Radar, Reflectors and Sea Kayaks: A Visibility Study

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Sea Grant Maine

United States Coast Guard 1790

Gulf of Maine Expedition Institute

MASKGI
The Maine Association of Sea Kayak Guides and Instructors

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- Background of the study . . .

- The Maine Coast – a busy waterfront community

- Fog occurs regularly on the Maine Coast

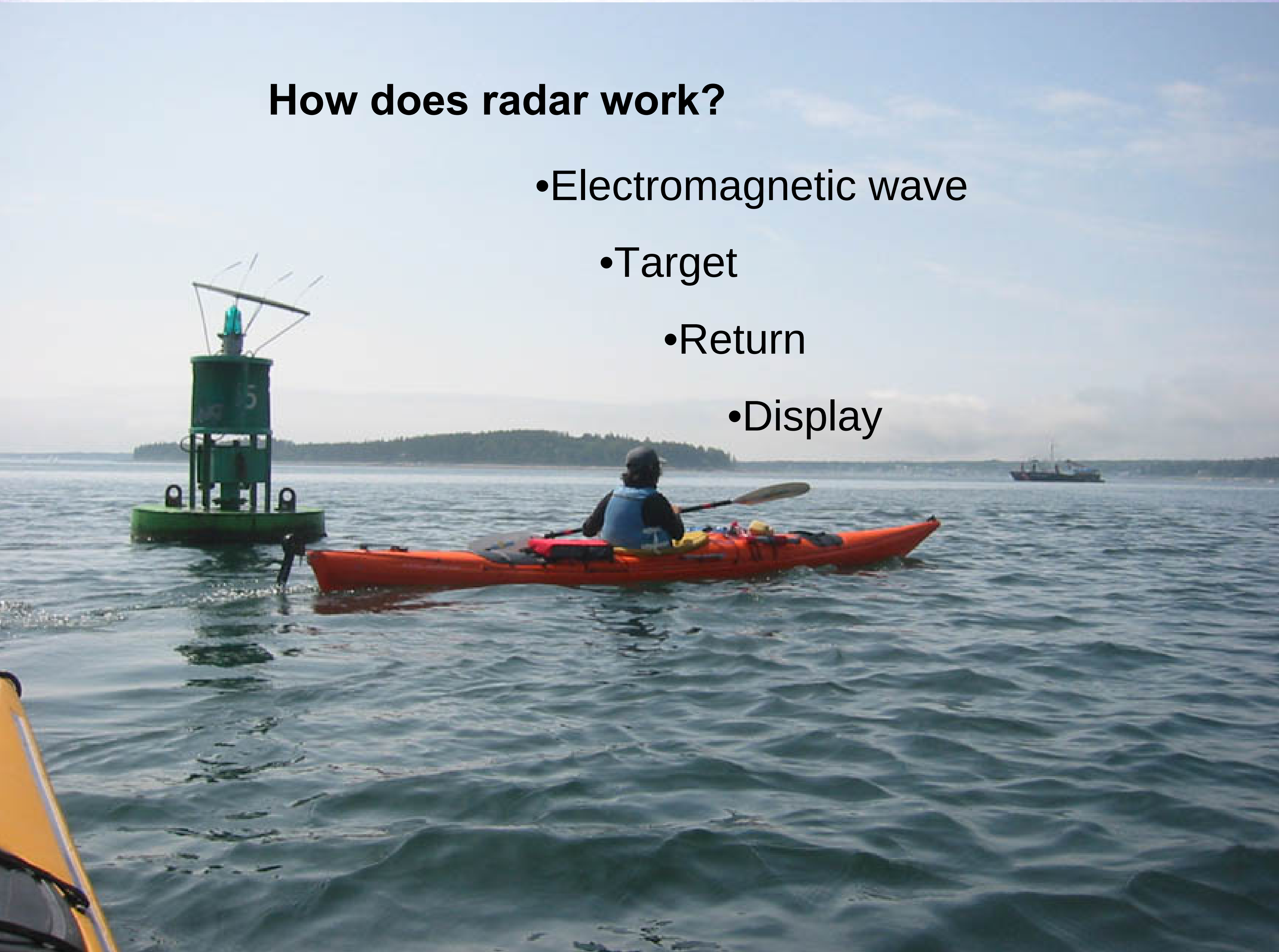
- Sea Kayaking – a major recreational sport and a significant commercial industry

Project goals:

1. Review the effectiveness of radar reflectors on sea kayaks.
2. Provide coastal boaters with knowledge to reduce risk of collision.
3. Open a dialog on safety between boaters along the coast of Maine.

How does radar work?

- Electromagnetic wave
- Target
- Return
- Display




Radar platform
INDIGO

Radar monitors

Radar reflectors

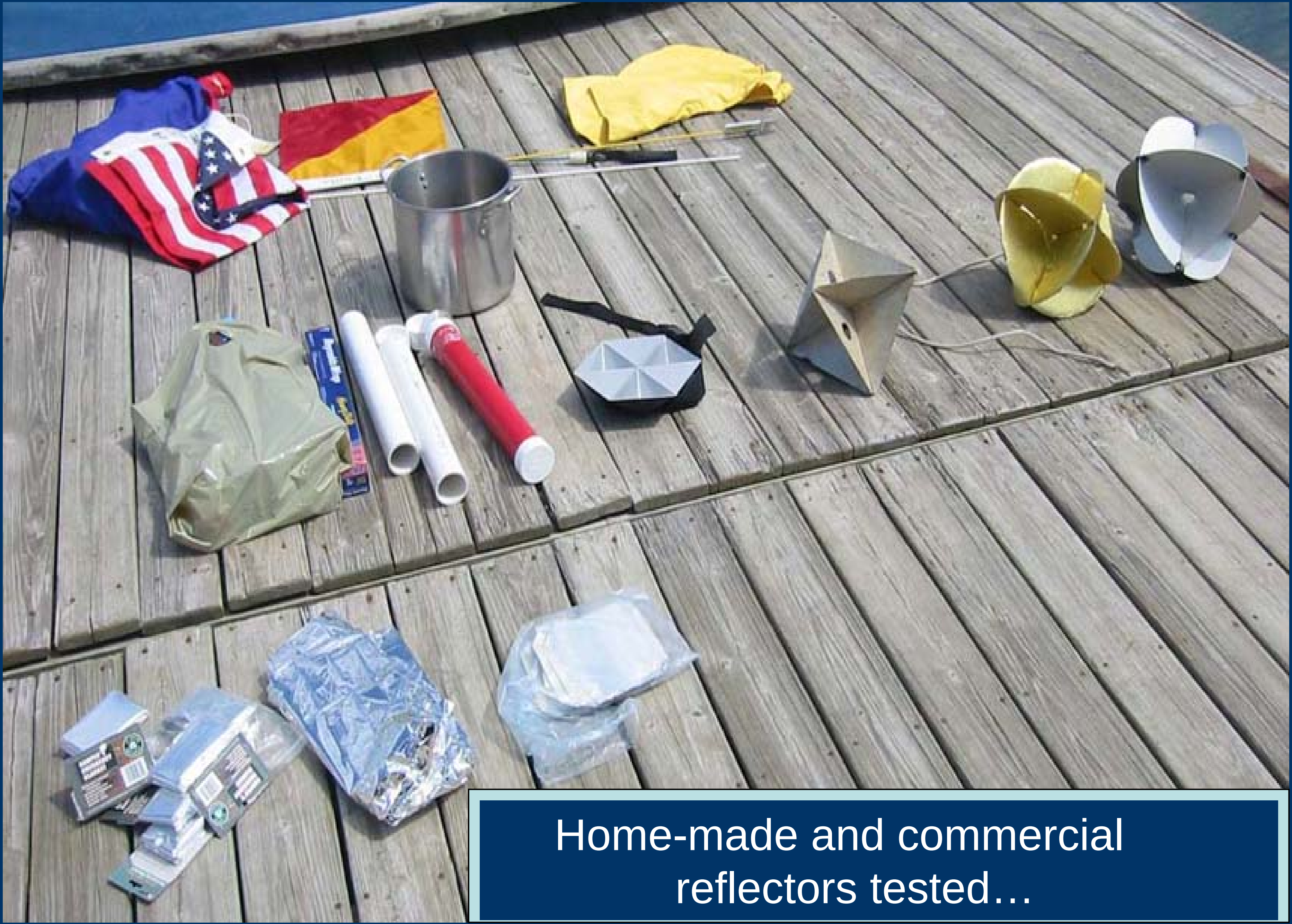
Project History:

1. Two initial radar/reflectors demonstrations in the spring of 2003:
    - MASKGI meeting at Southwest Harbor Coast Guard station
    - Maine Coast Natural History Seminar
2. Conflicting sets of results:
    - CG radar consistently able to detect sea kayaks at some level.
    - The vessel at MCNHS was not.
3. Need for standardized testing which led to ...

Visibility testing plan: 3 standardized sets of trials under various conditions

- 18-19 August 2003. College of the Atlantic, Bar Harbor. The college's research vessel, *Indigo*, was the radar platform.
- 06 July 2004. U.S. Coast Guard Group Southwest Harbor. U.S. Coast Guard vessel CG 55120 was the radar platform.
- 06 November 2004. U.S. Coast Guard Station, Boothbay Harbor. U.S. Coast Guard Auxiliary vessel *Equinox* was the radar platform.

Methodology



Home-made and commercial reflectors tested…

On radar-equipped vessel, each radar sweep logged as 0, 1, or 2, (with 2 representing strongest return).

Visibility Factor

0 - No signal

1 - Weak to moderate signal

2 - Strong signal

Up to 100 sweeps per run, data compiled into an average "Visibility Factor"

DISTANCE	LOCATION		SEA STATE	RADAR SETTINGS						DETECTION	SIGNAL QUALITY	
vessel to kayak	vessel (lat/long)	kayak (lat/long)	Beaufort scale	sea clutter	rain clutter	tuning	gain	range	ring	1=hit or 0=miss		
⅛ nautical mile												
¼ nautical mile												
½ nautical mile												
1 nautical mile												
2 nautical mile												

Data Form used in all three tests

- Kayaks were fitted with either a commercial or homemade reflector
- All kayaks were measured with no reflector as a control



- Each kayaker paddled a fixed route between two known points
- The radar platform moved to the appropriate range for each data sample

RESULTS

Norumbega Technologies Inc.

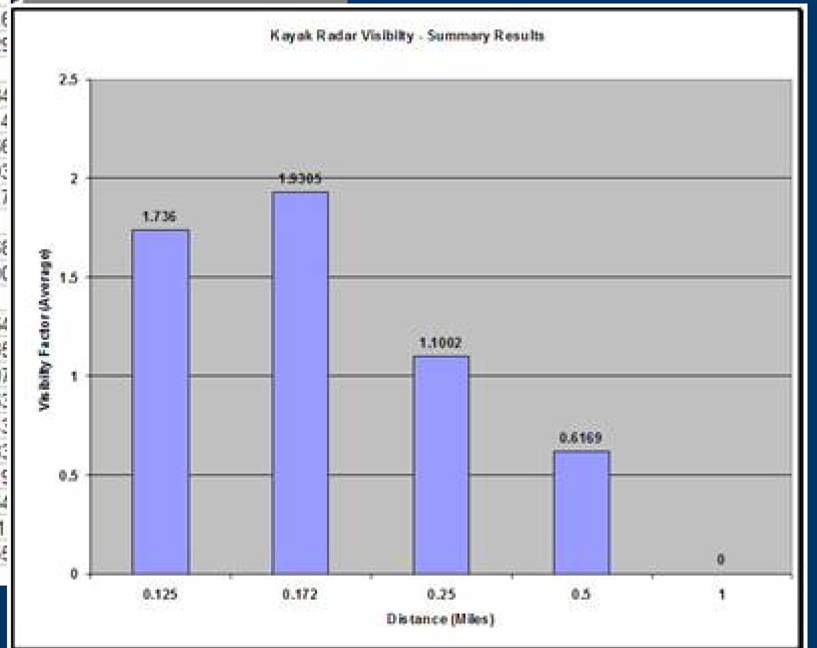
- Data was entered into a relational database for analysis

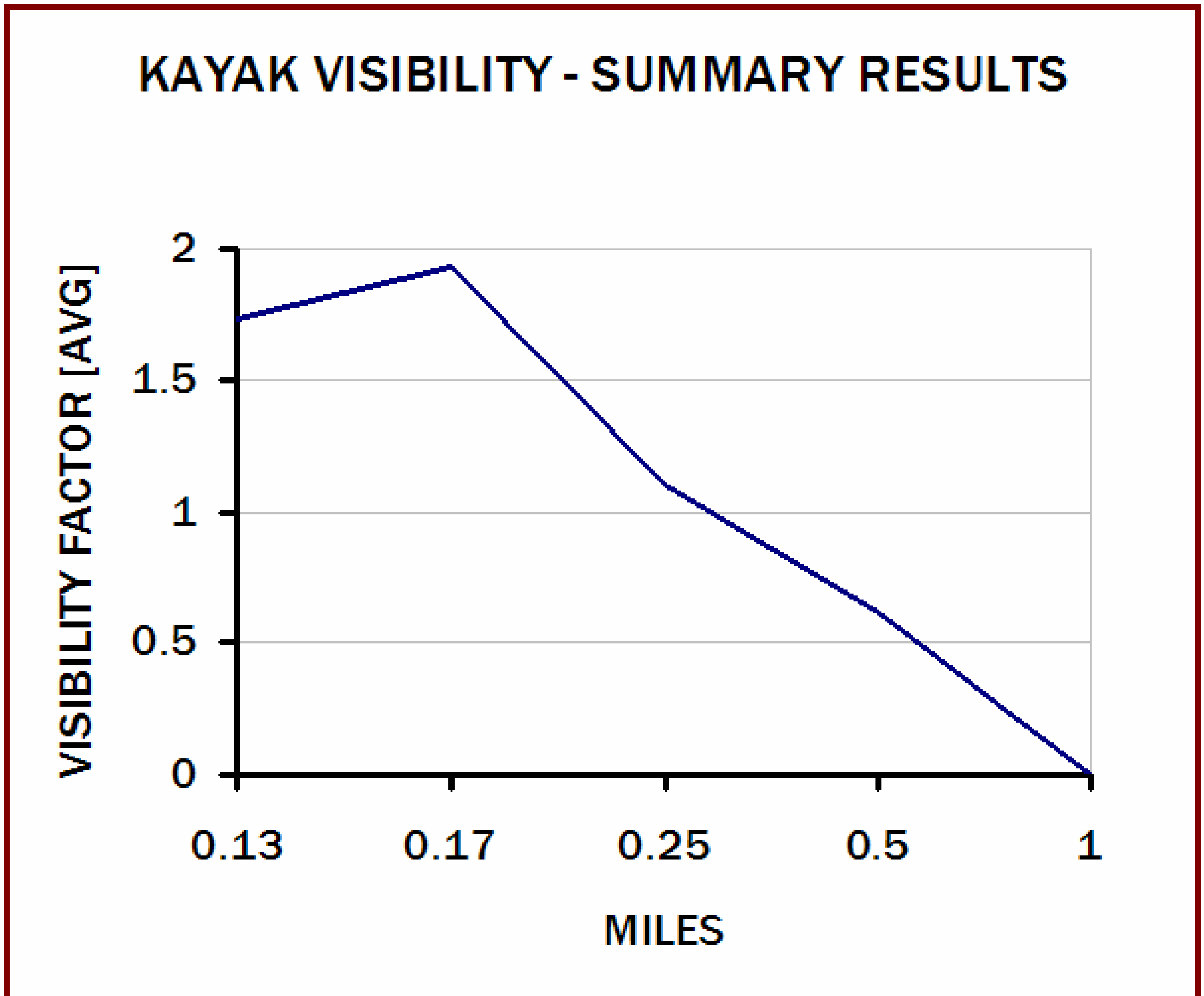
Microsoft Access - [DATA : Table]

ID1	DATE	VESSEL	LOCATION	BOAT	PADDLER	REFLECTOR	DISTANCE	SEA STATE
1	8/18/2003	INDIGO	BH	CHINOOK	PAUL	NONE	0.125	CALM
2	8/18/2003	INDIGO	BH	CHINOOK	PAUL	NONE	0.25	CALM
3	8/18/2003	INDIGO	BH	CHINOOK	PAUL	NONE	0.5	CALM
4	8/18/2003	INDIGO	BH	CHINOOK	RICH	NONE	0.125	CALM
5	8/18/2003	INDIGO	BH	CHINOOK	RICH	NONE	0.25	CALM
6	8/18/2003	INDIGO	BH	CHINOOK	RICH	NONE	0.5	CALM
7	7/7/2004	ATON	SW	CAPE HORN	GEORGE	WATCHDOG	0.125	CALM
8	7/7/2004	ATON	SW	CAPE HORN	GEORGE	WATCHDOG	0.25	CALM
9	7/7/2004	ATON	SW	CAPE HORN	GEORGE	WATCHDOG	0.5	CALM
10	7/7/2004	ATON	SW	CAPE HORN	GEORGE	WATCHDOG	0.5	CALM
11	7/7/2004	ATON	SW	CAPE HORN	GEORGE	WATCHDOG	1	CALM
12	11/6/2004	EQUINOX						
13	11/6/2004	EQUINOX						
14	11/6/2004	EQUINOX						
15	11/6/2004	EQUINOX						
16	11/6/2004	EQUINOX						
17	11/6/2004	EQUINOX						
18	11/6/2004	EQUINOX						
19	11/6/2004	EQUINOX						
20	11/6/2004	EQUINOX						
21	11/6/2004	EQUINOX						
22	11/6/2004	EQUINOX						
23	11/6/2004	EQUINOX						
24	11/6/2004	EQUINOX						
25	11/6/2004	EQUINOX						
26	11/6/2004	EQUINOX						
27	11/6/2004	EQUINOX						
28	11/6/2004	EQUINOX						
29	11/6/2004	EQUINOX						
30	11/6/2004	EQUINOX						
31	11/6/2004	EQUINOX						
32	11/6/2004	EQUINOX						
33	11/6/2004	EQUINOX						
34	11/6/2004	EQUINOX						
35	11/6/2004	EQUINOX						
36	11/6/2004	EQUINOX						

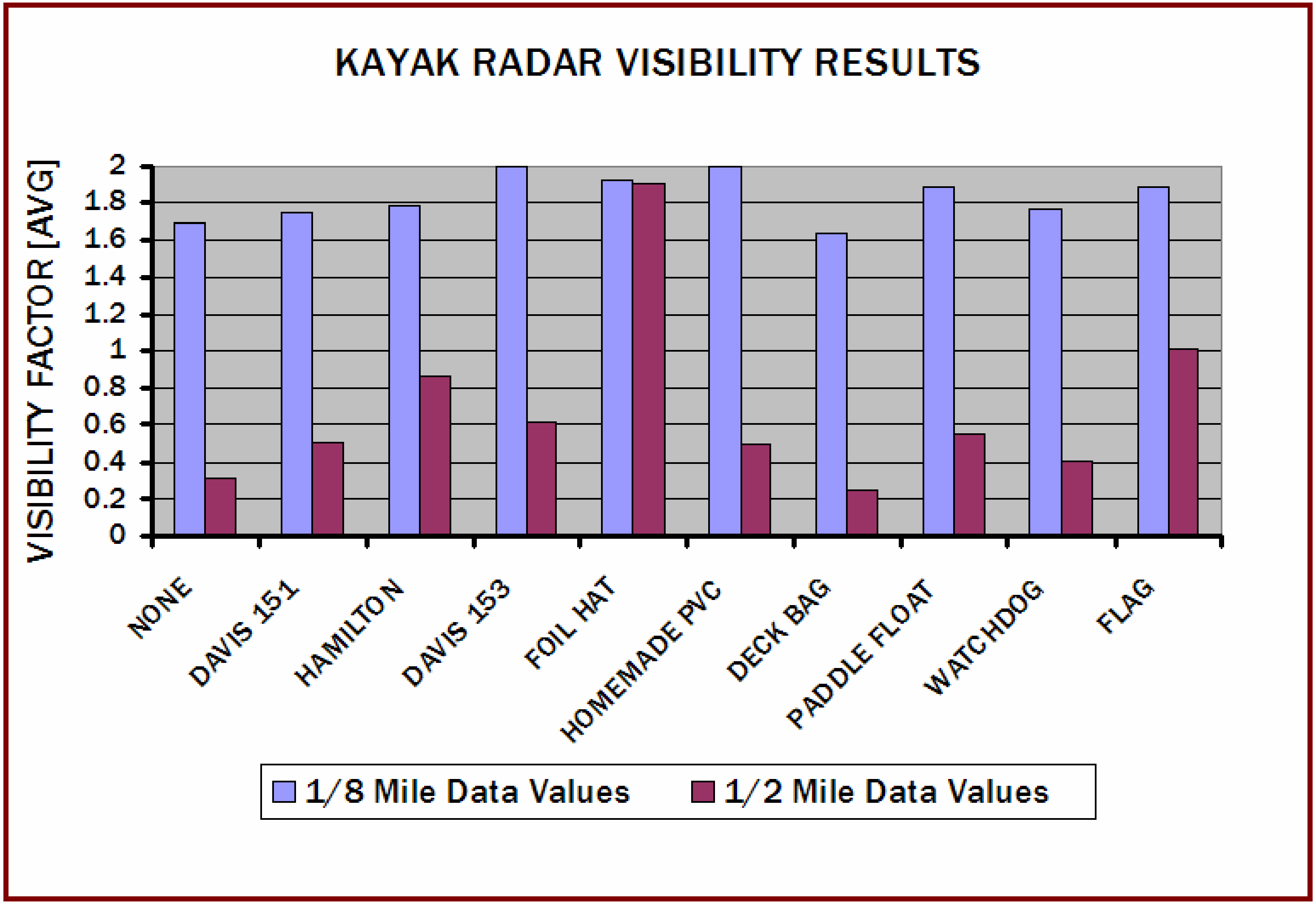
Microsoft Access - [Data_Sea_State : Select Query]

LOCATION	REFLECTOR	DISTANCE	VISIBILTY FACTOR
SW	DAVIS 151	0.125	1.75
SW	DAVIS 151	0.25	1.333
SW	DAVIS 151	0.5	0.1522
SW	DAVIS 151	0.5	0.8571
SW	DAVIS 153	0.5	0.3488
BB	DAVIS 153	0.5	0
SW	DAVIS 153	0.5	1.5
SW	DECK BAG	0.5	0
SW	DECK BAG	0.25	1.6
SW	DECK BAG	0.5	0.72
SW	DECK BAG	0.5	
SW	DECK BAG	0.125	1.384
SW	FLAG	0.5	0.714
SW	FLAG	0.125	1.666
SW	FLAG	0.5	1.193
SW	FLAG	0.5	0.7
SW	FLAG	0.125	
SW	FLAG	0.5	1.366
BB	FOIL HAT	0.5	1.90
SW	HAMILTON	0.125	
SW	HAMILTON	0.25	1.764
SW	HAMILTON	0.5	0.535
SW	HAMILTON	0.5	0.897
SW	HAMILTON	0.5	1.363
SW	HAMILTON	0.5	0.643
SW	HAMILTON	0.125	1.583
SW	JET SKI	0.5	1.315
SW	JET SKI	0.5	0.354
SW	NONE	0.125	1
BB	NONE	0.5	0.055
BB	NONE	0.5	

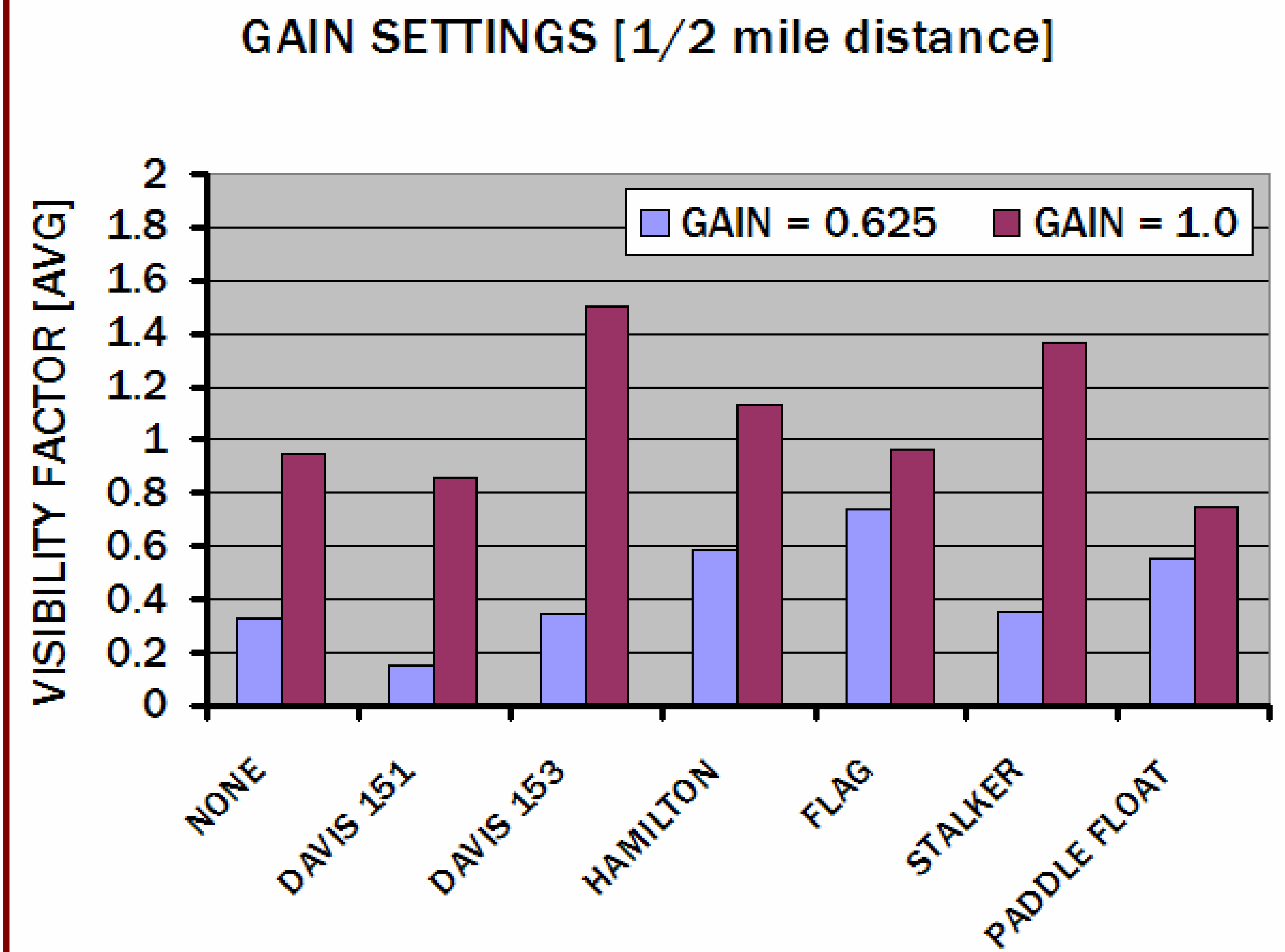


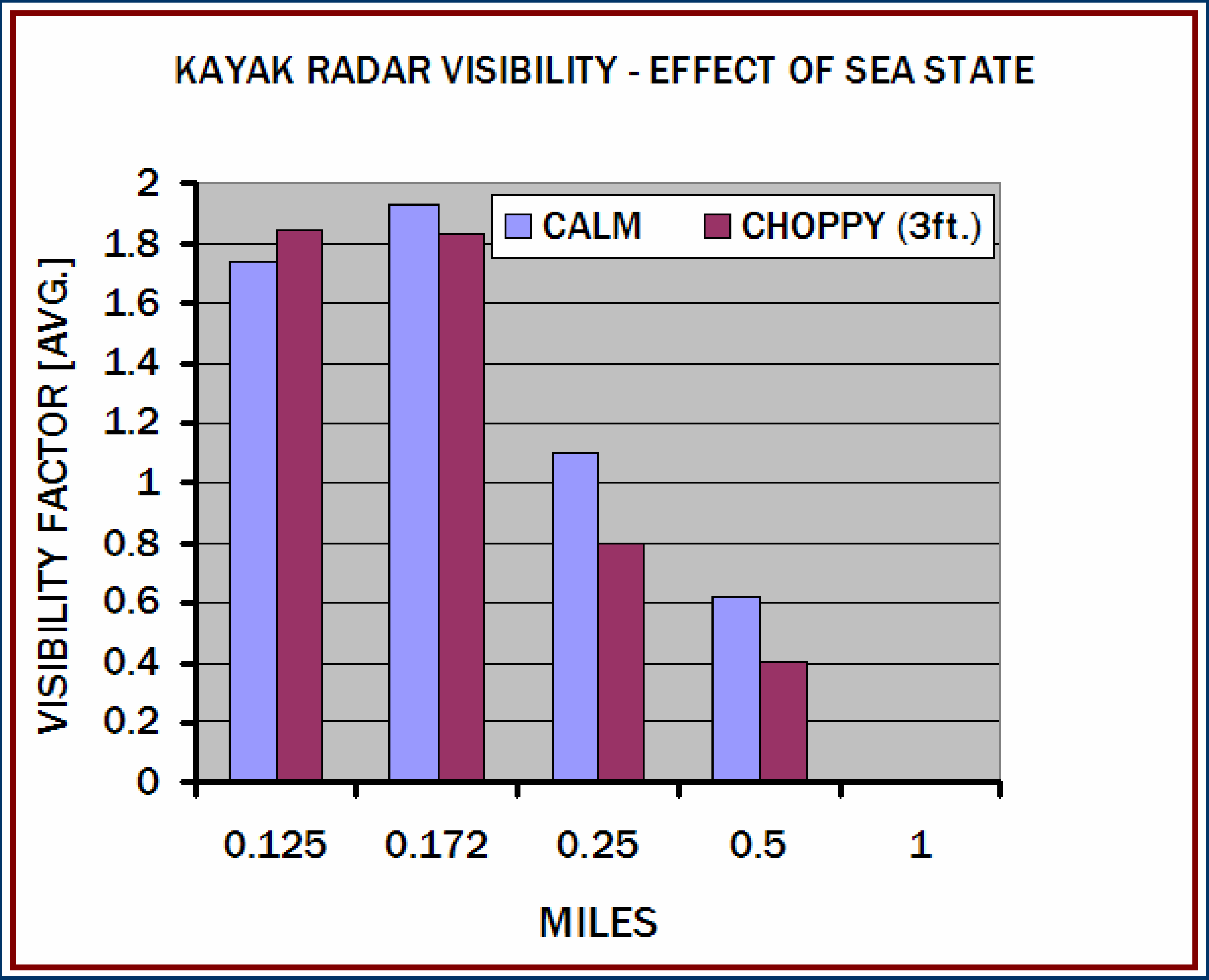


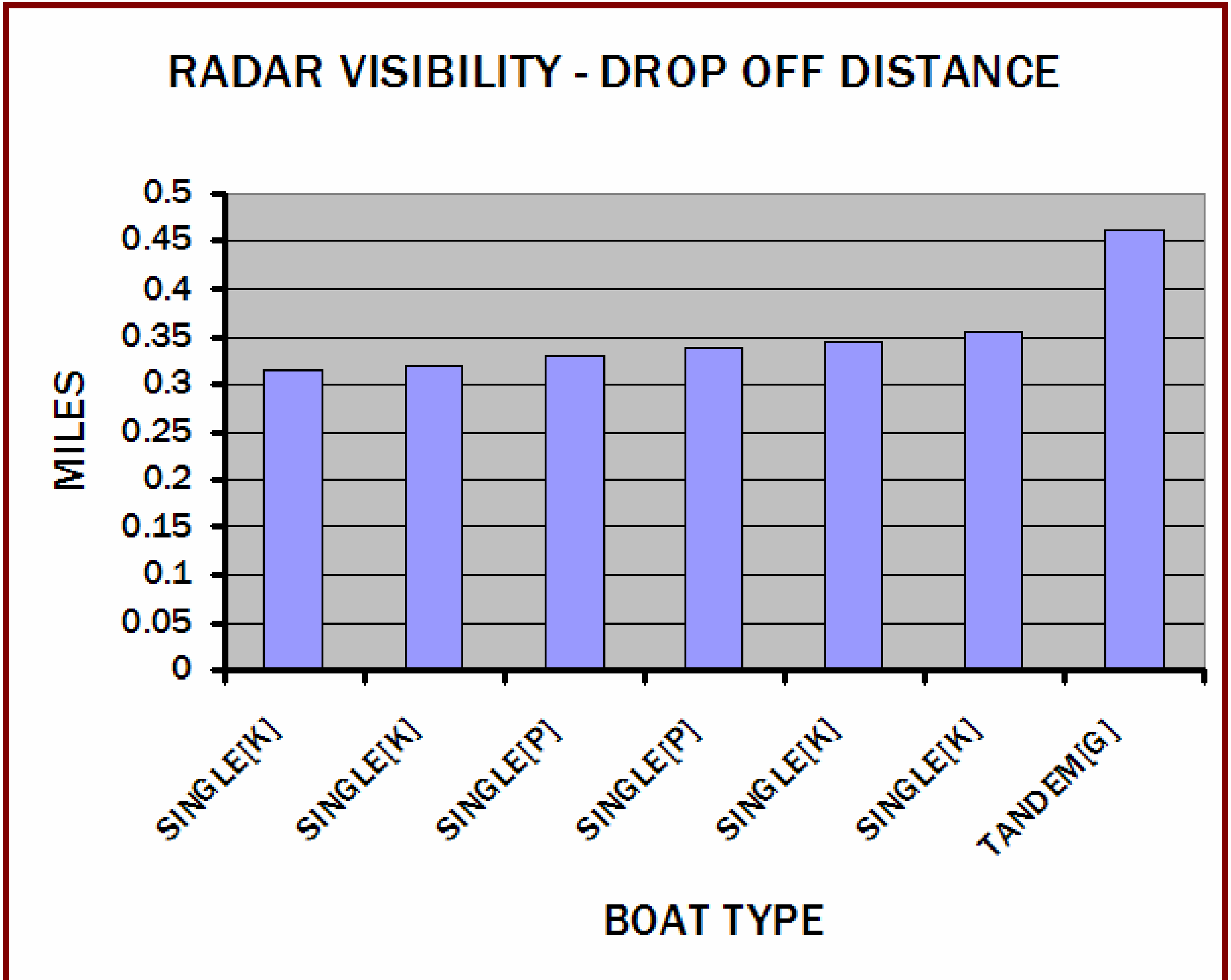
KAYAK VISIBILITY - SUMMARY RESULTS
VISIBILITY FACTOR [AVG]
2
1.5
1
0.5
0
0.13
0.17
0.25
0.5
1
MILES



KAYAK RADAR VISIBILITY RESULTS
VISIBILITY FACTOR [AVG]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
NONE
DAVIS 151
HAMILTON
DAVIS 153
FOIL HAT
HOMEMADE PVC
DECK BAG
PADDLE FLOAT
WATCHDOG
FLAG
1/8 Mile Data Values
1/2 Mile Data Values


GAIN SETTINGS [1/2 mile distance]
VISIBILITY FACTOR [AVG]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
GAIN = 0.625
GAIN = 1.0
NONE
DAVIS 151
DAVIS 153
HAMILTON
FLAG
STALKER
PADDLE FLOAT


KAYAK RADAR VISIBILITY - EFFECT OF SEA STATE
CALM
CHOPPY (3ft.)
VISIBILITY FACTOR [AVG.]
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.125
0.172
0.25
0.5
1
MILES



RADAR VISIBILITY - DROP OFF DISTANCE
MILES
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
SINGLE[K]
SINGLE[K]
SINGLE[P]
SINGLE[P]
SINGLE[K]
SINGLE[K]
TANDEM[G]
BOAT TYPE

- Lost in the radar shadow of Mt. Desert Island

- Low profile reflectors on rear deck of kayaks

Conclusions

- Choose and mount your reflector wisely.
- The greater the angularity of a radar reflector, the greater its visibility factor.
- The larger the kayak the greater its visibility factor.
- Kayaks paddling closely together in a pod formation produce a much more significant radar return than a kayak paddling singly with a radar reflector.
- At both 1/8 and 1/4 nautical mile, kayaks consistently showed up on radar.
- The angle of the sea kayak to the radar platform affects visibility.

Conclusions (cont.)

- Changing gain and sea clutter on the radar screen will increase the ability to detect kayaks.
- The visibility factor decreases with distance away from the radar platform.
- The higher the radar antenna is mounted, the less effect sea state has on kayak visibility.
- Motion of the radar platform can reduce its effectiveness at picking up targets
- The strength of the return is the dominant factor
- Radar is only effective when it is being watched.

Recommendations for:

- Research and development
- Radar-equipped vessel operators
- Paddlers

Recommendations for Paddlers

- Some form of radar reflector is better than none
- Radar reflector design needs to be functional for paddling
- Mount reflectors to generate the greatest return, consider both height and orientation

Recommendations for Paddlers

- Travel in tight pods to provide a greater radar return

- Plan crossings for narrow channels and known navigation references. Make *securite* calls on VHF 16 and local channel to advise crossing underway. Specify exact points of crossing.

Recommendations for Radar-equipped Vessel Operators

- Use your radar and watch screen through multiple sweeps
- Optimize radar settings for greatest return
- Monitor VHF 16 for *securite* calls.
- Slow down in known recreational boating areas

- A pod of kayaks as seen from CG 55120

Recommendations for Research and Development

- Design and market kayak-friendly reflectors that exceed results in this study
- Innovative options include hat and flag-style reflectors but models on the market fall short

The final report – Spring 2005

Available in *.pdf format:

www.seagrant.umaine.edu

www.maineseakayakguides.com

Radar, Reflectors and Sea Kayaks: A Visibility Study

Summer 2003 and 2004

Introduction

In recent years, sea kayaking has been growing in popularity throughout North America and especially in Maine. Sea kayakers are regularly observed along our coastal shores; and sea kayak guides and outfitters are becoming a significant part of the working waterfront, with commercial operations spanning from Kittery to Calais. With such popularity, the potential for kayak collisions with larger vessels increases dramatically.

Radar reflectors are used by sailboats, motorized recreational craft, and working boats of all sizes to increase their potential appearance on the radar of other vessels; the more obvious the "return" on a radar screen, the more likely an attendant boat captain is to avoid collision. On the coast of Maine, sea kayakers are increasingly using radar reflectors to increase their visibility, both in an effort to avoid collision and to facilitate search and rescue operations in the event of trouble. However, concrete information is lacking on just how effective radar reflectors are in helping kayaks appear on radar. Conventional wisdom is that the higher a reflector is mounted aloft (such as on a sailboat's mast), the better radar signal it will return. The intentional low-profile design of sea kayaks that makes them comparatively sea worthy in the hands of a capable paddler also makes sea kayaks difficult to see, both with the naked eye and on a radar screen.

The purpose of this study is to review the effectiveness of a variety of commercial and homemade radar reflectors in increasing the visibility of sea kayaks on radar. It is intended that the results of this study will 1) raise awareness about the efficacy of radar reflectors on sea kayaks; 2) provide all users of our coastal waters with knowledge to reduce the risk of radar-equipped vessels colliding with sea kayaks; and 3) begin a dialog between motor-/sail- vessel operators and sea kayakers along the coast of Maine.

This report summarizes the results of radar reflector tests conducted on the coast of Maine during the summers of 2003 and 2004.

Preparing the first round of radar reflector trials at the College of the Atlantic dock, summer 2003.

Project History

During the spring of 2003, two rounds of preliminary visibility tests were conducted with the Maine Association of Sea Kayak Guides and Instructors (MASKGI): one with the U.S. Coast Guard, the other with a lobsterman. Two conflicting sets of results emerged. Using a range of radar settings, the Coast Guard radar was consistently able to detect sea kayaks at various levels of intensity, depending on the model of radar reflector. The lobsterman's radar, similar in caliber to the Coast Guard's, was NOT able to "see" any of the paddlers, despite use of the same radar reflectors and similar sea conditions. The conflicting results of these preliminary tests pointed to a need for further systematic testing following a repeatable study design.

Maine Sea Grant, MASKGI, U.S. Coast Guard, Gulf of Maine Expedition Institute, and College of the Atlantic partnered to develop testing methodologies, run field tests, and provide results to sea kayakers and operators of radar-equipped vessels. For a complete list of project participants, see back page.

Top picture: Field tester with Davis #153 radar reflector on stern deck.

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Project supporters and volunteers:
U.S. Coast Guard *(First Coast Guard District Recreational Boating Safety Specialist Al Johnson and LT Kevin King, Office of Search and Rescue);*
U.S. Coast Guard Group Southwest Harbor *(LTJG Tom Gorgol, Chief Ken Hill and the Aids to Navigation team);*
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