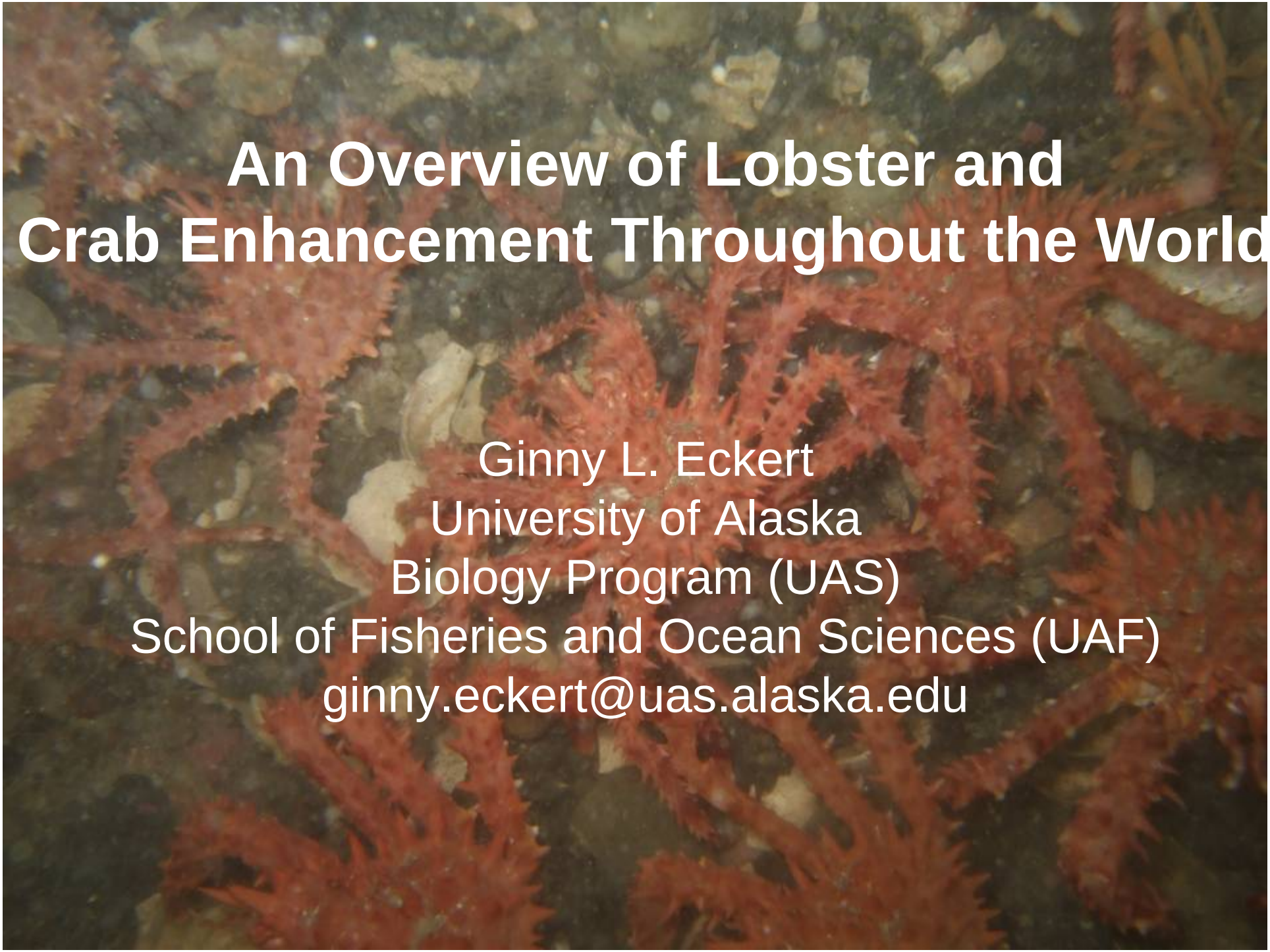

An Overview of Lobster and Crab Enhancement Throughout the World

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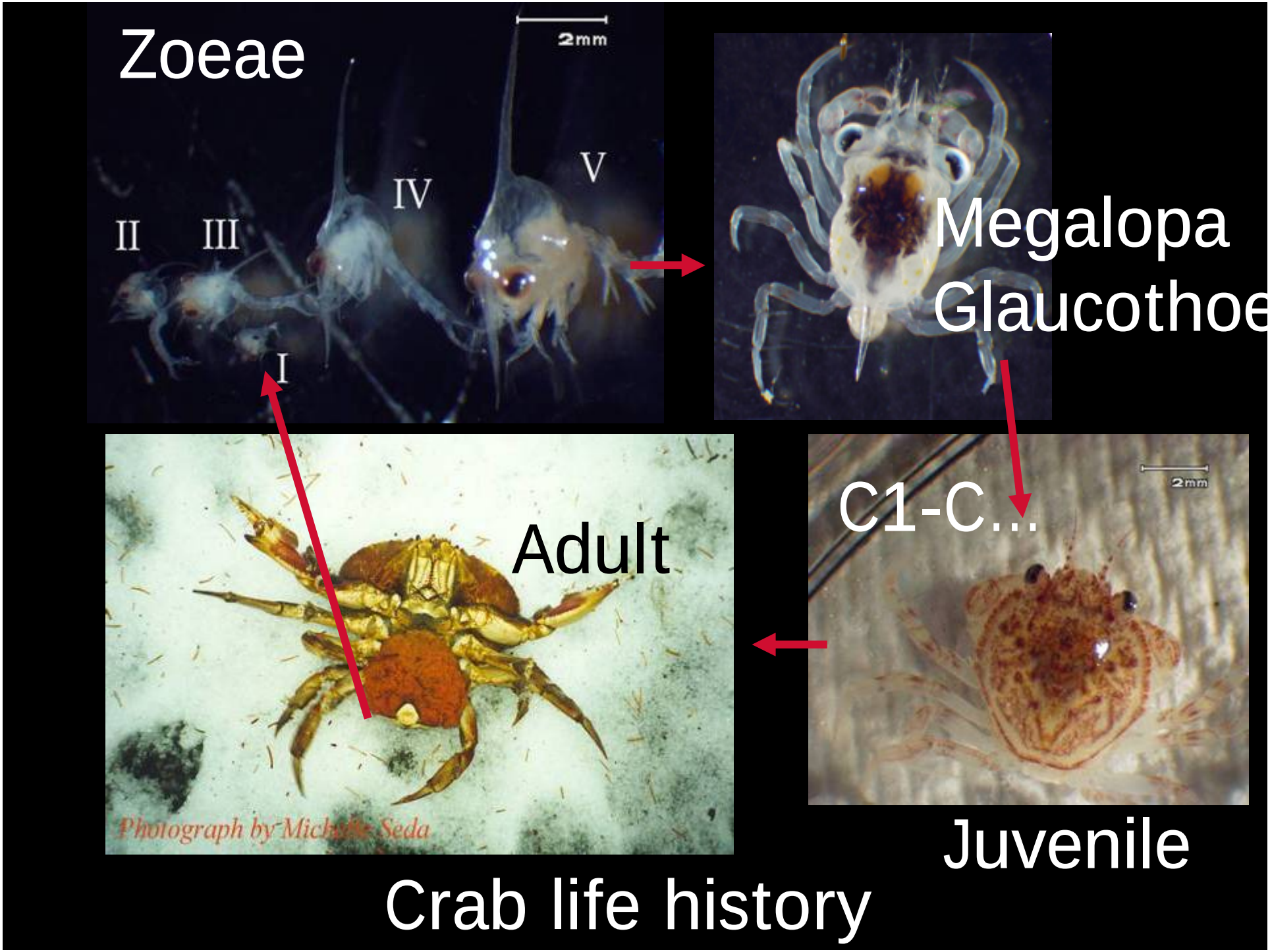

Zoeae
2mm
II
III
IV
V
I
Megalopa
Glaucothoe
C1-C...
2mm
Adult
Photograph by Michelle Seda
Juvenile
Crab life history

Stock enhancement programs - lobster

Hatcheries throughout New England in late 1800's – shut down in early 1900's – no effect of enhancement seen

Are American lobsters recruitment limited?

Recent releases of hatchery individuals demonstrates high mortality immediately after release (40,000 in 2005)

Current efforts to release later stage juveniles that are less mobile

American lobster, *Homarus americanus*

Castro et al. 2001 Marine and Freshwater Research 52:1253-1261
Tlusty et al. 2005 Aquaculture Nutrition 11: 191-198

Stock enhancement programs - lobster

Enhancement feasibility investigated in United Kingdom, France, Norway, and Ireland

Recruitment overfishing in Norway – highest potential for stock enhancement success

Norway – 1997 – 43% of landings and 73% of pre-recruits were of hatchery origin

Norway - sea ranching now on a commercial scale

European lobster, *Homarus gammarus*

Agnalt et al. 1999 *In Stock Enhancement and Sea Ranching*
Bannister and Addison 1998 Bulletin of Marine Science 62:369-387

Crab stock enhancement programs - Japan

Facilities throughout Japan active for last 30 years and now produce 60 million C1 juveniles annually

Over the last decade, releases of 28-42 million C4 juveniles annually

Contribution to fishery catch ranges from 9 to 59%

Evidence for enhancement to historical levels has not been found, however habitat degradation may contribute to low carrying capacity

swimming crab, *Portunus trituberculatus*

Secor et al. 2002 Maryland Sea Grant UM-SG-TS-2002-02

Crab stock enhancement programs - Maryland

Blue crabs declined 85% since 1990

Recruitment limited, overexploited

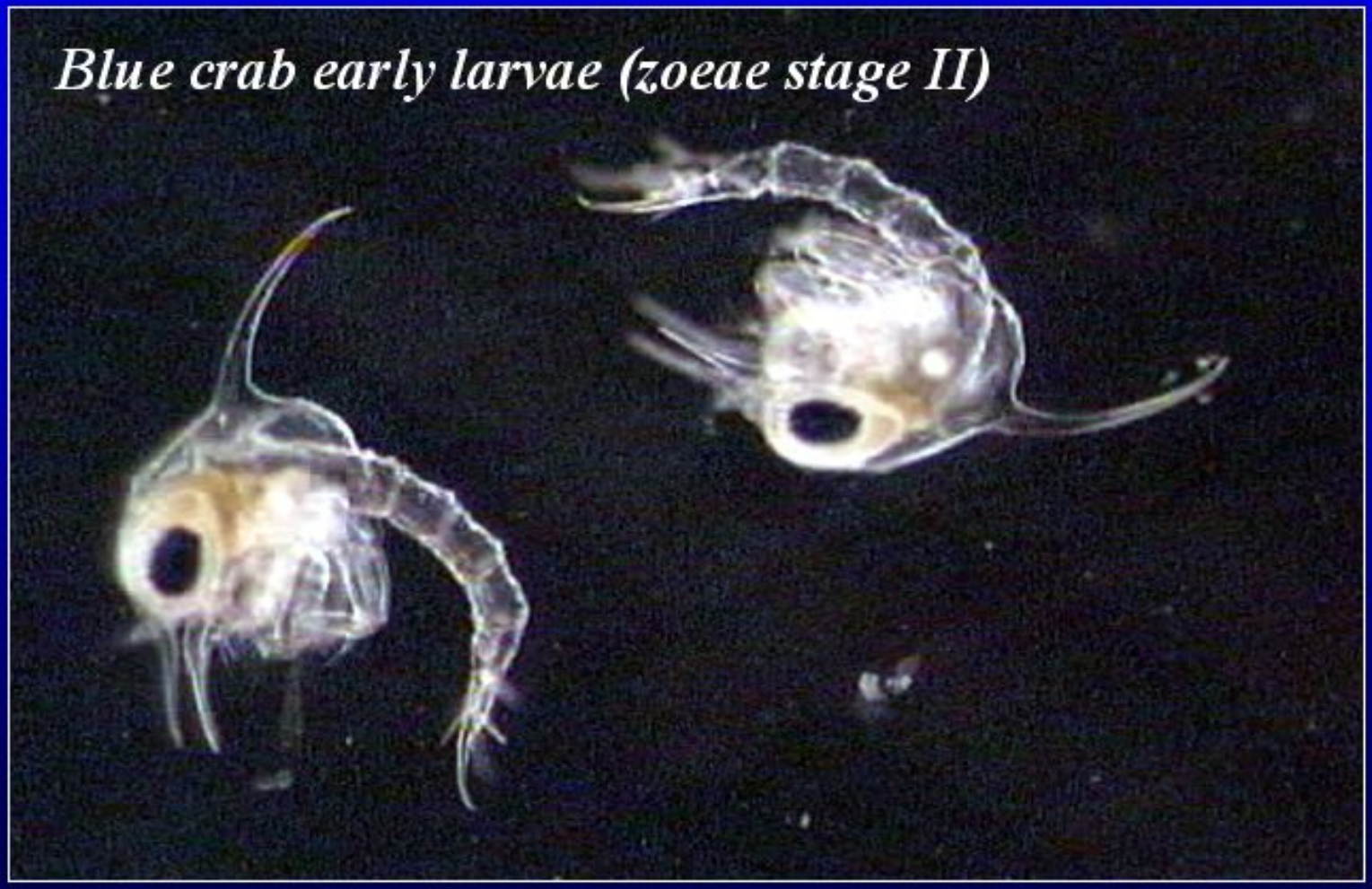
Scientists at Smithsonian Environmental Research Center, University of Maryland Biotechnology Institute, Virginia Institute of Marine Science, and North Carolina State University evaluating potential for stock enhancement

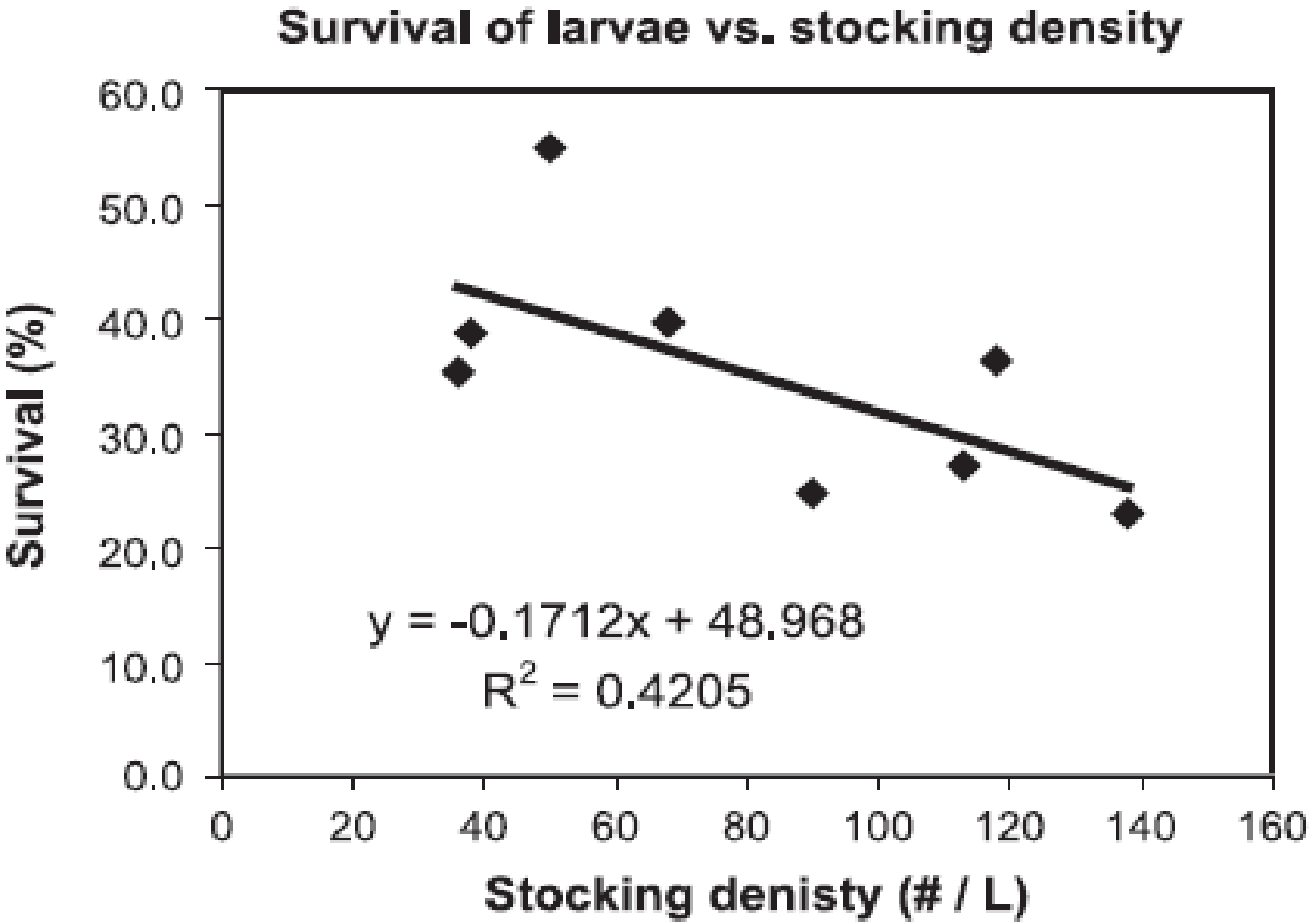
150,000 hatchery crabs released in a four-year study 2002-2005

Blue crab, *Callinectes sapidus*

Blue crab broodstock and spawning

Raising broods from wild females avoids genetic concerns from hatchery breeding (e.g., generations of hatchery raised salmon)


Blue crab early larvae (zoeae stage II)



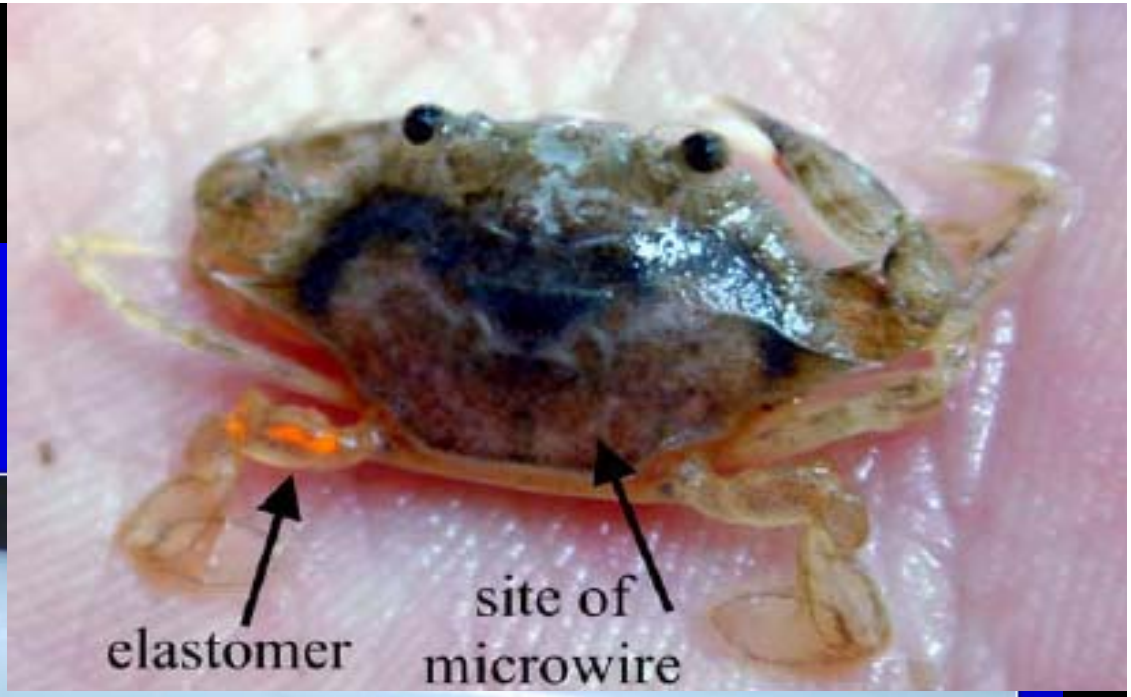
Zmora et al. 2005 Aquaculture 244:129-139

Mass production of blue crab juveniles 2002

Stage	Batch 1	Batch 2	Batch 3	Batch 4	Average
Hatched	129,000	1,019,360	1,044,000	450,000	
Larvae (reared)	129,000	369,000	416,000	240,000	
Megalopae[a]	63,000 (32,500)	145,194	167,014 (145,000)	103,000	
(Megalopae/Larvae)×100	48.8	39.4	40.1	42.9	42.8
Crabs	6012	6112	15,304	12,956	
(Crabs/Megalopae)×100	18.5	4.2	10.6	12.6	11. 5
$\frac{\text{Megalopae}}{\text{Larvae}} \times 100 \times \frac{\text{Crabs}}{\text{Megalopae}} \times 100$	9.0	1.7	4.25	5.4	5.1

Zmora et al. 2005 Aquaculture 244:129-139

Two month old blue crab COMB juveniles



Two month old tagged juveniles

Total production of blue crab juveniles during 2002, as well as the subset of the total production utilized in the stocking trials

	Total crabs produced	Total crabs released
Batch 1	6012	3800
Batch 2	6112	4800
Batch 3	15,304	9500
Batch 4	12,956	7000
Total	40,384	25,100

Hatch date	Release date
14 Feb.	2 May
13 May	19 July
17 June	15 Aug.
30 June	9 Sept.

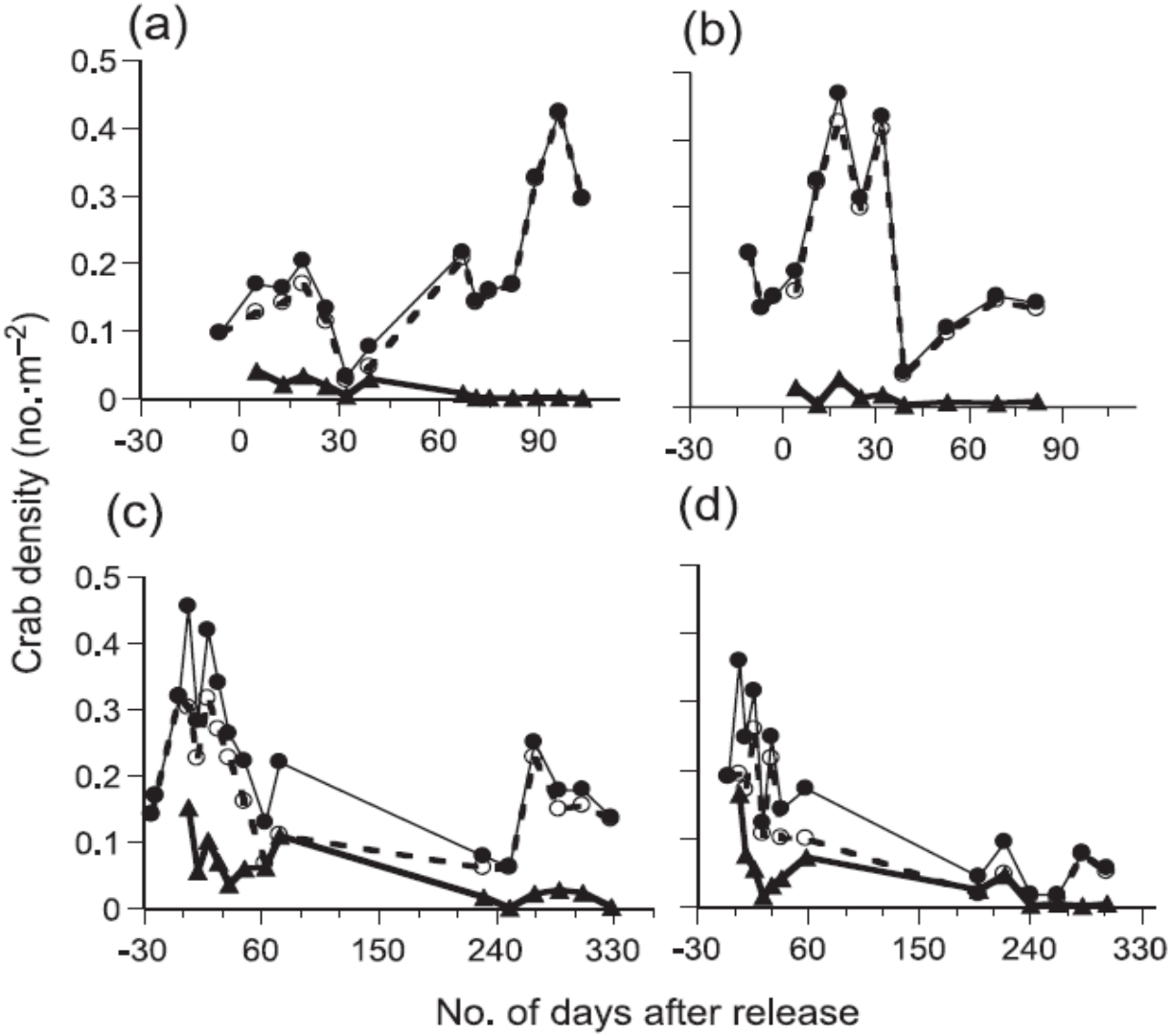
Zmora et al. 2005 Aquaculture 244:129-139

Davis et al. 2005 Canadian Journal of Fisheries and Aquatic Sciences 62:109-122

Release into the Chesapeake

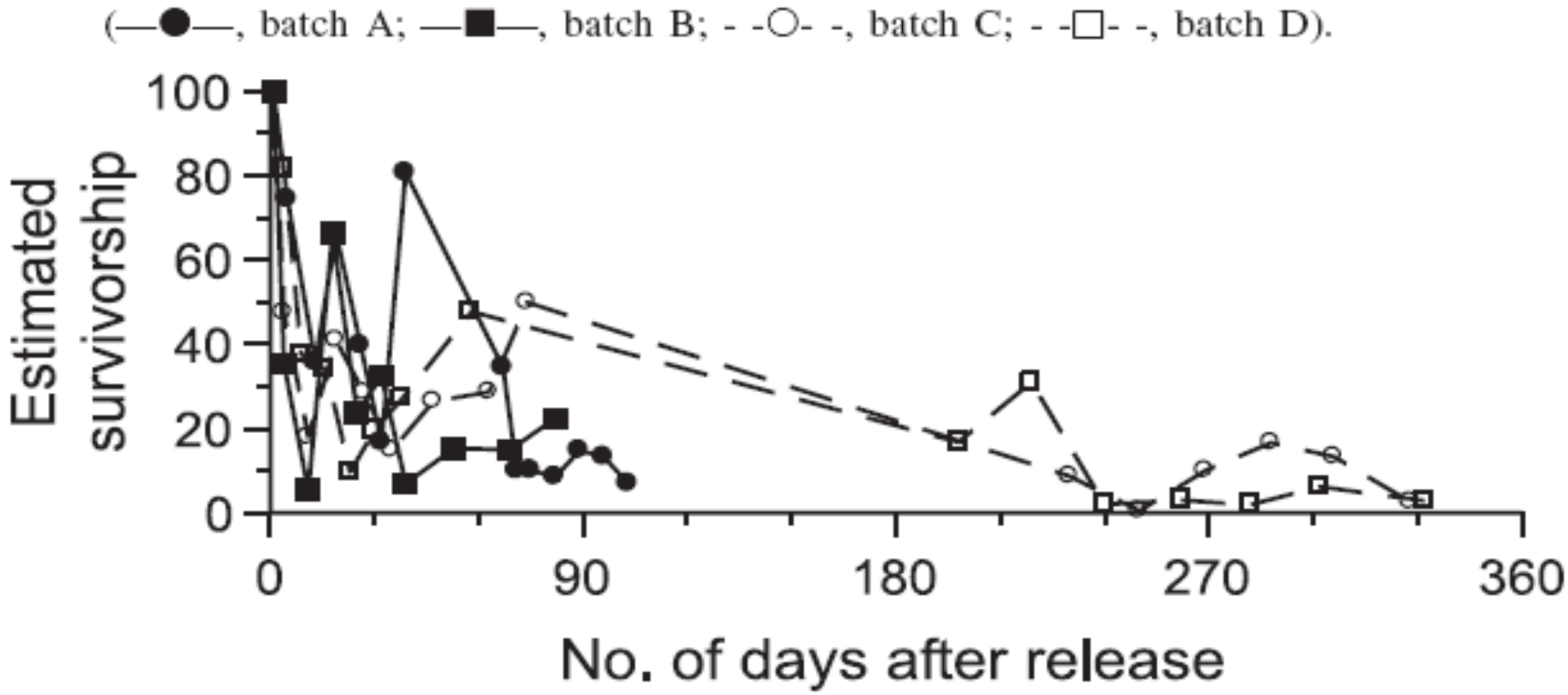
Enhancement in first year of release 7- 40%

Fig. 2. Densities of blue crabs (*Callinectes sapidus*) in the enhancement sites (- -○- -, all wild crabs; —▲—, all hatchery-raised crabs; —●—, total crabs (hatchery + wild)). (*a*) Batch A, which had an average enhancement value of 7%. (*b*) Batch B, also with an enhancement value of 7%. (*c*) Batch C, which had an enhancement level of 39%. (*d*) Batch D, with an enhancement level of 40%.



Davis et al. 2005 Canadian Journal of Fisheries and Aquatic Sciences 62:109-122

Survivorship to maturity estimated at 5 to 20%



Davis et al. 2005 Canadian Journal of Fisheries and Aquatic Sciences 62:109-122

Hatchery crabs compared with wild crabs

- similar in feeding, movement rates in field, growth rate
- smaller spines, but increased after several weeks
- lower burial frequency in sediment (predator avoidance), but increased after 2-4 days
- greater predation in field

Hatchery crabs

unlikely to compete with wild crabs

conditioning with sediment did not increase field survival

conditioning with predators to increase spine lengths did increase field survival

Davis et al. 2004 Transactions of the American Fisheries Society 133:1-14
Davis et al. 2005 Aquaculture 243:147-158

Other crab stock enhancement programs

Larvae do not feed

Survival of larvae to C1 ranges from 10 to 38% on small scale – Chile

Survival of larvae to C1 ranges from 0 to >70% in experimental tanks in Argentina

Small-scale temperature experiments demonstrate 29-90% larval survival at temperatures of 6, 9, 12 and 15 C

Southern king crab, *Lithodes santolla*

Chile - Paschke et al. 2006 Alaska Sea Grant AK-SG-06-04
Argentina – Lovrich and Tapello 2006 Alaska Sea Grant AK-SG-06-04
– Anger et al 2004 Journal of Experimental Marine Biology and Ecology 306: 217-230

Other crab stock enhancement programs - Japan

King crab larvae first cultured in Japan in 1940's

First efforts in large scale culture (500 L) 1980's – larval survival to C1 was 2.3%

Large scale hatchery production of *P. brevipes* conducted since 1980's – a million larvae raised each year

Production at the hatchery ranges from 0 to 800,000 C1 released per year – no follow up conducted

Red king crab, *Paralithodes camtschaticus*

Stevens 2006 Alaska Sea Grant AK-SG-06-04