Integrated development of alternative management tactics against burrowing shrimp on commercial oyster grounds

Dr. Kim Patten, WSU
Dr. Jim C. P. Liou & Dr. Thomas Weaver, U. of Idaho
Dr. Daniel Cheney and Dr. Steve Booth, Pacific Shellfish Institute.

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Brief review

- Willapa Bay and Grays Harbor, provide 25% of the oysters produced in the U.S.A. on ~ 15,000 acres of tidelands, >$35 million in annual revenues.
- Two indigenous species of burrowing shrimp reside inside burrows beneath the mudflat surface causing surface dwelling organisms (shellfish, eelgrass) to literally sink in the mud and die.

- Carbaryl (Sevin) has been used since the 1960s to suppress burrowing shrimp populations. In response to legal challenges, the industry has agreed to phase out the use of carbaryl by 2012. Without a management alternative to carbaryl, the bulk of the shellfish industry in SW Washington will cease to exist.

Project Objectives 2006

- Evaluate the potential of alternative pesticides to suppress burrowing shrimp in both topical and sub-surface applications
- Study how eelgrass and dry time affect efficacy of alternative pesticides against burrowing shrimp
- Continue to develop and test equipment for subsurface delivery of pesticides against burrowing shrimp
- Determine the impact of alternative burrowing shrimp management tactics on the benthic infauna.
- Evaluate the physics, mechanics, and impacts of substrate liquefaction on burrowing shrimp

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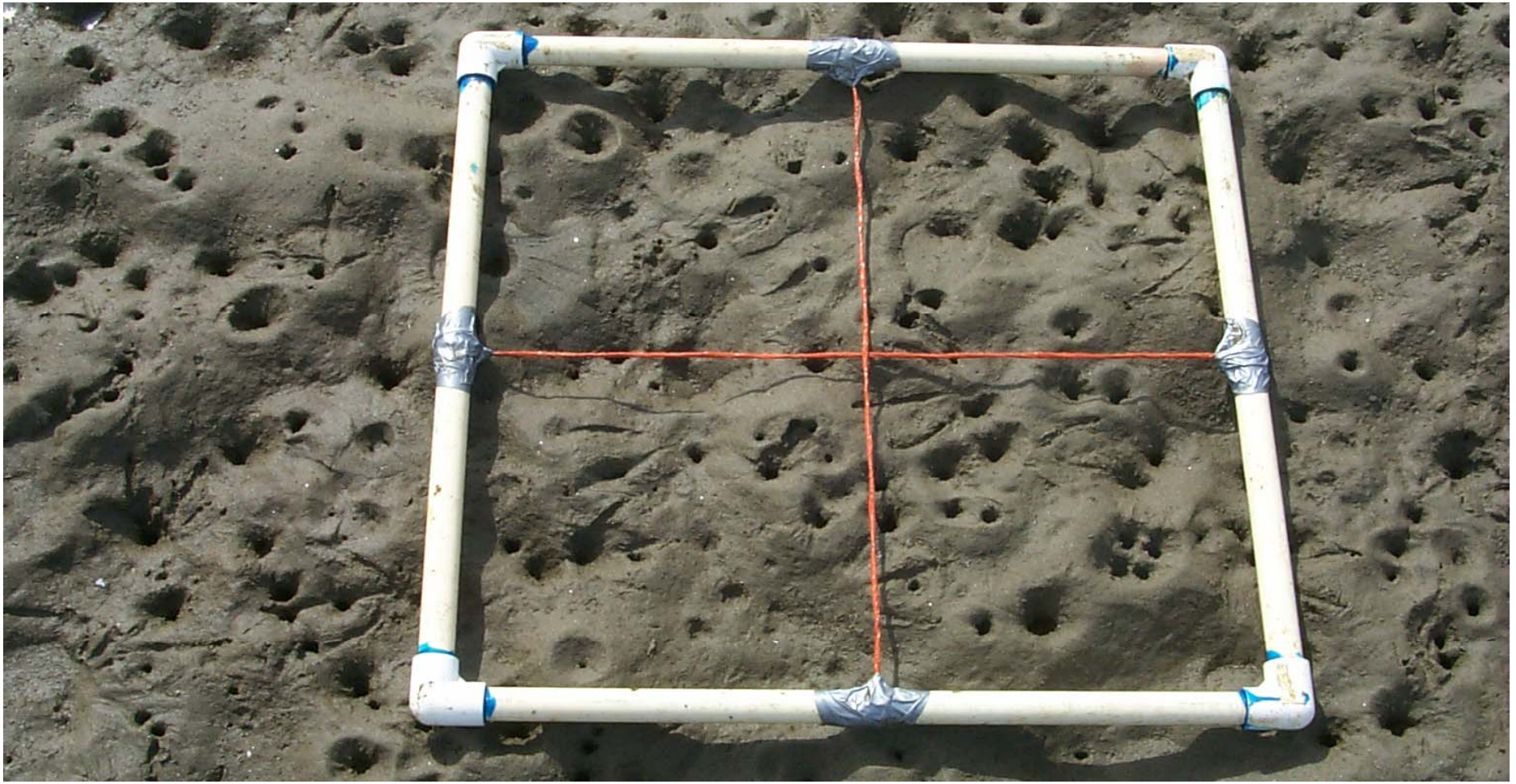
- Efficacy comparison to untreated check and carbaryl
- Products tested in the lab and field using broadcast and injection applications
- Efficacy based on post-treatment burrow counts (~2 weeks and 2 months)



Chemistries evaluated to date for efficacy

Essential plant oils

- clove oil
- cinnamon oil
- citronella oil
- cedar oil
- linseed oil
- garlic oil
- geranium oil
- peppermint oil
- rosemary oil
- thyme oil
- neem oil

Plant extracts or "natural" insecticides

- crushed chrysanthemums
- naturally extracted pyrethrums
  - Pryrenone
  - Pyganic
- mustard seed meal
- habanero pepper extract
- yucca extract
- sabadilla
- white pepper
- geranial
- citric acid
- malic acid
- hydrogen peroxide
- potassium salts of fatty acids
- SeaKlean

Fertilizers or mineral-based compounds

- aqua ammonium
- NaCl
- Lime
- copper
- urea ammonium nitrate
- sulfur
- ammonium thiosulfate
- Kyrocide
- ammonium sulfate

Insecticide

- Sevin (ultra low rates of carbaryl)
- Spectrus
- Belay (clothianidin)
- Esteem (pyriproxyfen)
- Methoprene
- Admire (imidacloprid)
- synthetic pyrethrums
  - Deltaguard (deltamethrin)
  - Bigrade (bifenthrin)
  - Mustang (zeta-cypermethrin)

Other compounds

- bleach
- $KMnO_4$
- 2-phenethyl propionate
- potassium sorbate

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Efficacy of subsurface injection chemicals – ground based (2005)

Compound	Mean burrow (#/m^2) count 1 to 2 months post treatment
Carbaryl 3 Lbs Ai/A	5 ✂ 1
Zeta-cypermethrin 0.02 Lbs Ai/Ac	6 ✂ 3
Carbaryl 1 Lb Ai/Ac	12 ✂ 2
Chrysanthemums (Ecozone) 20 Lbs /Ac	21 ✂ 1
Natural Pyrethrins (Pyganic) 128 Oz /Ac	20 ✂ 2
Deltamethrin 0.05 Lbs Ai/Ac	24 ✂ 4
Pyriproxyfen (Esteem) 0.01 Lbs Ai/Ac	24 ✂ 3
Sabadilla (Veratran) 20 Lbs/Ac	28 ✂ 5
Natural Pyrethrins (Pyganic) 16 Oz /Ac	28 ✂ 2
Natural Pyrethrins (Pyganic) 64 Oz /Ac	32 ✂ 2
Habanero Pepper Extract	32 ✂ 2
Chrysanthemums (Ecozone) 10 Lbs /Ac	35 ✂ 2
Copper (Cutrine) 4 Gal/Ac	32 ✂ 4
Bifenthrin 0.05 Lbs Ai/Ac	36 ✂ 3
Sulfur 10 Or 20 Lbs/Ac	37 ✂ 4
Sulfur 50 Lbs/Ac	48 ✂ 4
Cinnamon Oil (Cinnacure) 100 Oz/Ac	44 ✂ 5
Rosemary Oil (Ecotrol) 100 Oz/Ac	40 ✂ 4
Thiosol + Ammonium Sulfate	44 ✂ 4
Thiosol 200 Gal/Ac	68✂ 4
Aqua Ammonium (25 Gal/Ac)	80 ✂ 8
Chlorine (2.5 Gal/Ac)	88 ✂ 5
Untreated Control	88 ✂ 3

Efficacy of subsurface injection chemicals – water based (2006)

Compound	Mean burrow (#/m^2) count 1 months post treatment
imidacloprid 0.5 Lbs Ai/A	0 ✂ 0
imidacloprid 0.2 Lbs Ai/A	0.7 ✂0. 3
imidacloprid 0.1 Lbs Ai/A	6 ✂ 2
Carbaryl 3 lbs ai/A	3 ✂ 1
Mustard cake 4000 lbs/A	32 ✂ 5
Pyganic 128 oz/A	45 ✂ 6
Habenero 2 qt/A	61 ✂ 3
Mustang 0.01 lbs ai/A	37 ✂ 5
Methoprene 1 lb/A	32 ✂ 2
Ecozone 20 lbs/A	49 ✂ 9
Sulfur 20 lbs/A	42 ✂ 4
Sulfur 40 lbs/A	59 ✂ 7
Sulfur 53 lbs/A	27 ✂ 2
Sulfur 80 lbs/A	51 ✂ 3

Efficacy Comparison by Application Method *

Compound	**Broadcast spraying**	**Subsurface shanking or spikewheel**	**Registration potential**
Carbaryl (Low Rates)	Good to Excellent	Good to Excellent	could lose
Imidacloprid	Excellent	Excellent	reasonable
Zeta-cypermethrin	Excellent	None to Good	none
Bifenthrin	Fair	Poor	none
Deltamethrin	Fair	Poor	none
Crushed Chrysanthemums	None	Poor	fair
Naturally Extracted Pyrethrins	Good	Poor	fair
Habanero Pepper Extract	Poor	Poor	fair
Sabadilla	None	None	fair
Sulfur	None	None	good
Pyriproxyfen	Poor	None	fair

*Excellent= <5m^2; good= < 10 m^2; Fair=<25 m^2; none= >25 m^2

Objective 1 - Conclusion

- No natural or green chemistries consistently achieved efficacy that would be acceptable to growers.
- Imidacloprid was the only chemistry with consistent efficacy and potential for registration

2007 Work Plans

- Large-scale plots – imidacloprid, Pyganic, Sulfur
- Expanded efficacy trial with imidacloprid (timing, rates, sediment types, application methods)

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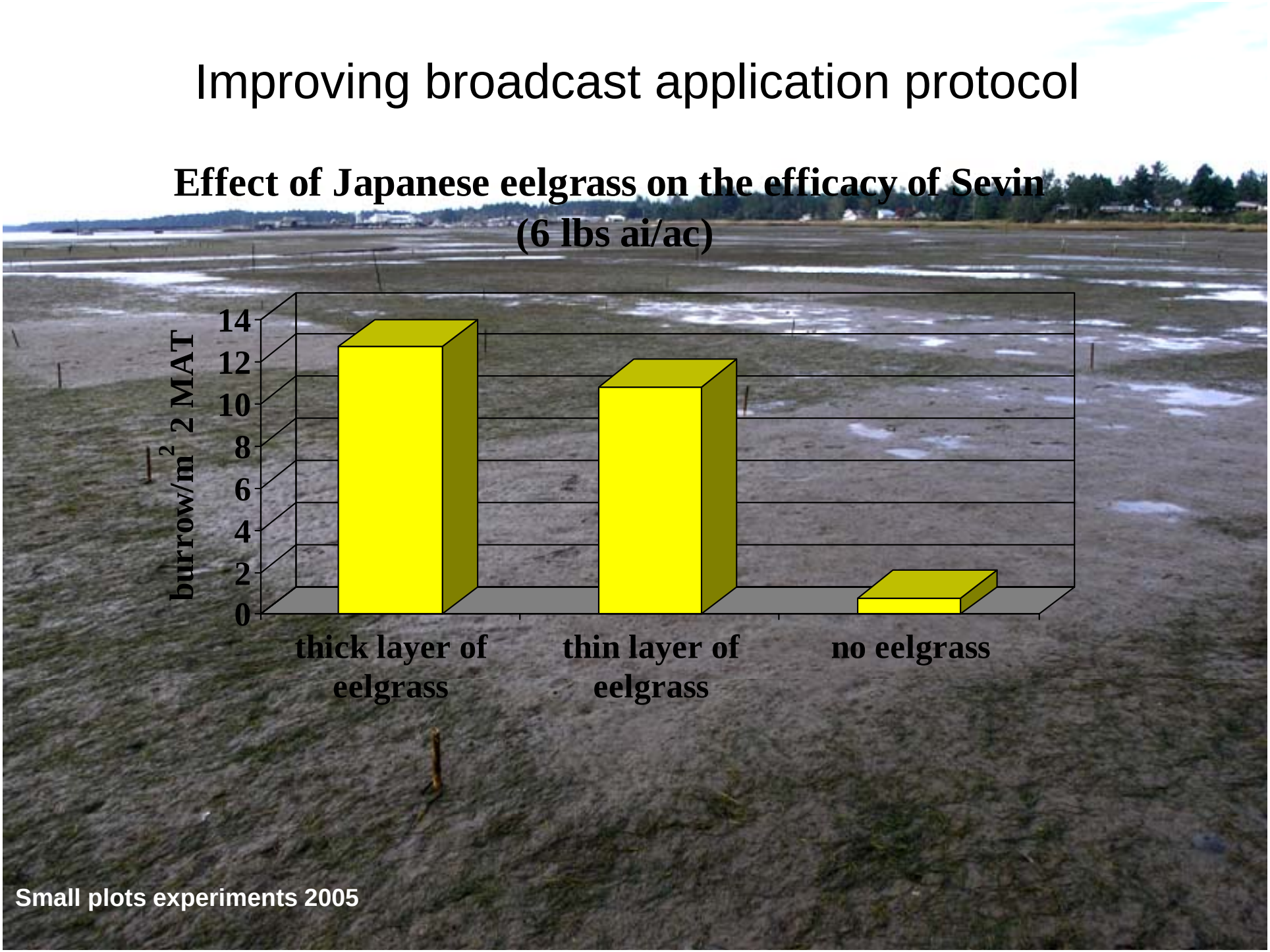
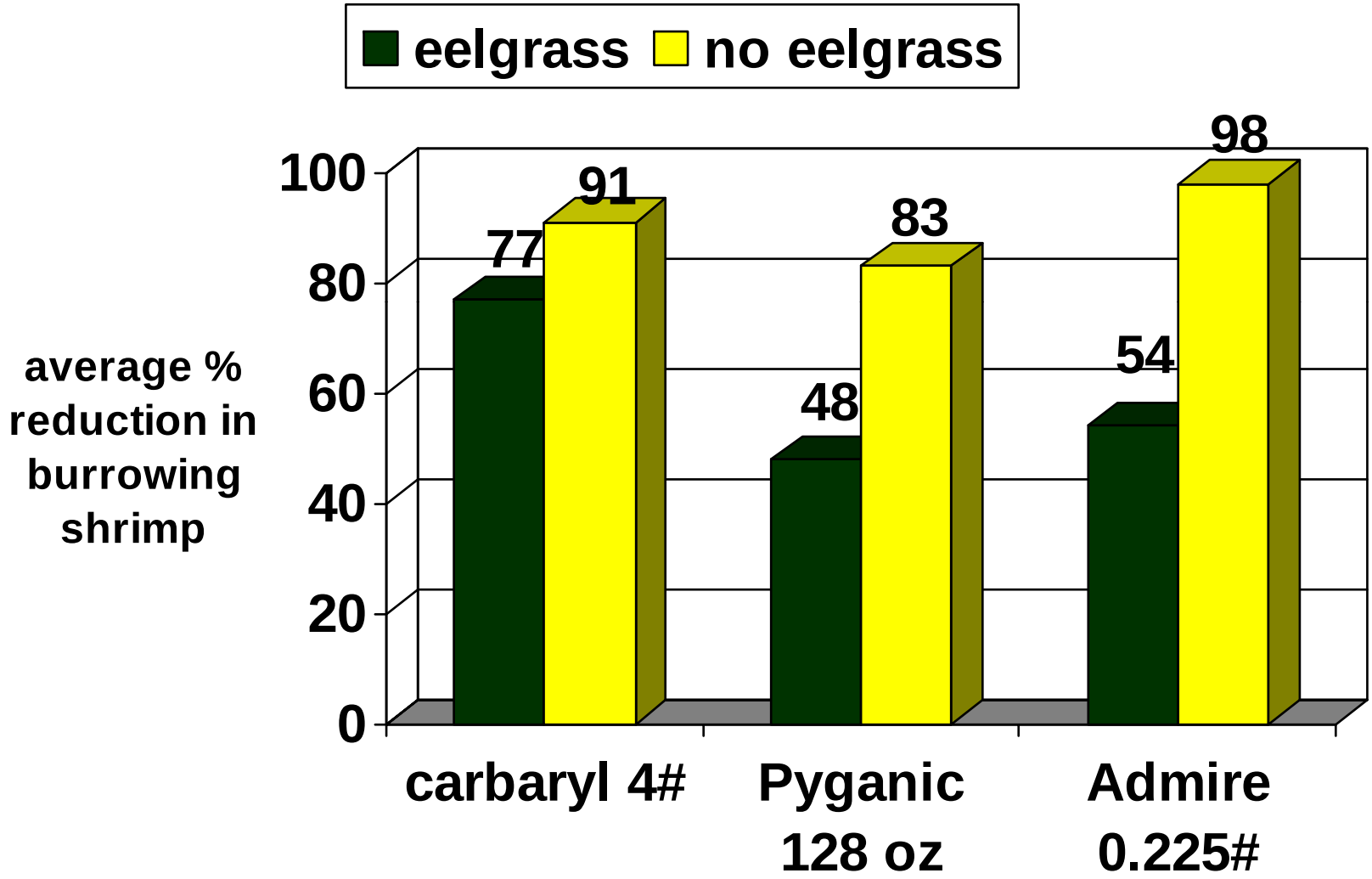
eelgrass effect on efficacy

Improving broadcast application protocol



2006

Summary of the four studies on the effect of eelgrass coverage on efficacy of broadcast insecticide used for burrowing shrimp control



Conclusion: Admire and Pyganic more affected by eelgrass than carbaryl