The decommissioned Argyll, Duncan and Innes oil fields are located almost entirely in Blocks 30/24, some 320 km southeast of Aberdeen in the UK Sector of the North Sea. Argyll, discovered in 1971 by Well 30/24-2, was the first UK field to produce oil from the North Sea, with start-up commencing in June 1975. Duncan and East Duncan, 6 km west of Argyll, were discovered by Well 30/24-15 in 1980 and Well 30/24-17 in 1981 respectively, and came into production in late 1983. Innes production began in 1985, following the Well 30/24-24 discovery in 1983.

The fields produced from several geological horizons including Upper Devonian sandstones, Lower Permian Rotliegend Group sandstones, Upper Permian Zechstein Group carbonates and Upper Jurassic sandstones at Argyll, Upper Jurassic sandstones at Duncan and Rotliegend Group sandstones at Innes.

Production was initially via the Transworld 58 (TW 58) floating production facility. In March 1983 the TW 58 was moved from Argyll to Innes, whilst Argyll and Duncan production was achieved via the larger Deep Sea Pioneer. Innes was later linked to the central floating production facility (RPF) by means of a subsea satellite manifold. Innes, Argyll and Duncan have now ceased production and were fully abandoned in 1993.

The current interests in Blocks 30/24 and 30/25a in per cent. are:-

- Elf: 25.00
- BHP*: 36.00
- LASMO: 12.50
- Monument Oil & Gas: 2.50
- Texaco: 24.00

**operator *

**LOCAL SETTING**

Argyll, Duncan and Innes are located on the Palaeozoic Argyll Ridge, at the southern extremity of the Central Graben. The nearest fields, to the northeast across the UK-Norway median line, are the Cretaceous chalk fields of the Ekofisk Complex. To the east is the decommissioned, stand-alone Angus development. The Auk field, located some 50 km northwest of the Argyll field area, is the closest Zechstein Group dolomite- and Rotliegend Group sandstone-producer. The Fulmar and Clyde fields, also to the northwest, produce from Upper Jurassic sands. The discovery in nearby Well 30/29-1 has been defined as the Iris accumulation.

**FIELD DESCRIPTION**

The Argyll field consisted of a northeast to southwest trending horst feature bounded by faults to the northeast, northwest and southeast and dip closed to the east. The main oil reservoirs were Permian Zechstein Group carbonates and Rotliegend Group sandstones. Further production was achieved from Devonian sandstones, and a small volume of oil was recovered from the Upper Jurassic. Triassic silts and Cretaceous chalks provided cap-rocks. Reservoir quality was moderate to good.

The reservoir fluid was low GOR oil, which produced by virtue of a strong natural aquifer. Gas lift was initiated in 1985 to maintain output during the latter stages of the field’s life.

The Duncan accumulation comprised good-quality oil in the Jurassic Fulmar Formation. The small Innes field produced oil from the Auk Formation via two wells. Production from Innes was originally via the Transworld 58 but from January 1987 produced via subsea flowlines tied back to the Deep Sea Pioneer.

All three fields have ceased production, Innes in February 1991 and Argyll and Duncan in October 1992. The whole complex was decommissioned in July 1993, at a cost of £15 million.
STRUCTURE AND STRATIGRAPHY

The Argyll field is located on the Palaeozoic Argyll Ridge, which is a southwesterly dipping high-relief fault-bounded block, occurring at the western margin of the Central Graben. It is cut by numerous small, north-northwest to south-southeast and northeast to southwest trending faults, resulting in the formation of an intensively faulted and complex structure.

The main reservoirs in Argyll were Devonian Sandstones, Zechstein carbonates (Argyll Formation) and Rotliegend sandstones (Auk Formation), which are encountered at depths ranging from 8700 to 9400 feet TVDSS. These thin up dip to a culmination adjacent to the main northwest trending fault bounding the field to the northeast. The Zechstein carbonates were the main producing zone, with 100 to 300 feet of net pay and a 131 to 167 feet oil-column. The gross thickness of the oil-column in the Rotliegend sandstones varied from 131 to 367 feet. The Zechstein carbonates and Rotliegend sandstones are progressively sealed by Zechstein evaporites (Turbot Bank Formation), Triassic mudstones (Smith Bank Formation) and Chalk (Valhall/Tor Formations) in a northeast to southwesterly direction.

The Upper Jurassic Fulmar Formation constitutes a secondary reservoir in Argyll and the main the reservoir in the Duncan field. It is sealed by overlying Cretaceous mudstones and chalks.

SEDIMENTOLOGY AND DEPOSITIONAL ENVIRONMENT

The Zechstein carbonates consist predominantly of dolomites deposited within a basin environment. Interbedded salts precipitated between the dolomites have been subsequently dissolved resulting in collapse of the dolomites. The carbonate sequence is divided into two shallowing upward cycles: the Halibut Bank and Tarbot Bank Formations.

The Rotliegend Group sediments comprise shallow desert-lake mudstones and marginal cross-beded aeolian dune sandstones at the base. The sands are overlain by low-sinuosity and braided-alluvial, current-rippled, fining upwards sandstones and thinly bedded sheet-flood sandstones. These are capped by arid/aloeid interdune sands and coarser grained, cross-bedded, aeolian dune sandstones. The alluvial systems advanced northward from the Mid-North Sea High source area over a low-lying plain with an ephemeral desert lake and marginal aeolian dune fields.

The Upper Jurassic Fulmar Formation comprises shallow-marine sandstones, which are clean and fine to medium grained. These sediments are interpreted as shoreface storm or sheet sands and provide better reservoir sands at Duncan compared to Argyll. The sands are 4-150 feet thick in Duncan and are sub-divided into 5 zones.

INTERPRETIVE STRUCTURAL CROSS SECTION

REPRESENTATIVE WELL SECTION - 30/24-15 - DUNCAN

REPRESENTATIVE WELL SECTION - 30/24-5 - ARGYLL
The Zechstein carbonates are subdivided into 2 zones, with much of the reserves produced from fracture and vugular porosity. The reservoir characteristics of the Rotliegend Group sandstones are a product of facies type and diagenetic history. The sequence can be subdivided into two reservoir genetic units, the Alpha and Beta units. The Alpha unit consists mainly of fairly homogeneous laterally extensive aeolian-influenced sandstones, confined to the central fairway (the Alpha Graben) in the field, and the Gamma unit of variable lithology, consisting of laterally restricted fluvial channel, alluvial-plain, desert-lake and minor dune facies, in which variations in the depositional processes and diagenesis principally control the reservoir characteristics.

The Alpha unit reaches a maximum thickness of 113 feet in the Alpha Graben and is stratigraphically thinned or truncated by faulting to the northeast and southwest. The underlying Beta unit has a maximum thickness of 35 feet. The thickest (about 550 feet) stratigraphically thinned or truncated by faulting to the northeast and southwest. The Rotliegend section is underlain by a thick sequence of Devonian braided stream sandstones of poorer reservoir quality. The Upper Jurassic Fulmar Formation forms a relatively thin, but laterally extensive, sheet-like sand body. It thins to zero to the east where it onlaps towards the crest of the Argyll structure.

**FLUID PROPERTIES**

Rotliegend and Zechstein oils in Argyll appear to have similar PVT properties except that the oil viscosity in the Zechstein may be somewhat lower than that in the Rotliegend at around 0.8 cp. Oil in Duncan has a higher GOR and formation volume factor than that in Argyll.

**CONTROLS ON RECOVERY**

Recovery estimates for Argyll steadily increased during the field’s life as infill drilling proved extremely successful in this highly complex faulted field. A strong natural aquifer provided pressure support and this combined with gas lift allowed a high recovery factor to be achieved. The good to excellent Jurassic sand quality in Duncan allowed a moderate to high recovery factor to be achieved.

Zechstein carbonates - average log porosities range from 8 to 18 per cent. whilst core porosities average only 5 per cent. The latter are not, however, considered representative, and much of the reservoir porosity may comprise vugs and fractures. Rotliegend sandstones - the 'Alpha' and 'Beta' unit sandstones have generally moderate to good porosity (17 to 28 per cent.), and good to very good permeabilities (300 to 3000 md). The 'Gamma' unit fluvial channel and aeolian dune sandstones have moderate to good porosities (12 to 28 per cent.) while permeabilities can be good (up to 1000 md).

Trends in porosity and permeability are controlled by facies type and diagenetic history. The clean 'Alpha' and 'Beta' unit sands have excellent reservoir characteristics with only minor authigenic cements and clays. The 'Gamma' unit displays rapid vertical and horizontal variations in reservoir quality. The fluvial sands in the north are characterised by extensive quartz overgrowths and kaolinite, whilst in the south and west dolomite cement and illite are present, although good secondary porosity is also present. Fulmar Formation - porosities are good, typically 20 to 25 per cent. and permeability values range from 1 to 1000 md. Trends are controlled by the primary textural characteristics of grain size and clay content.

**RESERVOIR PRESSURE**

Pressure data from wells drilled on Argyll before the start of production indicate a considerable spread. Based on PVT data, an oil gradient of 0.32 psi/ft was to be expected. The Zechstein and Rotliegend horizons appear to be in pressure communication and oil gradient of 0.32 psi/ft was to be expected. The Zechstein and Rotliegend horizons appear to be in pressure communication and were initially overpressured by some 1100 psi.

The Duncan field was similarly overpressured with an oil gradient of 0.32 psi/ft.
FULL FIELD LIFE ECONOMIC INDICATORS

Discount Rates | 0.0% | 5.0% | 8.0% | 10.0% | 12.0% | 15.0% | 20.0%
--- | --- | --- | --- | --- | --- | --- | ---
Pre Corporation Tax
Net Present Value | 445.3 | 238.3 | 234.4 | 230.7 | 172.0 | 130.4 | 98.8
Net Present Value (Deflated) | 1047.2 | 703.4 | 589.9 | 485.4 | 422.7 | 340.2 | 252.3
Profit (Deflated) | 1.5 | 1.5 | 1.5 | 1.4 | 1.4 | 1.3 | 1.3
Profit Ratio | 1.4 | 1.3 | 1.2 | 1.2 | 1.1 | 1.0 | 0.9
NPV Unit Oil Equivalent | 4.6 | 4.7 | 4.7 | 4.5 | 4.4 | 4.3 | 4.2
NPV Unit Oil Equivalent (Deflated) | 4.3 | 4.0 | 3.8 | 3.7 | 3.5 | 3.3 | 3.1
Post Corporation Tax
Net Present Value | 248.8 | 102.3 | 126.1 | 110.1 | 98.2 | 77.3 | 55.8
Net Present Value (Deflated) | 575.5 | 207.7 | 315.5 | 275.2 | 257.2 | 194.0 | 141.0
Profit (Deflated) | 0.9 | 0.5 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5
Profit Ratio | 0.8 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6
NPV Unit Oil Equivalent | 2.6 | 2.6 | 2.5 | 2.5 | 2.4 | 2.4 | 2.2
NPV Unit Oil Equivalent (Deflated) | 2.4 | 2.2 | 2.1 | 2.0 | 2.0 | 1.8 | 1.6
Nominal Rate of Return | 10.0
Real Rate of Return | 8.4
Earnings Data
Gross Revenue | 1317.7 | 839.0 | 647.5 | 553.0 | 477.5 | 387.4 | 283.8
Profit | 104.9 | 67.0 | 53.0 | 46.6 | 38.4 | 32.0 | 25.3
Corporation Tax | 215.7 | 132.0 | 180.3 | 195.6 | 175.5 | 121.1 | 44.1
Capital Expenditure | 220.7 | 203.9 | 181.5 | 144.0 | 122.0 | 101.4 | 75.2
Operating Costs | 441.2 | 203.4 | 158.6 | 106.8 | 141.5 | 112.6 | 86.2
Profit (Deflated) | 236.1 | 102.5 | 132.0 | 110.9 | 102.4 | 80.6 | 61.1
Profit Ratio | 0.9 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6
Petroleum Revenue Tax | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0
Capital Expenditure | 256.2 | 248.3 | 215.2 | 166.6 | 152.2 | 112.2
Operating Costs | 512.8 | 388.7 | 408.7 | 358.0 | 381.0 | 398.9
Pre Corporation Tax
Net Present Value | 2948.1 | 1998.1 | 1624.0 | 1428.2 | 1265.1 | 1068.0 | 829.5
Net Present Value (Deflated) | 6861.9 | 4480.8 | 3654.0 | 3180.4 | 2814.0 | 2380.8 | 1892.0
Profit (Deflated) | 266.0 | 263.4 | 198.6 | 166.8 | 141.5 | 112.6 | 80.2
Profit Ratio | 0.9 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6
NPV Unit Oil Equivalent | 2.6 | 2.6 | 2.5 | 2.5 | 2.4 | 2.4 | 2.2
NPV Unit Oil Equivalent (Deflated) | 2.4 | 2.2 | 2.1 | 2.0 | 2.0 | 1.8 | 1.6
NPV/Unit Oil Equivalent | 2.4 | 2.2 | 2.1 | 2.0 | 2.0 | 1.8 | 1.6
Net Present Value | 578.5 | 390.7 | 313.5 | 272.2 | 237.2 | 194.0 | 140.1
Post Corporation Tax
Net Present Value | 248.8 | 102.3 | 126.1 | 110.1 | 98.2 | 77.3 | 55.8
Net Present Value (Deflated) | 575.5 | 207.7 | 315.5 | 275.2 | 257.2 | 194.0 | 141.0
Profit (Deflated) | 0.9 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6
Profit Ratio | 0.8 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6
NPV Unit Oil Equivalent | 2.6 | 2.6 | 2.5 | 2.5 | 2.4 | 2.4 | 2.2
NPV Unit Oil Equivalent (Deflated) | 2.4 | 2.2 | 2.1 | 2.0 | 2.0 | 1.8 | 1.6
NPV/Unit Oil Equivalent | 2.4 | 2.2 | 2.1 | 2.0 | 2.0 | 1.8 | 1.6

PRODUCTION PERFORMANCE

HISTORICAL

Average Annual Oil Output (MMbbls/D)

--- | --- | --- | --- | --- | --- | --- | ---
1970 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1975 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1980 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1985 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1990 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1995 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
2000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

These cash flows include Argyll, Duncan, and Innes fields.

CASH FLOW REPORT

--- | --- | --- | --- | --- | --- | --- | ---
1970 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1975 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1980 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1985 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1990 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
1995 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
2000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

These cash flows include Argyll, Duncan, and Innes fields.

FACILITIES SPECIFICATIONS

Water Depth
(foot)
250
Platform Type
Floating production facility
Function
Production/accommodation
Jacket Weight
(tonne)
——
Total Weight
(tonne)
——
Accommodation
100
Well Slots
16
Wells
9 (Argyll) + flowlines from Duncan manifolds & Innes

PROCESSING AND EXPORT SPECIFICATIONS

Oil Throughput
(Barrels per day)
70000
Oil Export
CALM buoy + shuttle tankers
Gas Export
Fared
Note: Innes ceased production in 1991, Argyll and Duncan ceased in 1992. All three were decommissioned in 1993 at a cost of £15 million.