ChevronTexaco

High Acid Crudes

Crude Oil Quality Group
New Orleans Meeting

Anne Shafizadeh

ChevronTexaco Energy Research Technology Company

Gregg McAteer/John Sigmon

Ondeo Nalco Energy Services

ChevronTexaco

High Acid Crude

Jan Skippins/Kevin Bell/Jeff Kronk
ChevronTexaco Global Trading
Ara Bagdasarian
ChevronTexaco Energy Research Technology Company
David Johnson
Ondeo Nalco Energy Services

ChevronTexaco

Objective

- Introduce new commercial High Acid Crudes
- Provide understanding that High Acid Crudes are crudes of opportunity
  - Understand supply and demand balances
  - Review High Acid Crudes commonly sold into the USGC & USEC Markets
  - Understand economics of running HAC's
  - Identify concerns & problems associated with running HAC's

ChevronTexaco

What are High Acid Crudes?

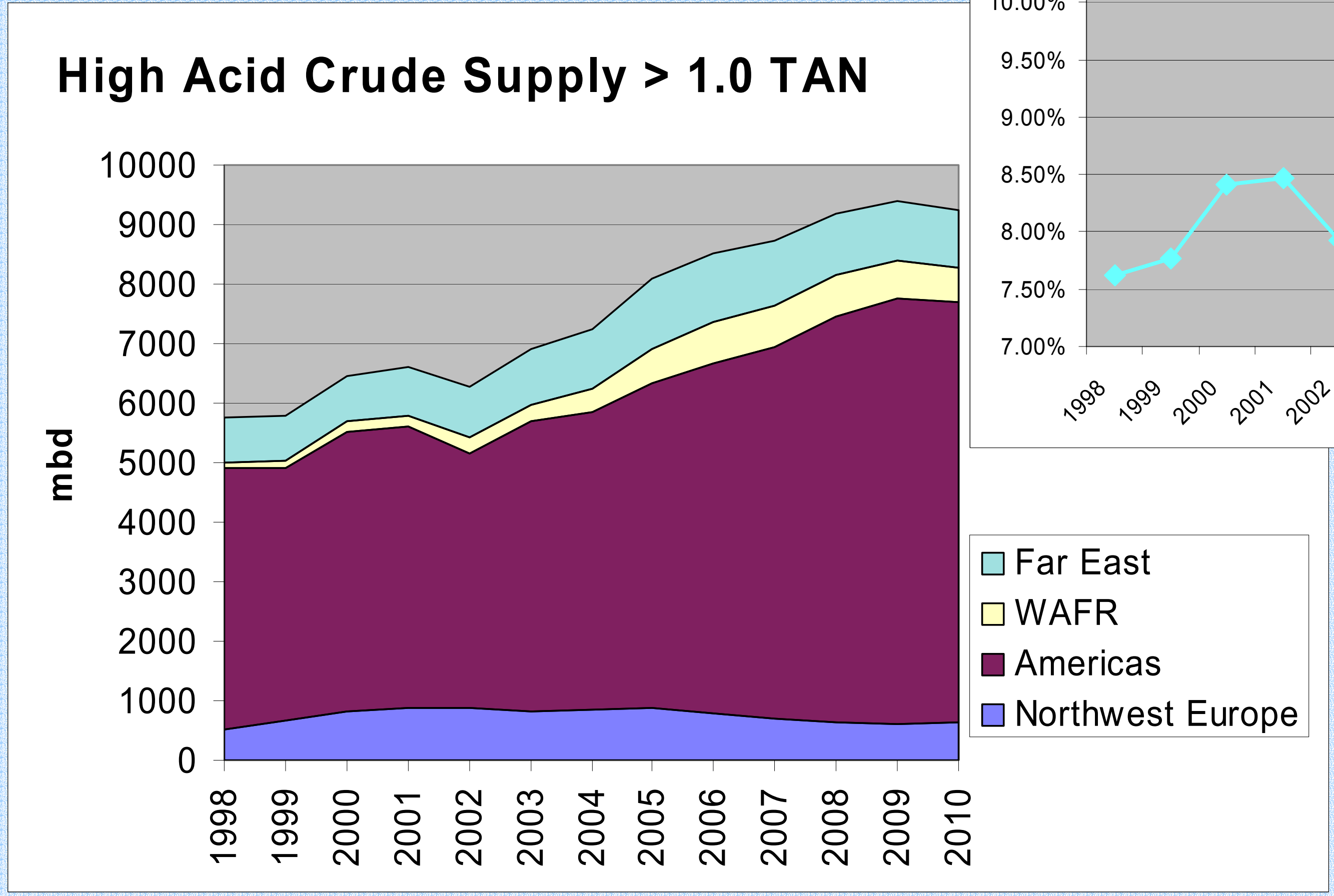
- TAN is the industry standard for measuring the acid content in crudes.
- High Acid crudes are defined as those crudes with a TAN of 1.0 or higher.
- TAN IS VERY MISLEADING
  - TAN = Total Acid Number
    - All organic acids
      - Light organic acids
      - Naphthenic acids
    - Any acids present in the crude that have been added during the production process
- While light organic acids do cause some overheads corrosion and other acids can cause other problems, the group of the acids that cause most corrosion in refineries are Naphthenic acids.
- It is believed there are more than 1000 Naphthenic Acid species
  - Some are very corrosive others are relatively inert
  - Different species distil at different temperatures and can concentrate in specific areas in the refinery.
- You cannot determine how corrosive a crude will be or which parts of the refinery it will affect from it's TAN

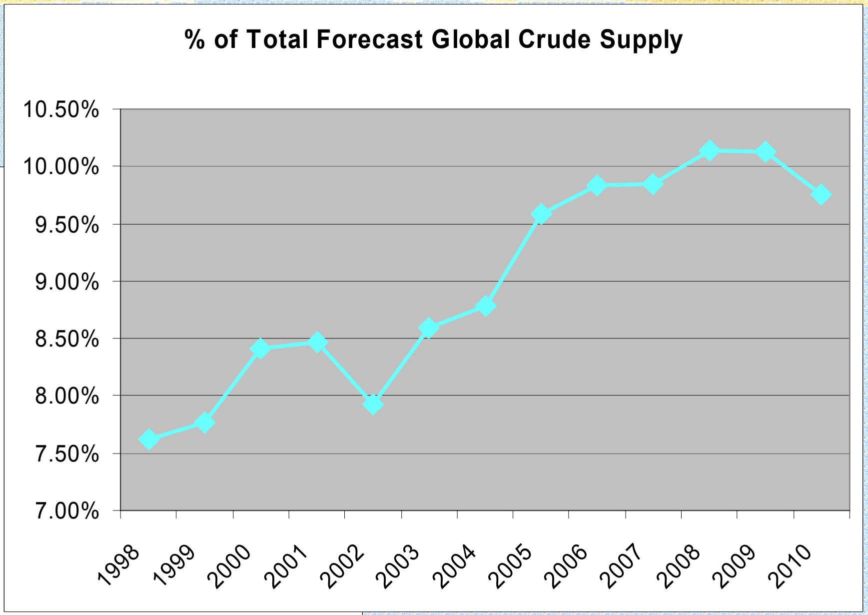
ChevronTexaco

Naphthenic Acid Crude Formation

- Naphthenic acids are carboxylic acids formed mainly by either aerobic or anaerobic biodegradation : -
  - Aerobic biodegradation - micro-organisms metabolize hydrocarbons (often as their sole source of energy) in the presence of oxygen : -
    - Shallow reservoirs e.g. San Joaquin Valley, Duri, Alba other North Sea
    - Reservoirs penetrated by meteoric waters (oxygen containing) e.g. Niger Delta, Gulf of Mexico, Venezuela
  - Anaerobic biodegradation - micro-organisms metabolize hydrocarbons without the presence of oxygen :-
    - Deep water reservoirs where no meteoric waters are present e.g. some Gulf of Mexico, Angola Block 14
- Light Paraffins then intermediate hydrocarbons are biodegraded first leading to heavy oils.
- As light crude production is diminishing and heavy crude production is increasing we will see more HAC's in the market.

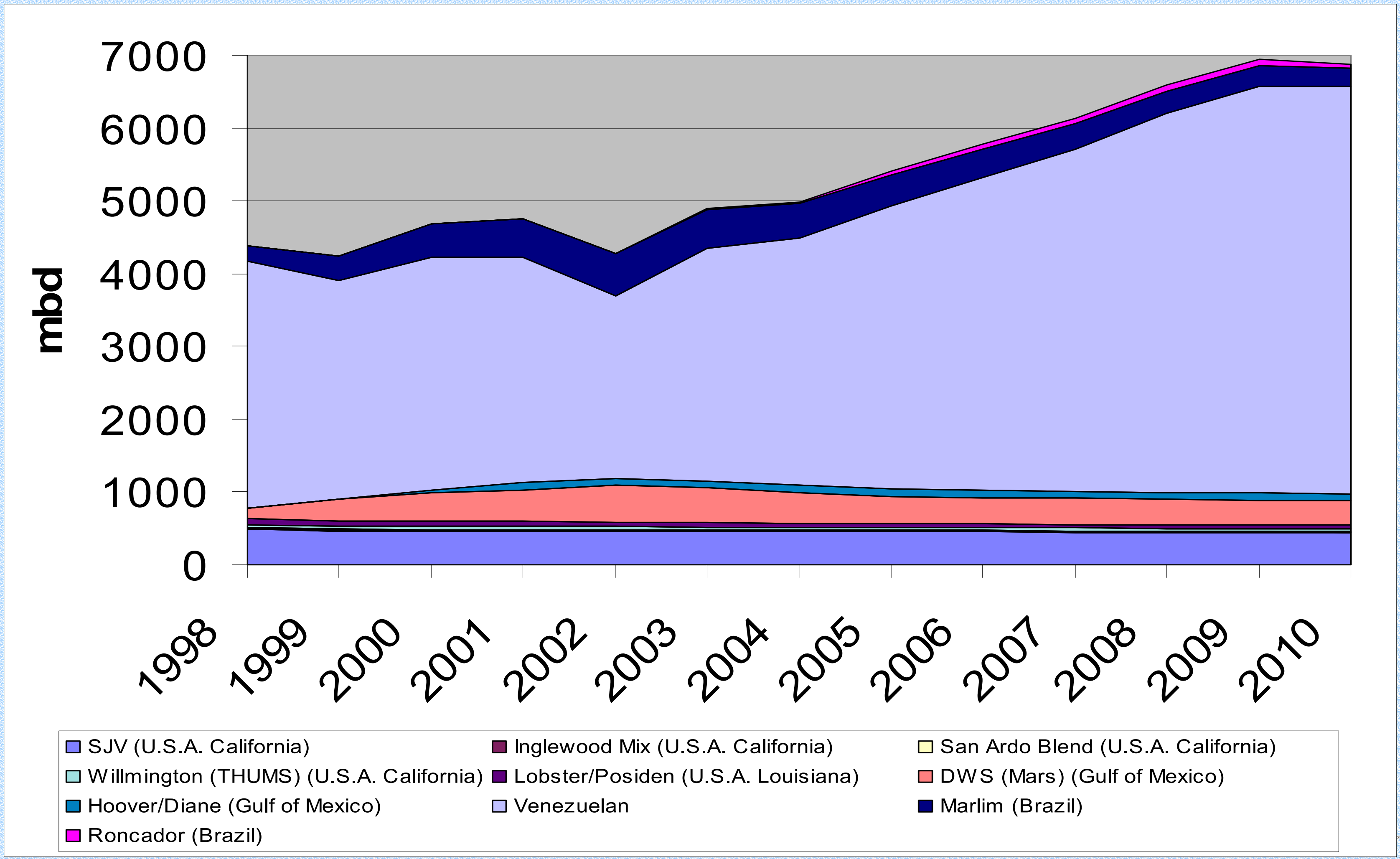
High Acid Crude Balance



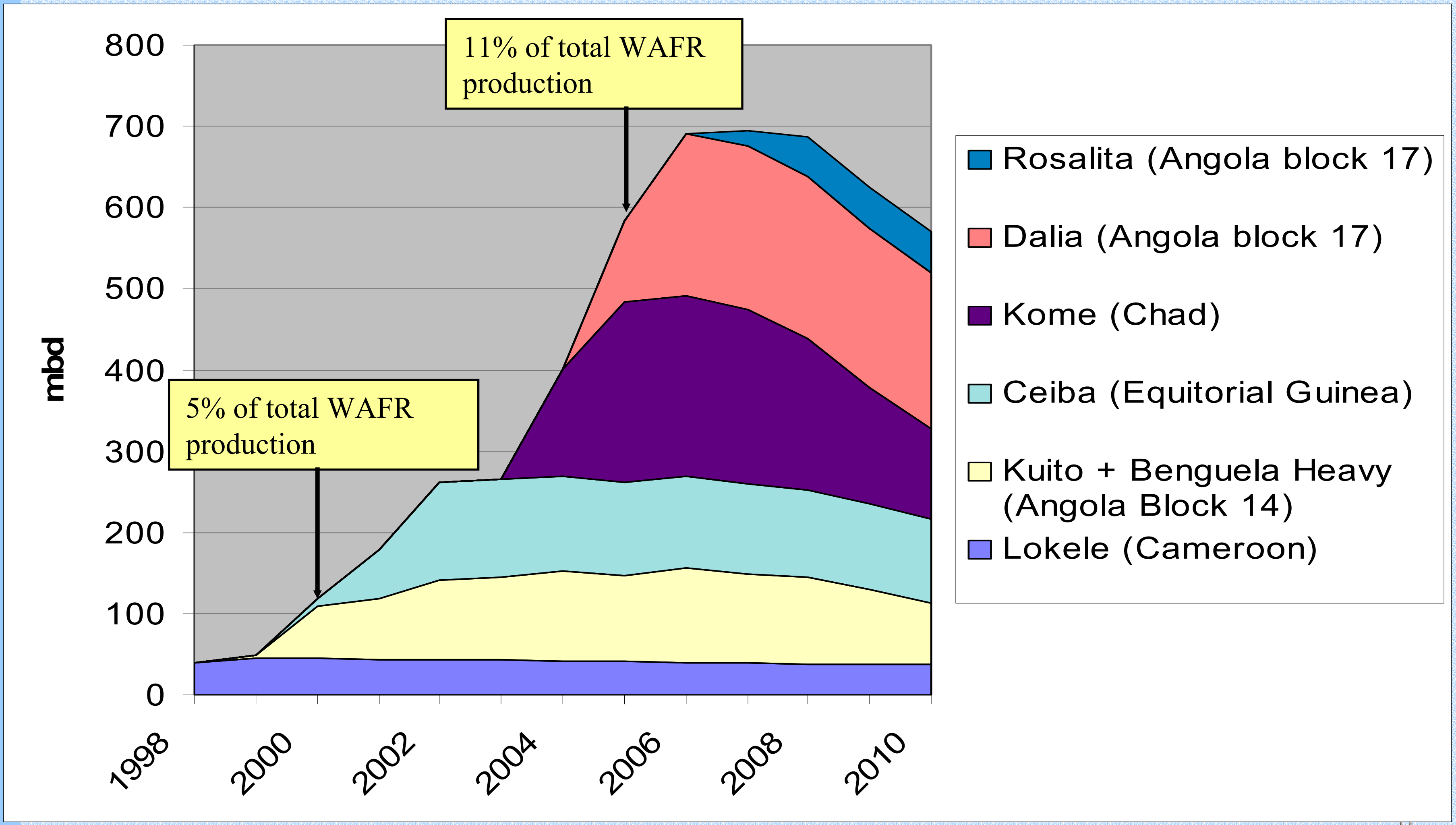


ChevronTexaco

Americas HAC (>1.0 TAN) Production

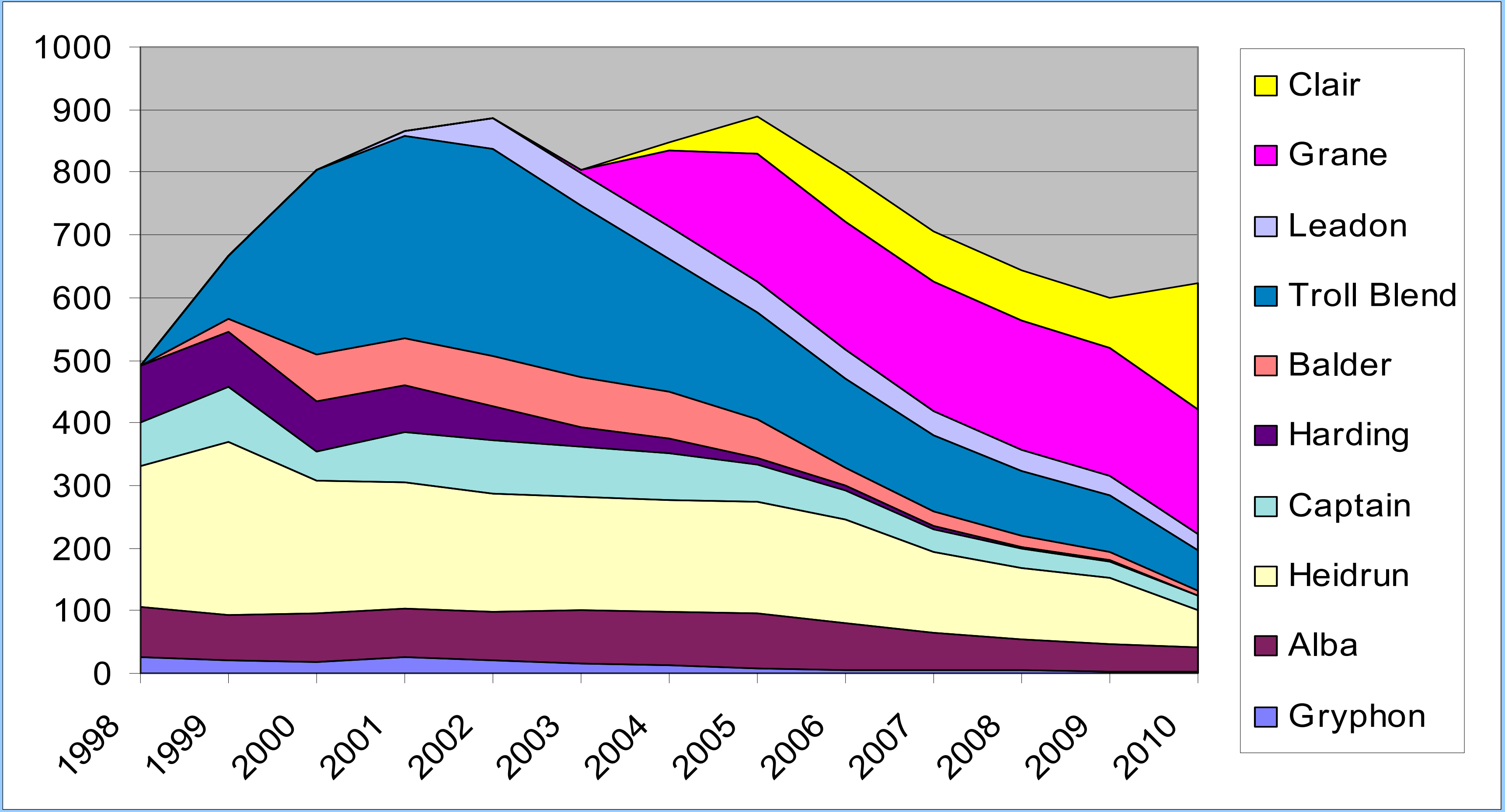


West Africa (WAFR) HAC (>1.0 TAN) Production



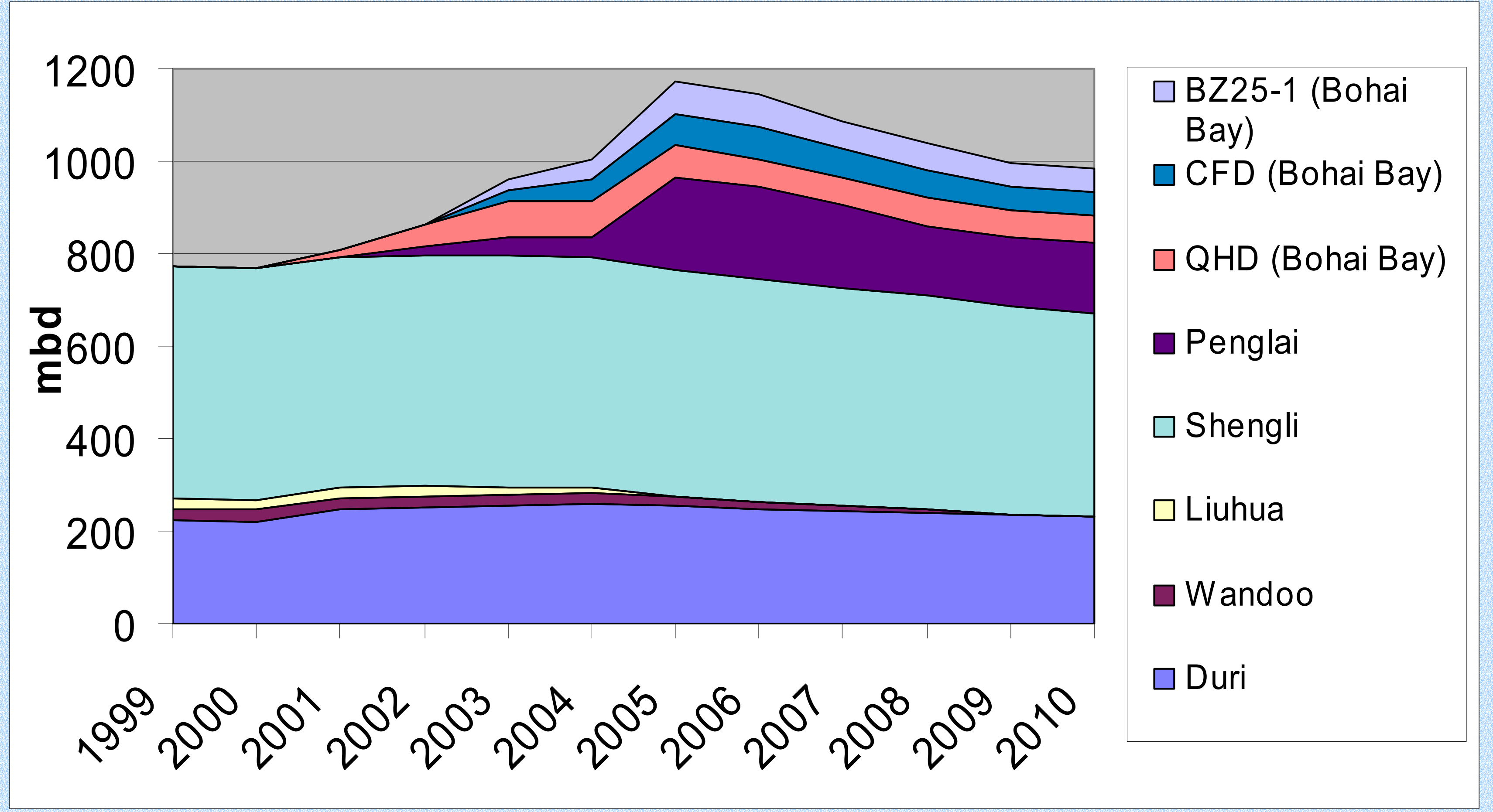
ChevronTexaco

North Sea HAC (>1.0 TAN) Production



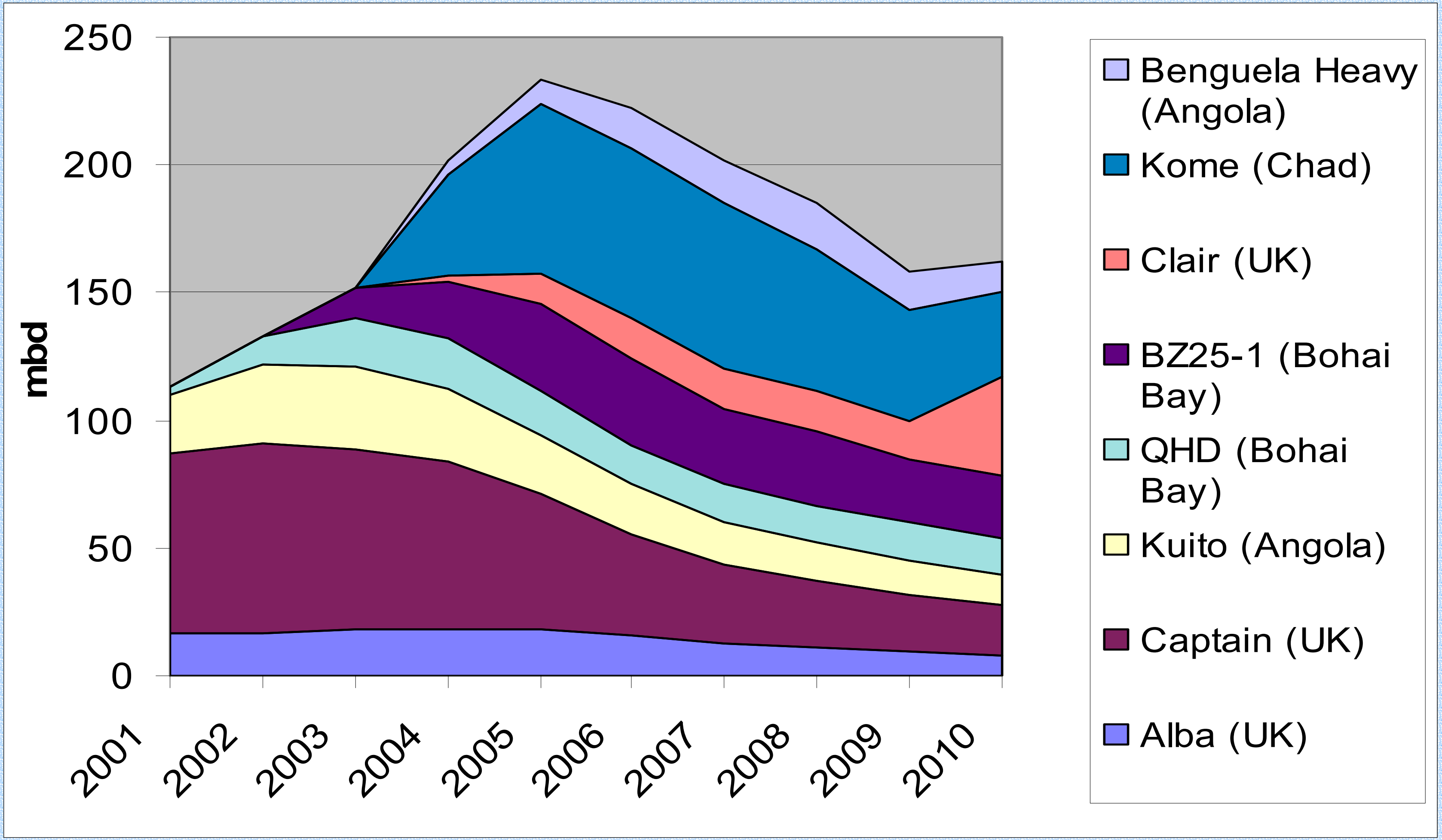
ChevronTexaco

Far East HAC (>1.0 TAN) Production



ChevronTexaco

ChevronTexaco HAC Equity Production



Finds in Guantas and Hebron excluded - projects not yet approved

ChevronTexaco

Global Supply/ Demand Balance

2002	Supply	Demand
Northwest Europe	890	920
Mediterranean		180
Americas	4270	4259
Africa/Middle East	262	25
Far East	862	620
HAC into Fuel Oil		280
Total	6284	6284

ChevronTexaco

Global Supply/ Demand Balance

- HAC are plentiful in most global regions and are increasing their % of total crude supply.
- North America absorbs most of this excess.
- South America is a net exporter of approx. 2.5 MMbd of crude. A large percentage of this is High Acid crude blends. Approx. 500 mbd is refined in South America, mostly local production.
- North West Europe which has traditionally been a net exporter of HAC's is now balanced (increased refinery HAC runs) :-
  - HAC's from NWE are exported to the USEC, USGC, Mediterranean and even the Far East.
  - HAC's are imported from West Africa & South America.
- Capetown is the only African refinery processing HAC's, while West African HAC production is rapidly increasing and being exported out of the region.

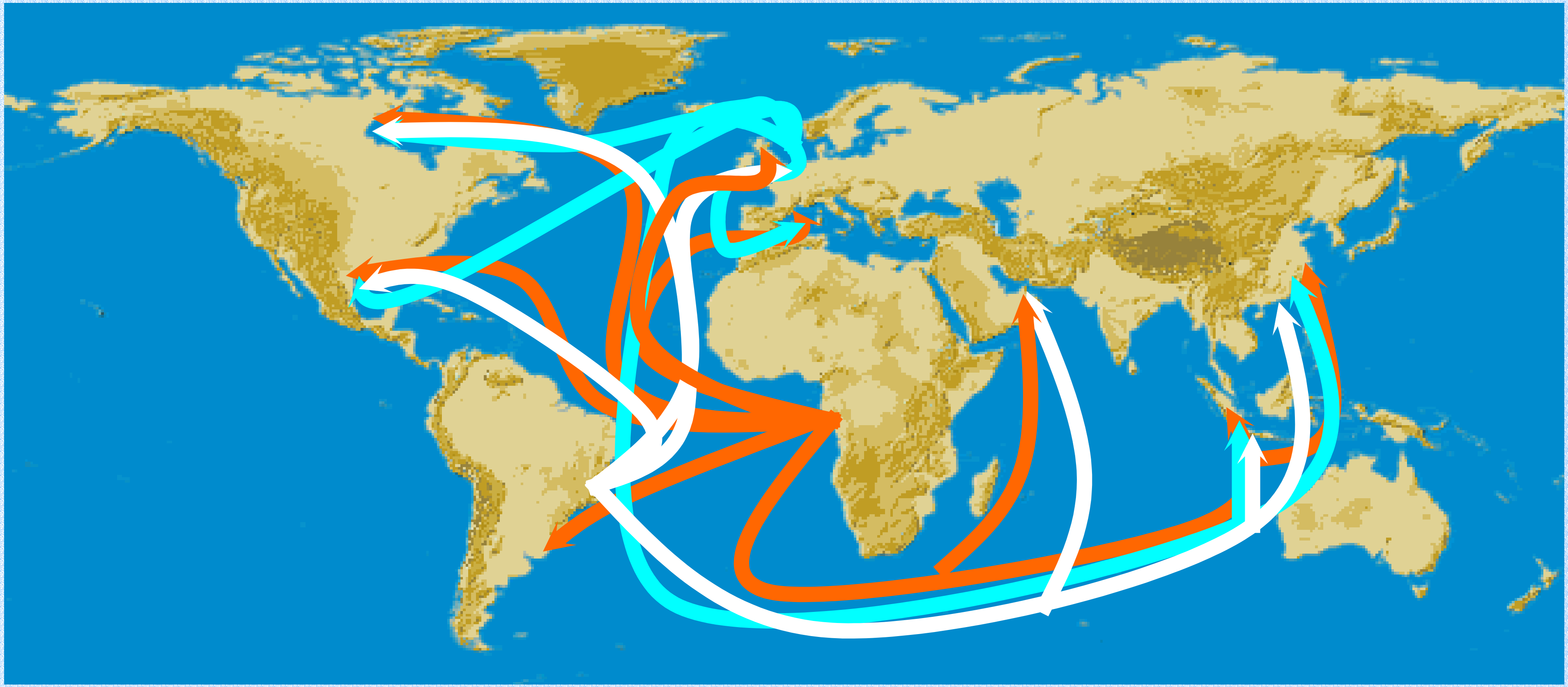
ChevronTexaco

Global Supply/ Demand Balance

- The Mediterranean currently imports only approx. 180 mbd of HAC.
  - With increasing West African and Americas production, the Mediterranean refiners are likely to take more HAC.
- The Far East has moved from being a net importer of 25-40 mbd for the refining market to being long due to increased production from Bohai Bay and Penglai. Note approx. 250 mbd of Far East HAC production goes into the burning market. There are now some exports to the USWC. Far East refiners are beginning to process HAC.
- There is no known HAC production in the Middle East (except 1 field offshore Saudi), Mediterranean or the FSU. Fujairah is the only Middle East refinery processing HAC's

ChevronTexaco

High Acid Crude Flows



ChevronTexaco

High Acid Crudes Available to the USGC/USEC/ECC Market

- **South America**
  - Marlim
  - Roncador (2003/2004)
  - Venezuelan Blends
- **West African**
  - Kuito
  - Ceiba
  - Kome (2004)
  - Dalia (2H 2005)
  - Rosalita (2007)
- **NWE**
  - Alba *
  - Troll Blend
  - Gryphon
  - Heidrun
  - Captain *
  - Harding *
  - Leadon *
  - Grane (4Q 2003)
  - Clair (4Q 2004)

(* Shuttle tanker loaded - freight economics will only make it occasionally possible to arbitrage these crudes.)

ChevronTexaco

Examples of Venezuelan HAC Blends

	Bachaquero	Menemota	Pilon	Merey	Laguna Blend
API	12.2	21.3	14.5	16.0	23.6
S	2.71	2.5	1.92	2.49	2.07
TAN	3.65	1.15	1.52	1.24	1.03

Many other custom blends are available.

ChevronTexaco

Quality & Logistics Brazil/ West Africa HAC's

(producing fields only)

Crude Name Country	Marlim Brazil	Kuito Angola	Ceiba Equitorial Guinea
Production 2002 mbd	580	100	120
API	20.1	20	28
Sulphur, wt. %	0.75	0.64	0.6
Pour Point deg C	-40	-29	-48
UOPK	11.6	11.7	11.9
TAN, mgKOH/g	1.15	2.2	1.06
Standard Parcel Size mb	1000	920	1000
VLCC Loading	Y	Y	Y
Terminal Operator	Petrobras	ChevronTexaco	Amerada Hess
Notes	Flexable parcel size from tankage in the Caribbean.	Min pcl size 300mb. Min vessel size 80 MDWT.	Min parcel size 350 mb.

ChevronTexaco

Quality & Logistics NWE HAC's (producing fields only)

Crude Name Country	Alba UK	Troll Blend Norway	Heidrun Norway	Gryphon UK	Captain UK	Harding UK	Leadon UK
Production 2002 mbd	80	330	190	20	85	55	50
API	19.4	27.2	28.1	21.3	19.1	19.8	17.9
Sulphur, wt. %	1.25	0.27	0.43	0.4	0.7	0.63	0.47
Pour Point deg C	-35	-42	<-42	-42	-29	-37	-18
UOPK	11.8			10.9	11.6	11.5	
TAN, mgKOH/g	1.42	1.03	2.41	4.2	2.36	2.9	3.9
Standard Parcel Size mb	500	1000	500	450	500	500	425
VLCC Loading	Dedicated shuttle tankers	Y	Dedicated shuttle tankers to Mongstadt.	Dedicated shuttle tankers	Dedicated shuttle tankers	Dedicated shuttle tankers	Dedicated shuttle tankers
Terminal Operator	ChevronTexaco	Statoil	Statoil	Kerr McGee	ChevronTexaco	BP	Kerr McGee
Notes	700 mb parcels may also be loaded. Smaller parcels can be supplied with vessel deadfreight. Transhipment at Nigg Bay or Scapa Flow.	Loads at Mongstadt in parcels of 500 to 2,000,000 mb.	Loads FOB Mongstadt from stroage in parcels of 500 to 2,000,000 mb.	Transhipment at Nigg Bay or Scapa Flow.	Transhipment at Nigg Bay or Scapa Flow.	Transhipment at Nigg Bay or Scapa Flow.	Transhipment at Nigg Bay or Scapa Flow. 1st cargo mid Nov. Production assay not yet available.

ChevronTexaco

Kuito

KUITO CRUDE SPECIFICATIONS	
Specific Gravity	0.94
Gravity, API	19.0
Sulphur, wt%	0.68
UOPK	11.5
Acid No., mg KOH/g	2.1
Pour Point, Deg C/Deg F	-30/-25

- **100 mbd field production**
- **ChevronTexaco market 51% of total production**
- **Kuito FPSO vessel is 40 miles from Malongo Terminal.**
- **FPSO storage capacity is 1400 mb.**
- **Export berth is SBM (CALM type buoy) that can accommodate VLCC's as 1st or 2nd load port making Kuito an ideal coload for other West African grades.**
- **Max vessel DWT is 320 metric tons, Min vessel DWT is 80,000 metric tons.**
- **Nominal cargo size is 920 mb, however, parcels between 300 and 920 mb can be loaded.**
- **Loading rate is 35,000 bph.**

ChevronTexaco

Kuito in the Refinery

Advantages

- Distillates have good cold properties
- Good quality resid. with less than 1% S.
- High VGO yield

Disadvantages

- Low cetane index and smoke point in distillates
- High resid. yield
- High Nitrogen content

Typical buyers of Kuito will be refiners with hydrotreating, coking, & visbreaking. Also asphalt refiners & topping/reforming refiners wishing to make 1% fuel oil. Refiners are restricted on quantities of Kuito they can run due to its Nitrogen content.

ChevronTexaco

Captain

CAPTAIN CRUDE SPECIFICATIONS	
Specific Gravity	0.9378
Gravity, API	19.1
Sulphur, wt%	0.7
Acid No., mg KOH/g	2.1
Pour Point, Deg C/Deg F	-27/-17

- **85 mbd field production**
- **ChevronTexaco markets 100% of total production.**

- **Captain FPSO vessel is 80 miles North East of Aberdeen in the UK.**
- **FPSO storage capacity is 550 mb.**
- **Delivered by shuttle tankers within UK/Cont.**
- **Nigg Bay and Scapa Flow can be used as a transshipment points for deliveries outside the shuttle tanker radius.**
- **Cargo size is 500 mb**

ChevronTexaco

Captain in the Refinery

Advantages

- Low S
- Distillates have good cold properties
- Low CCR i.e. good coker feed
- High VGO yield
- Good Asphalt feed

Disadvantages

- Low cetane index in distillates
- High resid. yield

Typical buyers of Captain are coking refiners, visbreaking refiners, asphalt refiners and cracking refiners. Refiners are restricted on quantities of Captain they can run due to the cetane index of the distillates.

ChevronTexaco

ALBA

ALBA CRUDE SPECIFICATIONS	
Specific Gravity	0.9233
Gravity, API	19.4
Sulphur, wt%	1.25
UOPK	11.8
Acid No., mg KOH/g	1.42
Pour Point, Deg C/Deg F	-35/-35

- **75-80 mbd Field Production**
- **ChevronTexaco markets 25 mbd.**

- Alba is loaded from an FSU (825 mb storage capacity).
- Delivered by shuttle tankers within UK/Cont.
- Nigg Bay and Scapa Flow can be used as a transshipment points for deliveries outside the shuttle tanker radius.
- Cargoes 500 mb or 700 mb, part cargoes of 200 mb can also be supplied.

ChevronTexaco

Alba in the Refinery

Advantages

- Distillates have good cold properties
- Low CCR i.e. good coker feed
- High VGO yield
- Good Asphalt feed when co-reduced with Maya, Iranian Heavy or similar grades
- Suitable for fuel oil blending

Disadvantages

- Low cetane index in distillates
- High resid. yield
- Viscosity too low to batch run for asphalt

Typical buyers of Alba are coking refiners, visbreaking refiners, asphalt refiners and fuel oil blenders. Refiners are restricted on quantities of Alba they can run due to its S and the cetane index of the distillates.

ChevronTexaco

ChevronTexaco HAC's becoming available in the next few years

- **Kome (2004)**
  - Chad
  - Expected start-up 2H 2004 @ 200 mbd
  - 19 API, 0.1S, 5 TAN
- **Benguela Heavy (2004)**
  - Angola Block 14
  - Expected start up end 2004 @ 50 mbd
  - 24 API, 0.9S, 1.25 TAN
  - Likely be exported as part of Kuito stream
- **Clair (4Q 2004)**
  - UK North Sea - West of Shetland
  - Expected start up 4Q 2004 @ 60 mbd
  - Export via pipeline to Sullom Voe
  - 23 API, 0.5S, 1.2 TAN

ChevronTexaco

Other HAC's becoming available in the next few years

- **Roncador (2003/2004)**
  - Offshore Brazil
  - Expected start-up not yet known
  - 17.8 API, 0.63S, 1.48 TAN
- **Dahlia (2005)**
  - Angola Block 17
  - Expected start up 2H 2005 @ 200 mbd
  - 22.6 API, 0.48S, 1.6 TAN
- **Rosalita (2007)**
  - Angola Block 17
  - Expected start up 4Q 2007 @ 50 mbd
  - 22 API, 0.5S. 1.5 TAN
- **Grane (2004)**
  - Norwegian North Sea
  - Expected start-up end 2003 @ 120 mbd rising to 200 mbd in 2005
  - 19 API, 0.9S, 2.1 TAN

ChevronTexaco

Summary

- There is a sizeable and increasing global supply of HAC's
  - 6.3 million Bbls per day - 2002
  - 8.1 million Bbls per day - 2005
  - 9.2 million Bbls per day - 2010
- There is limited ability or willingness by refiners to run HAC's
- Most HAC's not refined in local regions come to North America.
- TAN although the industry standard measure is very misleading

Economics of running High Acid Crudes

ChevronTexaco

HAC

Crude selection (1)

	"A"	"H"	"K"	"S"	"U"	"G"
Gravity (API)	19.4	27.3	19.0	23.8	31.3	22.2
Sulfur (wt%)	1.3	2.9	0.7	4.0	1.4	3.0
TBP YIELDS (VOL %)						
Butanes and Lighter	0.1	2.9	0.2	1.7	1.8	0.6
Light Gasoline	0.2	5.7	0.6	7.0	5.5	3.0
Light Naphtha	1.0	8.4	5.2	9.6	10.2	8.1
Heavy Naphtha	2.8	8.2	5.0	7.2	8.8	6.8
Kerosene	6.6	8.1	8.9	7.4	9.6	6.8
Atm. Gas Oil	17.5	13.9	16.1	12.8	15.6	12.9
Lt Vacuum Gas Oil	15.4	11.0	16.3	11.9	14.2	12.9
Hvy Vacuum Gas Oil	26.9	14.8	23.0	17.7	17.0	20.2
Vacuum Residuum	29.6	27.0	24.6	24.7	17.3	28.8
Run it?	*?*	*?*	*?*	*?*	*?*	*?*

ChevronTexaco

HAC

Crude selection (2)

	"A"	"H"	"K"	"S"	"U"	"G"
Gravity (API)	19.4	27.3	19.0	23.8	31.3	22.2
Sulfur (wt%)	1.3	2.9	0.7	4.0	1.4	3.0
Acid Number	**1.4**	**0.3**	**2.1**	**0.3**	**0.1**	**0.3**
TBP YIELDS (VOL %)						
Butanes and Lighter	0.1	2.9	0.2	1.7	1.8	0.6
Light Gasoline	0.2	5.7	0.6	7.0	5.5	3.0
Light Naphtha	1.0	8.4	5.2	9.6	10.2	8.1
Heavy Naphtha	2.8	8.2	5.0	7.2	8.8	6.8
Kerosene	6.6	8.1	8.9	7.4	9.6	6.8
Atm. Gas Oil	17.5	13.9	16.1	12.8	15.6	12.9
Lt Vacuum Gas Oil	15.4	11.0	16.3	11.9	14.2	12.9
Hvy Vacuum Gas Oil	26.9	14.8	23.0	17.7	17.0	20.2
Vacuum Residuum	29.6	27.0	24.6	24.7	17.3	28.8
Run it?	?	?	?	?	?	?

ChevronTexaco

HAC

Crude selection (3)

	"A"	"H"	"K"	"S"	"U"	"G"
Gravity (API)	19.4	27.3	19.0	23.8	31.3	22.2
Sulfur (wt%)	1.3	2.9	0.7	4.0	1.4	3.0
Acid Number	**1.4**	**0.3**	**2.1**	**0.3**	**0.1**	**0.3**
TBP YIELDS (VOL %)						
Butanes and Lighter	0.1	2.9	0.2	1.7	1.8	0.6
Light Gasoline	0.2	5.7	0.6	7.0	5.5	3.0
Light Naphtha	1.0	8.4	5.2	9.6	10.2	8.1
Heavy Naphtha	2.8	8.2	5.0	7.2	8.8	6.8
Kerosene	6.6	8.1	8.9	7.4	9.6	6.8
Atm. Gas Oil	17.5	13.9	16.1	12.8	15.6	12.9
Lt Vacuum Gas Oil	15.4	11.0	16.3	11.9	14.2	12.9
Hvy Vacuum Gas Oil	26.9	14.8	23.0	17.7	17.0	20.2
Vacuum Residuum	29.6	27.0	24.6	24.7	17.3	28.8
Run it?	*no way!*	*yes*	*no way!*	*yes*	*yes*	*yes*

….challenge your assumptions!

Recap...

- Sizeable and increasing supply of HAC
- Limited ability or willingness to run HAC
- Solutions are available to the HAC problem
  - Metallurgy
  - Corrosion inhibition

Increasing supply…. Limited demand

- Acid grades have traditionally traded below the relative refining value versus non acid grades
  - This effect we term the “Acid Discount” or “Refining Benefit”

Acid Crudes - Valuation Methodology

- **Substitute for grades in regular slate**
  - HAC unlikely to be run on batch basis
  - Appropriate choice of substitution grade
    - Characteristics & refining configuration
    - Documented pricing

ChevronTexaco

HAC

Alba Valuation

- **Assume Urals base slate**
  - Substitute 20% for Alba
  - Both priced basis Rotterdam - no freight element
- **Refinery configuration: typical sized units for a NWE refinery with FCC**
- **Products: latest specs, NWE prices**

ChevronTexaco

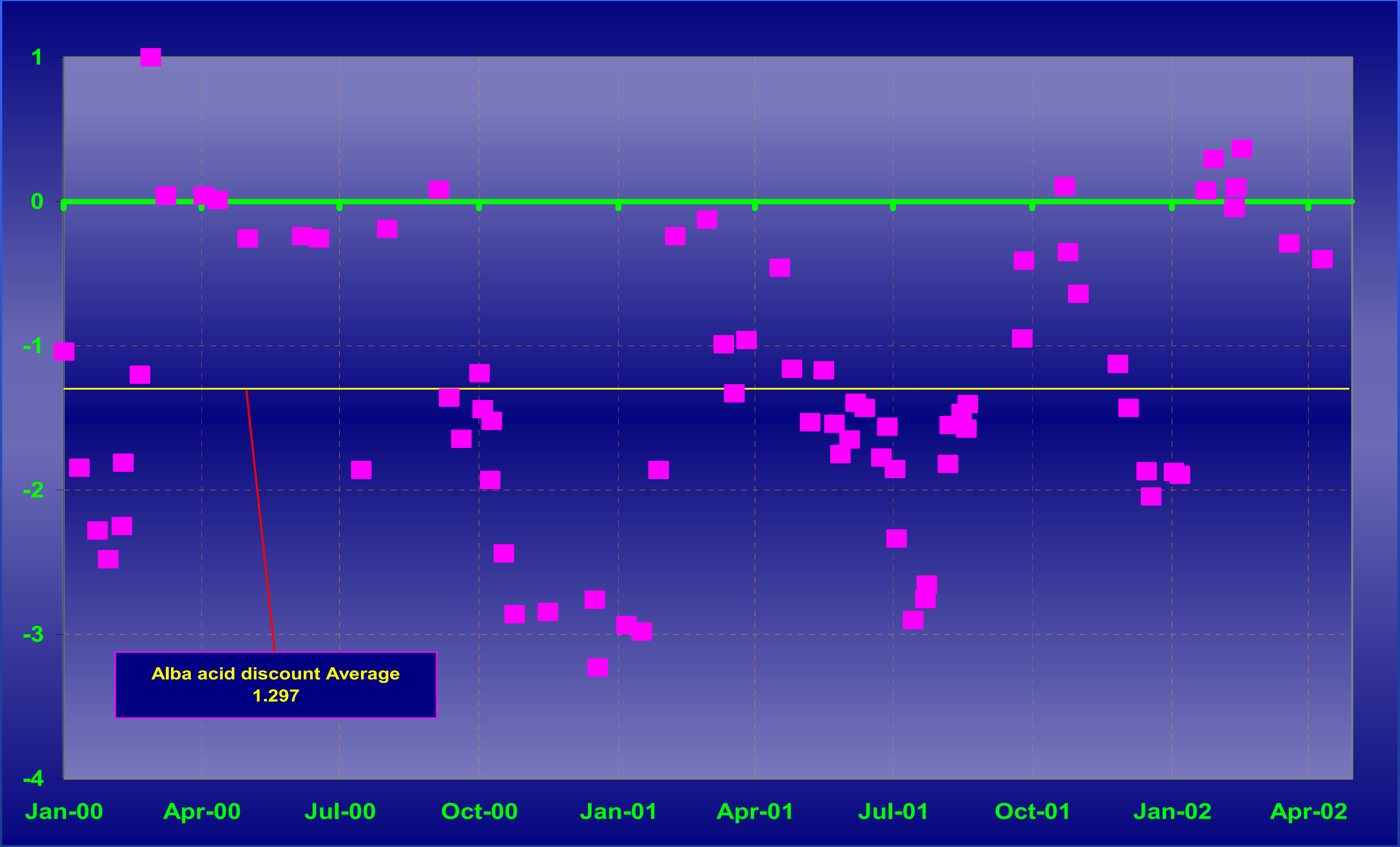
HAC

Alba Valuation

ChevronTexaco

HAC

Acid Discount - Alba



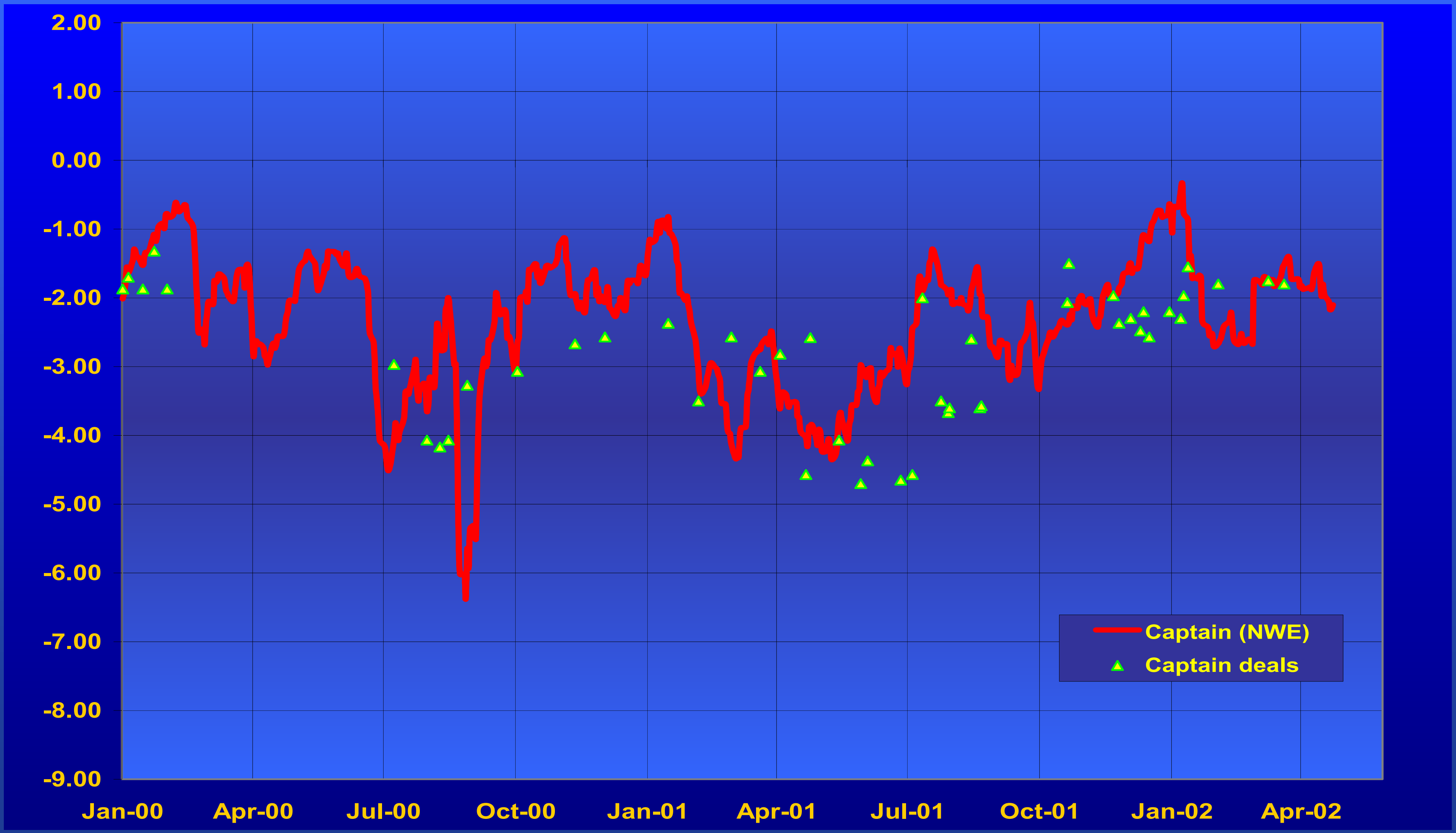
Captain Valuation

- **Same method used as for Alba**
- **Assume Urals base slate**
  - Substitute 20% for Captain
  - Both priced basis Rotterdam - no freight element
- **Refinery configuration: typical sized units for a NWE refinery with FCC**
- **Products: latest specs, NWE prices**

ChevronTexaco

HAC

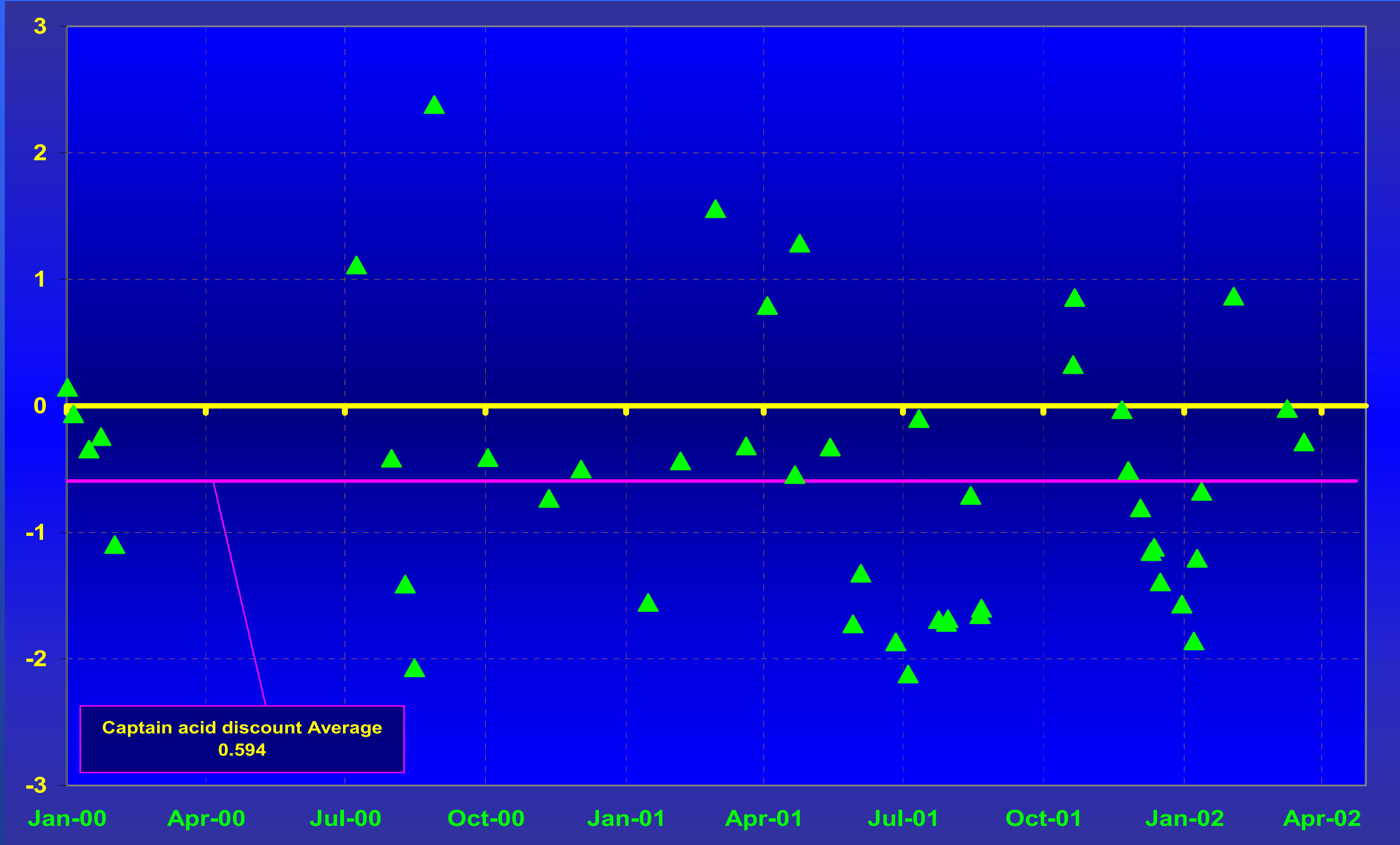
Captain Valuation



ChevronTexaco

HAC

Acid Discount - Captain

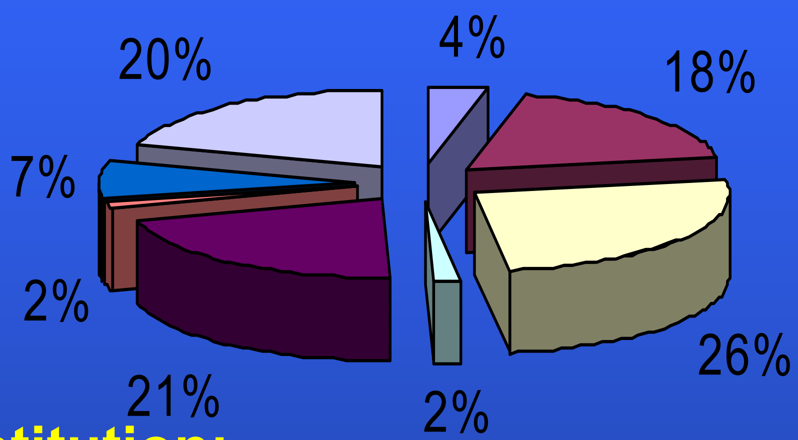


ChevronTexaco

HAC

Kuito Valuation

- **Unlike Alba & Captain, Kuito has no "home" market**

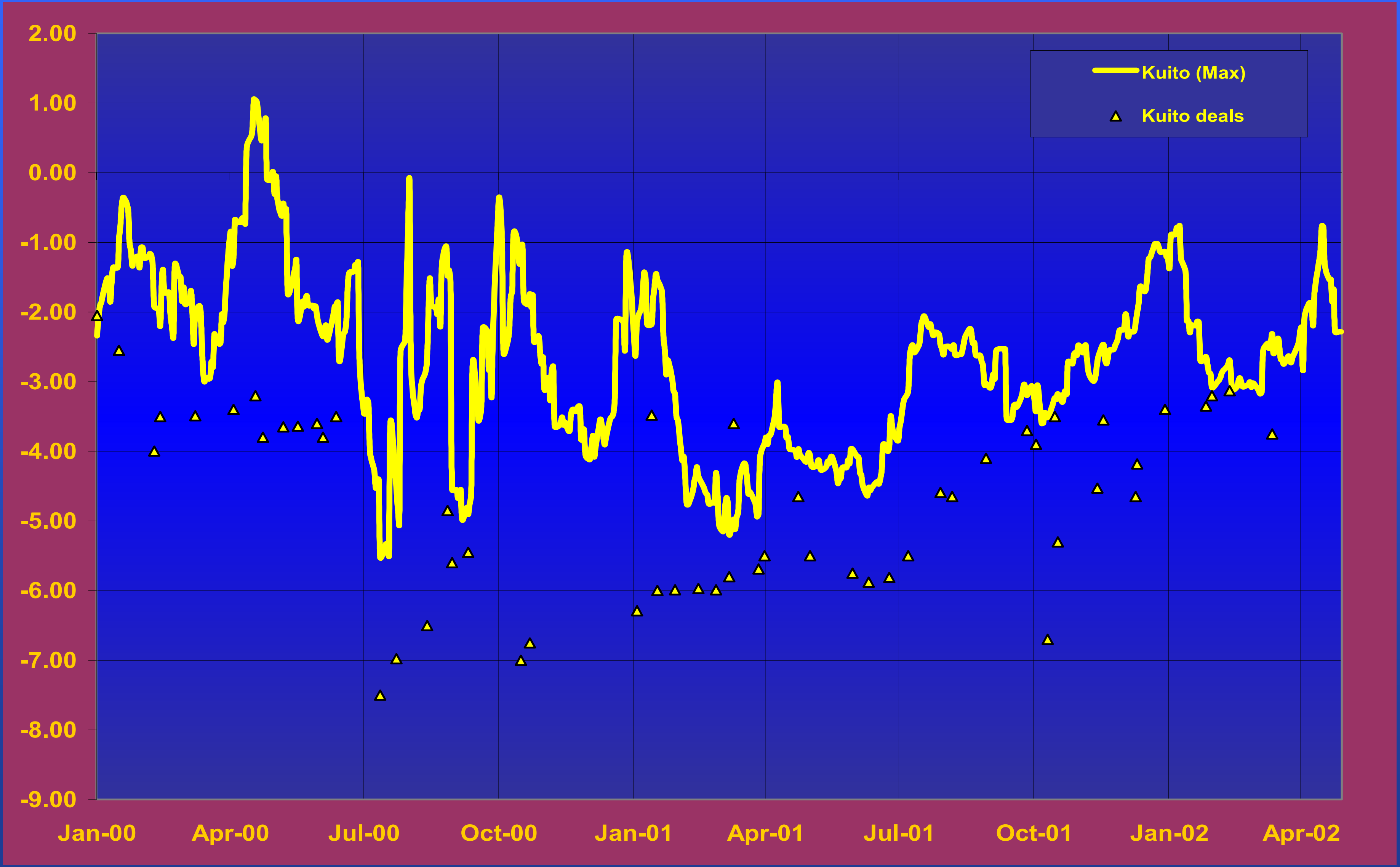


- **20% Kuito substitution:**
  - for Urals in NWE and Med.
  - for Escravos in USAC (US AtlanticCoast)
  - for Maya in USGC
  - freight is a factor in all cases
- **Refinery configurations: Coking in USGC and cracking refineries in all other areas**
- **Latest specs and prices for each region**

ChevronTexaco

HAC

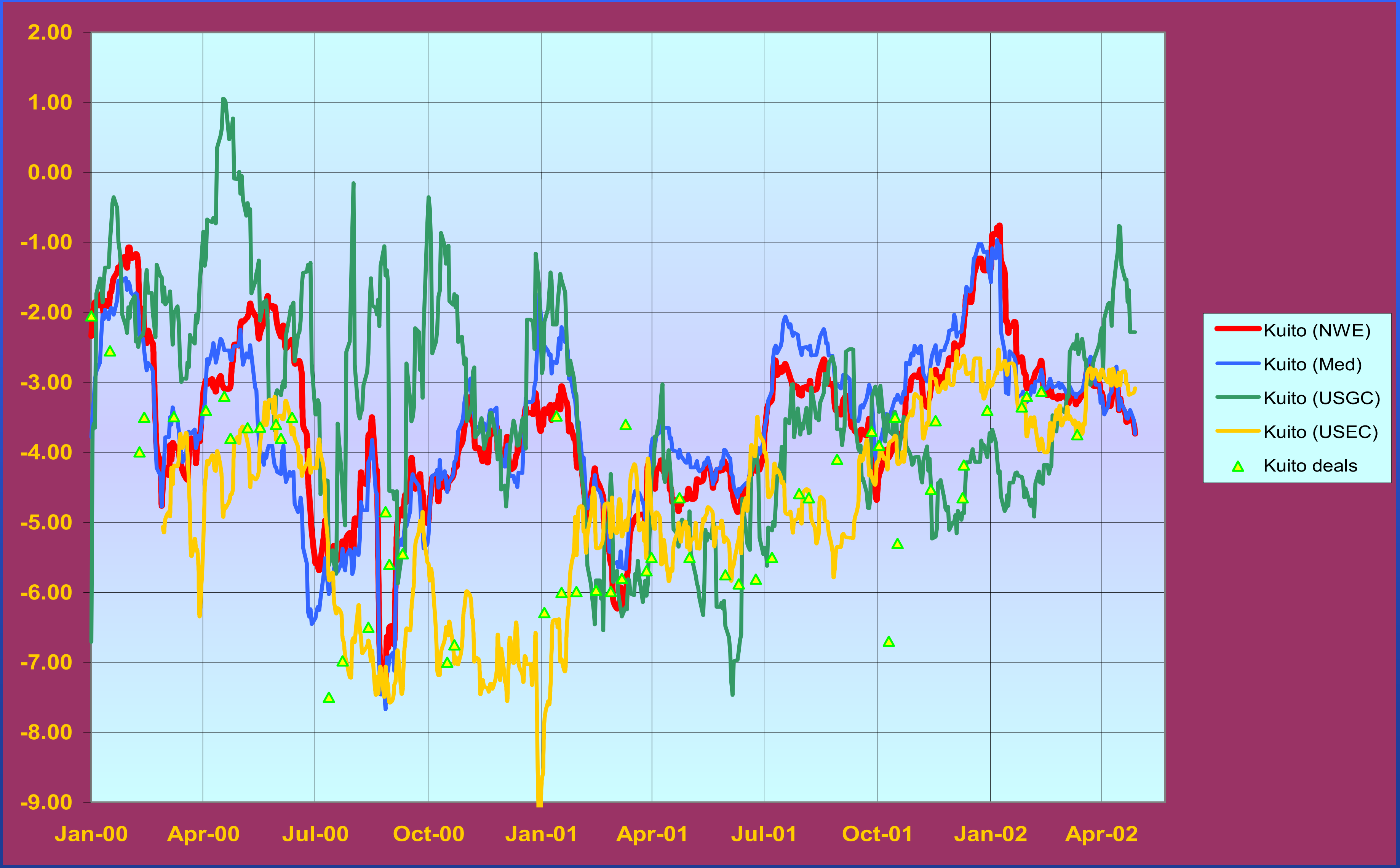
Kuito Valuation



ChevronTexaco

HAC

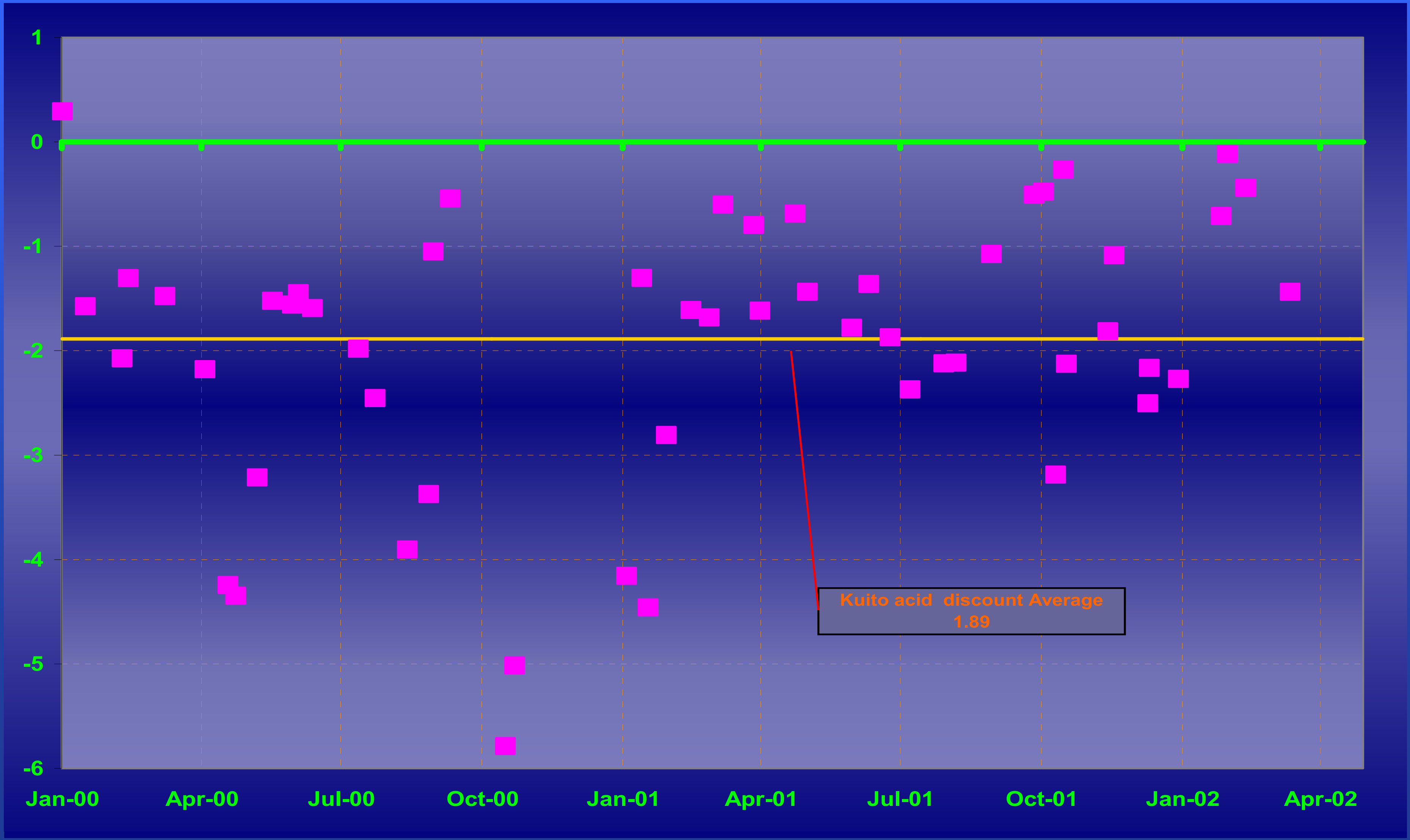
Kuito Valuation



ChevronTexaco

HAC

Acid Discount - Kuito



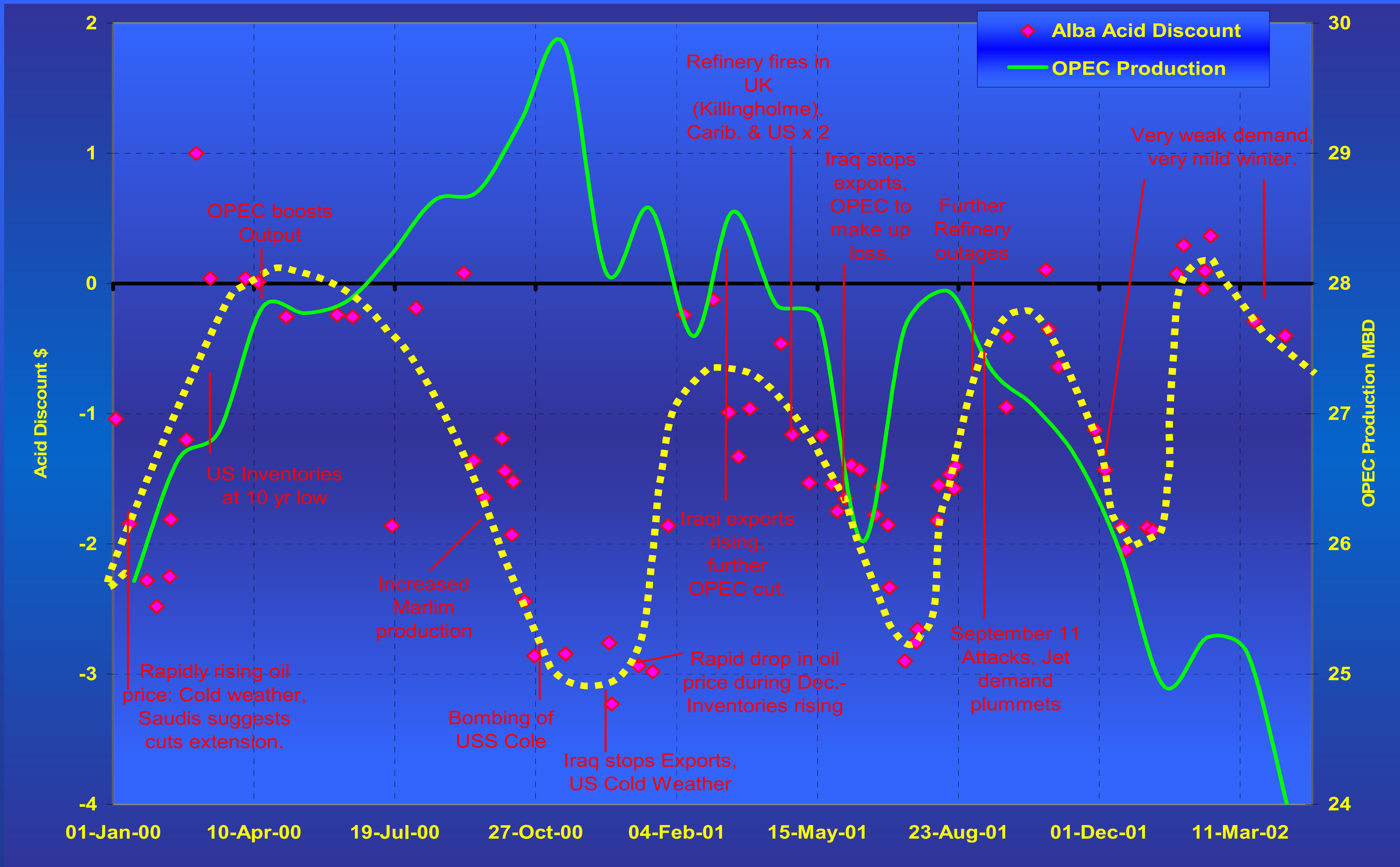
Factors which have impacted HAC Market Prices

- Changes in OPEC quotas
- Changing HAC supply/demand balance
  - Increased Marlim Production
- Fuel oil demand for HAC

ChevronTexaco

HAC

Acid Discount vs. OPEC Production



HAC Market discounts

- **Acid discount has widened:**
  - ~ -$0.50 / TAN from 1998 Purvin & Gertz study
  - ~ -$0.75 / TAN from latest study:
  - Increased production of HAC
  - Refinery upgrades have not kept pace

General Market Trading ranges

- Alba Dtd-5.00 to -2.00
- Captain Dtd-5.00 to -1.50
- Gryphon Dtd-2.50 to -1.50
- Troll Dtd-1.50 to +0.75
- Heidrun Dtd-2.50 to -0.50
- Kuito Dtd-5.50 to -2.00
- Ceiba Dtd-5.00 to -2.50
- Lokele Dtd-4.40 to -3.20
- Marlim WTI-5.50 to -2.50

In conclusion

- High Acid crudes may offer value relative to other grades
- Cost of mitigation is relatively low