

“Global” assessment of pelagic gelatinous zooplankton



photo: Larry Madin

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Gelatinous plankton

varied taxonomically:

Cnidaria: scyphozoan “jellyfish”, cubomedusae
holoplanktonic hydrozoans, siphonophores

Ctenophora

Chordata: salps, doliolids, appendicularians

Mollusca: pteropods

high volume: tissue ratio

translucent

varied trophic levels



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Chordata: salps, doliolids, appendicularians

Mollusca: pteropods

delicate

high volume: tissue ratio

difficult to sample

translucent

few taxonomic experts

varied trophic levels

little interest until recently

Why study jellies?



Given climate change and overfishing in world ocean, might expect increased success of gelatinous creatures:

- increasing temperature and salinity: increased phytoplankton and zooplankton prey
- decreased competition for food given overfishing of commercial fish stocks
- tolerance for low O_2 environments (coastal eutrophication)

Why study jellies?



Many regional coastal and shelf studies show increased incidence and peak abundance of blooms (population explosions) in recent years

BUT:

- basic biology and biogeography poorly known for most species
- little known in pelagic
- important part of pelagic ecosystems
- can have important impact on fish stocks
- no comprehensive, quantitative synthesis

Challenges

- Few taxonomic experts
- Only “recent” (~30 years) interest in recording/quantifying jellies in plankton sampling
- Delicate structure makes traditional plankton sampling ineffective for many taxa
- Bloom/bust life cycle and benthic stage make sampling sufficiently very difficult, and trends hard to interpret

We would like to know:

- What are biogeographic and diversity patterns of pelagic gelatinous zooplankton globally?
- Have these patterns changed through time? How?
- Are the oceans being “jellied”? Why?

Are there sufficient data of good enough quality to answer these questions?!?

Blue water dives

Larry Madin and
Richard Harbison
(WHOI)

SCUBA dive in open
ocean opportunistically

experts in gelatinous
plankton



>30 years of data **UNIQUE**
very little published; explored!

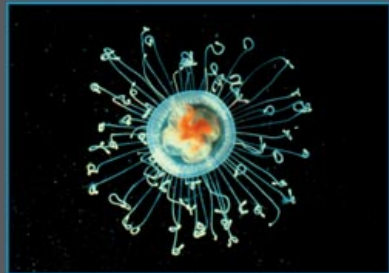
photo: Vicki McAllister



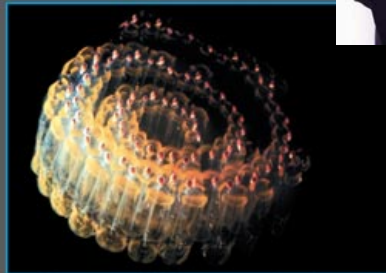
Aequorea macrodactyla



Periphylla periphylla



Turritopsis nutricula



Pegea socia in aggregate stage

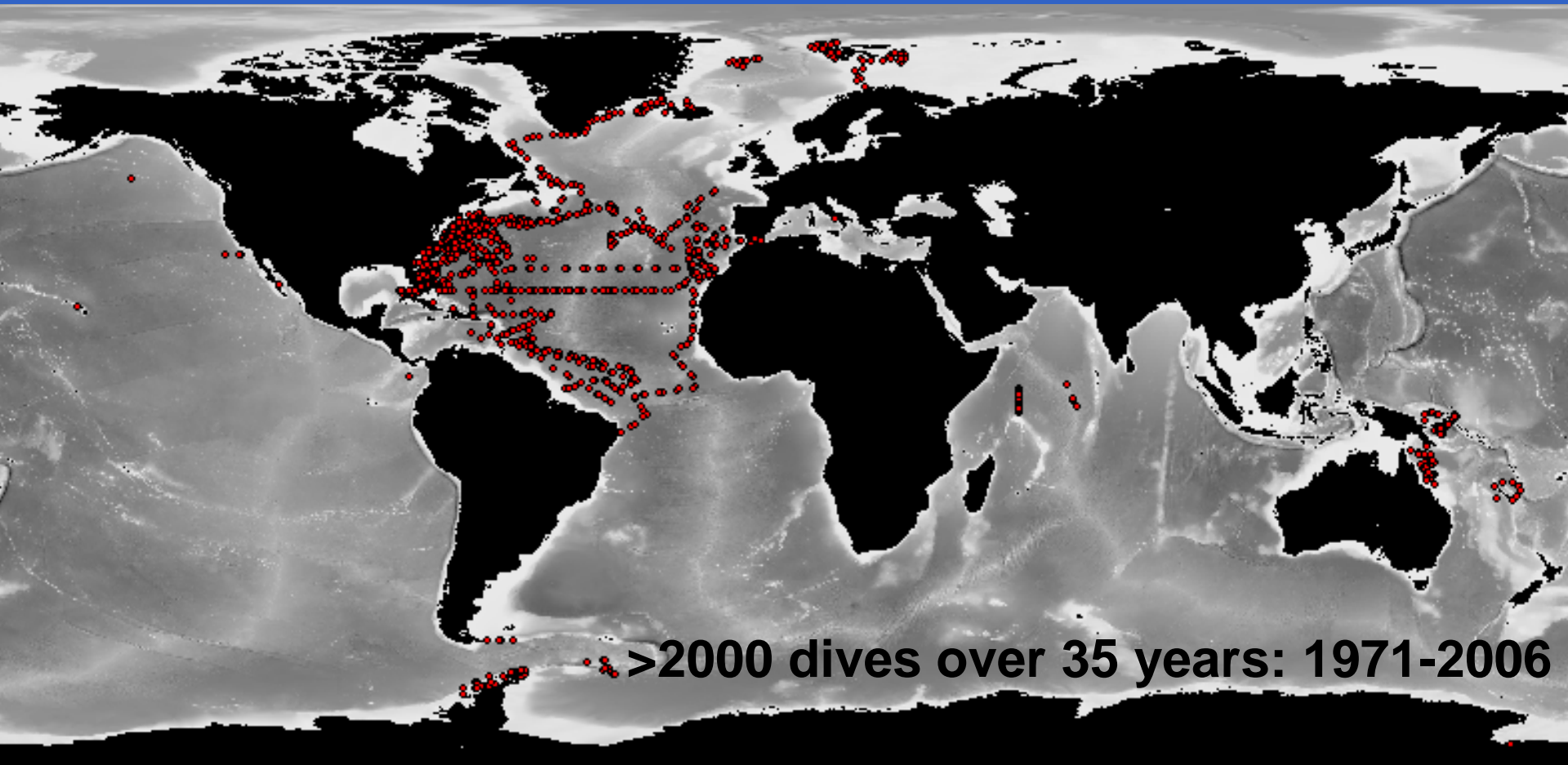


photo: Terry Rioux

poster: WHOI

photo: WHOI

Madin-Harbison dives



**Largest dataset we know of with resolution to Genus/species,
non-destructive sampling**

Archive sources

We have identified a number of oceanographic cruises from 1899 and later with:

- capable jelly taxonomists
- vertical plankton sampling
- abundance and size (often) of jelly species found
- oceanographic sampling (temperature, salinity)

May be useful for seeing large ecosystem effects, insight into particular species



H.B. Bigelow 1912

*Ernst Mayr Library of the
Museum of Comparative
Zoology, Harvard University*

Strategy

- **Biogeography of pelagic gelatinous species**
(blue water dives, archive sources):
 - species ranges, seasonality of patterns
 - community structure
- **Latitudinal gradients in pelagic gelatinous biodiversity**
(blue water dives)
- **Temporal trends in pelagic regions with sufficient data**
(e.g, slope waters, Atlantic Bight, USA)
 - model species categorical abundance (or presence/absence)
against environmental, spatial and temporal variables
- **Meta-analysis of regional studies: Is the ocean being “jellied”?**
(everything we can find with multi-decade data!)

Analytical tools

- mapping of species ranges in GIS
- calculation of biodiversity indices by site or grid cell
comparison to latitudinal gradients, physical and environmental measures
- depending on the nature of further datasets found, temporal analyses will range in complexity from:
 - logistic regression (presence/absence data)
 - mixed models using categorical abundance
 - mixed models on actual abundance/biomass
- meta-analytic methods to look at global trends

...still investigating the possibilities

Some sample datasets

Method	Source	Region	Timespan	Resolution	Author
Blue water SCUBA dives	Madin, Harbison (WHOI)	North Atlantic	1971-2006	Genus/species: categorical abundance	largely unpublished
Bottom trawl surveys	DFO Canada	Gulf of St. Lawrence, Canada	1985-2002	Biomass: "large jellyfish"	Govt. report: Benoit et al. 2003
Plankton tows (ichthyoplankton surveys)	DFO Canada	Scotian Shelf, Gulf of Maine	1977-1982; 1983-1985	Phylum/Class: categorical abundance	Jelly data unpublished
Continuous Plankton Recorder	SAHFOS	High latitudes, North Atlantic	1946-2006	Presence/Absence of nematocysts	Wright, in prep.
Bottom trawl surveys	RACE division of AFSC	Eastern Bering Sea Shelf	1979-1997+?	Biomass: "large jellyfish"	Brodeur et al. 1999
Trawl surveys	SEAMAP	Northern Gulf of Mexico	1985-1997 (2002/3)?	Standardized biomass: for large jelly species	Graham 2001
Trawl surveys	ICES	North Sea	1971-1986	Relative abundance: large jelly species	Lynam et al. 2005
Plankton net sampling	Villefranche Bay weekly sampling	Western Mediterranean	1966-1993	Relative abundance: hydromedusae	Buecher et al. 1997, Buecher 1999

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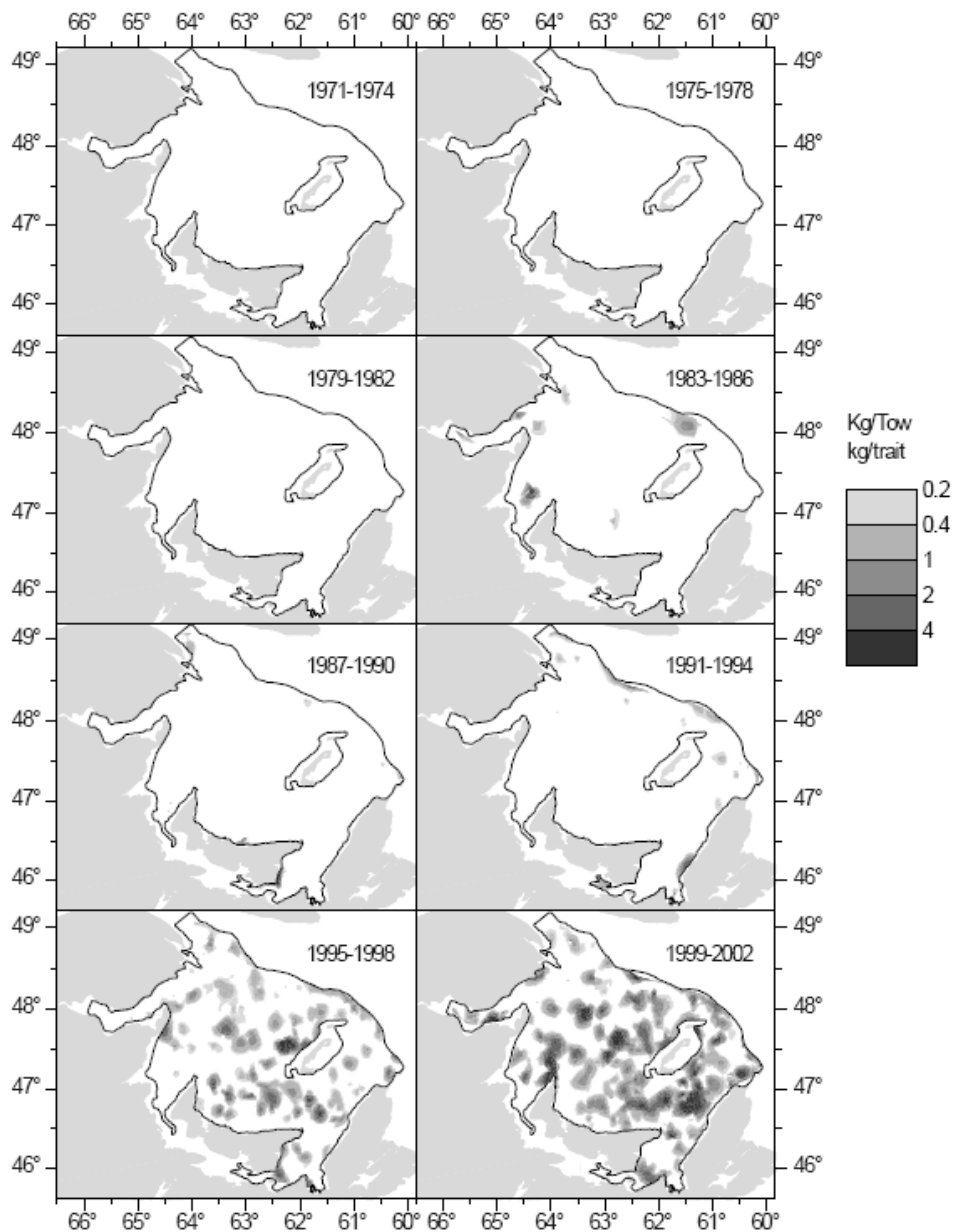


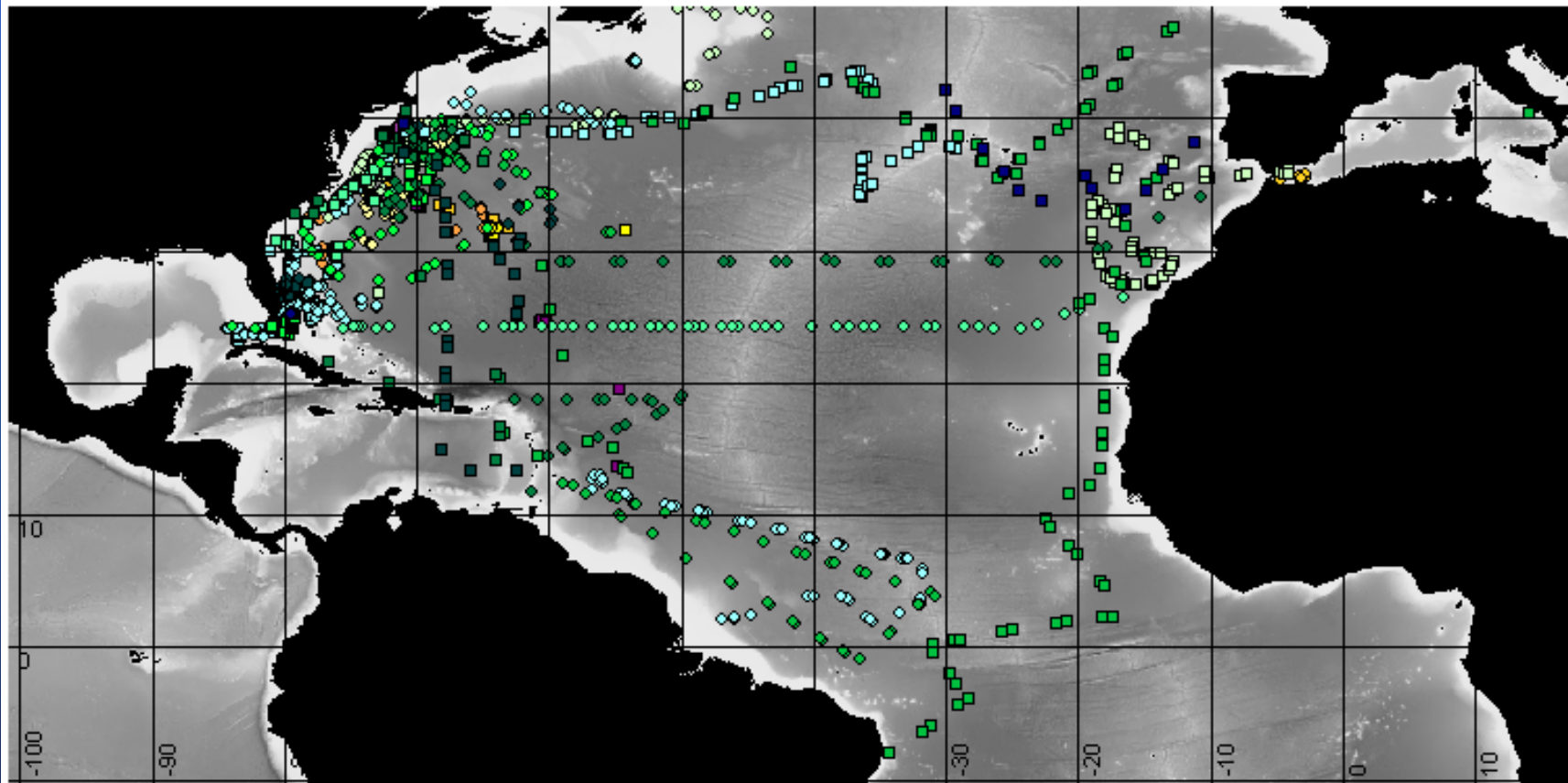
Figure 105. September distribution of catches (kg) of Large Jellyfish, Scyphozoa

Southern Gulf of St.
Lawrence, eastern
Canada

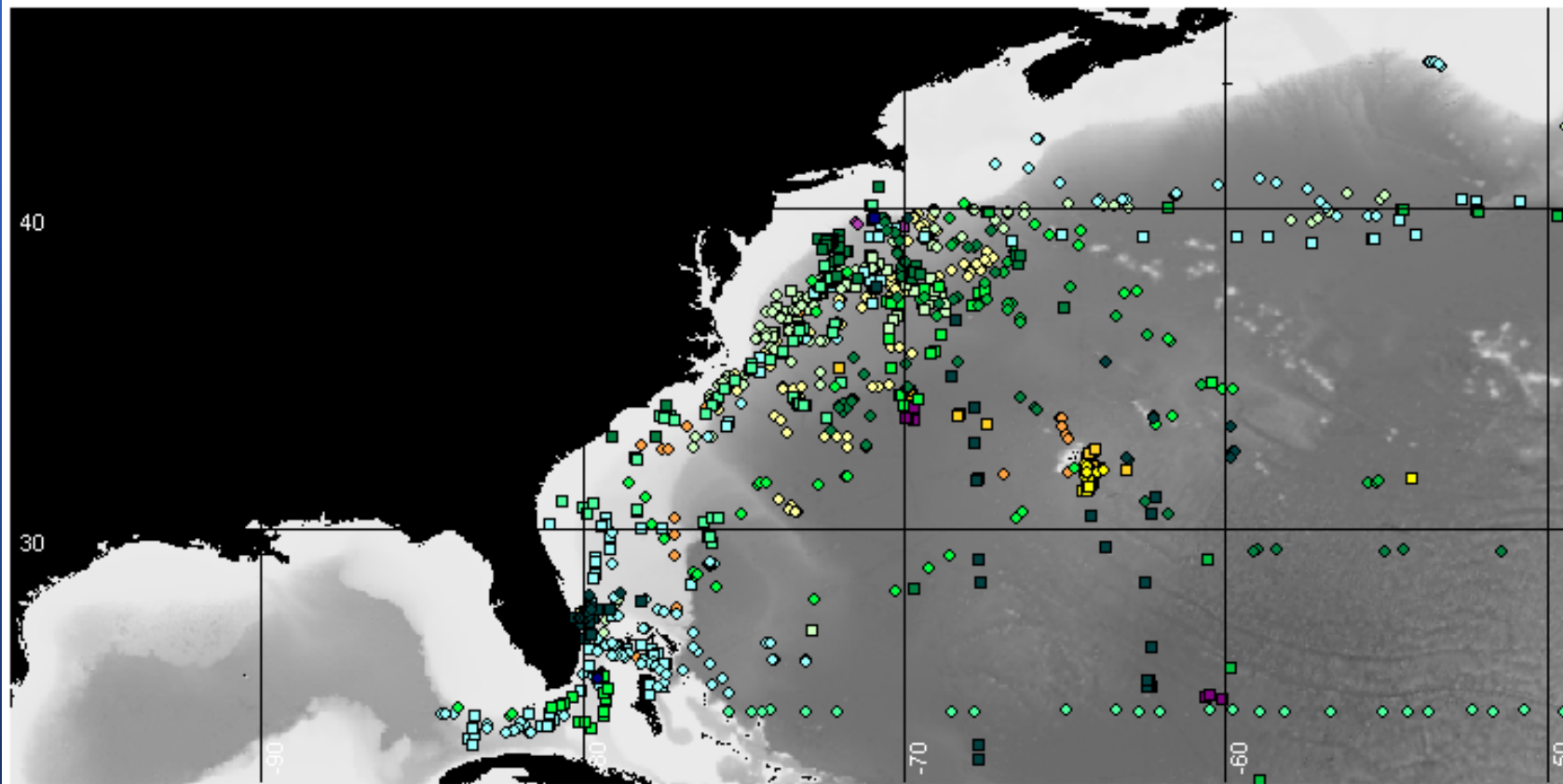
Annual bottom trawl
surveys, DFO Canada

Benoît et al. 2003.

North Atlantic



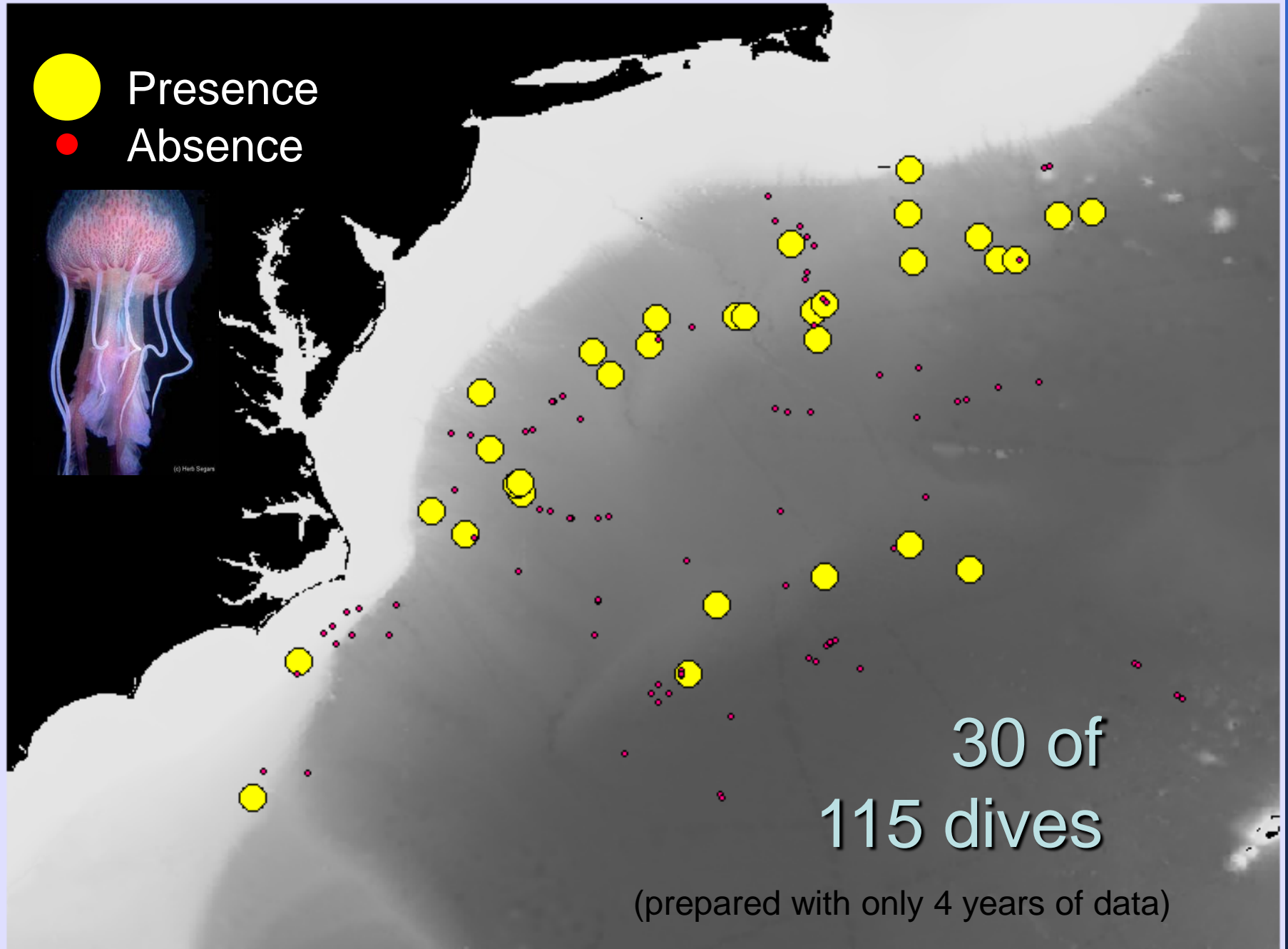
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Pelagia sp. sightings

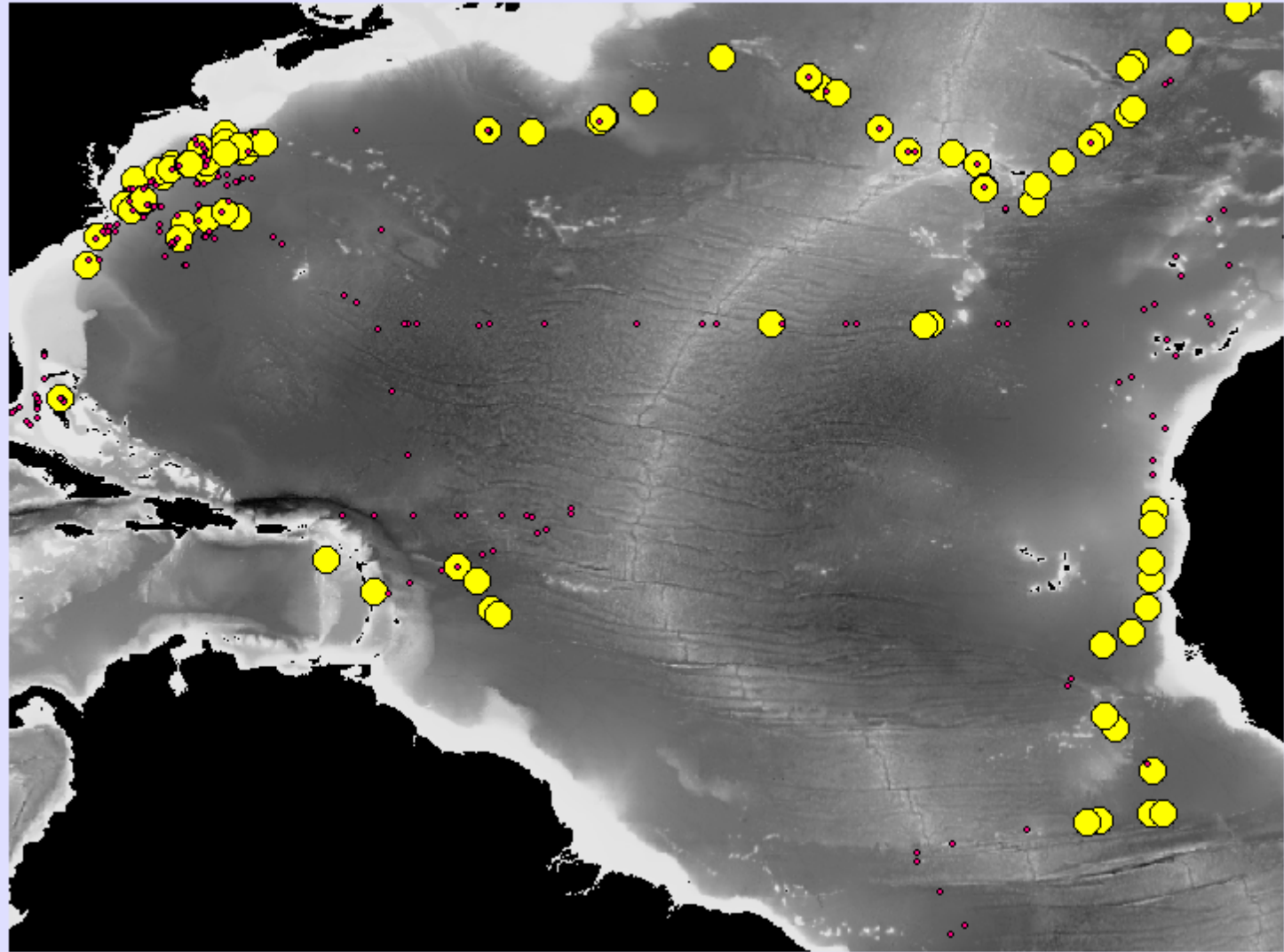
● Presence
● Absence



30 of
115 dives

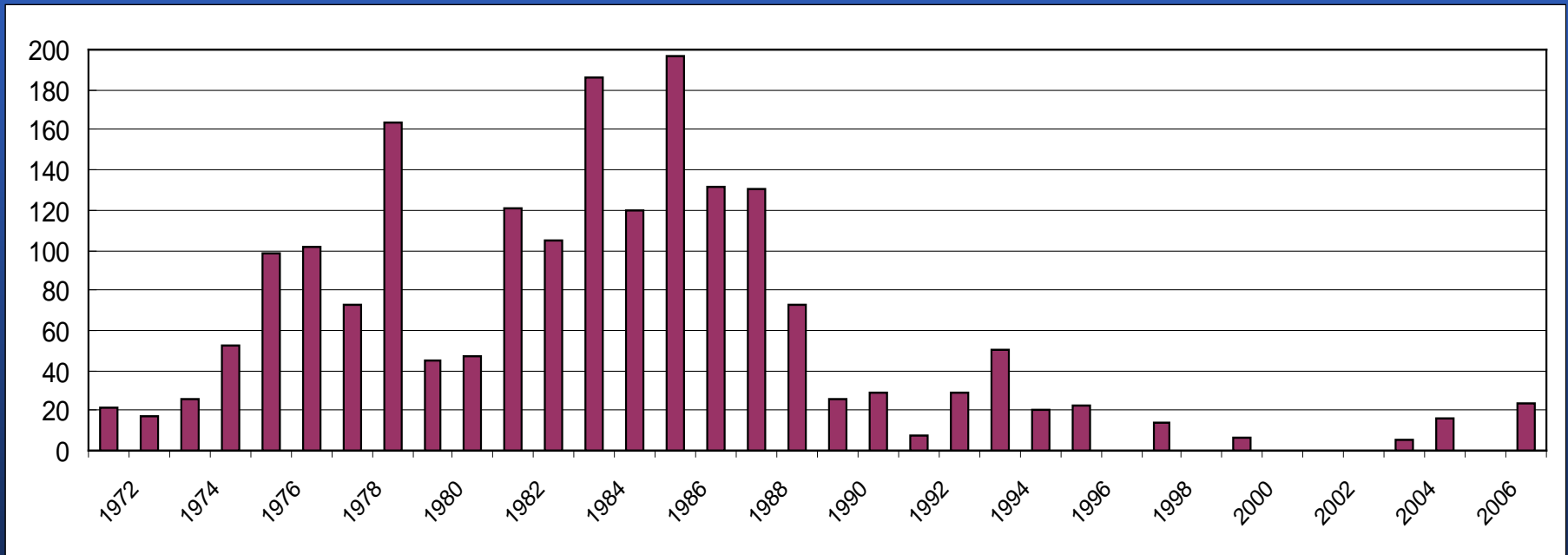
(prepared with only 4 years of data)

Pelagia sp. sightings



Current dive counts

n=1957 blue water dives (with positions recorded)



~200 dives still to be entered in 1990's and 2000's

Dives by month

and year

Year	1	2	3	4	5	6	7	8	9	10	11	12
2006		7	5	12								
2005												
2004										1	4	11
2003						5						
2002												
2001												
2000												
1999					6							
1998												
1997			6	8								
1996												
1995		4	4	2	2	6	4					
1994				5						7	8	
1993		11	2			22	3				1	11
1992					12						17	
1991			7									
1990		18	11									
1989								21			5	
1988			14	1		14	44					
1987		13	33	1		46	24	8	2	2		
1986				24	43	10	55					
1985	1	9	26	17		31	66	17	5	24		
1984			43				53	2	17	5		
1983		15	23				57	34		57		
1982	4	38	7		43	13						
1981		11	1		14	8		52	12	2	5	16
1980					19	8				11	9	
1979					20	22						3
1978		2	8			34	74	2		4	40	
1977			41				8		17		2	4
1976	4	22	9	17		20	9	17	4			
1975	2	20			15	23	1	21	1		15	
1974	5				4	5	8	19	4	7		
1973						1		3	10	1	9	2
1972	2	1	1				12	1				
1971								3	9	9		

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DiveData : Table

	LatDec	LongDec	Loca	Divers	NDivers	SeaWea	Sunny	Night	Wind	WindMore	Visibility	VisMore	Drift	SurfTemp	Tem
	25.413333	281.935	NA	LM* CC GD DC	4	Clear	NA	N	10	NA	100 +		1	26.5	NA
	25.405	281.93	NA	GD* DC LM	3	Sunny	Y	N	10	NA	-999	NA	-999	26.5	NA
	25.4	281.92833	NA	DC* GD LM CC	4	Partly sunny	N	N	-999	NA	80	NA	1	26.5	NA
	25.428333	281.94833	NA	LM DC* CC	3	Sunny; Calm	Y	N	-999	NA	100 +		1	26	NA
	25.413333	281.95833	NA	LM* DC CC GD	4	Sunny	Y	N	-999	NA	60	NA	1.5	26	NA
	25.37	282.06167	NA	LM CC* DC GD	4	Sunny	Y	N	15	NA	100 +		2	26.5	NA
	25.398333	281.96333	NA	DC* LM GD CC	4	Sunny	Y	N	-999	NA	70	NA	-999	26	~
	25.216667	280.74	NA	LM CC GD* DC	4	Sunny; Calm	Y	N	-999	NA	100 +		0	28.2	27 at
	25.405	280.68667	NA	CC* DC LM GD	4	NA	NA	N	-999	NA	100 +		1	27.2	NA
	25.728333	280.58667	NA	LM* CC DC GD*	4	Calm	NA	N	-999	NA	100 +		1	27.7	NA
	37.6	288.03333	NA	LM* KS DA JL	4	Sunny	Y	N	20	NA	100	NA	2	-999	NA
	37.6	287.56667	NA	GD* CC* DR KF PC	5	NA	NA	N	-999	NA	70	NA	2	28.9	NA
	37.3	286.9	NA	LM GD	2	Calm	N	Y	10	NA	0	Night	0	26	NA
	37.283333	286.88333	NA	CC DA JL PC*	4	NA	NA	N	-999	NA	100	NA	3	27	NA
	37.35	287	NA	LM GD KS KF*	4	NA	NA	N	-999	NA	100	NA	1	28.9	NA
	36.95	286.58333	NA	LM GD	2	Dark	N	Y	-999	NA	0	Night	2	28.4	NA
	36.666667	286.18333	NA	PC* CC DA KS JL	5	NA	NA	N	20	R:20-30	70	NA	2	28	NA
	36.733333	286.16667	NA	LM GD DA JL KF*	5	Showers	N	N	20	NA	100 +		3	28	NA
	36.016667	285.5	NA	DR* CC LM JL DA	5	NA	NA	N	-999	NA	70	NA	-999	29	NA

Record: 1 of 544

Dive Details

Microsoft Access

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BlueWaterDivesJan15 : Database

Species Table : Table

ID	BWPNo	Month	Day	Year	OrgOrig	OrgCode	OrgGenus	OrgSpecies	SalpForm	Location	AbunColl	AbunObsCo	Abun
1	1314	3	25	1985	Cyclosalpa polae	CPL	Cyclosalpa	polae	NA	coll	.	NA	.
2	1314	3	25	1985	Cyanea	CYN	Cyanea	sp	NA	obs	NA	1	few
3	1314	3	25	1985	Pelagia	PEL	Pelagia	sp	NA	obs	NA	ma	ma
4	1314	3	25	1985	AEQ	AEQ	Aequorea	sp	NA	obs	NA	sin	sin
5	1315	3	26	1985	Corolla sp	COR	Corolla	sp	NA	coll	1	NA	few
6	1315	3	26	1985	EVX	EVX	Eurhamphaea	sp	NA	obs	NA	sin	sin
7	1315	3	26	1985	Forskalias	FOR	Forskalia	sp	NA	obs	NA	pl	pl
8	1315	3	26	1985	Agalma	AGS	Agalma	sp	NA	obs	NA	sin	sin
9	1316	3	26	1985	SLC	SLC	Salpa	cylindrica	sol	both	5	pl	pl
10	1316	3	26	1985	EVX	EVX	Eurhamphaea	sp	NA	coll	1	NA	few
11	1316	3	26	1985	Diphyids	DIP	Diphyid	sp	NA	obs	NA	pl	pl
12	1316	3	26	1985	Forskalia	FOR	Forskalia	sp	NA	obs	NA	few	few
13	1316	3	26	1985	Corolla	COR	Corolla	sp	NA	obs	NA	2	few
14	1317	3	27	1985	SLC	SLC	Salpa	cylindrica	sol; agg	both	.	pl	pl
15	1317	3	27	1985	CAF	CAF	Cyclosalpa	affinis	agg	coll	.	NA	.
16	1317	3	27	1985	CPL	CPL	Cyclosalpa	polae	sol; agg; who	both	.	pl	pl
17	1317	3	27	1985	EVX	EVX	Eurhamphaea	sp	NA	both	1	2-4	few
18	1317	3	27	1985	Forskalias	FOR	Forskalia	sp	NA	obs	NA	pl	pl
19	1317	3	27	1985	Diphyids	DIP	Diphyid	sp	NA	obs	NA	pl	pl
20	1317	3	27	1985	Pegea	PSP	Pegea	sp	who	obs	NA	sin	sin

Record: 5 of 2023

Creatures Present

Latin binomial species name of the organism. "sp" = Organism was only identified to the genus level