Dissolved oxygen and oxygen management – intensive production of catfish.

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Ohio Aquaculture and Fish Management Conference, Jan. 26-27, 2018, Columbus OH

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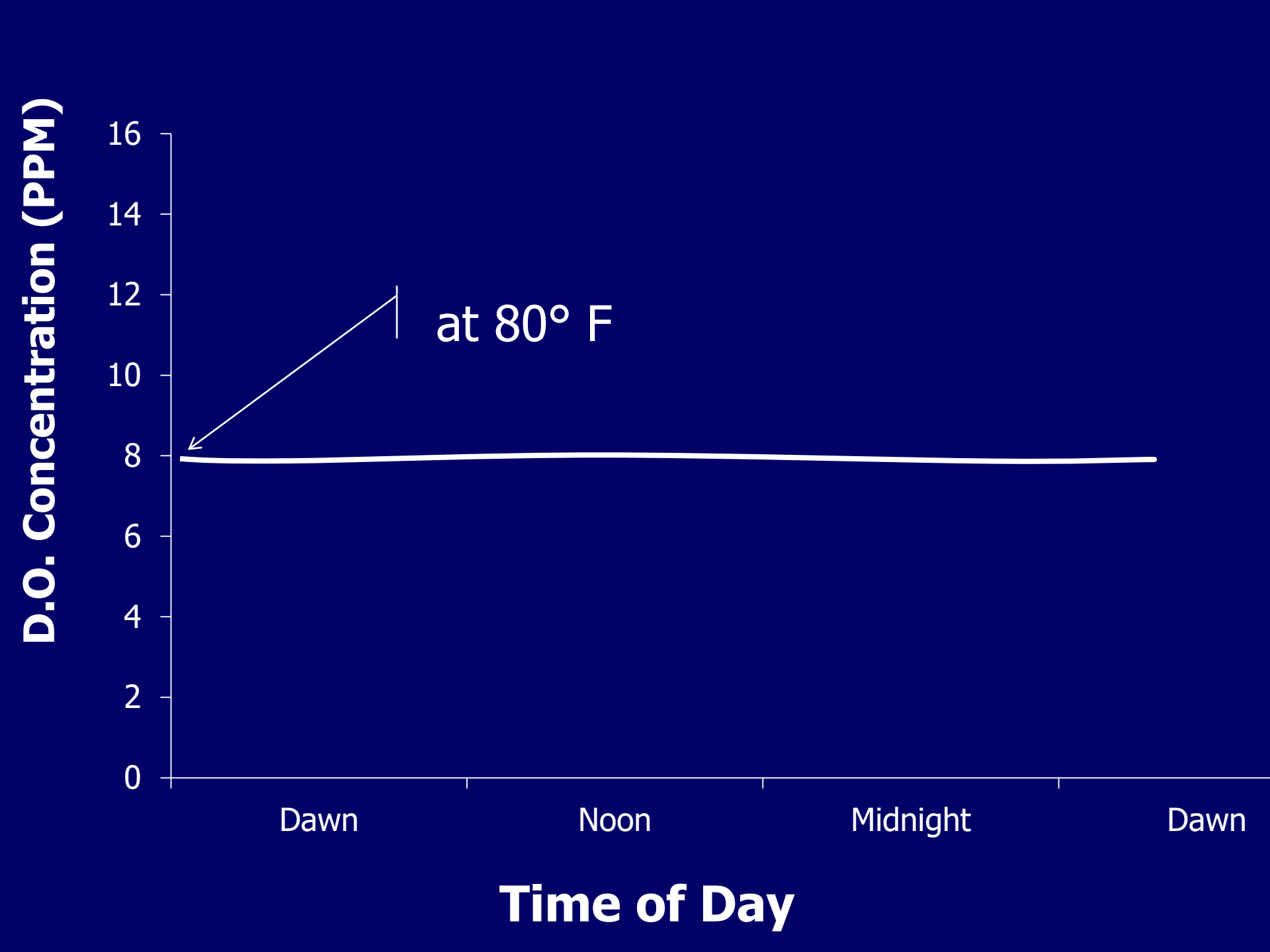
Composition of Air

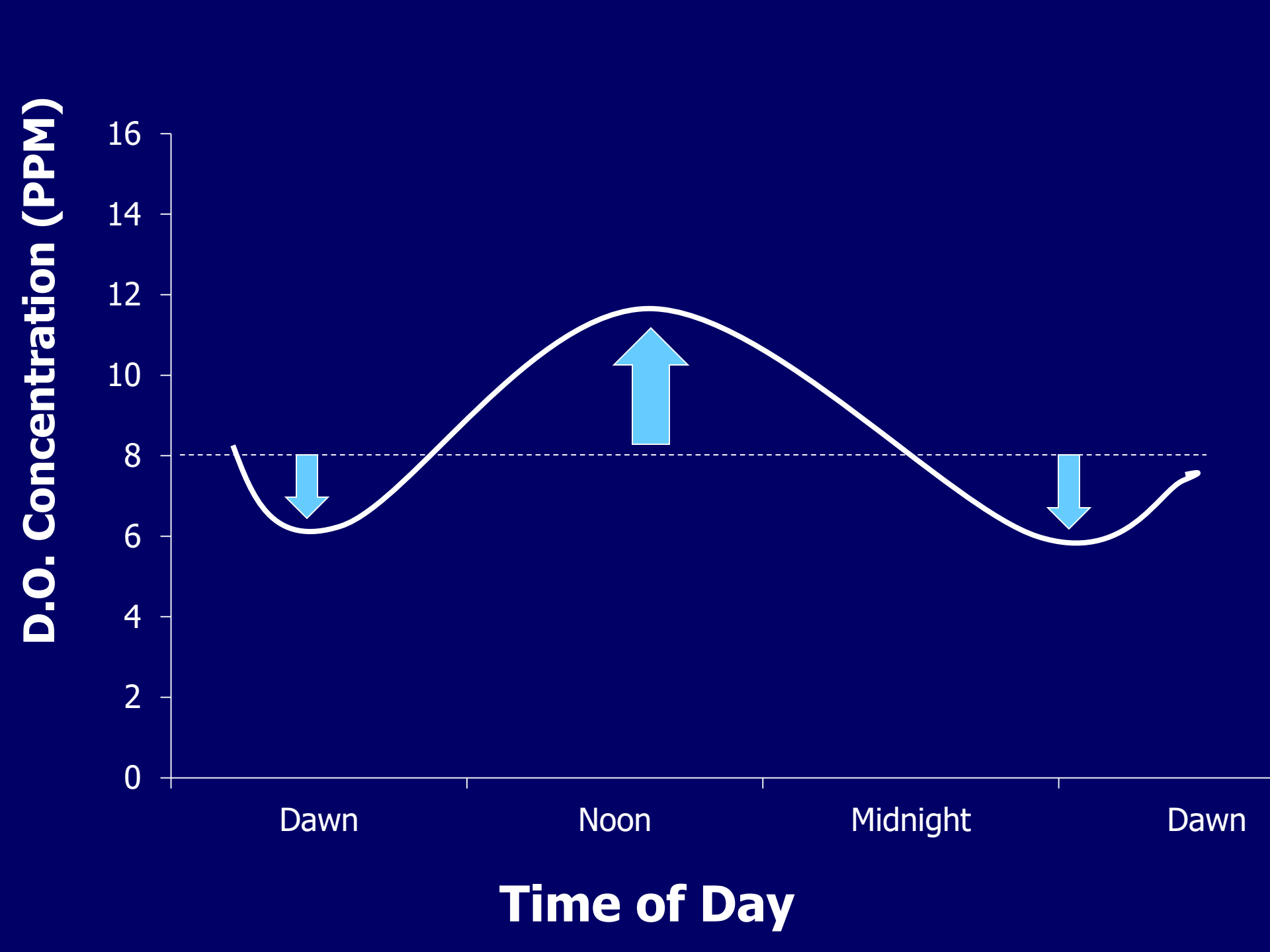
• Nitrogen	N_2	• 78.1%
• Oxygen	O_2	• 20.9%
• Argon	Ar	• 0.93%
• Carbon Dioxide	CO_2	• 0.033%
• Neon	Ne	• 0.00182%
• Helium	He	• 0.00052%

Oxygen in air and water

	Air	**Water**
Volume	• 500 ml	• 500 ml
Weight	• 0.656 g	• 500 g
% O_2	• 21%	• 0.0000075%
Weight O_2	• 0.14 g	• 0.00375 g

Temperature (C)	O_2 Saturation (mg/L)
35 (95 F)	6.9
30 (86 F)	7.5
25 (77 F)	8.2
20 (68 F)	9.1
15 (59 F)	10.1
10 (50 F)	11.3


D.O. Concentration (PPM)
16
14
12
10
8
6
4
2
0
at 80° F
Dawn
Noon
Midnight
Dawn
Time of Day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16
14
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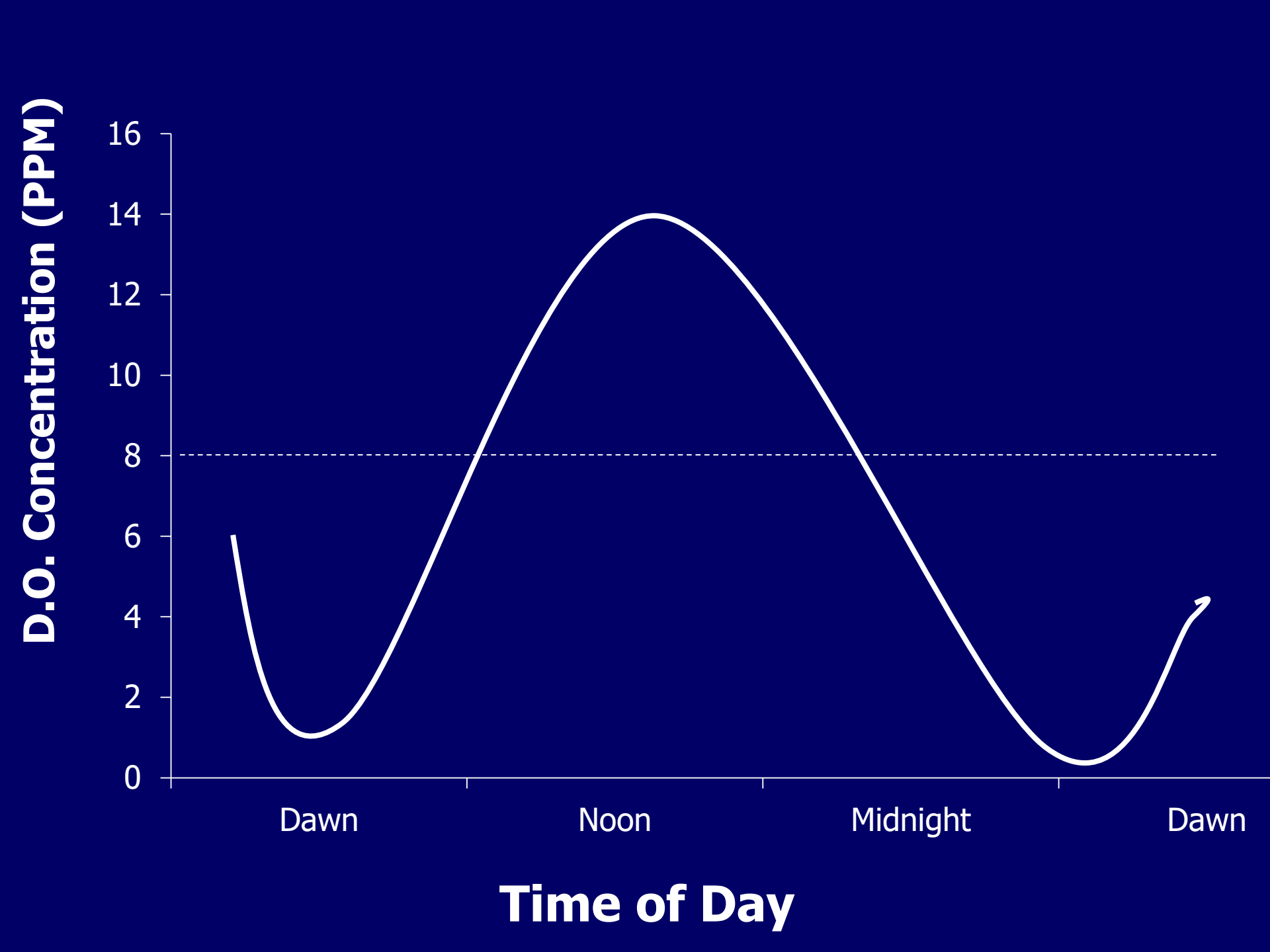
6
4
2
0
Dawn
Noon
Midnight
Dawn
Time of Day


D.O. Concentration (PPM)
16
14
12
10
8
6
4
2
0
Dawn
Noon
Midnight
Dawn
Time of Day

Production without aeration

- 30 lb·acre^{-1}·day^{-1} Max. safe feeding rate: Swingle, 1959.

- 1500-1800 lb/acre average commercial production: Report to the Fish Farmers, 1970.

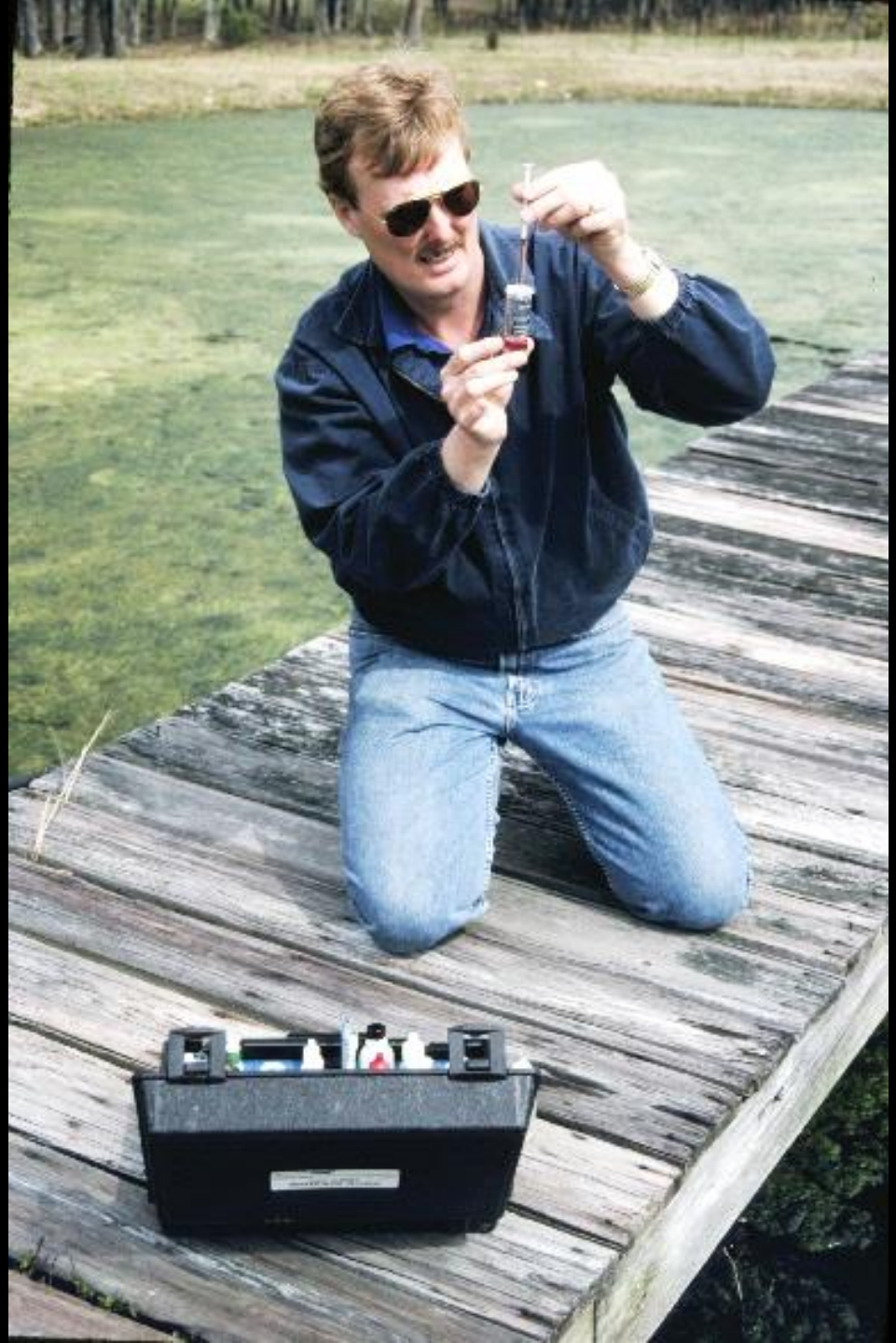

JIM BEAM

Monitoring ponds: “Routine observation before sunrise should be made during July and August. If the fish are surfacing, large volumes of water from an adjacent pond will usually remedy the situation.”

From: Report to the Fish Farmers, 1970.

Emergency Aeration


'94 1 2




YSI MODEL 51B
OXYGEN METER
mg/l
°C
READ TEMP AND SET DIAL
ZERO
FULL SCALE
CALIB
ZERO
FULL SCALE


YSI
55
DISSOLVED OXYGEN
ON/OFF
LIGHT
MODE
ENTER
YSI
550A
Mode
YSI incorporated

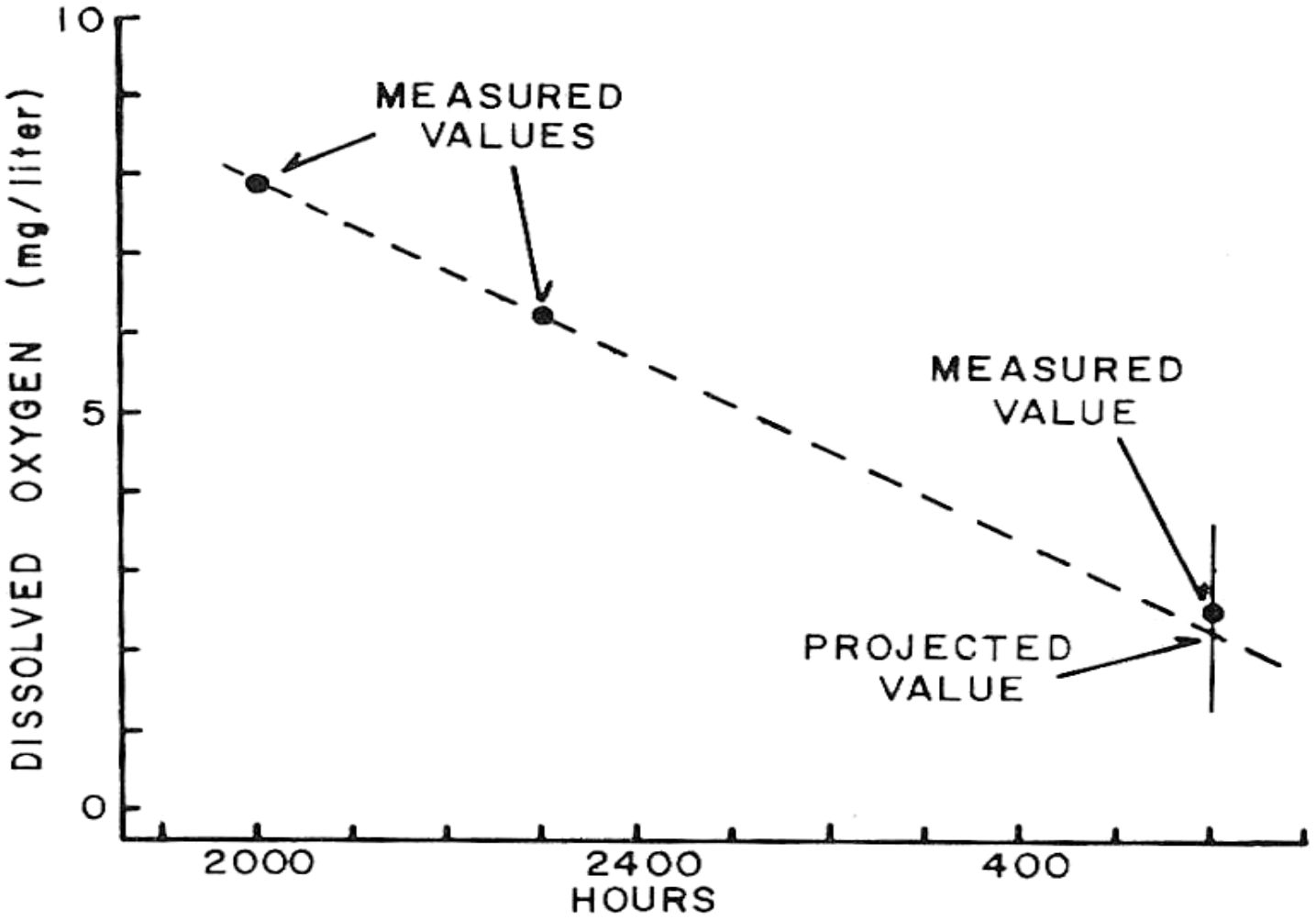
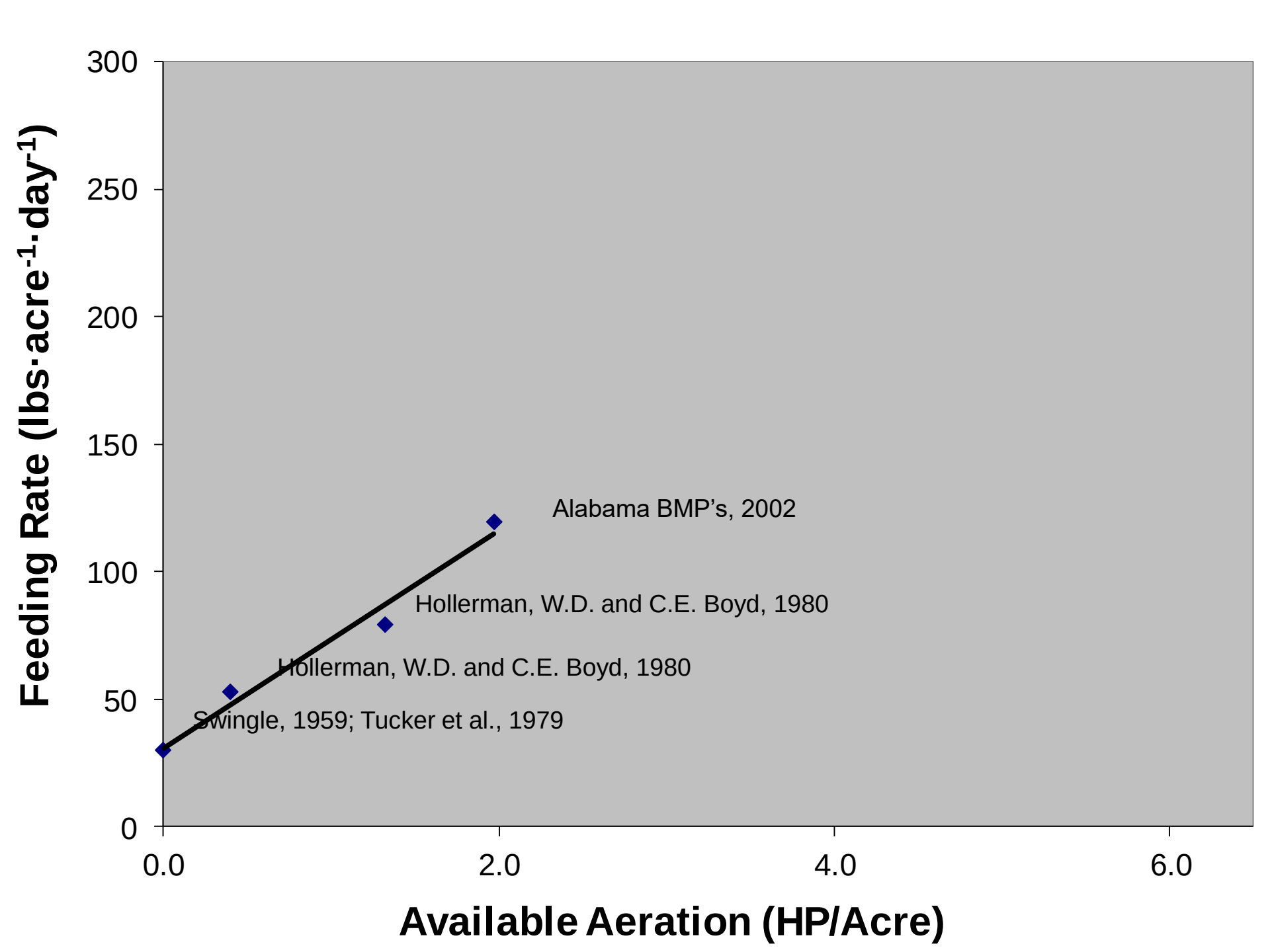


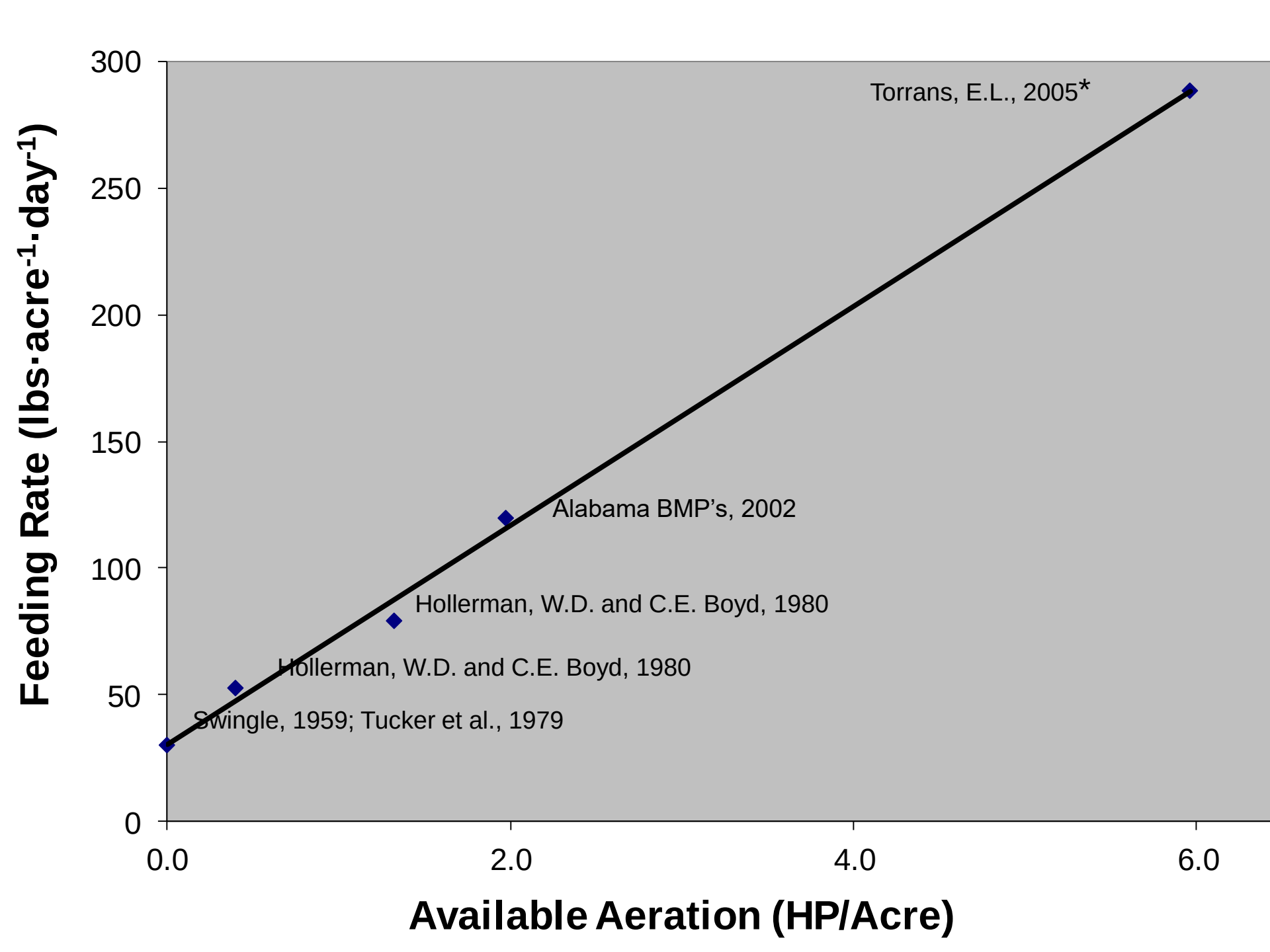
FIGURE 5.—*Illustration of the method for calculating DO concentration at dawn by projecting DO measurements made at dusk and 3 h later.*

From: Boyd, C.E., R. P. Romaire and E. Johnson, 1975. TAFS107(3):p. 490.


Fish pump or “bankwasher”

10 hp floating electric paddlewheel aerator


300
250
200
150
100
50
0
0.0
2.0
4.0
6.0
Feeding Rate (lbs·acre-1·day-1)
Available Aeration (HP/Acre)
Alabama BMP's, 2002
Hollerman, W.D. and C.E. Boyd, 1980
Hollerman, W.D. and C.E. Boyd, 1980
Swingle, 1959; Tucker et al., 1979


Feeding Rate (lbs·acre-1·day-1)
300
250
200
150
100
50
0
0.0
2.0
4.0
6.0
Available Aeration (HP/Acre)
Torrans, E.L., 2005*
Alabama BMP's, 2002
Hollerman, W.D. and C.E. Boyd, 1980
Hollerman, W.D. and C.E. Boyd, 1980
Swingle, 1959; Tucker et al., 1979


5
6
7
ROYCE
INSTRUMENT CORPORATION
MODEL 9300
ALARM
DO TEMP
RUN
CAL
PGM
TEST
DISSOLVED OXYGEN ANALYZER

What D.O. *concentration* do catfish need?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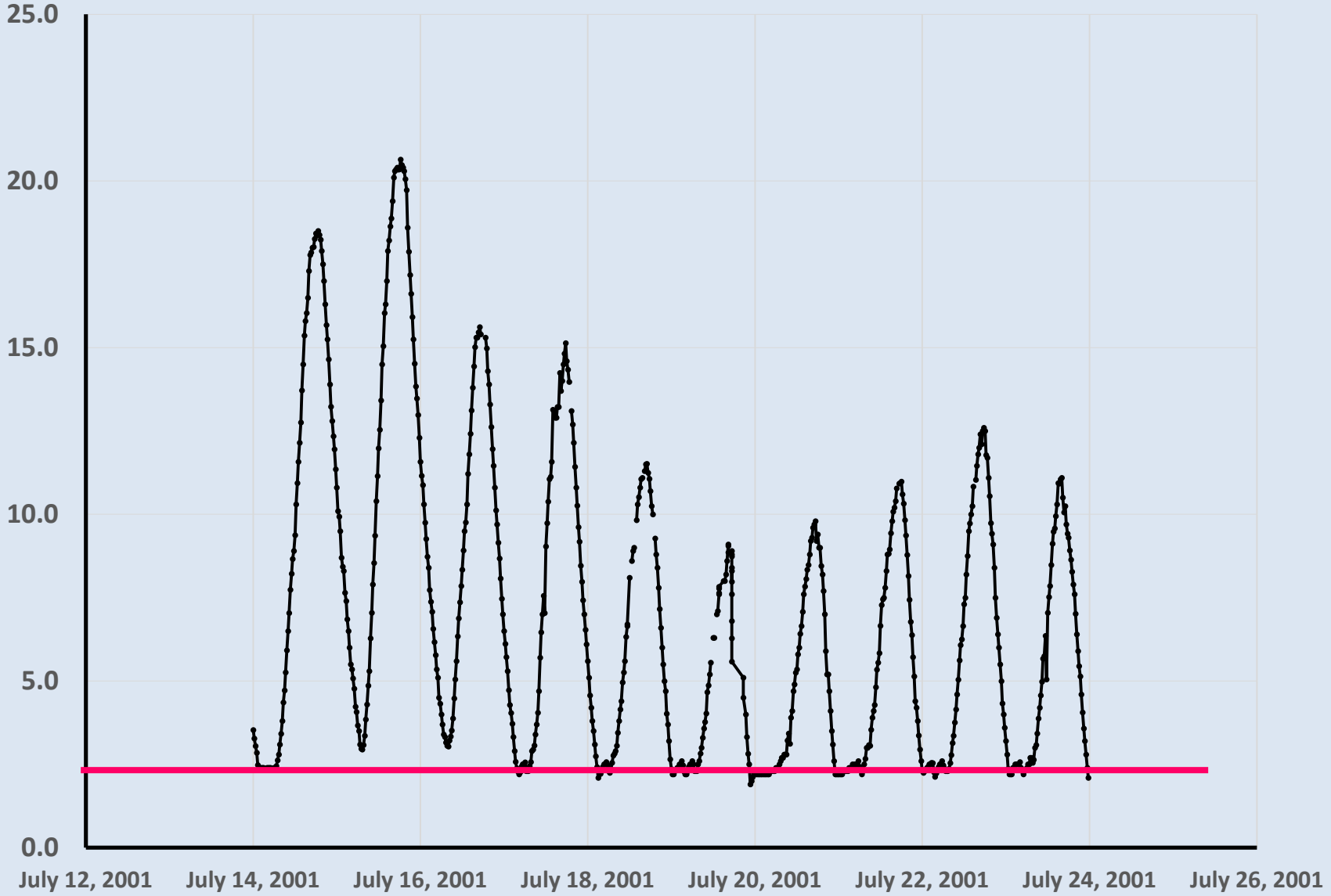
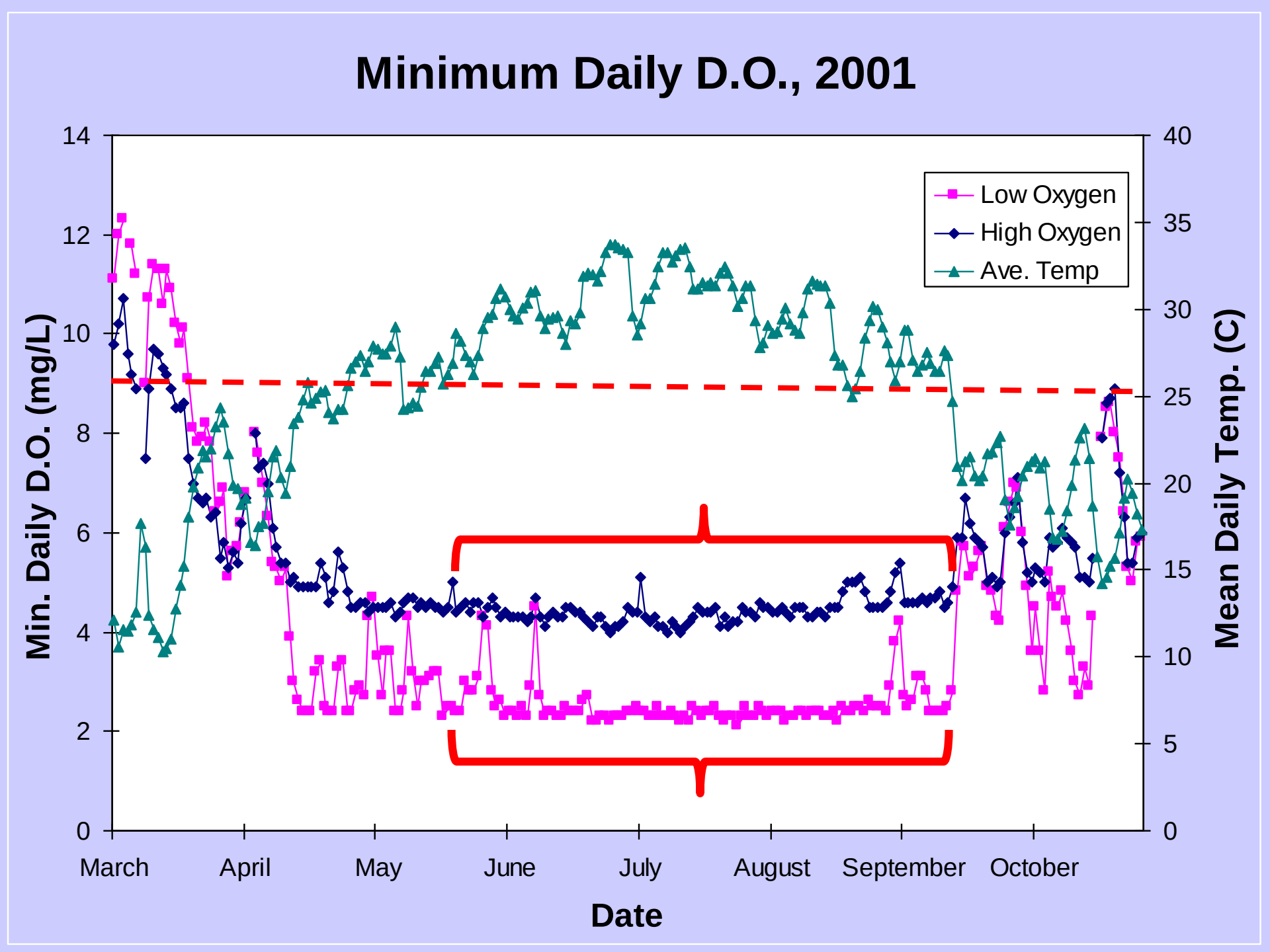
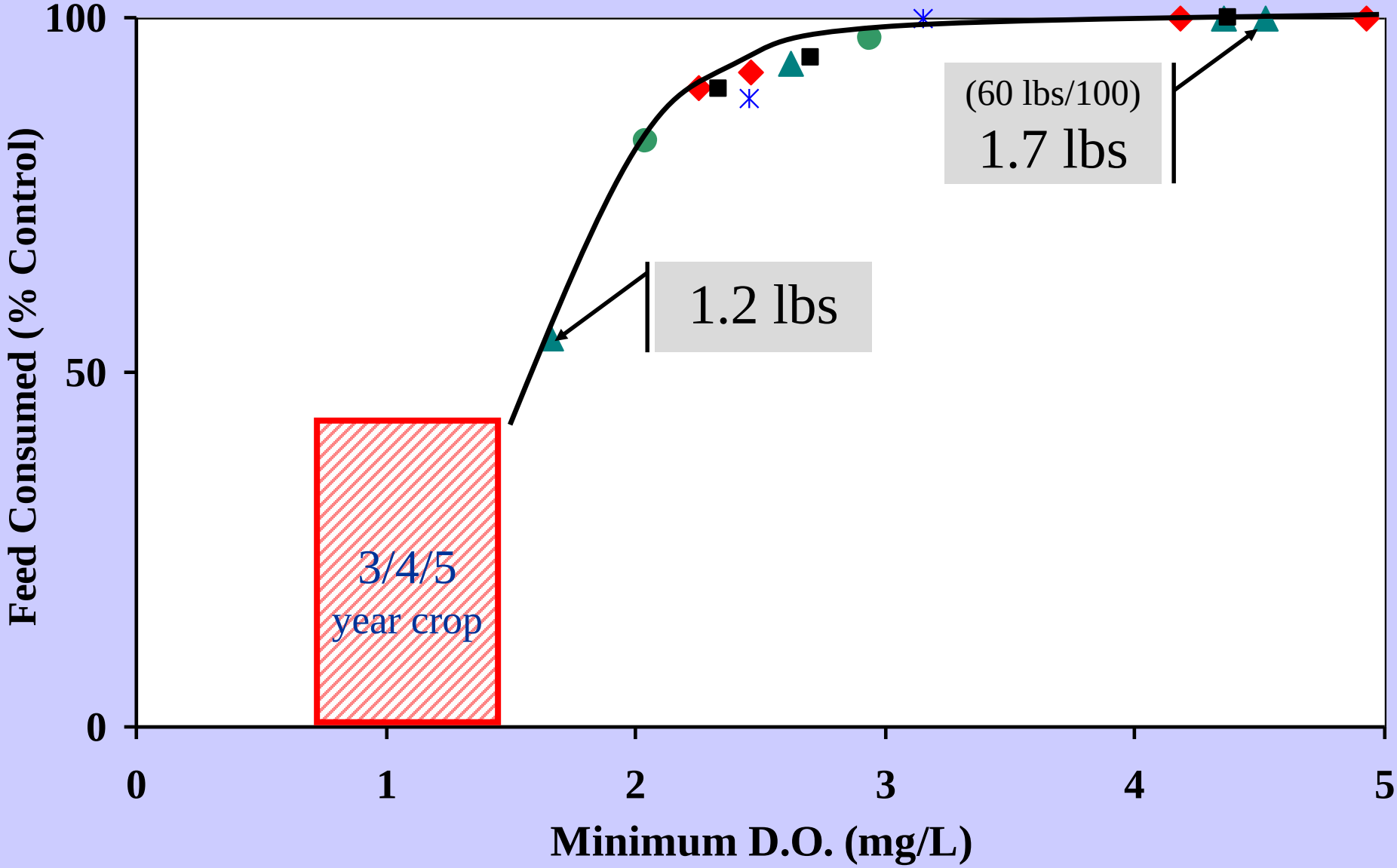
Sample DO Data

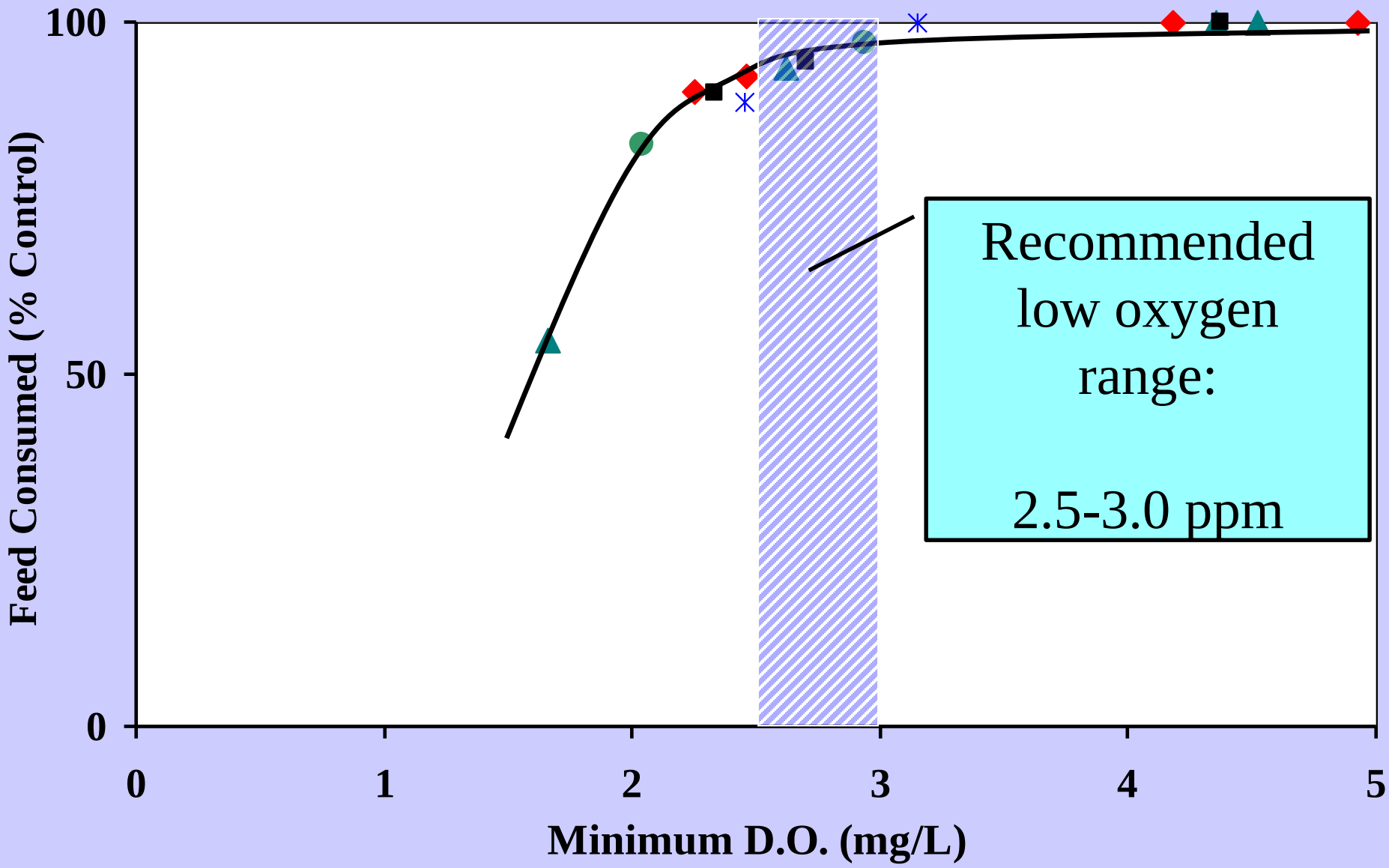


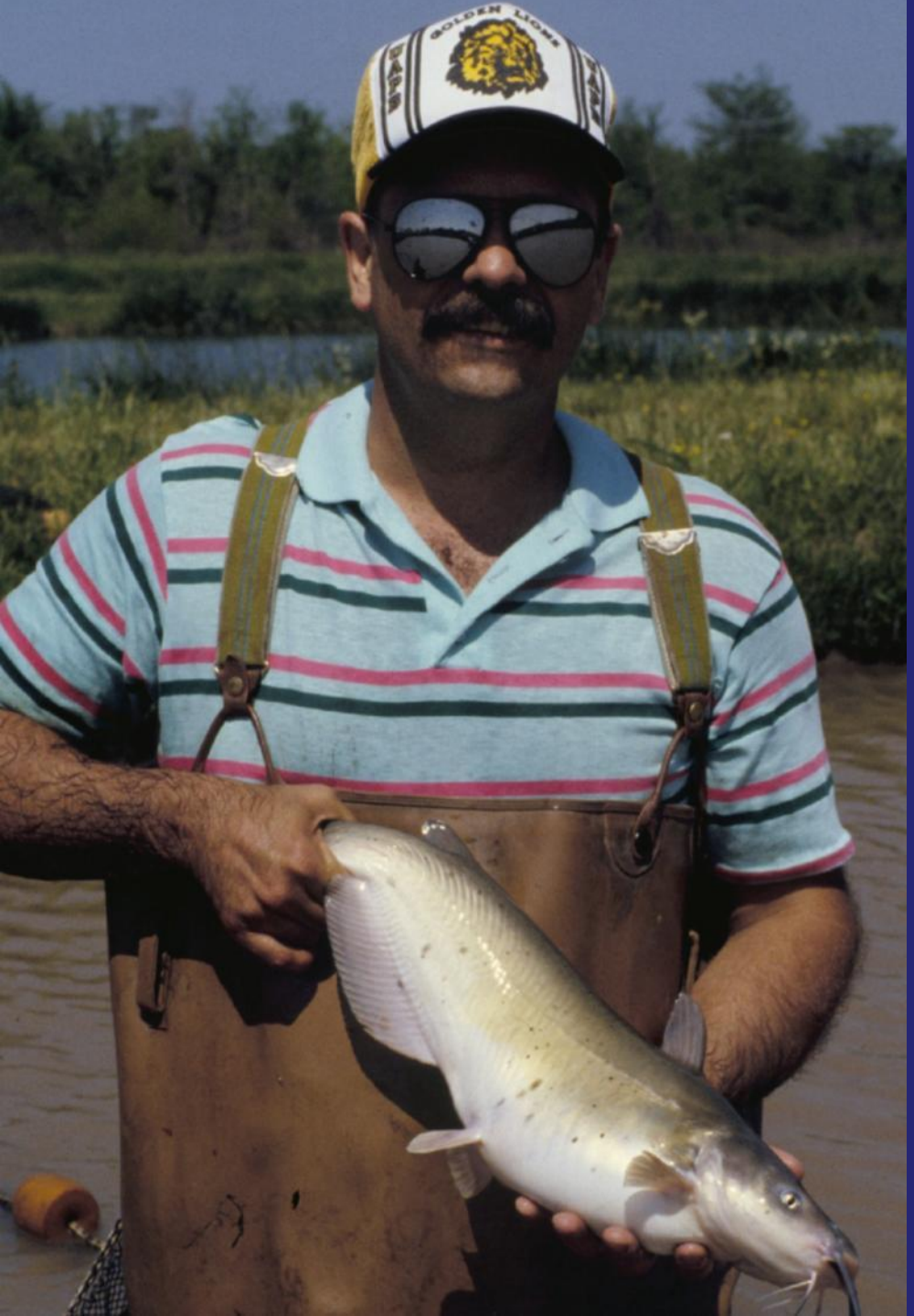

Minimum Daily D.O., 2001
Min. Daily D.O. (mg/L)
Mean Daily Temp. (C)
Date
Low Oxygen
High Oxygen
Ave. Temp
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
March
April
May
June
July
August
September
October

Torrans - Catfish Oxygen Studies



Torrans - Catfish Oxygen Studies





23-months old

(16 months + winter)

Three pounds


ESC
Columnaris
Aeromonas
PGD (hamburger gill)
Catfish trematodes
Anemia
Winter kill
Bird predation
Ich, Trichodina, Costia, etc

Does DO affect FCR???

- Poor FCR with very low morning DOs (maintenance ration)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Does DO affect FCR???

- Poor FCR with very low morning DOs (maintenance ration)
- Poorer feeding response at lower DOs, or with sick fish, making over-feeding more likely

Does DO affect FCR???

- Poor FCR with very low morning DOs (maintenance ration)
- Poorer feeding response at lower DOs, or with sick fish, making over-feeding more likely
- *Reduced food consumption* with morning DOs below 3 ppm, resulting in *reduced growth*, a *longer production cycle*, *greater mortality*, and a *poorer FCR*.

What FCR is Possible on a Commercial Farm?

1.8 – 2.2

Goal: Maintain a morning D.O. of 2.5-3.0 ppm, feed more feed/fish, resulting in faster growth and a shorter production cycle

- More efficient use of aerators – Oxygen Monitoring Systems)

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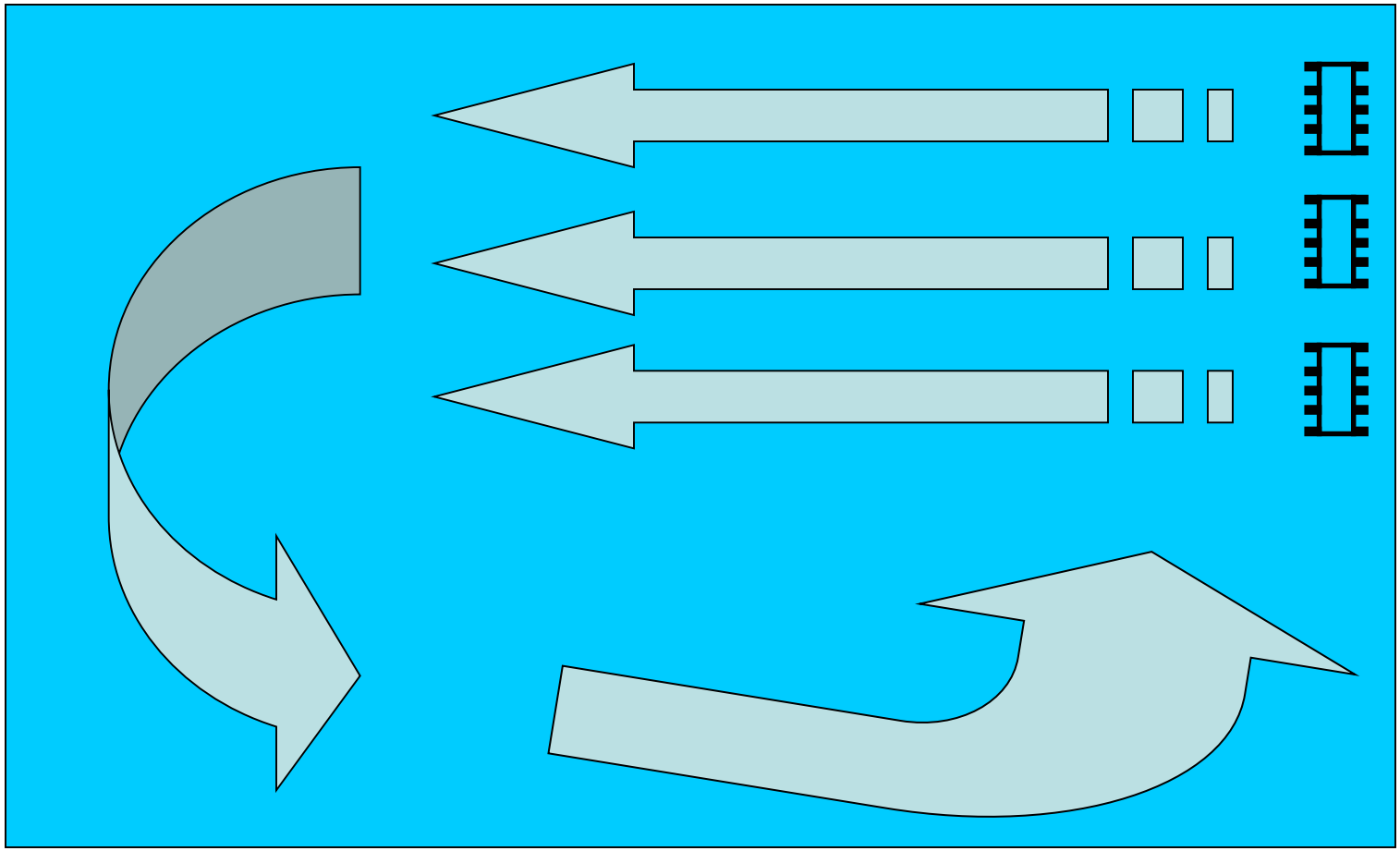
- Add more aerators – Higher D.O.
- Use aerators more efficiently – Concentrate the D.O. on the fish and reduce energy costs

Where does the O_2 go?

Water Column (Plankton)	**60%**
Sediment (Bacteria)	**20%**
Fish (at 6000lbs/ac)	**20%**


TREATMENT

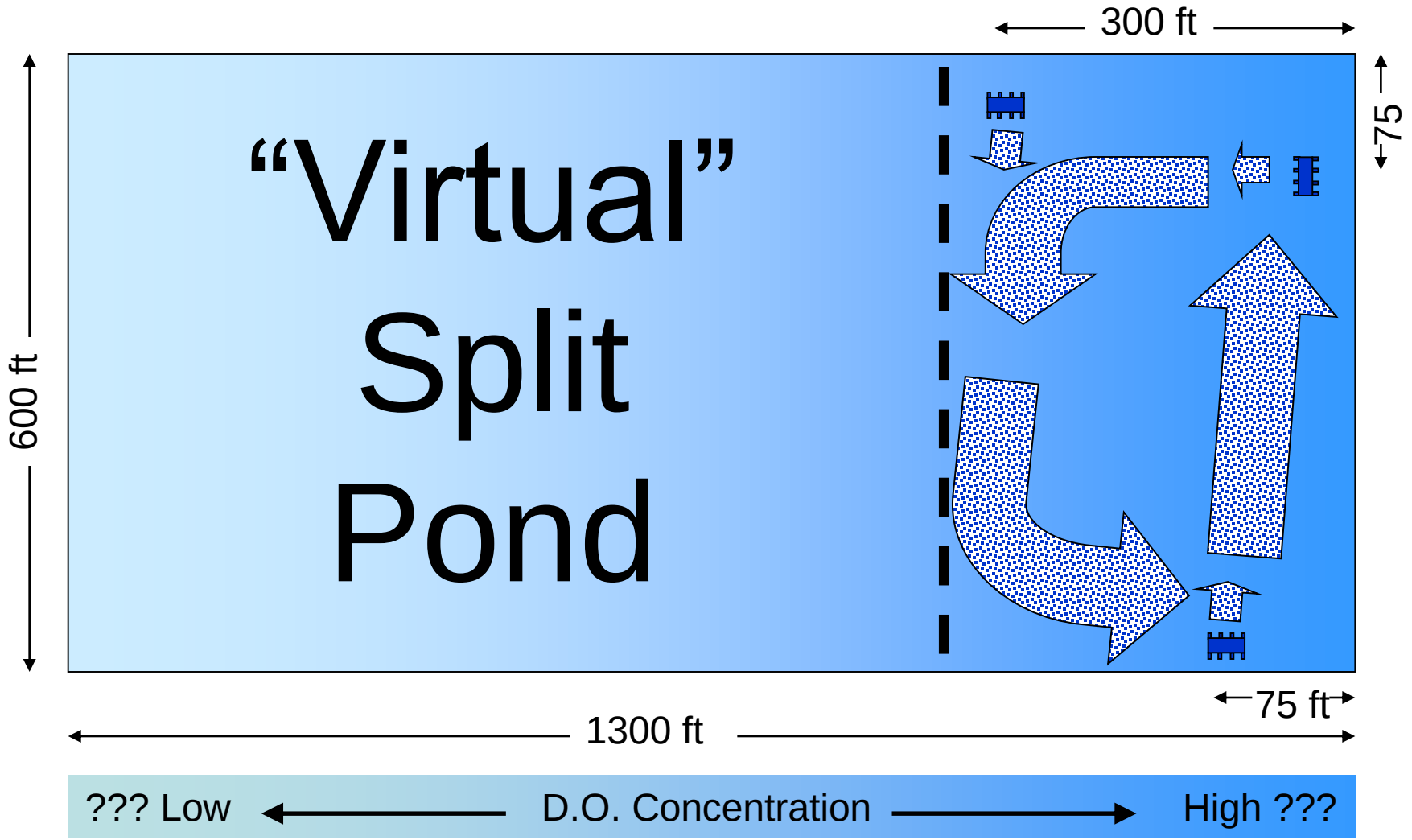
“Standard” Paddlewheel Placement



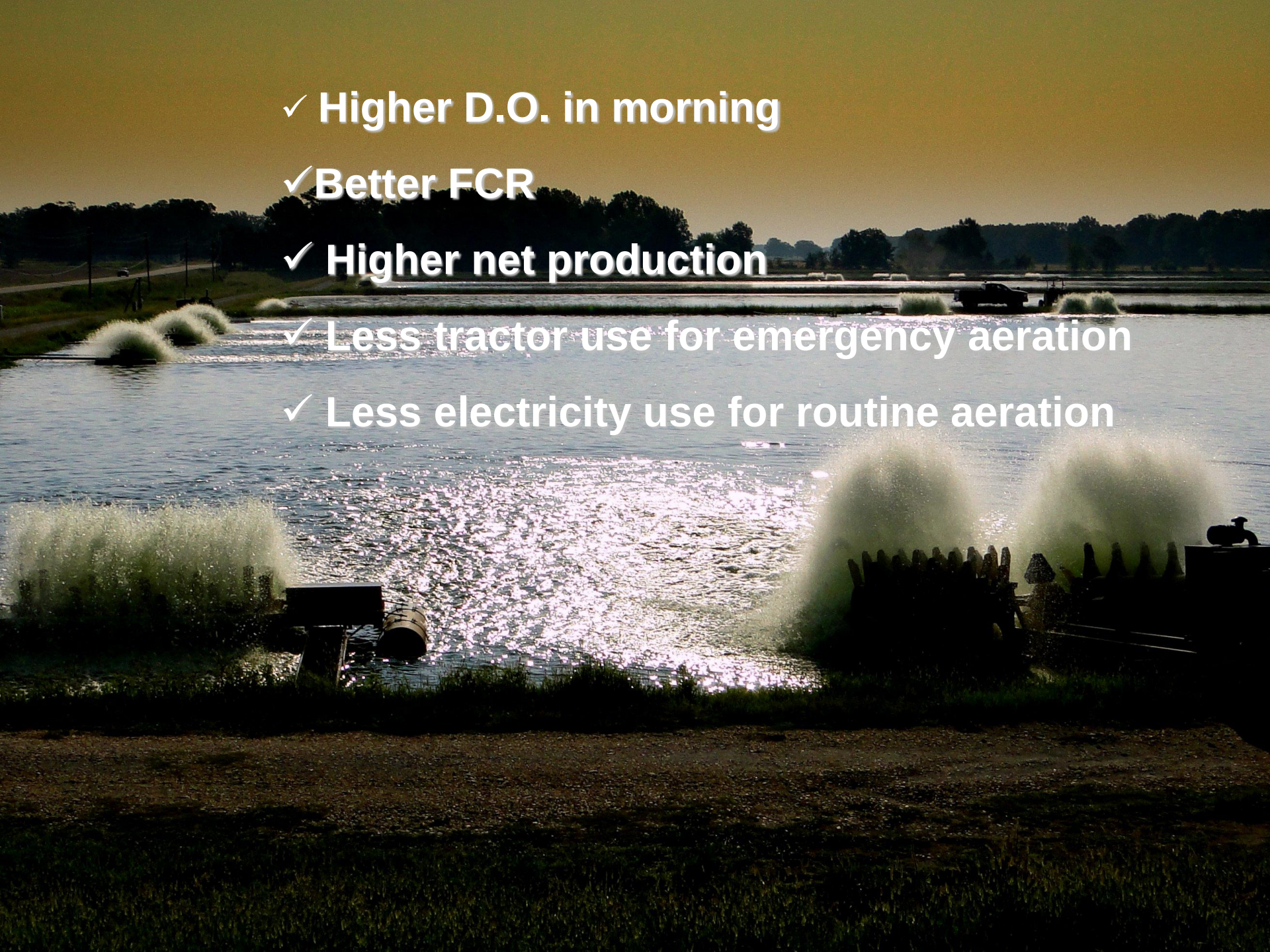
Circulation in large pond with paddlewheels placed in a “bank”

“New” Paddlewheel Placement

(Minimize Circulation)




© 2015 Google


✓ Higher D.O. in morning
✓Better FCR
✓ Higher net production
✓ Less tractor use for emergency aeration
✓ Less electricity use for routine aeration

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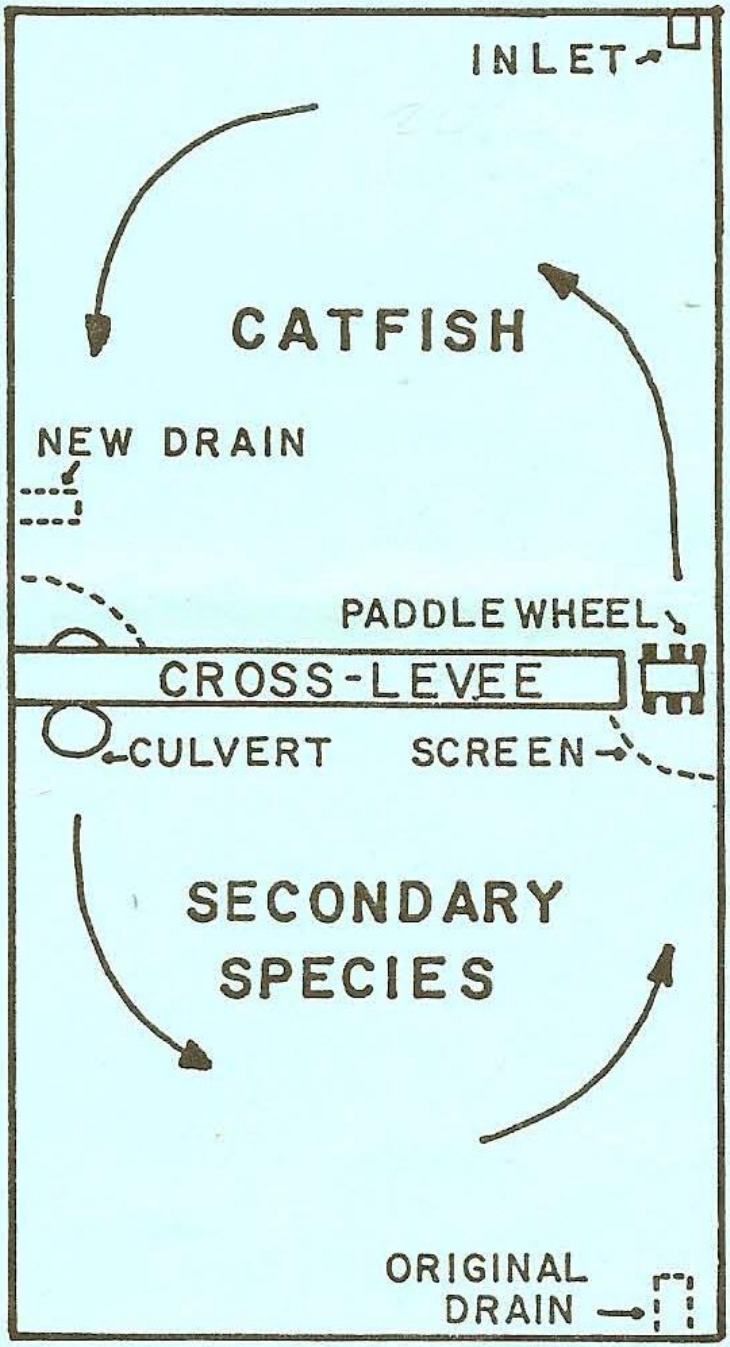
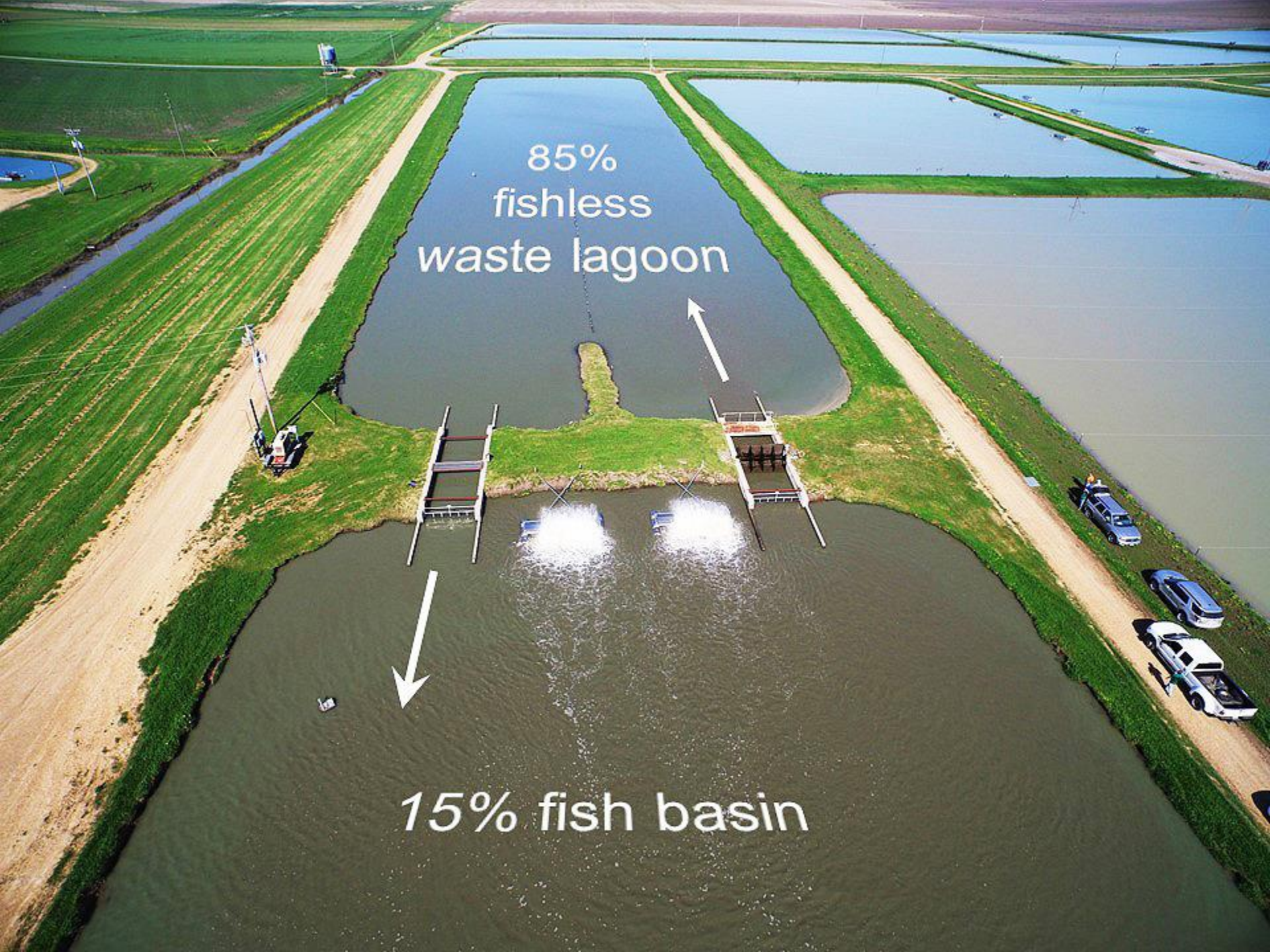


Polyculture Production System

COOPERATIVE EXTENSION SERVICE
University of Arkansas Division of Agriculture, United States Department of Agriculture, and County Governments Cooperating
AQUAFARMING
ARKANSAS
Vol. 2, No. 2, Apr.-June, 1984


Partitioned
Aquaculture
System


“Split Pond”
(Dr. Craig Tucker)


85%
fishless
waste lagoon
15% fish basin


N
© 2015 Google
Google earth
1996
Imagery Date: 11/28/2013 33°32'24.28" N 90°25'41.36" W elev 120 ft eye alt 8499 ft

Intensively-Aerated Smaller Commercial Ponds

Photo courtesy of Danny Oberle


Image © 2012 GeoEye

Year	Pond	Pond Size (acres)	Aeration (hp/acre)	Net Prod. (lbs/acre)	FC R
2012	35	4.6	6.5	13,607	2.05
2012	36	5.9	5.1	10,655	2.15
2012	41	4.9	6.1	11,829	2.34
2012	42	3.6	8.3	19,874	1.8
Mean		4.8	6.5	13,991	2.08
2013	35	4.6	6.5	11,076	2.4
2013	36	5.9	5.1	12,510	1.87
2013	41	4.9	6.1	10,607	2.64
2013	42	3.6	8.3	16,836	1.91
Mean		4.8	6.5	12,757	2.2
2014	35	4.6	6.5	13,707	2.01
2014	36	5.9	5.1	12,715	1.94
2014	41	4.9	6.1	14,693	1.64
2014	42	3.6	8.3	17,878	1.87
Mean		4.8	6.5	14,748	1.87
Grand Mean				13,832	2.05

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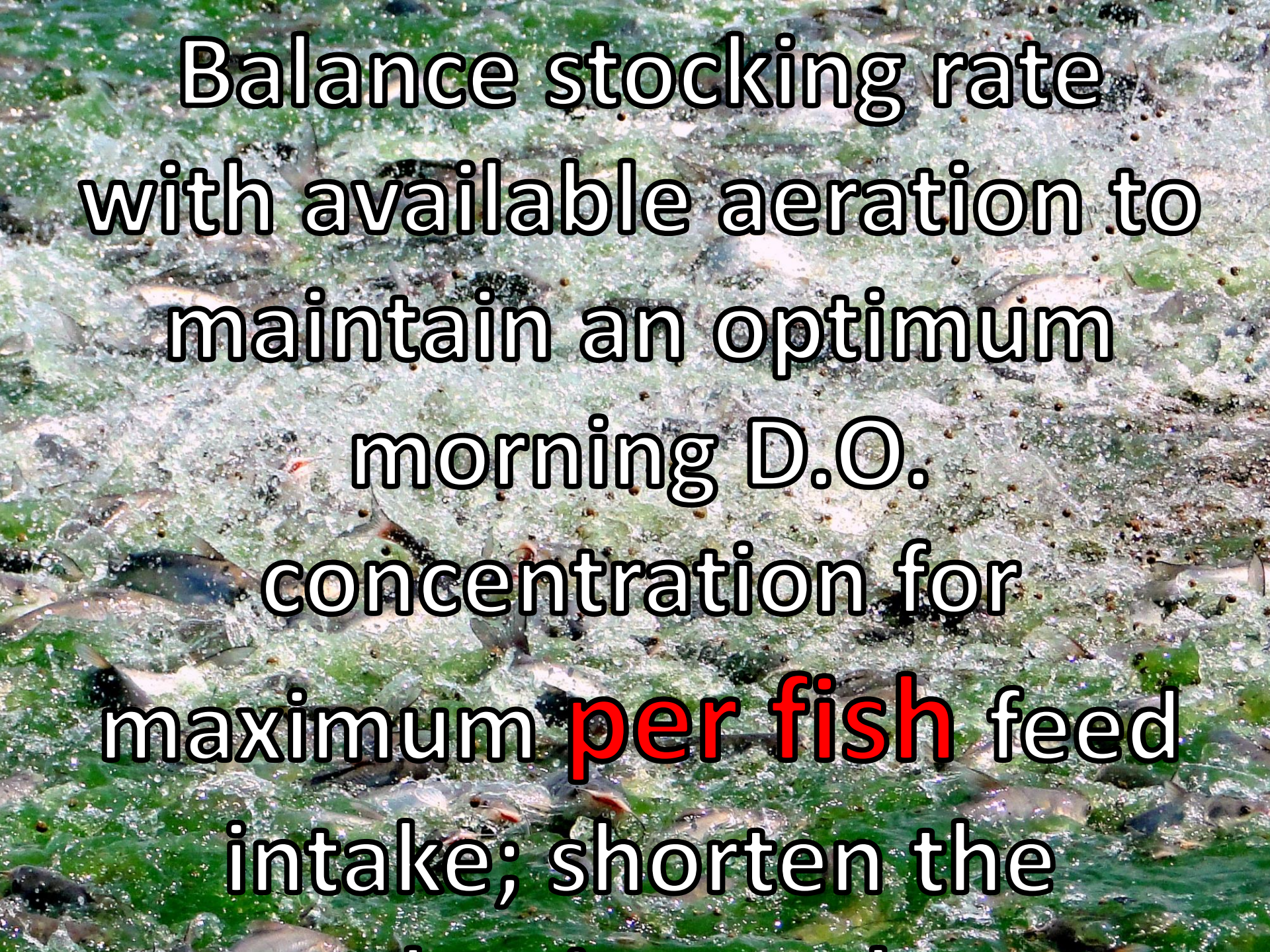
Mean		4.8	6.5	14,748	1.87
Grand Mean				13,832	2.05
			5.1	11,960	1.97
			6.1	12,376	2.21
			6.5	12,797	2.15
			8.3	18,196	1.86

Aeration doesn't cost money – it makes money!!

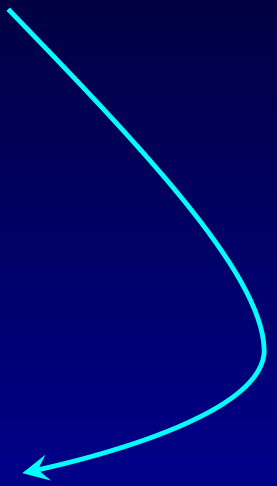
Treatment	Low Density	High Density
Stocked/Acre (n)	5,000	20,000
Mean Weight (lbs/fish)	2.21	1.60
Net Production (lbs/acre)	10,178	27,703
Survival (%)	96.3	92.5
Total feed (lbs/acre)	17,983	49,209
FCR	1.77	1.78
Aerator Hours (HP-Hr/Acre)	3,529	12,477
KW-Hrs/Acre	2,633	9,308
$$$ @ 0.10/KW	$263	$931
Cost/lb fish	$0.026	$0.034


Balance stocking rate
with available aeration to
maintain an optimum
morning D.O.
concentration for
maximum per fish feed
intake; shorten the

Water use for food production

(includes water used for feed production for animals)

Crop	m^3 per kg
Pond aquaculture (world average)	15
Beef cattle	15
Swine	5
Poultry	4
Cage-cultured salmonids	3
Eggs	3
Catfish (MS split-ponds with BMPs)	3
Grains	2
Fruits	0.9
Vegetables	0.3



Boyd, C.E., E.L. Torrans, and C.S. Tucker. 2017.

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Journal of the World Aquaculture Society. doi: 10.1111/jwas.12469.

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