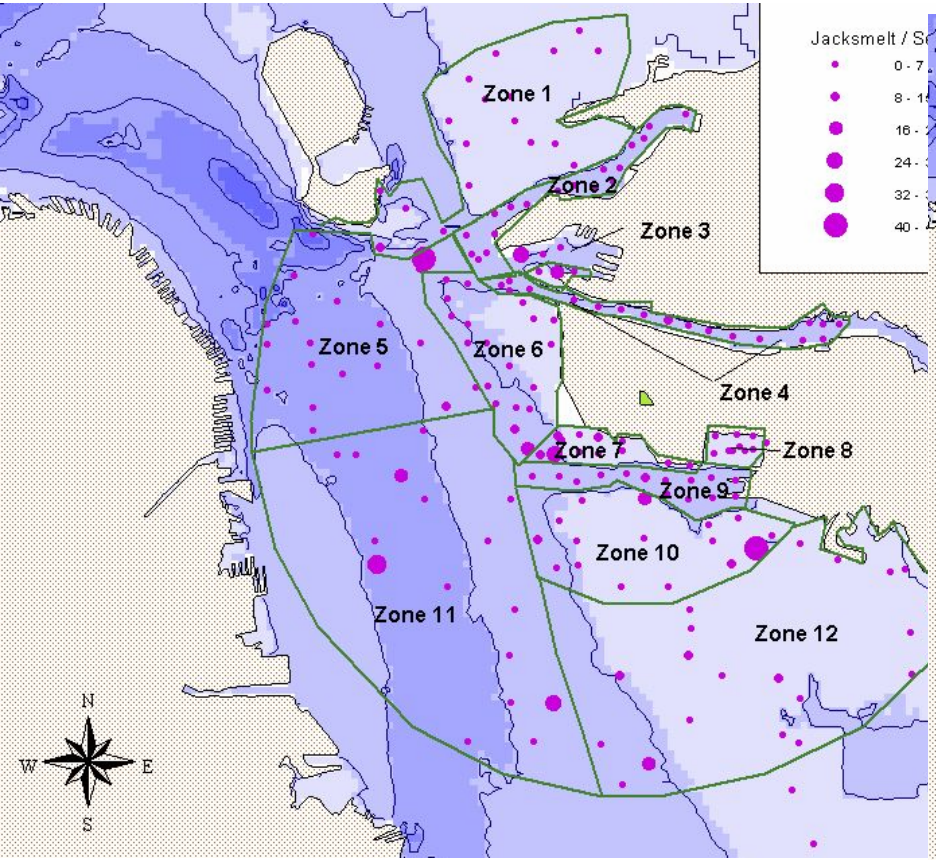
2003-2004 least tern sightings

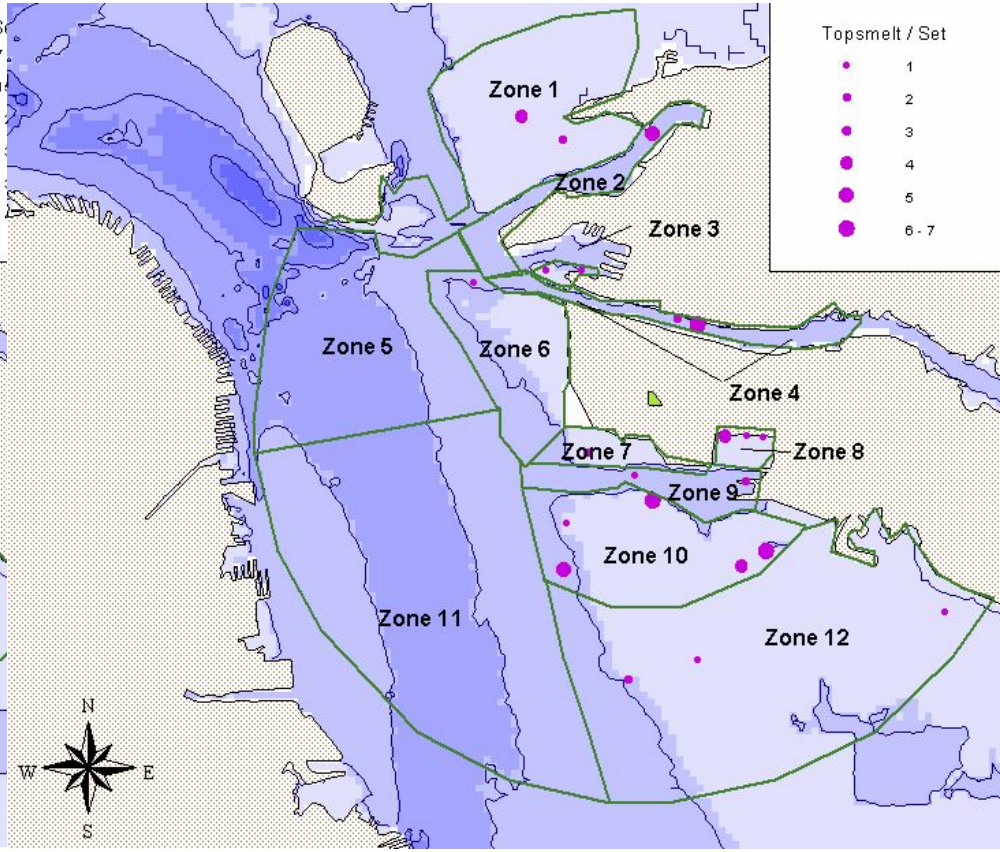




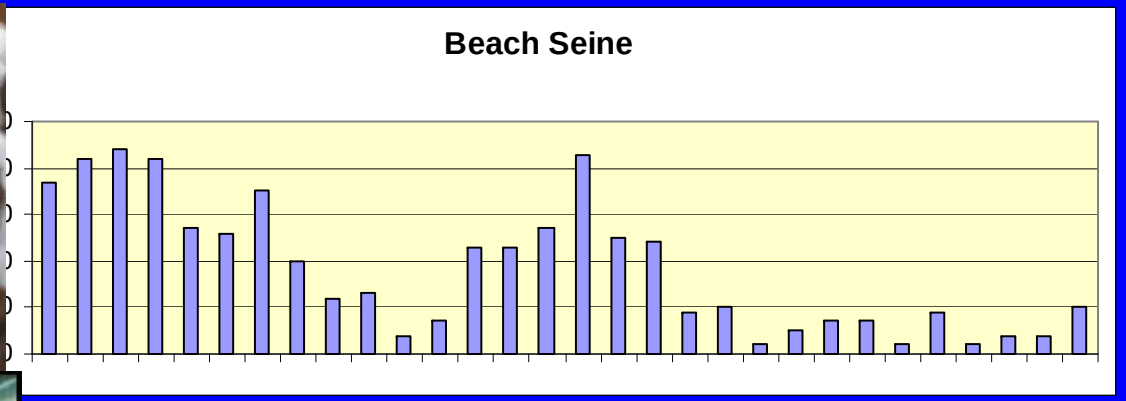
2003 Purse Seine

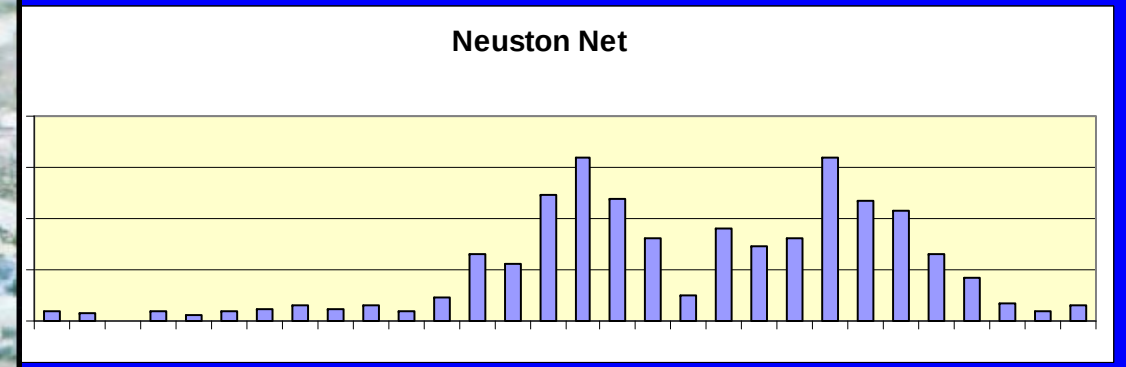
Jacksmelt and Tosmelt, all sizes

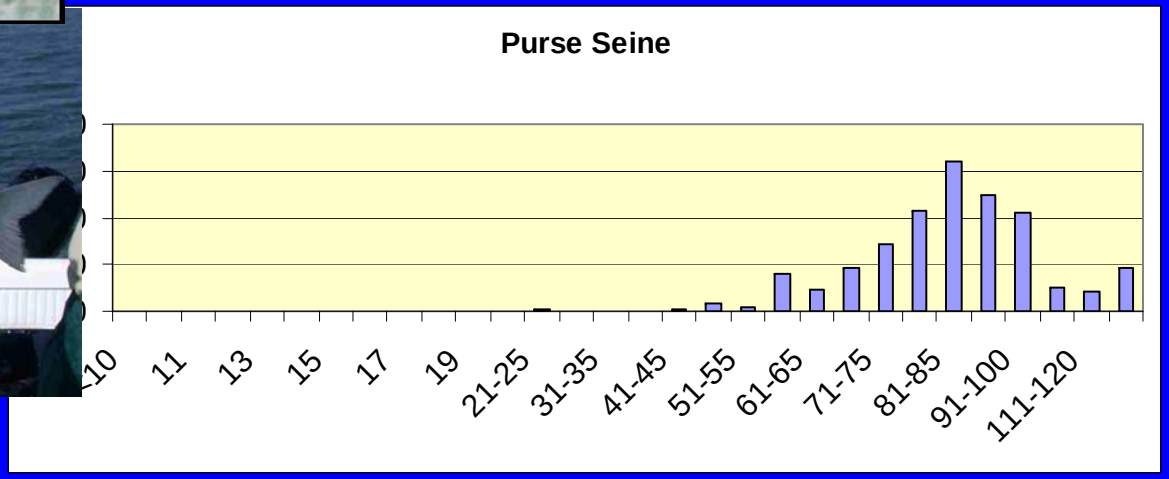




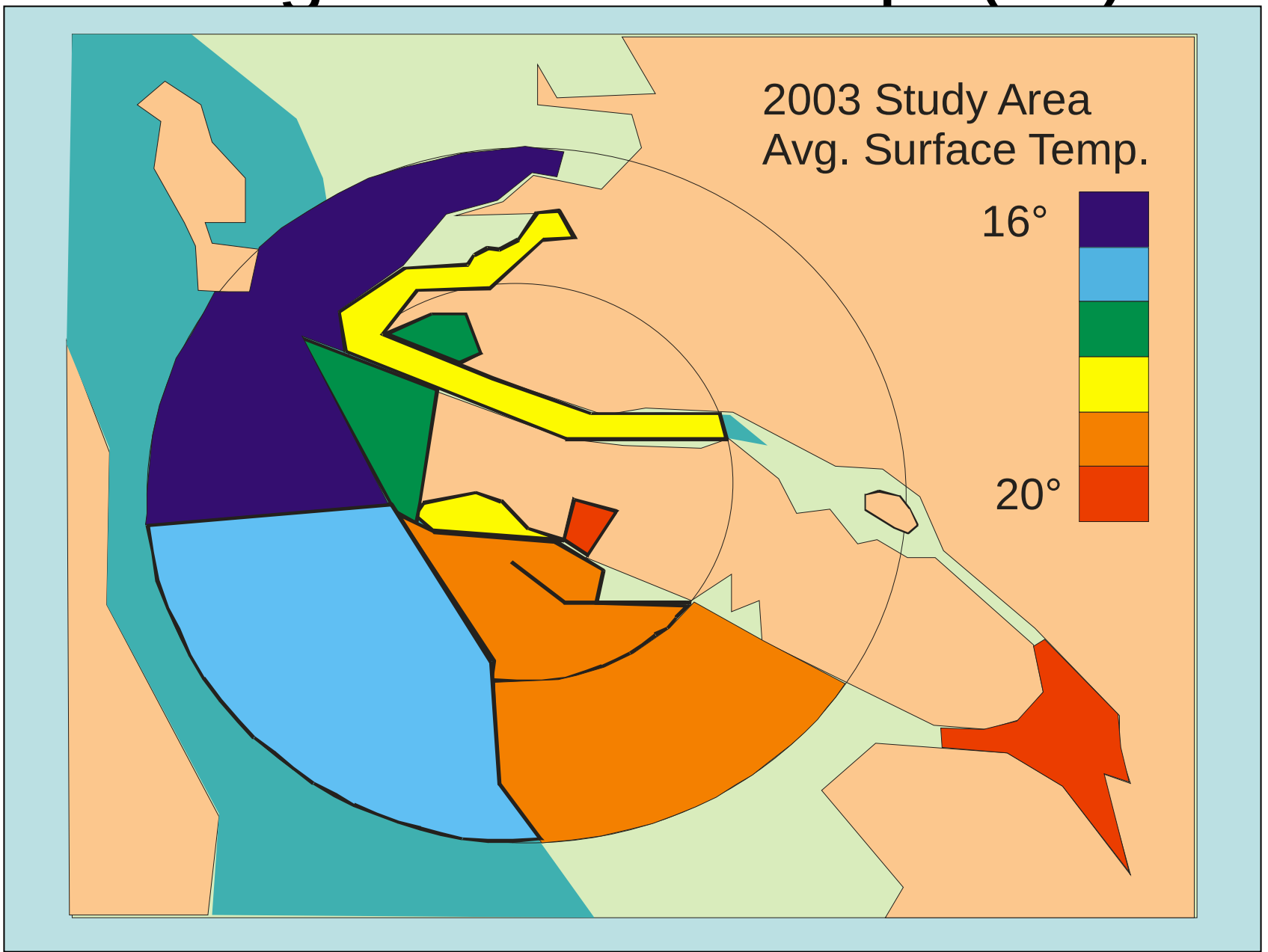
2003 Length Frequencies by Net



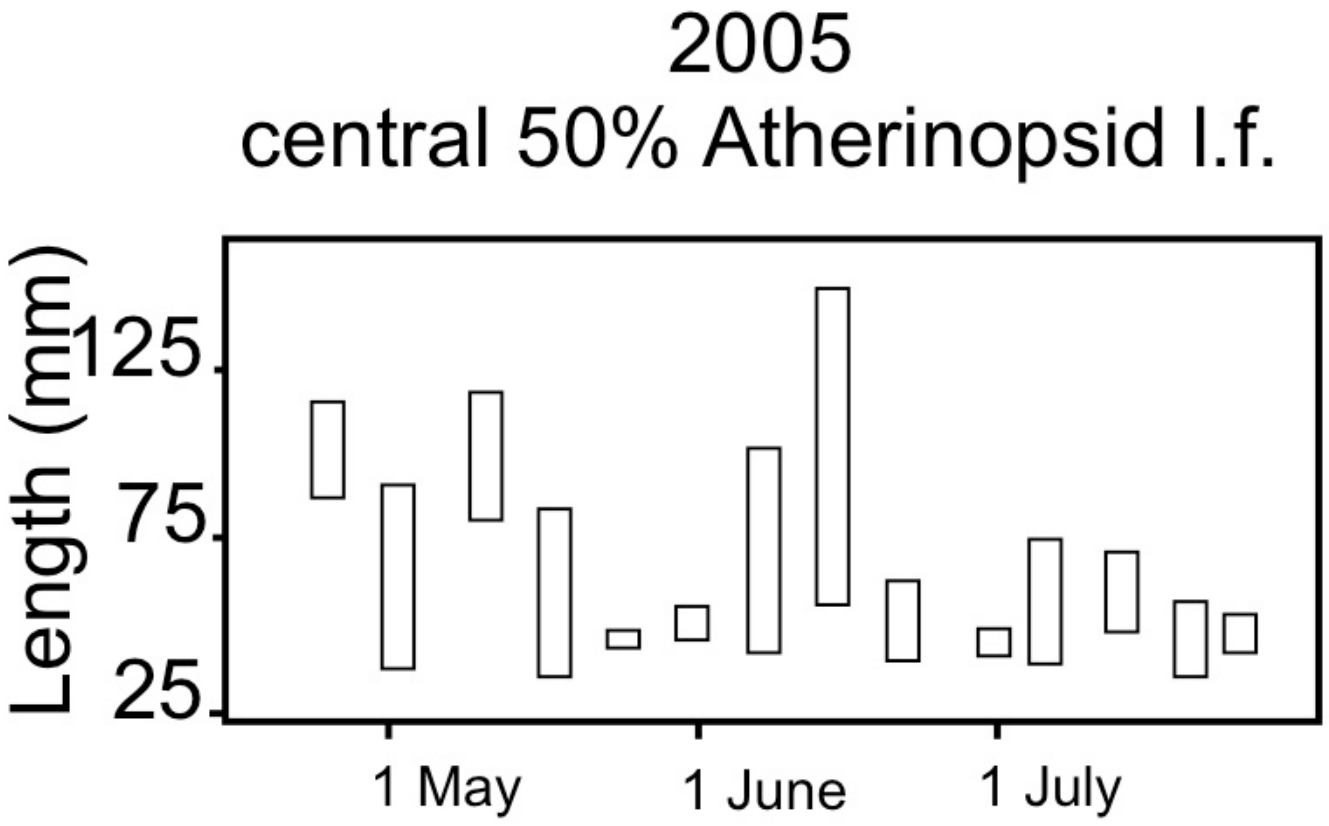




Avg. Surface Temp. (C˚)

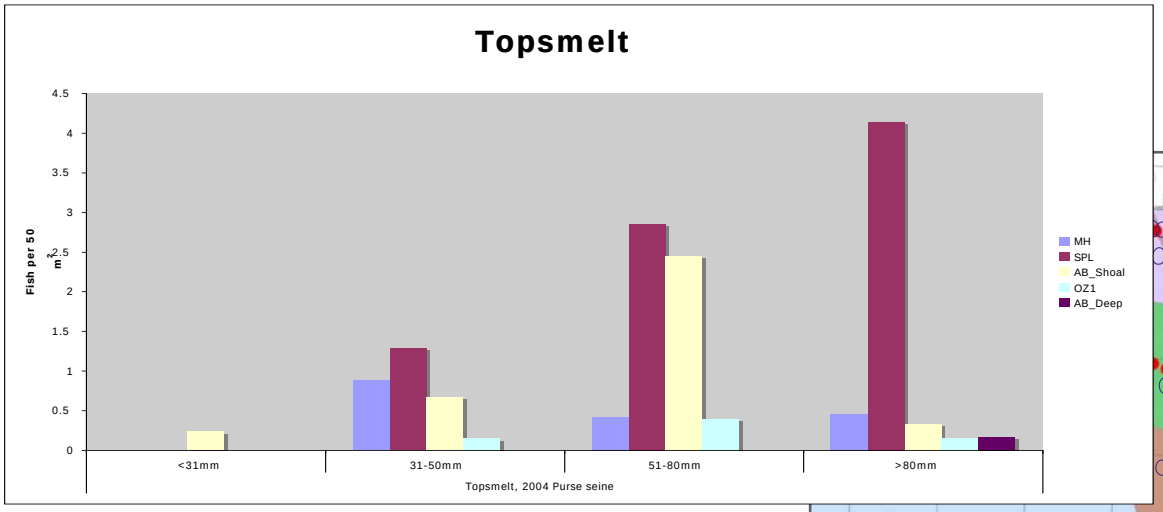


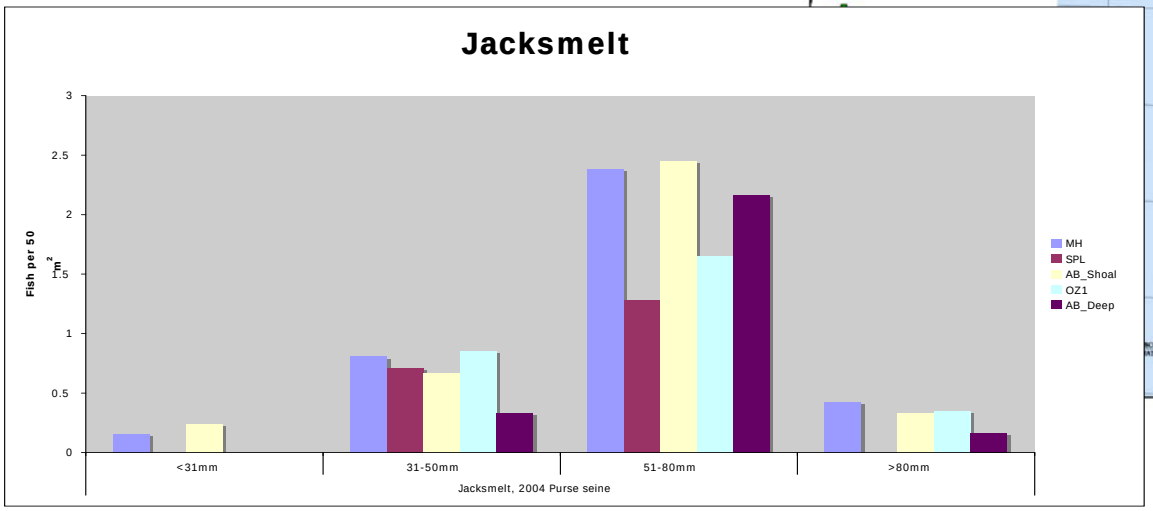
Atherinopsids spawn throughout tern season

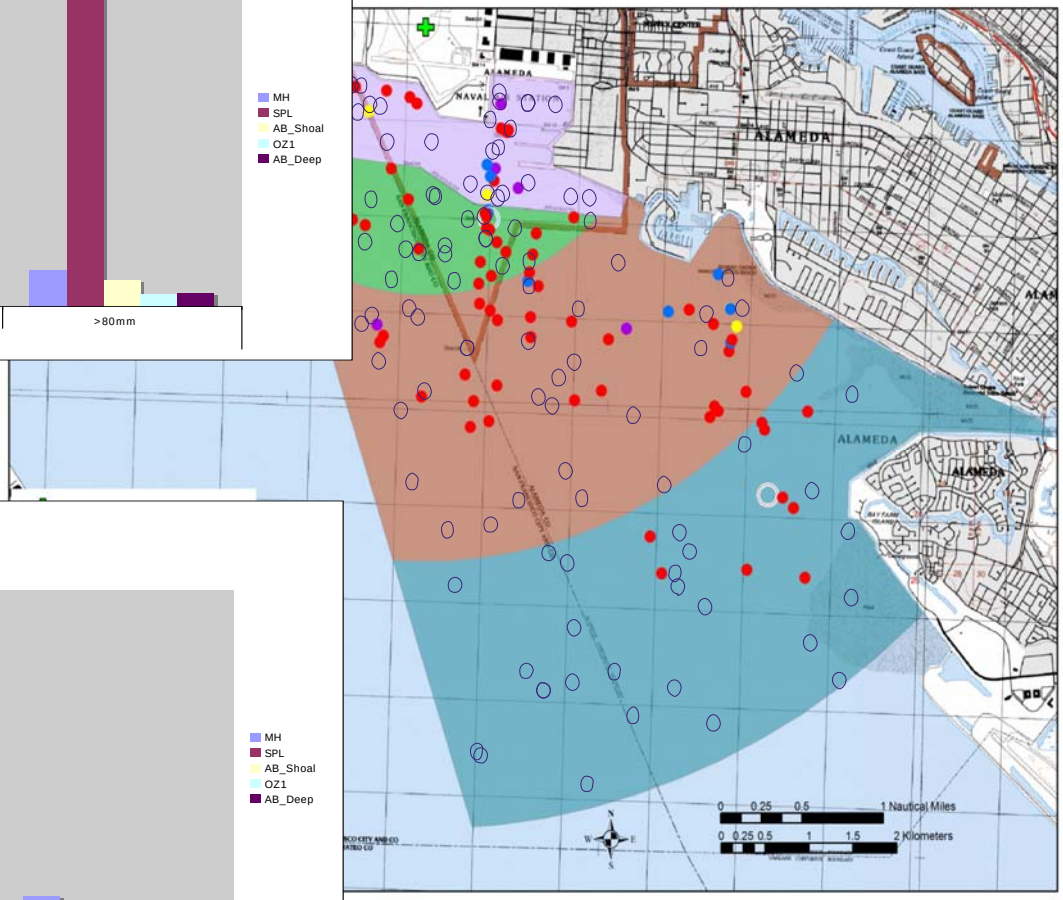


(purse seine data)

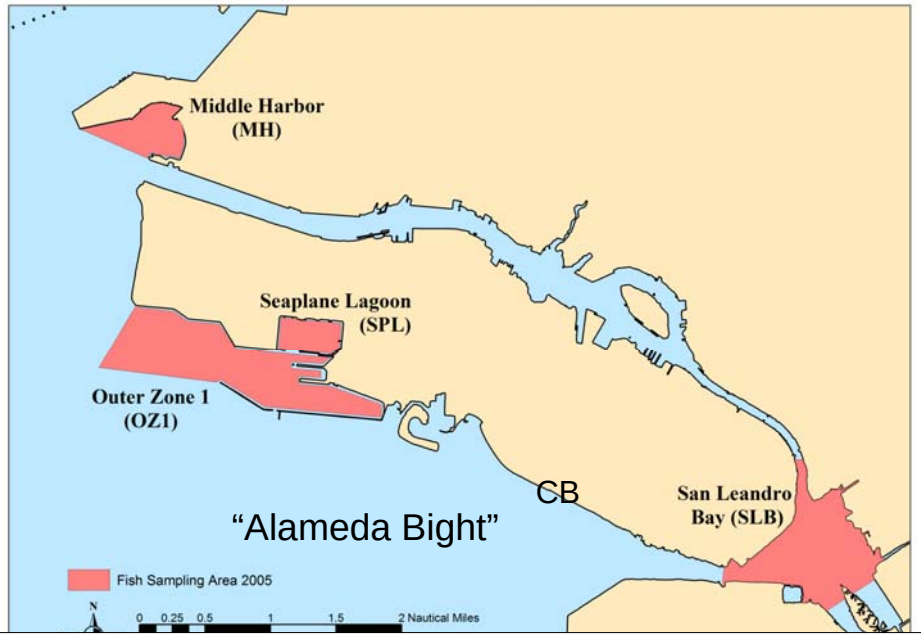
2004 Purse Seine

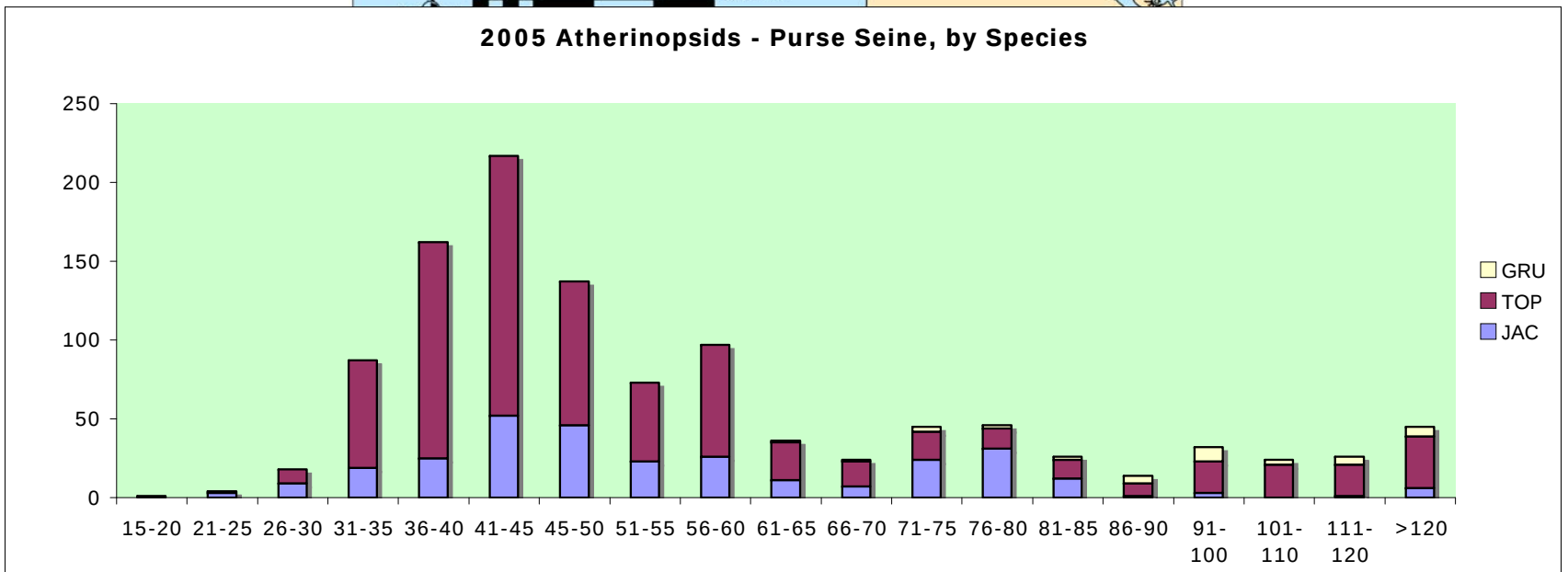




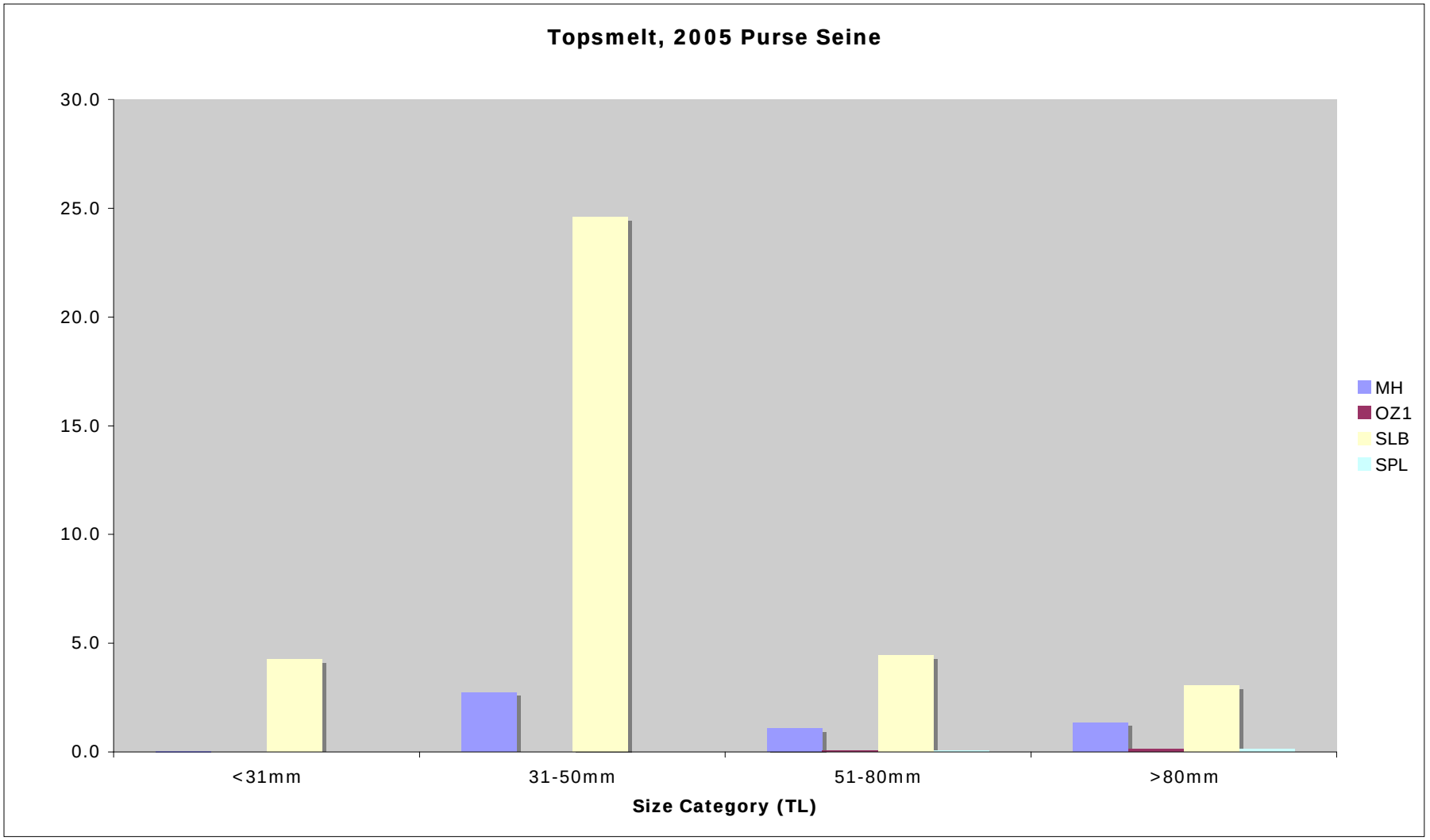


2005 Sampling Sites





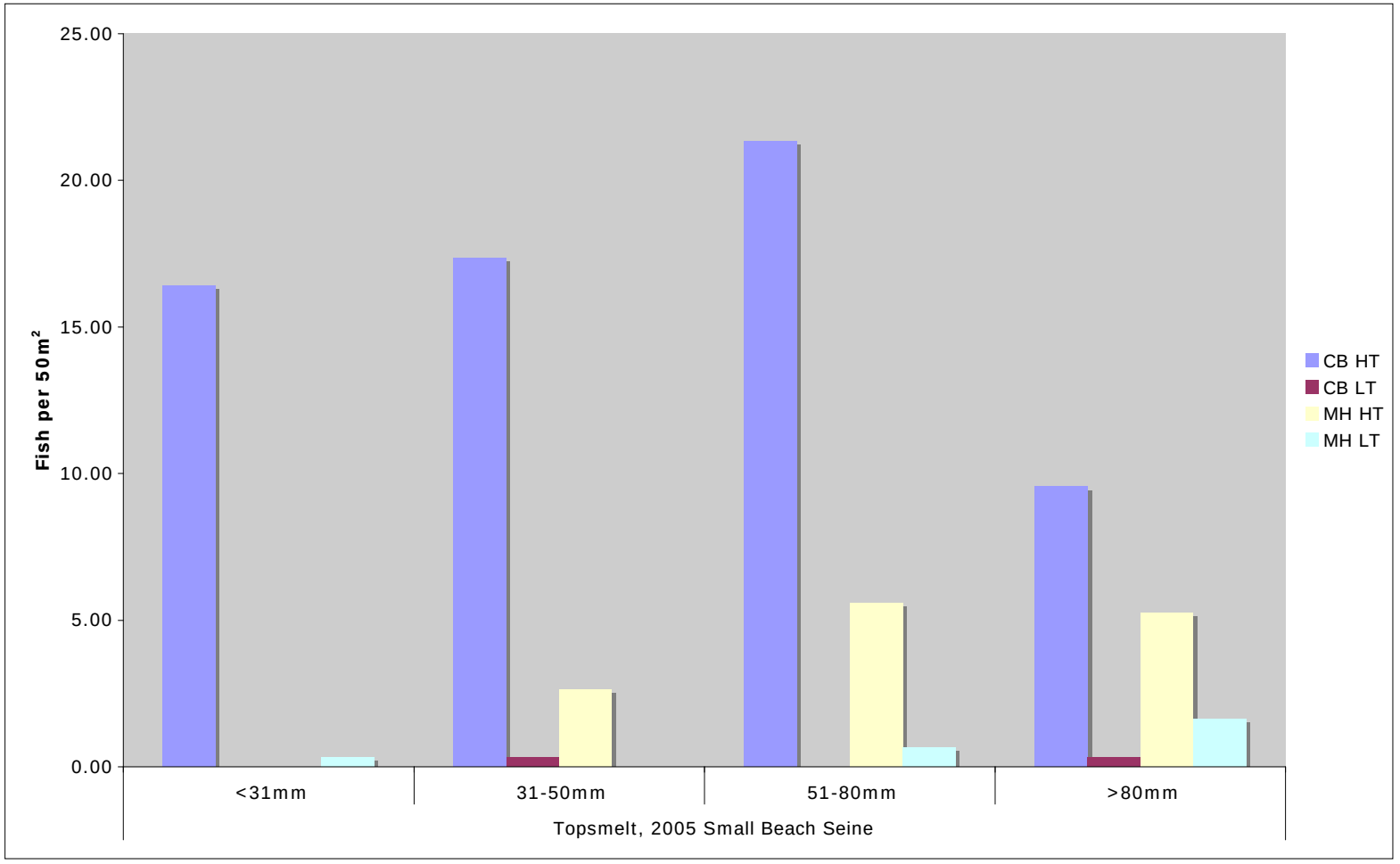
“Offshore” Topsmelt SPL, OH



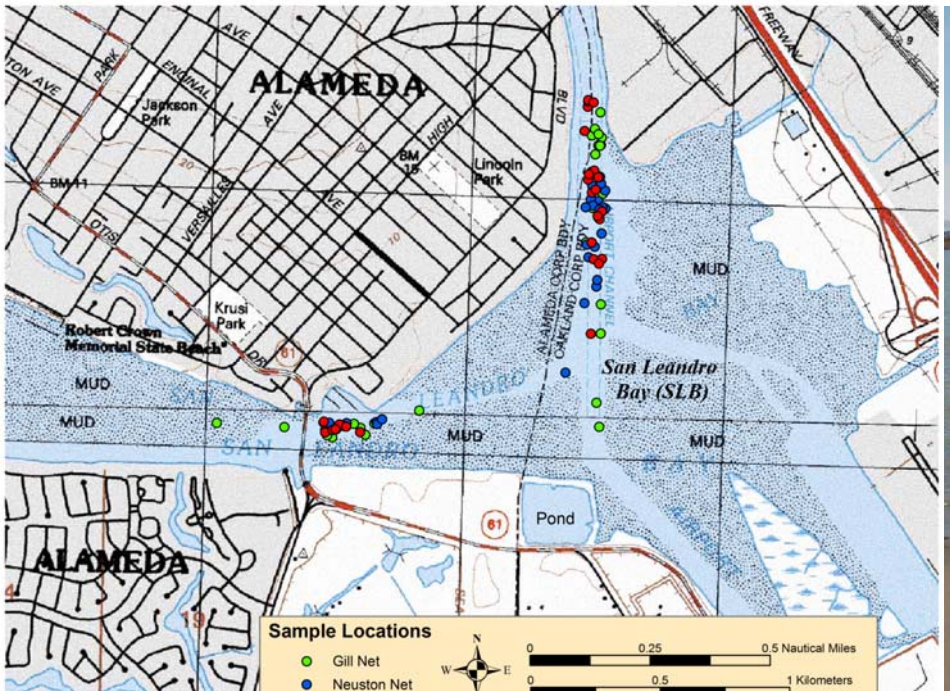
2005 Topsmelt, Beach Seine

Unid.
Atherinopsids

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.



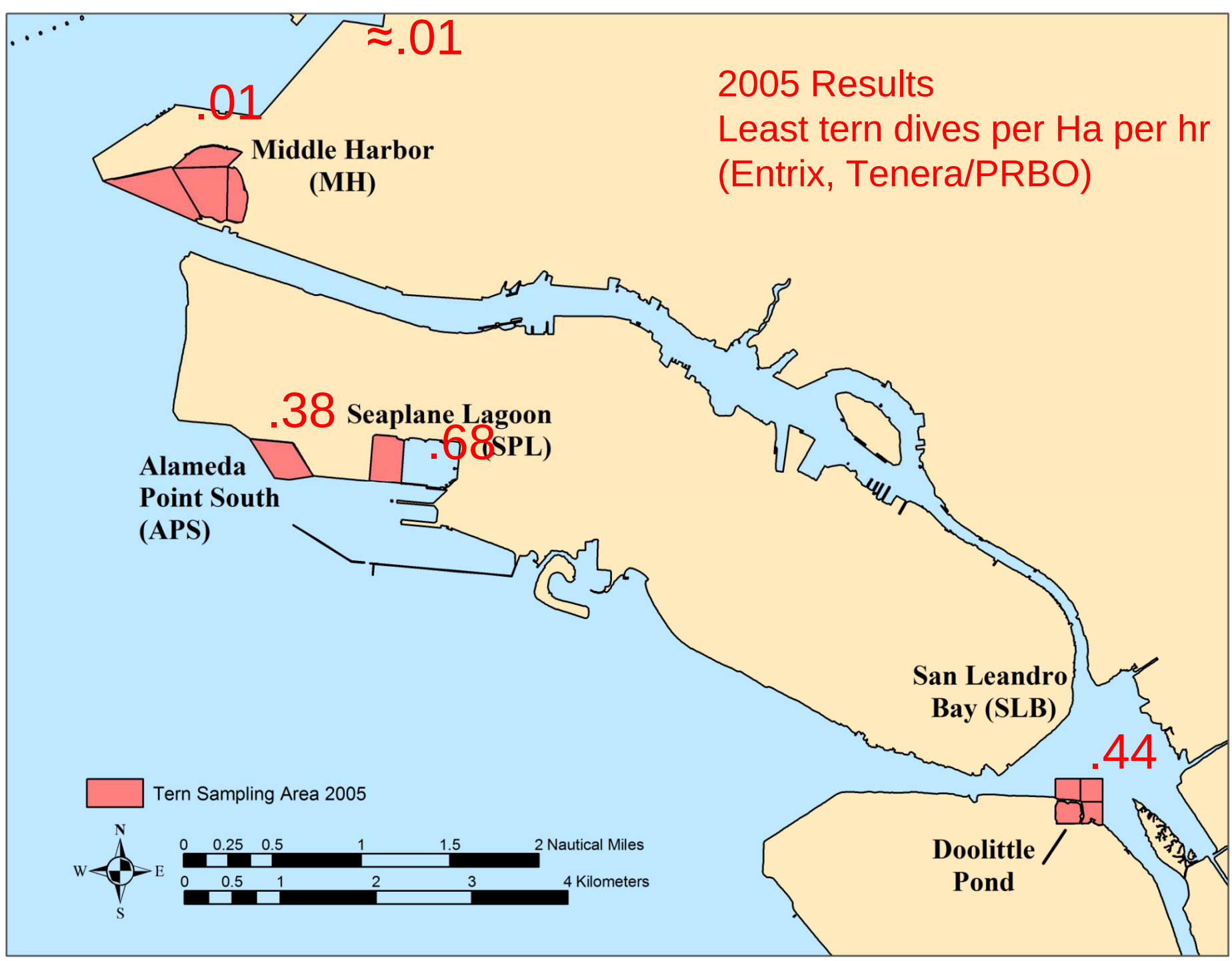
Small Atherinopsids are Intertidal



2003-2004 tern results

- Nestling diet dominated by small silversides
- Small silversides found almost exclusively in shoal water
- Tern foraging significantly correlated

(-) with depth but not with turbidity


≈.01
.01
Middle Harbor
(MH)
2005 Results
Least tern dives per Ha per hr
(Entrix, Tenera/PRBO)
.38
Seaplane Lagoon
.68
(SPL)
Alameda
Point South
(APS)
San Leandro
Bay (SLB)
.44
Doolittle
Pond
Tern Sampling Area 2005
N
W
E
S
0 0.25 0.5 1 1.5 2 Nautical Miles
0 0.5 1 2 3 4 Kilometers

Forage base accounting

Table 1. Comparative dive rates and calculated fish captures, 2005 estimates.

Location	Area (acres)	dives/acre/hr	fish per day*
MHEA	166	0.005	8
Seaplane Lagoon study area	39	0.275	100
Alameda Point South study area	40	0.154	57
San Leandro Bay sudy area	53	0.178	89
Bailey's "Primary Foraging Area"	400	0.202	756
Remainder of foraging area***	24000	0.005	1121
Total			2130

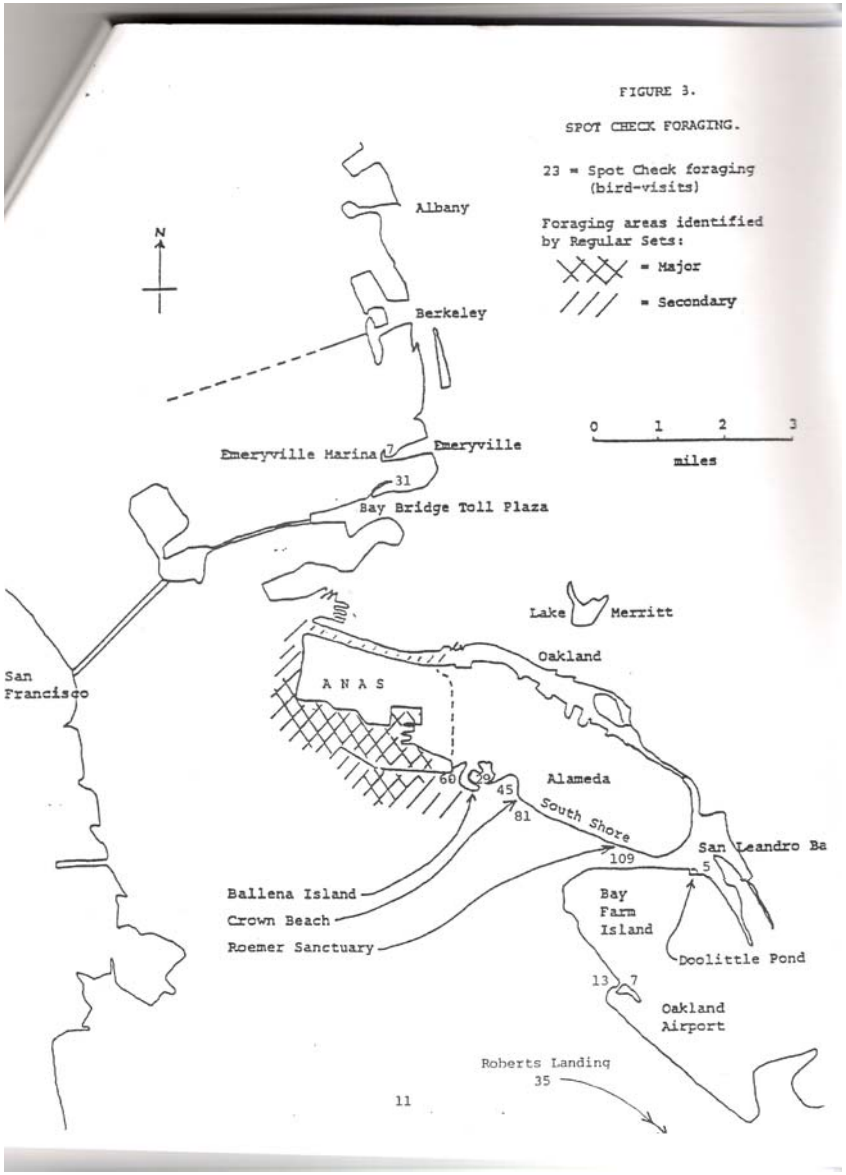
* asumes a success rate of 0.67

** estimated from Bailey's (1992) Figure 3

*** based on minimum total foraging area as estimated by Ehrler et al. (2006), assuming the same foraging rate as MHEA

Table 2. Comparative dive rates and calculated fish captures, 2005 estimates.

Location	Area (acres)	dives/acre/hr	fish per day*
MHEA	166	0.005	8
Seaplane Lagoon study area	39	0.275	100
Alameda Point South study area	40	0.154	57
San Leandro Bay sudy area	53	0.178	89
3 x Bailey's "Primary Foraging Area"	1200	0.202	2268
Remainder of foraging area***	23200	0.005	1083
Total			3605



Conclusions-Science

Terns

- Historic “data” on tern foraging patterns flawed
- Terns range over >> 100 km^2
- Dive rate data emphasize importance of shoals
- Dredged channels and berths are little-used by terns or their main prey

Fish

- Atherinopsids most available /appropriate to Alameda least terns
- Beaches support larval + juvenile atherinopsids
- San Leandro Bay warm, shallow, appears to be nursery area

Conclusions-Dredging

- Work Windows are an appropriate management tool in the absence of site-specific information
- Site-specific information is useful only when resource agency personnel are willing to consider it